Chapter 10 Review Questions

Solutions can be found in Chapter 12.

Section I: Multiple Choice

1. An X-ray with a frequency of 1.0×10^{18} Hz is an example of an electromagnetic wave. The equation for the electric field of such an X-ray could be given by $E = A\cos(\omega t)$ with…

(A) A measured in N/C and $\omega = 1.0 \times 10^{18}$ Hz.
(B) A measured in $N \cdot s/C$ and $\omega = 1.0 \times 10^{18}$ Hz.
(C) A measured in N/C and $\omega = 2.0\pi \times 10^{18}$ Hz.
(D) A measured in $N \cdot s/C$ and $\omega = 2.0\pi \times 10^{18}$ Hz.

2. In Young's double-slit interference experiment, what is the difference in path length of the light waves from the two slits at the center of the first bright fringe above the central maximum?

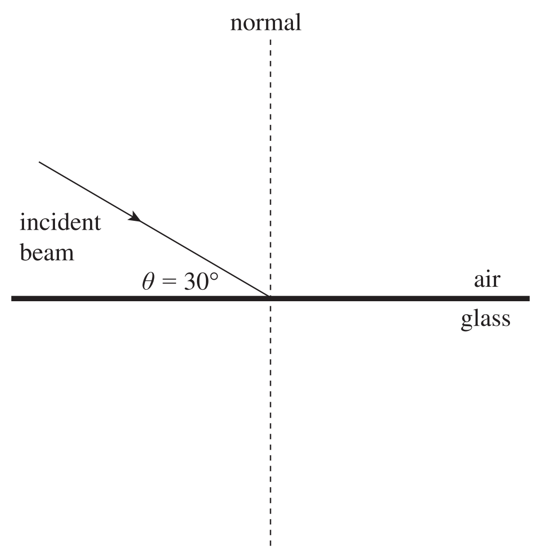
(A $\frac{1}{4}\lambda$

(B) $\frac{1}{2}\lambda$

(C) λ

(D) $\frac{3}{2}\lambda$

3. A beam of light in air is incident upon the smooth surface of a piece of flint glass, as shown:



As the incident angle is increased toward $\theta = 90°$, what observation is made of the refracted ray? All angle references are relative to the surface as shown for both rays.

(A) The refracted ray angle increases as the incident angle increases, but the value of the refracted angle is always smaller than the incident angle.
(B) The refracted ray angle increases as the incident angle increases, but the value of the refracted angle is always larger than the incident angle.
(C) The refracted ray angle increases as the incident angle increases until at some angle total internal reflection begins to occur.
(D) The refracted ray angle decreases as the incident angle increases, but the value of the refracted angle is always smaller than the incident angle.

4. A convex lens constructed of glass makes a real image of an object when it is in air. When the object is located d_o in front of the lens, the image appears in air at a distance d_i behind the lens. What occurs if the object is still at d_o, but the object and the lens are submerged in water with an index of refraction between that of air and the glass of the lens?

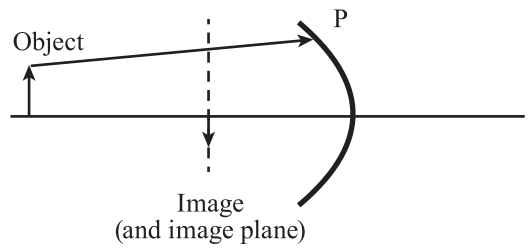
   (A) The image is still at d_i and is still real.
   (B) The image is at a position closer to the lens than d_i and is real.
   (C) The image is at a position farther from the lens than d_i and is real.
   (D) The image becomes virtual.

5. A beam of light traveling in Medium 1 strikes the interface to another transparent medium with a lower index of refraction, Medium 2. If the intensity of light is measured to be less in Medium 2 than in Medium 1, then it can be concluded that

   (A) The decrease in intensity was caused by the change in the speed of light in the different media.
   (B) Total internal reflection occurred at the interface.
   (C) The angle the light travels relative to the normal in Medium 2 will be the same as the angle the light had traveled relative to the normal in Medium 1.
   (D) Some part of the light was reflected and/or absorbed at the interface.

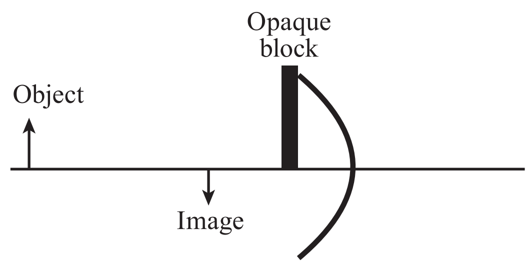
6. If a clear liquid has a refractive index of 1.45 and a transparent solid has an index of 2.90 then, for total internal reflection to occur at the interface between these two media, which of the following must be true?

	incident beam originates in	at an angle of incidence greater than
(A)	The solid	30°
(B)	The liquid	30°
(C)	The liquid	60°
(D)	Total internal reflection cannot occur.	



7. The above picture shows a converging mirror and an object, as well as the image, which is formed from standard ray tracing. Also shown, a dotted vertical line indicates the image place for this configuration. Also shown in a ray that travels from the top of the image to the point P on the curved mirror. The point P lies above the line which is parallel to the optic axis from the tip of the image. Where will the reflected ray from point P intersect the image plane?

   (A) On the optic axis
   (B) Below the optic axis but above the tip of the image
   (C) At the tip of the image
   (D) Farther from the optic axis than the tip of the image



8. The above picture shows a converging mirror and an object, as well as the image, which is formed from standard ray tracing. After the image is formed, an opaque block, also shown in the picture, is inserted to block the top half of the mirror. What changes, if any, will be observed in the image?

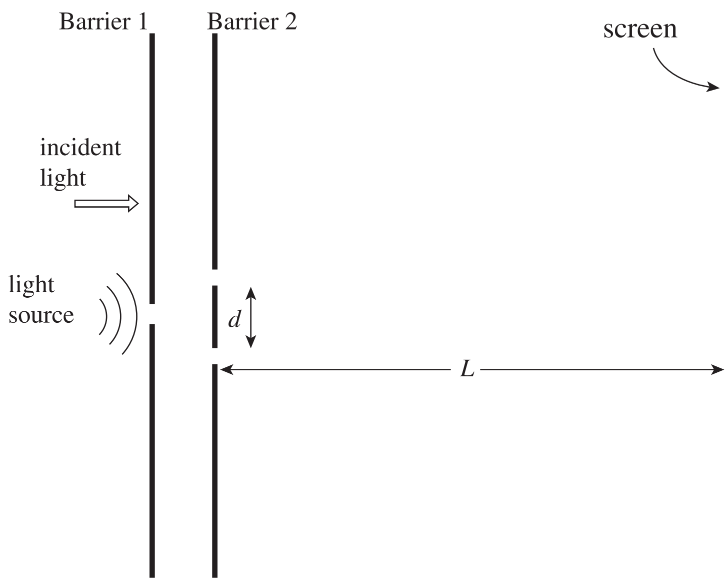
   (A) The image will remain complete but will be diminished in brightness.
   (B) Part of the image will be absent, but the rest will be as bright was it was before the insertion of the block.
   (C) Part of the image will be absent and the part which remains will be diminished in brightness.
   (D) No change will be observed.

9. You are tasked with creating a real image using a diverging lens as your imaging system. Which of the following criteria are true about both the image and the object?
   (A) A real image can be created only if the object is farther away from the lens than the focal length.
   (B) A real image can be created only if the object is closer to the lens than the focal length.
   (C) A real image can be created regardless of whether the object is farther away from the lens or closer to the lens than the focal length.
   (D) A real image cannot be created using only a diverging lens.

10. Three double slit experiments are conducted and an interference pattern is observed in each. The second experiment has an identical set up to the original except a shorter wavelength of light is used. The third experiment has an identical set up to the original except the slits are closer together. What is true about the observed interference patterns for the experiments?
   (A) Both the second and third experiment have closer fringes than the original.
   (B) The second experiment has closer fringes than the original and the third has farther fringes.
   (C) The second experiment has farther fringes than the original and the third has closer fringes.
   (D) Both the second and third experiment have farther fringes than the original.

Section II: Free Response

1. Two trials of a double-slit interference experiment are set up as follows. The slit separation is $d = 0.50$ mm, and the distance to the screen, L, is 4.0 m.



(a) What is the purpose of the first (single-slit) barrier? Why not use two light sources, one at each slit at the second barrier? Explain briefly.

In the first trial, white light is used.

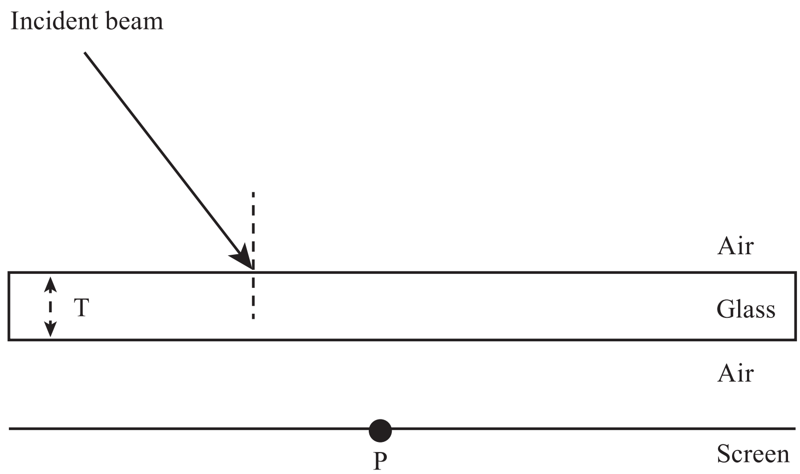
(b) What is the vertical separation on the screen (in mm) between the first-order maxima for red light ($\lambda = 750$ nm) and violet light ($\lambda = 400$ nm)?

(c) Locate the nearest point to the central maximum where an intensity maximum for violet light ($\lambda = 400$ nm) coincides with an intensity maximum for orange-yellow light ($\lambda = 600$ nm).

In the second trial, the entire region between the double-slit barrier and the screen is filled with a large slab of glass of refractive index $n = 1.5$, and monochromatic green light ($\lambda = 500$ nm in air) is used.

(d) What is the separation between adjacent bright fringes on the screen?

2. A beam of light shines on a screen with only air between the light source and the screen. The spot where the light strikes the screen is marked and called point P. Then, as the image below shows, a piece of glass with thickness T is placed in the path of the beam. The glass is surrounded on top and bottom by air. The normal to the glass slab at the point where the incident beam strikes the glass is drawn as a dashed line.



(a) Two students are discussing what observations will be made in this new arrangement.

Student 1: The spot on the screen will still be at point P. According to Snell's Law, the light will bend at the first interface and then unbend at the second interface and that it is travelling parallel to its original path. This will cause the spot on the screen will be at the same location.

Student 2: The beam after the glass cannot be parallel to the beam before the glass. Snell's Law is n_{in} sin(θ_{in}) = n_{out} sin (θ_{out}), and because θ_{out} is different from θ_{in} at the first interface, the angles have to be different at the second interface as well.

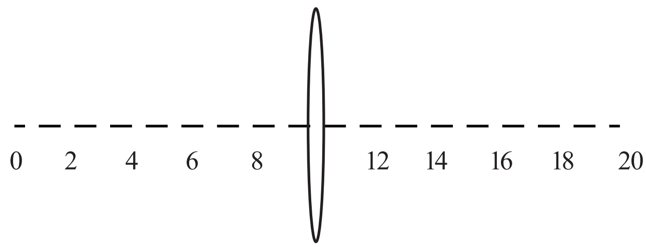
i. Which parts, if any, of Student 1's reasoning is correct?
ii. Which parts, if any, of Student 2's reasoning is correct?
iii. Which parts, if any, of Student 1's reasoning is incorrect?
iv. Which parts, if any, of Student 2's reasoning is incorrect?

(b) Use ray tracing to draw the path of the beam from where it is incident on the glass to where it strikes the screen. Use appropriate labels to indicate which angles are the same and which are different.

(c) In a paragraph length explanation without relying solely on equations, explain how your answer in part (b) would be different if the area between the screen and the glass were filled with water (whose index of refraction is between that of air and that of glass).

3. An experiment is set up with an object, a single converging lens, and a screen to make an image appear on the screen. The lens has a focal length of 3 cm. The arrangement is configured so that the image which appears on the screen is the same size as the object. The lens is placed at a position labeled 10 cm on the optic axis.

   (a) Draw a diagram of the experimental set up along the optic axis below. Justify your answer.



   (b) If the converging lens were replaced with a convex mirror of the same focal length, explain how (if at all) your experimental set-up would have to change to produce an image of the same height as the object.

   (c) In a clear, coherent paragraph length response, explain what a virtual image is. Explain what steps would have to be taken to experimentally verify the existence of a virtual image.