# Physics 111 <br> Practice Third Hour Exam <br> November 1, 2007 

Name

| Multiple Choice | $/ 20$ |
| :--- | ---: |
| Problem 1 | $/ 30$ |
| Problem 2 | $/ 20$ |
| Problem 3 | /30 |
| --------------------------100 |  |

## Part I: Free Response Problems

Please show all work in order to receive partial credit. If your solutions are illegible no credit will be given. Please use the back of the page if necessary, but number the problem you are working on. The numbers in parentheses following the question correspond to the point values for each part.

1. A converging lens has a focal length $f_{c}=10 \mathrm{~cm}$ and is placed 30 cm to the left of a diverging lens with focal length $f_{d}=-15 \mathrm{~cm}$. Suppose that an object is placed 18 cm to the left of the converging lens.
a. What is the location of the $1^{\text {st }}$ image from the converging lens and what is its magnification?
$d_{i 1}=22.5 \mathrm{~cm}$
$M_{c}=-1.25$
b. Using this image as the object for the diverging lens, what is the location of the final image and what is its magnification?
$d_{o 2}=7.5 \mathrm{~cm}$
$d_{i 2}=-5.0 \mathrm{~cm}$
$M_{d}=0.667$
c. What is the total magnification of the system?

$$
M_{\text {total }}=-0.834
$$

d. Now, consider a situation in which there is only a single converging lens with focal length $f$. If an object is placed on the left side of the lens at a distance $x$ measured from the left-side focal point and the image of this object is observed on the opposite side of the lens at a distance $x$ ' measured from the right-side focal point, show that $f^{2}=x x^{\prime}$. This is called the Newtonian form of the thin-lens equation.

2. Suppose that Europium (Eu) x rays are used in a Compton Effect experiment and are directed at stationary electrons ( $\mathrm{m}_{\mathrm{e}}=9.11 \times 10^{-31} \mathrm{~kg}$ ) in a carbon target. If theses x rays have an energy of 41.535 keV , and are completely backscattered, answer the following questions.
a. What is the wavelength of the incident Europium x rays?

$$
\lambda=2.9794 \times 10^{-11} \mathrm{~m}
$$

b. What is the wavelength of the scattered photons?

$$
\lambda_{f}=3.4620 \times 10^{-11} \mathrm{~m}
$$

c. What is the kinetic energy of the recoiling electron?

$$
K E_{e}=5.79 \mathrm{keV}=9.264 \times 10^{-16} \mathrm{~J}
$$

d. What is the velocity of the electron and is it relativistic?
$v=0.149 c=4.51 \times 10^{7} \frac{\mathrm{~m}}{\mathrm{~s}}$ Since this is slightly greater than $0.1 c\left(3 \times 10^{7} \mathrm{~m} / \mathrm{s}\right)$ the electron is relativistic.
3. Suppose that you are performing a double slit experiment where the slits are located 10 m from the viewing screen. Further, suppose that you know neither the slit width nor the slit separation. You see a $1^{\text {st }}$ order diffraction minimum and measure it to be located 20 mm from the optic axis. Next you count (including the central fringe) 7 bright fringes within the central diffraction maximum.
a. If you are using purple light with a wavelength of 400 nm , what is the slit width?

$$
a=2.0 \times 10^{-4} \mathrm{~m}=0.2 \mathrm{~mm}
$$

b. What is the spacing between the centers of the slits?

$$
d=0.0008 \mathrm{~m}=0.8 \mathrm{~mm}
$$

c. Describe in full detail, how the experiment would change if the experiment were performed in benzene? (Hint: Benzene is a liquid with index of refraction 1.50)

## Part II: Multiple-Choice

Circle your answer to each question. Any other marks will not be given credit. Each multiple-choice question is worth 2 points for a total of 20 points.

1. In a double slit experiment, the distance between the centers of adjacent maxima (bright spots) on a remote screen is 1 cm . What happens to this distance when the slit width is quadrupled?
a. It increases to 2 cm .
b. It increases to 4 cm .
c. It reduces to 0.5 cm .
d. It reduces to 0.25 cm
e. None of the above.
2. In the following diagram, light is incident at $66^{\circ}$, what is the critical angle on the upper surface of the waveguide, if the waveguide is in air with $\mathrm{n}_{\mathrm{air}}=1.00$ ?
a. $31.2^{\circ}$
b. $42.5^{\circ}$
c. $47.5^{\circ}$
d. $58.8^{\circ}$
e. $90.0^{\circ}$

3. In the following three diagrams, tell if the image is real or virtual, and enlarged or reduced in size.


Answer for 3: $\qquad$
4.


Answer for 4: $\qquad$
5.


Answer for 5:
6. An eagle's eye has a diameter of 6.2 mm and has a refractive index (for the material in its eye) of 1.36. How far away are two objects located below the eagle, if the eagle can see the two objects separated by 9.6 mm ? Assume that $\lambda=555 \mathrm{~nm}$ ?
a. 897 mm
b. 89.7 cm
c. 120 cm
d. 89.7 m
e. 120 m
7. Coherent light passes through a rectangular aperture of height h and width w . If h and w are both doubled, the diffraction pattern will change according to
a. its height will double and width will halve
b. its height and width will double
c. its height and width will halve
d. its height will halve and width will double
e impossible to find with given information
8. A proton is traveling at 0.99 c , what is its kinetic energy?
a. $4.960 \times 10^{-19} \mathrm{kgm} / \mathrm{s}$
b. $5.010 \times 10^{-19} \mathrm{kgm} / \mathrm{s}$
c. $4.960 \times 10^{-18} \mathrm{kgm} / \mathrm{s}$
d. $3.516 \times 10^{-18} \mathrm{kgm} / \mathrm{s}$
e. none of the above
9. Suppose that a double convex lens is used to produce a real image. What happens to the image if the lens is covered with an opaque substance everywhere except for a small circular spot near the center of the lens?
a. The bottom half of the image disappears.
b. The top half of the image disappears.
c. The entire image is visible but dimmer.
d. The image completely disappears
e. Nothing happens to the image.
10. What is the energy of a copper $x$-ray if it has momentum $4.267 \times 10^{-24} \mathrm{kgm} / \mathrm{s}$ ?
a. 0.5 keV
b. 2.0 keV
c. 8 keV
d. 0.25 MeV
e. 8 MeV

Multiple Choice Answers

1. E
2. B
3. Real \& Inverted
4. Real \& Inverted
5. Virtual \& Erect
6. E
7. C
8. E
9. C
10. C
