Conceptual Questions and Short P (2 Points Each) Circle the BEST answer!
1. A lens produces a sharply-focused, inverted image on a screen as shown. What will you see on the screen if the lens is removed?
   a. The image will be as it was, but much dimmer.
   b. The image will be right-side-up and sharp.
   c. The image will be right-side-up and blurry.
   d. The image will be inverted and blurry.
   e. There will be no image at all.

2. The image shown is:  a. real   b. virtual   c. magical

3. The first-order diffraction of monochromatic x rays from crystal A occurs at an angle of 20°. The first-order diffraction of the same x rays from crystal B occurs at 30°. Which crystal has the larger atomic spacing?
   a. Crystal A  b. Crystal B          c. Same   d. Impossible to determine

4. White light passes through a diffraction grating and forms rainbow patterns. For each rainbow, a. the red side is on the right, the violet side on the left.
   b. the red side is on the left, the violet side on the right.
   c. the red side is closest to the center of the screen, the violet side is farthest from the center.
   d. the red side is farthest from the center of the screen, the violet side is closest to the center.

5. Match the light intensity patterns with the type of slit diffraction:
   (a) Single Slit Diffraction: ______ Double Slit Diffraction: ______ Diffraction Grating ______

6. For a convex lens, if the object is located a shorter distance than the focal length, the image will be
   a) real, upright and larger  b) real, inverted and smaller  c) real, upright and smaller
   d) virtual, upright and larger  e) virtual, inverted and larger

7. For a concave mirror, if the object is located a greater distance than the focal length, the image will be
   a) real, upright and larger  b) real, inverted and smaller  c) real, upright and smaller
   d) virtual, upright and larger  e) virtual, inverted and larger

8. Light of wavelength $\lambda_1$ illuminates a double slit, and interference fringes are observed on a screen. When the wavelength is changed to $\lambda_2$, the fringes get further apart. How does the size of $\lambda_2$ compare to $\lambda_1$?
   A) $\lambda_2$ is larger than $\lambda_1$.   B) $\lambda_2$ is smaller than $\lambda_1$.   C) Not enough information to answer.

9. A film of index of refraction $n_1$ coats a surface with index of refraction $n_2$. When $n_1 < n_2$, the condition for destructive interference for reflected monochromatic light of wavelength $\lambda$ in air is
   a. $t = m\frac{\lambda}{n_1}$.   b. $t = \left(m + \frac{1}{2}\right)\frac{\lambda}{n_1}$.   c. $2t = m\frac{\lambda}{n_1}$.   d. $2t = \left(m + \frac{1}{2}\right)\frac{\lambda}{n_1}$.   e. $4t = m\frac{\lambda}{n_1}$.

10. White light falls on a soap bubble and blue wavelengths are destroyed. What color do you see?
   a. cyan   b. magenta   c. yellow   d. red   e. green   f. blue
Short Problems (7 points each) Show your work for ANY credit. Box Answers. Circle the best answer.

1. A diver in the water shines an underwater searchlight at the surface of a pond ($n = 1.33$). At what angle (relative to the normal) will the light be totally reflected?
   a. 47°
   b. 41°
   c. 51°
   d. 58°
   e. 49°

2. The large space telescope that has been placed into an Earth orbit has an aperture diameter of 2.4 meters. What angular resolution will this telescope achieve for visible light of wavelength $\lambda = 4.8 \times 10^{-7}$ m?
   a. $2.44 \times 10^{-7}$ rads
   b. $2.44 \times 10^{-4}$ rads
   c. $2.44 \times 10^{-3}$ rads
   d. $1.22 \times 10^{-6}$ rads
   e. $2.00 \times 10^{-6}$ rads

3. Monochromatic light from a He-Ne laser ($\lambda = 632.8$ nm) is incident on a diffraction grating containing 5000 lines/cm. Determine the angle of the first-order maximum.
   a. 18.4°
   b. 39.2°
   c. 14.6°
   d. 27.7°
   e. 13.9°

4. Light reflected off a plate-glass window ($n = 1.5$) is found to be completely polarized at angle-of-incidence $\theta$. Find $\theta$.
   a. 56.3°
   b. 5.7°
   c. 21.2°
   d. 18.6°
   e. 33.7°

5. Three polarizing disks whose planes are parallel are centered on a common axis. The direction of the transmission axis in each case as shown relative to the common vertical direction. An unpolarized beam of light is incident from the left on the first disk with intensity $I_i = 10.0$ W/m². Calculate the transmitted intensity $I_f$ in W/m² when $\theta_1 = 20.0°$, $\theta_2 = 40.0°$, and $\theta_3 = 60.0°$.
   a. 0.73
   b. 1.30
   c. 1.47
   d. 3.90
   e. 6.89
1. A narrow beam of white light enters an equilateral prism made of crown glass at 45.0 degrees incident angle as shown. At what angle does the red (660.0 nm) component of the light emerge from the prism relative the normal of the right side? The index of refraction for red light in crown glass is 1.512.

Redraw the prism large enough to have room to label rays and angles.
2. Coherent light of wavelength 650.0 nm is sent through two parallel slits and an interference pattern is formed on a screen at a distance $L=2.50$ m behind the slits. Each slit is $a = 0.700 \mu$m wide. Their centers are $d = 2.80 \mu$m apart.

a) Derive from scratch the equation for the position of constructive interference fringes on the screen above the center of the central bright fringe in terms of the variables $L$, $d$, $n$, $\lambda$, and $\theta$.
b) Find the angle to the 3rd bright fringe.
c) Find the intensity of light on the screen at the center of the 3rd bright fringe, expressed as a fraction of the light intensity $I_{\text{max}}$ at the center of the pattern.
3. An object, height 2.00 cm, is located 3.00 cm from a diverging lens with a focal length of -5.00 cm.
   A. Use the lens equation to find the location, magnification and height of the image.
   B. Draw the situation to scale to locate the image, identifying the three rays. Measure the image location
      and height and calculate the magnification. Compare your result for the image location with what you
      found in part A. Please label everything. NEATNESS COUNTS. Box and label your answers.