PY106 Fall 2022 Quiz 4

Yang Jeong Yong

TOTAL POINTS

38.5 / 40

QUESTION 1

Problem 1 17 pts

1.1 1(a) 2 / 2

✓ **+ 2 pts** **Correct: Maximum. E field and B field are perpendicular.**

+ 0 pts Incorrect

1.2 1(b) 2 / 2

✓ **+ 2 pts** **Correct: +z direction. Right hand rule.**

+ 0 pts Incorrect

1.3 1(c) 3 / 3

✓ **+ 3 pts** **Correct: $$I_A = I_0/2 = 300/2 = 150 W/m^2$$**

+ 0 pts Incorrect

1.4 1(d) 3 / 3

✓ **+ 3 pts** **Correct: $$ I = E_{max}^2/(2c \mu_o)$$**

Solve for $$E_{max} = \sqrt{2c \mu_o I}$$ = $$\sqrt{(2)(3 \times 10^8 m/s) (4 \pi \times 10^{-7} T m/A)(150 W/m^2)} = 336 V/m$$

+ 1.5 pts Correct equation used, incorrect value entered for mu or minor calculation error

+ 0 pts Incorrect or blank

1.5 1(e) 2 / 2

✓ **+ 2 pts** **Correct: 90 degrees. If no angle in C allows any light, then angle between A and B must be 90 degrees since cos(90)=0**

+ 0 pts Incorect or blank

1.6 1(f) 2 / 2

✓ **+ 2 pts** **Correct: $$\theta_C=80$$ degrees. We want maximum intensity coming out of C (given A and B), so set $$\theta_C$$ to same angle as B.**

+ 1 pts Initial calculations and work shown

+ 0 pts Incorrect or blank

1.7 1(g) 3 / 3

✓ **+ 3 pts** **Correct: $$I_B=I_C = I_A cos^2(\theta_B - \theta_A) = (150 W/m^2) cos^2(80-20) = (150 W/m^2) cos^2(60) = (150)(0.5)(2) = 37.5 W/m^2$$**

+ 1.5 pts Work shown, minor calculation error

+ 0 pts Incorrect or blank

QUESTION 2

2 Problem 2 2 / 2

✓ **+ 2 pts** **Correct: n1 < n2. Light bends toward the normal, so it's traveling from lower to higher index of refraction.**

+ 0 pts Incorrect or blank

QUESTION 3

Problem 3 5 pts

3.1 1(a) 1.5 / 3

+ 3 pts Correct: 45 cm

M = 1, di = -do

Distance of eye to mirror (35 cm) plus distance from mirror to image |di|=10 cm. D = 35 + 10 = 45 cm

✓ **+ 1.5 pts** **Work shown, minor calculation error**

✓ **+ 0 pts** **Incorrect or blank**

3.2 1(b) 2 / 2

✓ **+ 2 pts** **Correct: f = -3.0 m.**

do = +3.0 m. height image is half your height, so m=0.5 = - di/do. Thus di= - 0.5 do

1/f = 1/do + 1/di = 1/do + 1/(-0.5 do)

1/f = -1/do

f= -do = - 3.0 m

+ **1.5 pts** Missing negative, or minor calculation mistake

+ **0 pts** Incorrect or blank

QUESTION 4

Problem 4 11 pts

4.1 4(a) 3 / 3

✓ **+ 3 pts Correct: di = +30 cm**

1/f = 1/do + 1/di

di= (do f)/(do - f)

(15)(10)/[15-10] = 150/5 = +30 cm

– OR –

1/f = 1/do + 1/di

1/10 = 1/15 + 1/di

3/30 = 2/30 + 1/di

1/30 = 1/di. di = +30 cm

+ **1.5 pts** Incorrect magnitude or minor calculation error

+ **0 pts** Incorrect or blank

4.2 4(b) 3 / 3

✓ **+ 3 pts Correct: M = -2.**

M= -di/do = -30 cm/15 cm = -2

+ **1.5 pts** Magnitude or minor calculation error

+ **0 pts** Incorrect or blank

4.3 4(c) 2 / 2

✓ **+ 2 pts Correct: do toward infinity (i.e., as far away from the lens as possible)**

+ **0 pts** Incorrect or blank

4.4 4(d) 3 / 3

✓ **+ 3 pts Correct: do = +5 cm**

Virtual image, one focal length away di= -f = - 10 cm.

1/f= 1/do + 1/di

1/10 = 1/do + 1/(-10)

2/10 = 1/do

do=10/2 = + 5 cm

+ **1.5 pts** Work shown minor calculation mistake

+ **0 pts** Incorrect or blank

QUESTION 5

Problem 5 5 pts

5.1 5(a) 1 / 1

✓ **+ 1 pts Correct: Virtual**

+ **0 pts** Incorrect or blank

5.2 5(b) 1 / 1

✓ **+ 1 pts Correct: Converging**

+ **0 pts** Incorrect or blank

5.3 5(c) 3 / 3

✓ **+ 3 pts Correct: f = +20 cm**

M=+2 = -di/do. Thus, di=-2do

1/f=1/do+1/di

1/10+1/(-2*10) = 1/10 - 1/20= 2/20 - 1/20 = 1/20. f= +20 cm

+ **1.5 pts** Minor calculation mistake work shown

+ **0 pts** Incorrect or blank

PY106 Quiz 4 – November 30, 2022 **Show work to receive partial credit**

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PROBLEM 1 – 8.5 points

Assume our coordinate system has x and y in the plane of the page, +x to the right, +y up, and +z straight out of the page. At a certain location and time, an electromagnetic plane wave has its electric field is at its maximum amplitude and is pointing in the +y direction and its magnetic field is pointing in the -x direction.

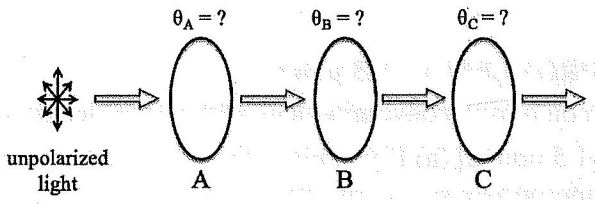
[1 point] (a) At this location and time, the magnitude of the magnetic field is at its:

[✓] Maximum [ ] Minimum [ ] There is no magnetic field [ ] Not enough information to tell

[1 point] (b) In what direction is the electromagnetic plane wave travelling?

[ ] +x [ ] -x [ ] +y [ ] -y [✓] +z [ ] -z

[1.5 points] (c) A source of unpolarized light with an intensity of 300 W/m^2 is incident on a linear polarizer, Polarizer A, with an unknown transmission axis. What is the intensity of the wave after passing through the Polarizer A?



unpolarized → $\frac{1}{2} I_0$

$\frac{1}{2}(300) = 150$

$I_A =$ 150 W/m^2

[1.5 points] (d) What is the electric field's maximum amplitude after passing through Polarizer A?

$I = \frac{E_{max}^2}{2 c \mu_0} = 150 = \frac{E_{max}^2}{2(3\times10^8)(4\pi\times10^{-7})}$ $E_{max} = \sqrt{113097.3355}$

$E_{max,A} =$ 336.3 V/m

[1 point] (e) You leave linear Polarizers A and B as is and you rotate linear Polarizer C between 0° and 90°. As you do this, you observe that no light ever comes out of Polarizer C. From this, determine the angle between Polarizer A and B. *If there is not enough information to determine the angle, put an* **X** *in the answer box.*

after going through A, appl'y $I_0 \cos^2(\Delta\theta)$

$I_0 \cos^2(\Delta\theta) = 0$ $\Delta\theta = 90$

$\Delta\theta_{AB} =$ 90 °

[1 point] (f) You find out that Polarizer A is set at a transmission angle of 20° and you rotate Polarizer B until it is set at a transmission angle of 80°. You now observe there is light coming through Polarizer C. What transmission angle should you set Polarizer C to get the maximum possible intensity of light out of Polarizer C?

maximize intensity → $I_0 \cos^2(\Delta\theta)$

↳ $\cos^2(\Delta\theta)$ is maximized when $\Delta\theta = 0 \rightarrow \theta$ is same

$\theta_C =$ 80 °

[1.5 points] (g) Following from (f), what is the maximum intensity of light coming out of Polarizer C?

$\frac{1}{2}(300) = 150$ ↳ $150\cos^2(60) = 37.5$

$I_C =$ 37.5 W/m^2

PROBLEM 2 – 1 point

[1 point] An incident light ray (red laser with wavelength 656 nm) passes from a material with index of refraction n_1 to another material with index of refraction n_2. The incident angle is 50° and the refracted angle is 40° (both measured from the normal). How are n_1 and n_2 related? Hint: As usual, it may be helpful to draw a picture.

[ ] $n_1 = n_2$ [ ] $n_1 > n_2$ [✓] $n_1 < n_2$ [ ] Not enough information to say

$n_1 \cdot \sin(\theta_1) = n_2 \sin(\theta_2)$

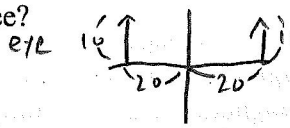
$n_1 \sin(50) = n_2 \sin(40)$

$n_1 = \frac{n_2 \sin(40)}{\sin(50)} = n_2(0.839)$

Therefore, $n_2 > n_1$

PROBLEM 3 – 2.5 points

[1.5 points] (a) You place a 20 cm tall stick 10 cm in front of a plane mirror. You then put one of your eyes 35 cm away from the mirror and you see both the object in front of you and the image in the mirror. How far from your eye is the image of the stick that you see?

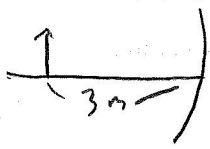


eye distance + 20cm
= 55cm

55 cm

[1 point] (b) You are standing 3.0 m from a convex security mirror in a store. You estimate the height of your image to be half of your actual height. What is the focal length of the mirror?

$\frac{1}{f} = \frac{-1}{d_o}$ ↳ $f = -3$ m



$2h_o = h_i$

$m = \frac{h_i}{h_o} = \frac{h_i}{2h_i} = \frac{1}{2} = \frac{-d_i}{d_o} \rightarrow -2d_i = d_o$

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$ $\frac{1}{f} = \frac{1}{d_o} - \frac{2}{d_o}$ $= -\frac{1}{d_o}$

$f =$ −3 m

PROBLEM 4 – 5.5 points

You have a converging lens with a focal length of 10 cm and an object that is 2 cm tall.

[1.5 points] (a) If you place the object 15 cm away from the lens, what is the image distance? Be sure to use appropriate sign conventions. $f=10$, $h_o=2$, $d_o=15$

$\frac{1}{10} = \frac{1}{15} + \frac{1}{d_i}$ $\frac{1}{10} - \frac{1}{15} = \frac{1}{d_i}$ $\frac{1}{30} = \frac{1}{d_i}$

$d_I =$ 30 cm

[1.5 points] (b) Following from (a), what is the magnification of the image that forms?

$m = -\frac{d_i}{d_o} = \frac{-30}{15} = -2$

$M =$ −2

[1 point] (c) If you want a real image that is as close to the lens as possible, where should you put the object?

[ ] $d_O \approx 0$ (i.e., as close to lens as possible) [ ] $d_O = f/2$ [ ] $d_O = f$ [ ] $d_O = 2f$

[✓] $d_O \approx \infty$ (i.e., as far from the lens as possible)

[1.5 points] (d) If you want a virtual image that is one focal length away from the lens, how far from the lens should you put the object?

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$ $d_i = -10$ cm

$\frac{1}{-10} + \frac{1}{d_o} = \frac{1}{10}$ $\frac{1}{d_o} = \frac{1}{10} + \frac{1}{10} = \frac{1}{5}$

$d_O =$ 5 cm

PROBLEM 5 – 2.5 points

You want to magnify reading material by a factor of 2 when a book is placed 10.0 cm behind a lens. You look through the lens and see an upright and magnified image.

[0.5 point] (a) Describe the type of image this would be… [ ] Real [✓] Virtual

[0.5 point] (b) What type of lens is needed… [✓] Converging [ ] Diverging

[1.5 points] (c) What is the focal length of the lens?

$2h_o = h_i$ $m = 2 = \frac{-d_i}{d_o}$ $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

$m = \frac{h_i}{h_o} = \frac{2h_o}{h_o} = 2$ $2d_o = -d_i$ $= \frac{1}{d_o} + \frac{1}{-2d_o} = \frac{1}{2d_o} = \frac{1}{f}$ ↳ $\frac{1}{20} = \frac{1}{f}$

$f =$ 20 cm