Do NOT open out the exam until instructed to do so!

Name: ___________________ UIN: ___________________

Signature: _______________ E-mail: ___________________

Section Number: ___________ (5 points off for a wrong sec. #)

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<td>525</td>
<td>T 2:20-5:10pm</td>
<td>Milan Poudel</td>
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<td>526</td>
<td>T 3:55-6:45pm</td>
<td>Morgan Priolo</td>
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<td>527</td>
<td>T 5:30-8:20pm</td>
<td>Dan Xie</td>
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- You have the full class period to complete the exam.
- Formulae are provided on a separate colored sheet. You may NOT use any other formula sheet.
- When calculating numerical values, be sure to keep track of units.
- You may use this exam or come up front for scratch paper.
- Be sure to put a box around your final answers and clearly indicate your work to your grader.
- Clearly erase any unwanted marks. No credit will be given if we can’t figure out which answer you are choosing, or which answer you want us to consider.
- Partial credit can be given only if your work is clearly explained and labeled.
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Problem 1 (20 points):
The figures show a small plant near a thin lens. The ray shown is one of the principal rays for the lens. Each square is 2.0 cm along the horizontal direction, but the vertical is not the same scale. Use the information from the diagram to answer the following questions.
(a) (5 pts) Is this converging or diverging lens?
(b) (5 pts) What is the focal length of the lens?
(c) (5 pts) Locate the image by drawing the other two principal rays.
(d) (5 pts) Using the lens formula, calculate the image position. To receive a full credit this result must be consistent with the graphical solution in part (c).

Set Up

We find $s = 10.0 \text{ cm}$, $f = 18.0 \text{ cm}$

Solution

(a) The ray is bent toward the optic axis after it passes through the lens.

The lens is converging.

(b) $f = 18.0 \text{ cm}$

(c) See the ray diagram.

(d) $\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$

$\therefore s' = \frac{sf}{s-f}$

$= \frac{(10.0 \text{ cm})(18.0 \text{ cm})}{10.0 \text{ cm} - 18.0 \text{ cm}}$

$= \frac{180}{-8}$

$= -22.5 \text{ cm}$

The image is located 22.5 cm to the left of the lens.

Both must agree.
Problem 2 (20 points):
(10 pts) In a PHYS 202 lab, your group finds that when monochromatic light falls on a metal, no electrons are emitted unless the frequency of the light is greater than some minimum value, called the threshold frequency. Why are no electrons ejected from the metal if the frequency of the light is below the threshold frequency, even though the intensity of the light very strong?

A photon striking the surface of a conductor is absorbed by an electron. If the photon energy is greater than the potential-energy barrier (work function $\Phi$), the electron can escape from the surface. Namely, $E \gamma > \Phi \rightarrow \gamma_{\text{threshold}} = \Phi / h$

(5 pts) Now, the frequency of the light is above the threshold frequency. Your group observes electrons to be emitted from the metal. The intensity of this light is increased, but its wavelength and the temperature of the metal are held constant, what will your group observe? (There may be more than one correct answer.)

(a) The number of electrons emitted from the metal does not change.
(b) The number of electrons emitted from the metal increases.
(c) The maximum speed of the emitted electrons does not change.
(d) The maximum speed of the emitted electrons increases.  

(b) & (c)

(5 pts) Silicon films becomes better electrical conductors when illuminated by light with wavelength shorter than 1090 nm (called photoconductivity), and electrons are emitted from the films by light with wavelength shorter than 260 nm. Calculate the energy of light (= photon) and deduce the energy levels of electrons in the Silicon film to explain the photoconductivity.

![Diagram of energy levels and photon energies](image)

There are two energy levels (−4.8 eV and −3.66 eV). If electrons are in the $E = -3.66$ eV state, the mobility of electrons are higher, resulting in becoming a better electrical conductor.
Problem 3 (20 points):
(a) (10 pts) An insect 3.75 mm tall is placed 22.5 cm to the left of a thin planoconvex lens. The left surface of this lens is flat, the right surface has a radius of curvature of magnitude 13.0 cm, and the index of refraction of the lens material is 1.70. Calculate the location and size of the image this lens forms of the insect. Is it real or virtual? Erect or inverted?

\[ \frac{1}{f} = (n-1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right) \quad \text{\( R_1 \rightarrow \infty \), \( R_2 = -13.0 \, \text{cm} \)} \]

\[ \frac{1}{f} = (0.70) \left( \frac{1}{\infty} - \frac{1}{-13.0 \, \text{cm}} \right), \quad \therefore \, f = 18.6 \, \text{cm} \]

\[ \frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \quad \therefore \, s' = \frac{sf}{s-f} = 10.7 \, \text{cm} \]

\[ m = - \frac{s'}{s} = - \frac{10.7 \, \text{cm}}{22.5 \, \text{cm}} = -4.76 \]

\[ \therefore \, y' = m \, y = (-4.76) (3.75 \, \text{mm}) = -17.8 \, \text{mm} \]

\[
\text{inverted}
\]

(b) (10 pts) A sample of hydrogen atoms is irradiated with light with a wavelength of 85.5 nm, and electrons are observed leaving the gas. If each hydrogen atom were initially in its ground level, what would be the maximum kinetic energy, in electron volts, of these electrons? Note Planck constant is \( h = 4.136 \times 10^{-15} \, \text{eV} \cdot \text{s} \).

\[ E_\gamma (\lambda=85.5 \, \text{nm}) = \frac{hC}{\lambda} = 14.5 \, \text{eV} \]

\[ K_{\text{max}} = E_\gamma - 13.6 \, \text{eV} \]

\[ = 0.9 \, \text{eV} \]