Master copy

Physics 7C Midterm 1

Professor Mina Aganagic

October 2, 2007

Please write your discussion SECTION NUMBER on your blue book (or meeting day and hour if you don't remember the section number). Please put all answers in Blue Books.

1 25 pts

A thin cylindrical object of mass m and cross-sectional area A is being levitated by shining a laser that emits light incident normal to the bottom face of the object. Assume it is reflective and the cross-section of the laser beam is the same as the object.

a. What is the power P (energy emitted per unit time) necessary to keep the object levitated? For a typical laser emitting 1 W of power, what mass does this correspond to?

b. In terms of P, A, and physical constants, what is the amplitude of the magnetic field B_o, coming from the laser?

c. In some coordinate system, the magnetic field incident on the object can be written $\vec{B} = B_o \sin(kx - wt)\hat{y}$. Write the corresponding electric field in terms of the preceding quantities.

d. Could we have written $\vec{B} = B_o \cos(kx - wt)\hat{x}$? Explain.

e. Could we have written $\vec{B} = B_o \sin(kx^2 - wt)\hat{y}$? Explain.

2 30 pts

A light bulb of height 5 cm is placed 30 cm from a concave mirror as shown. The mirror has a focal length of 20 cm and is located to the left of the bulb. There is a convergent lens of focal length 20 cm located 5 cm from the bulb to the right. The lens forms two images of the bulb, one from the light directly coming from the bulb and the other from the reflection of the bulb in the mirror.

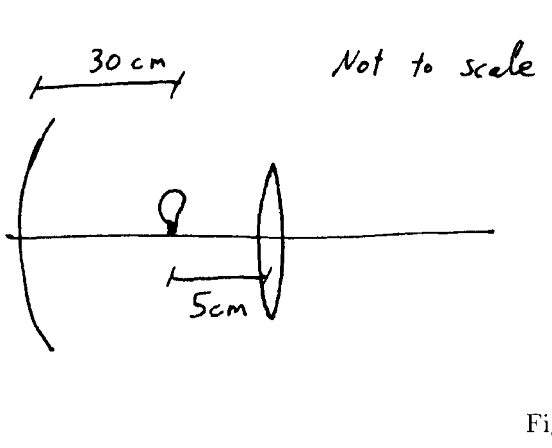


Figure 1:

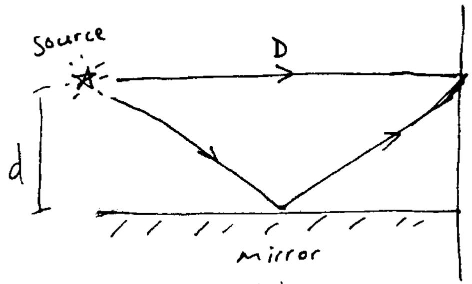
a. For each of the two images formed, draw a ray diagram that locates the image. Make sure the figures are legible.

b. For each image, answer:

- What is the distance from the bulb to the image in *cm*?
- What is the height of the image in *cm*?
- Is the image real or virtual (i.e. do light rays really pass through the point where the image is formed or not)?
- Is the image erect/upright or inverted (with respect to the bulb)?

3 25 pts

Another ~~version of a two slit~~ experiment can be done by bouncing light off a mirror. Suppose a point-like source of light with wavelength λ is located a distance D from a flat screen as shown in the figure. A distance d below the source is a flat mirror, at right angle to the screen. Take $d \ll D$.



(a)
One set of rays meeting at screen.

See back for picture & comment given during exam.

Figure 2:

a. Find the location of the image of the source.

-2 phase 9 **b.** The source and its image produce two waves that interfere. Defining an angle θ as measured from the mirror, find the values for θ which give interference maxima on the screen (in terms of d, D, and λ). [hint: consider any consequences to the phase upon reflection.] You don't have to use all given values.

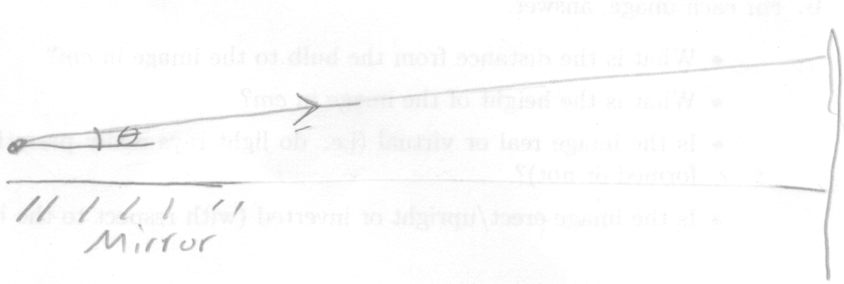
10 **c.** What is the intensity pattern as a function of θ and draw the intensity profile on the screen copying the figure and labeling the $\theta = 0$ point.

10 **d.** Repeat parts a through c assuming the whole thing is placed under water with index of refraction n_w. Does the frequency of the source change? You may simply write down the new answers.

4 20 pts

Two perfectly flat glass plates (index of refraction $n_g = 1.5$) are separated at one end by a piece of paper .065 mm thick. A source of 550 nm light illuminates the plates from above, as shown.

$65 \cdot 10^{-6} / 550 \cdot 10^{-9} = 650/55 \cdot 10 = 118$



Use small angle

So no ambiguity of θ.

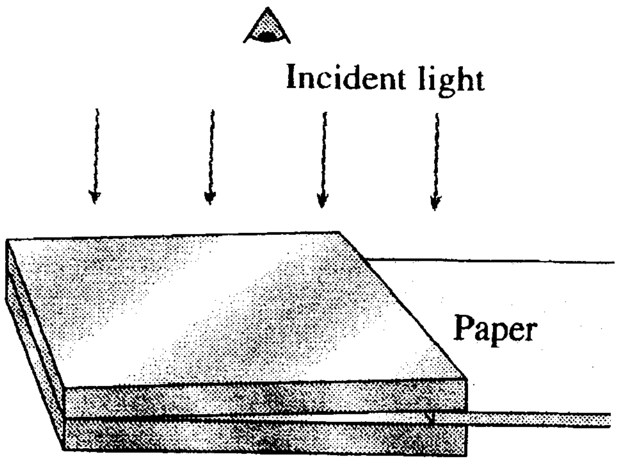


Figure 3:

a. Assuming the glass plates are 1cm thick clearly explain (in words or pictures) which two waves (or rays) will produce an observable interference pattern.

b. Write down their phase difference, clearly explaining where each contribution comes from. What will this depend on in this setup?

c. Compute the number of bright interference fringes that an observer looking down on the plates will see. What will these fringes look like?

d. Suppose you now view the setup directly from underneath. How many bright fringes do you see? Why?

They were told they could assume an L,