

Physics 116, W 07
OE Vilches

Answers to multiple choice questions

Q1 - The sound from Source 2 has to travel an extra meter.

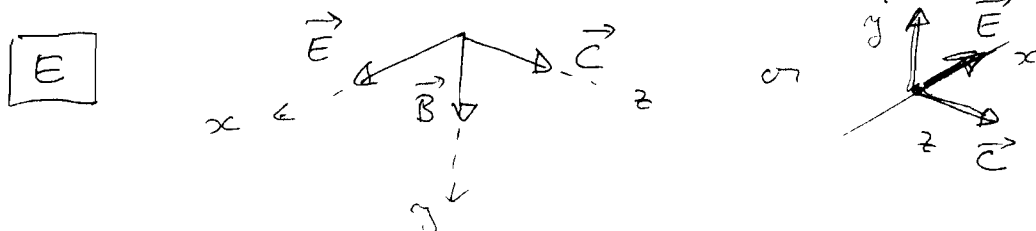
[A] $\frac{340 \text{ m/s}}{170 \text{ /s}} = \lambda = 2 \text{ m.}$

So half λ fits in 1 m and there is destructive interference (like Tycho problem) - Intensity is zero

Q2 - Frequencies are different, so there are oscillations in the amplitude (beats) - When in phase, Intensity is $(2)^2 = 4$ times the intensity of individual sources -

So $f_{\text{beats}} = f_2 - f_1 = 5 \text{ Hz}$, "I" oscillates between 0 and 16 Watts/m^2

Q3 - \vec{E} , \vec{B} and \vec{C} have to be like a "right handed" system of coordinates - Here \vec{E} is polarized horizontally



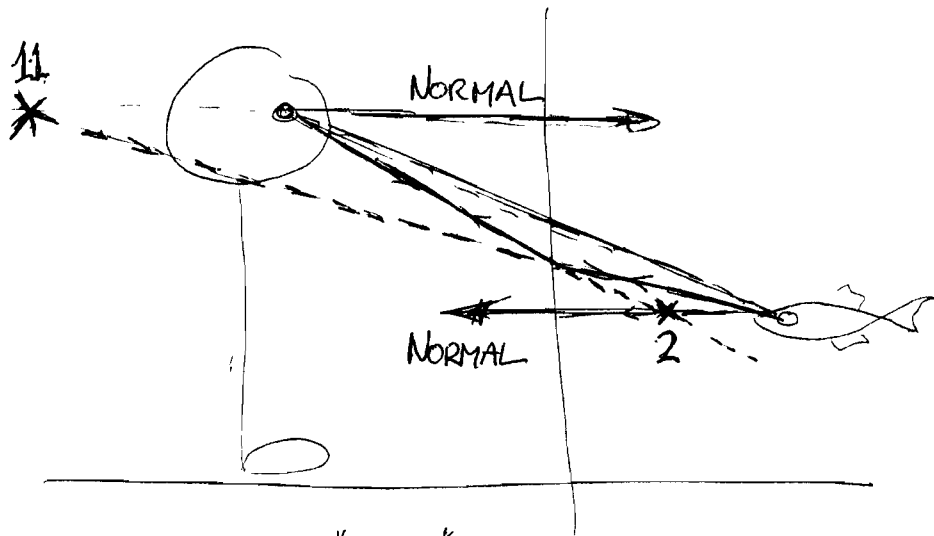
Q4 - Energy in an electromagnetic wave is carried equally in the electric and magnetic fields, half in each.

[D]

Q5 - Unpolarized light intensity gets cut in half by first polarizer - Second polarizer cuts it further by $\cos^2 60^\circ$

[E] This was a clicker question that everyone had right in class.

$$I_{\text{through}} = 20 \frac{\text{W}}{\text{m}^2} \times 0.5 \times \cos^2 60^\circ = 2.5 \text{ W/m}^2$$

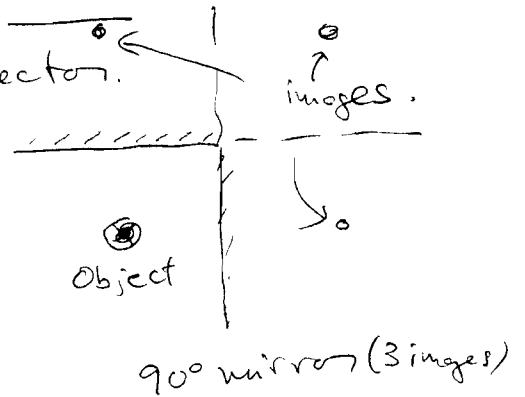
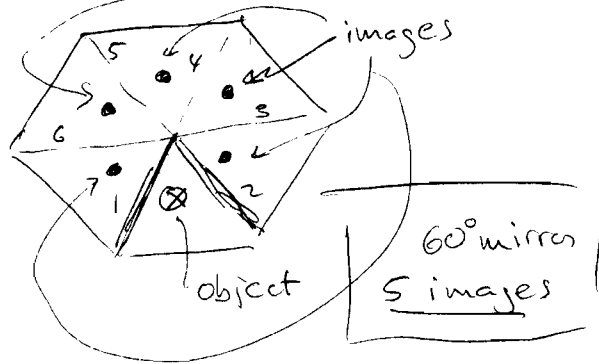


[B] Q6 - Humanoid "sees" fish closer to glass, just like class demo with stick and block of glass, or yard stick in water tank, on extension of refracted ray

[A] Q7 - Fish "sees" person also on extension of his (its) refracted ray.

[Q8] Each mirror acts as a reflector.

[D]

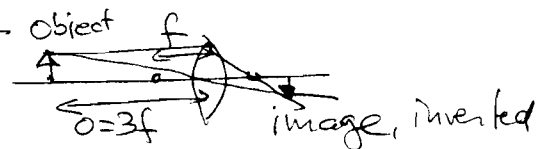
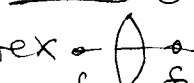


[E] Q9 - Convex mirror on top makes smaller, ^{virtual} image close to mirror, while concave mirror on bottom makes an enlarged, ^{virtual} image inside the mirror further away from surface

[Q10]

[B]

Double convex



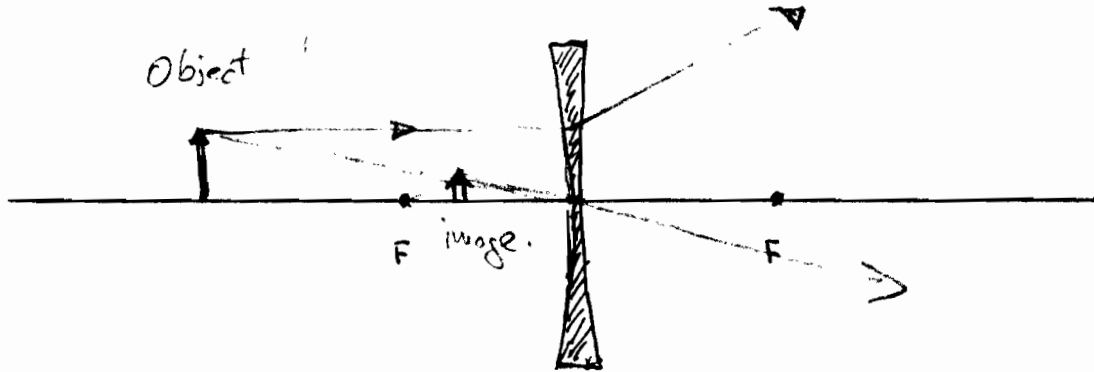
$$d_i = \frac{f d_o}{d_o - f} = \frac{f \cdot 3f}{3f - f} = \frac{3f}{2} \quad M = -\frac{d_i}{d_o} = -\frac{\frac{3f}{2}}{3f} = -\frac{1}{2}$$

SOLUTION OEV

Problem 1 (25 points)

In this and next problem, please write neatly and show all your work. No credit just for a numerical answer without showing how you got it.

A. (10 points) The drawing below shows an object (the arrow) and a double concave lens made of glass with index of refraction $n = 1.5$. Find the image of the object by ray tracing.

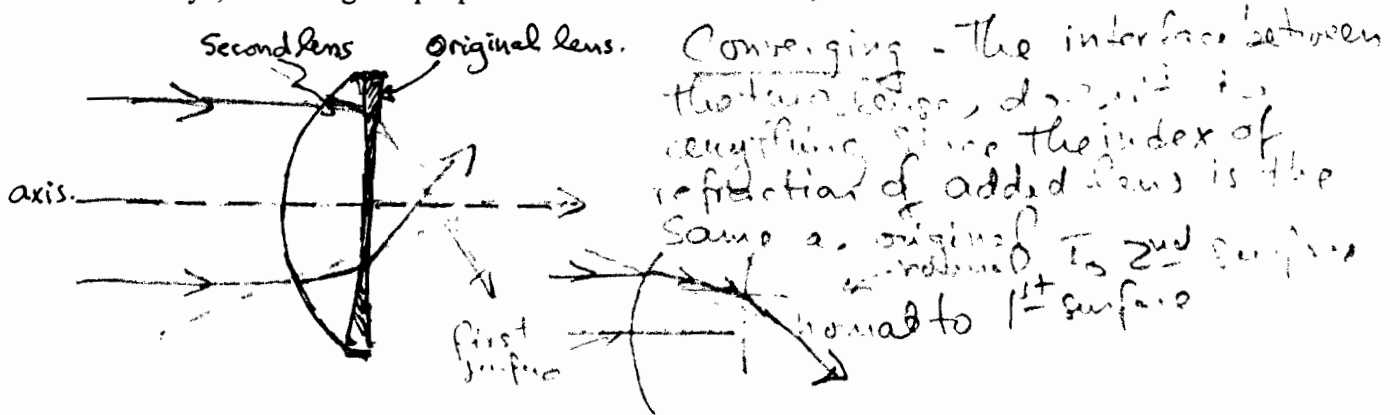


B. (9 points) The lens above has $f = -0.5$ meters. It is used to form the image of a 1 m height object 10 m in front of the lens. Calculate the distance from the lens at which the image is formed and the height of the image. Make sure to show your work.

$$\frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{1}{-0.5} - \frac{1}{10} \Rightarrow i = \frac{fo}{o-f} = \frac{(-0.5)(10)}{10 - (-0.5)} = -0.476 \text{ m}$$

$$H_i = M H_o = -\frac{i}{o} H_o = -\left[\frac{-0.476}{10}\right] \times 1 \text{ m} = +0.048 \text{ m}$$

C. (6 points) A second lens is added to the first, so the combination looks like below. The index of refraction of the second lens is the same as the one of the first lens. Is the new combination a "converging" or a "diverging" lens? Support your answer by tracing one or two rays, including the proper normals to the surfaces, etc...



Problem 2 (25 points)

This problem will be graded mostly on method since there is a possibility of carry forward numerical errors. Points are rough guides. Make sure to answer in order.

The electric field in a linearly polarized electromagnetic wave has an amplitude (or peak value) of 810 Newton/Coulomb (or Volts/meter).

a) (6 points) Calculate the peak value of the magnetic field in this wave

$$E_{\text{peak}} = c B_{\text{peak}} \Rightarrow B_{\text{peak}} = \frac{E_{\text{peak}}}{c} = \frac{810 \frac{\text{N}}{\text{C}}}{3 \times 10^8 \frac{\text{m}}{\text{s}}} = 2.7 \times 10^{-6} \text{ Tesla}$$

b) (5 points) Calculate the peak intensity of this wave

Use E_{peak} or B_{peak} or both.

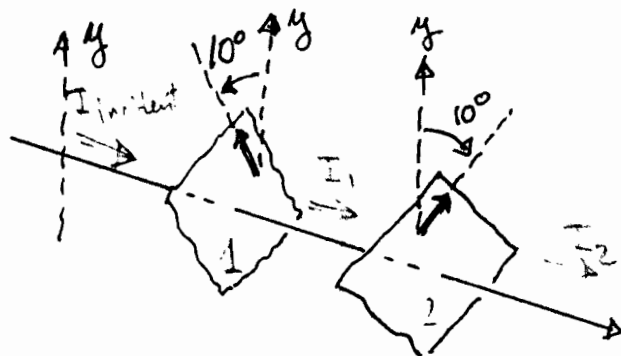
$$I_{\text{peak}} = \frac{1}{2} \epsilon_0 c E_{\text{peak}}^2 = 8.85 \times 10^{-12} \frac{\text{Coulomb}^2}{\text{Nm}^2} \times 3 \times 10^8 \frac{\text{m}}{\text{s}} \times \left(810 \frac{\text{N}}{\text{Coul}}\right)^2 = 1742 \frac{\text{W}}{\text{m}^2}$$

$$= 1742 \frac{\text{Nm}}{\text{m}^2 \text{s}} = 1742 \frac{\text{Watt}}{\text{m}^2}$$

c) (4 points) Calculate the average intensity of this wave

$$I_{\text{Average}} = \frac{1}{2} \epsilon_0 c E_{\text{peak}}^2 = 871 \frac{\text{Watt}}{\text{m}^2}$$

d) (10 points) Assume that the answer to (c) is 900 Watts/m². If the wave is polarized in the y-direction, calculate the intensity transmitted through the two polarizers shown in the sketch below which are perpendicular to the direction of travel of the wave. Angles shown are for the easy axis of transmission with respect to the y-axis.



$$I_{\text{incident}} = 900 \frac{\text{Watts}}{\text{m}^2}$$

$$I_2 = I_1 \cos^2 20^\circ = I_{\text{incident}} \cos^2 10^\circ \cos^2 10^\circ$$

angle
polarizer
intensity

$$= 900 \frac{\text{W}}{\text{m}^2} \cos^2 10^\circ \cos^2 10^\circ$$

$$= 771 \frac{\text{W}}{\text{m}^2}$$