UNIVERSITY OF CALIFORNIA AT BERKELEY

Physics 7C – (Stahler)

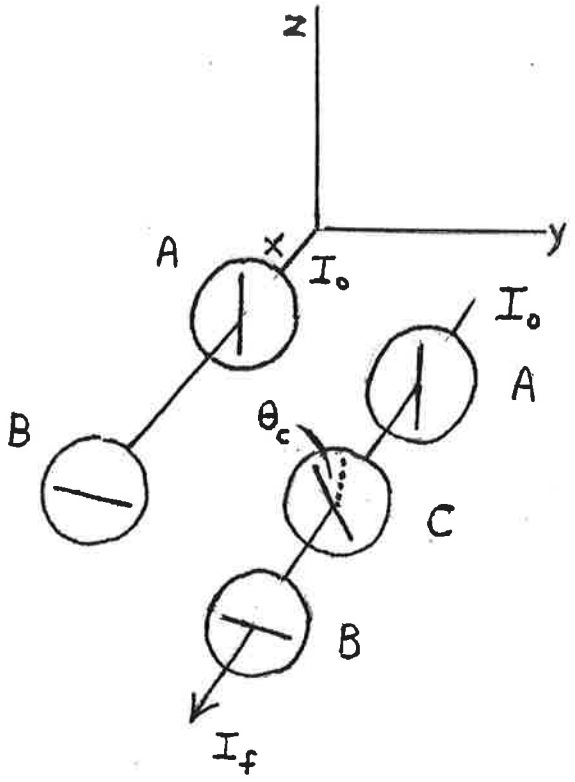
Spring 2017

SECOND MIDTERM

Please do all your work in your blue (or green) books. This printed exam is for you to keep, as are your notes on the single sheet of paper. On the cover page of your blue or green book, write your name, SID, discussion section number, and GSI name.

You must attempt all four problems. If you become stuck on one, go on to another and return to the first one later. Be sure to show all your reasoning clearly, i.e., do not simply write down equations. **Remember to circle your final answer!**

Problem 1 (30 points)



Unpolarized light of intensity I_o propagates along the x-axis and passes through two polaroid filters, as shown above. The transmission axis of filter A is in the z-direction, while that of B is in the y-direction. The final intensity of light passing through B, which we denote as I_f, is zero.

You now insert a third polaroid filter C between A and B. The transmission axis of C is at an angle θ_C with respect to the z-axis. You find that I_f/I_o is no longer zero, but has a value that depends on θ_C.

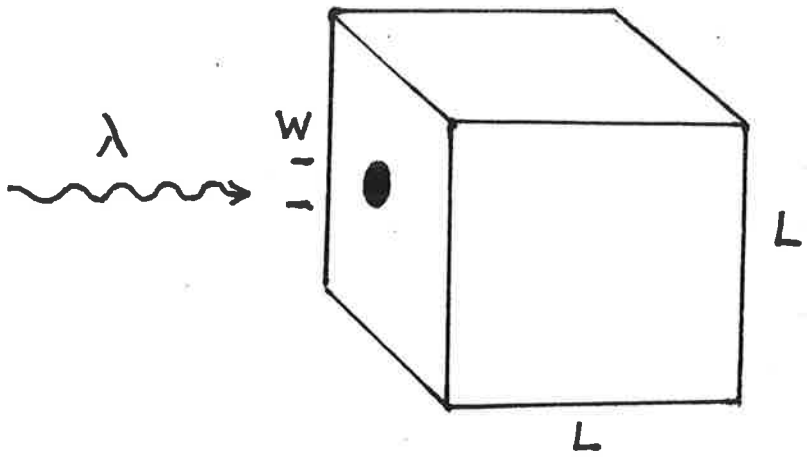
(a) Derive an expression for I_f/I_o in terms of θ_C. From your expression, find that angle θ_C^* for which I_f/I_o is a maximum.

(b) What is I_f/I_o when $\theta_C = \theta_C^*$?

With A, B, and C in place, and keeping $\theta_C = \theta_C^*$, you insert yet another polaroid D **between A and C**. Its transmission axis is at the angle $\theta = \theta_C^*/2$ with respect to the z-axis.

(c) What now is I_f/I_o?

Problem 2 (25 points)



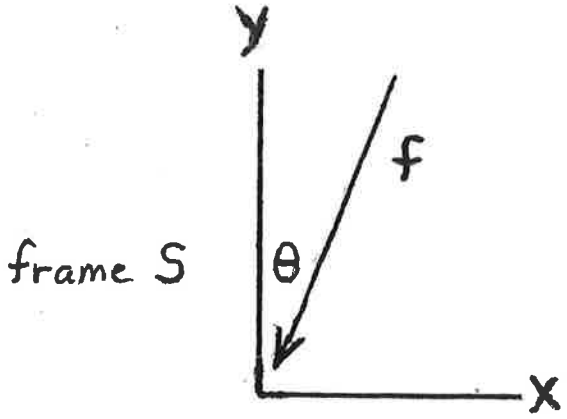
A hollow cube, made of stiff cardboard, has sides of length L. On the face of the cube is a small, circular hole of width W. Monochromatic light of wavelength λ enters the hole and creates a bright, circular spot of diameter S on the opposite face, inside the cube.

(a) Neglecting diffraction, what is S?

(b) Diffraction increases the spot size. Write a second, improved expression for S that takes diffraction into account.

(c) For what hole diameter W is S the smallest possible value?

Problem 3 (20 points)

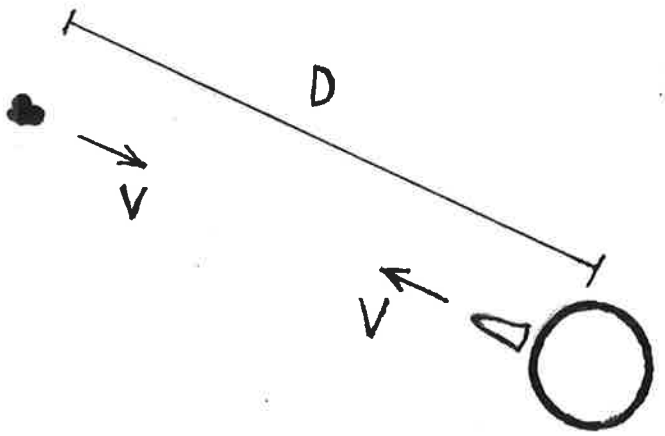


In the lab frame S, a photon of frequency f travels downward at an angle θ to the y-axis. In another frame S$'$ that moves along the x-axis with velocity V, the photon is directed vertically downward.

(a) What is the magnitude and direction of the frame velocity V?

(b) In the frame S$'$, what is the photon frequency f'?

Problem 4 (25 points)



An asteroid is heading straight for the Earth. At $t = 0$, it is at distance D, and is traveling at speed $V = c/2$. At this time, we launch a rocket designed to destroy the asteroid. The rocket, which also travels at the same speed V, carries a clock that starts running at launch.

(a) What is the speed of the asteroid as seen from the rocket?

(b) At what time after its launch does the rocket crash into the asteroid, as measured by the clock on board the rocket?