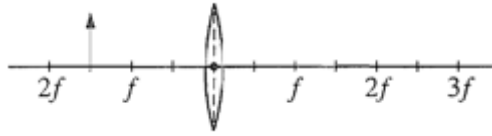


## Optics Practice

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1.



An object is placed at a distance of  $1.5f$  from a converging lens of focal length  $f$ , as shown above. What type of image is formed and what is its size relative to the object?

(A) Type: Virtual

Size: Larger

(B) Type: Virtual

Size: Same size

(C) Type: Virtual

Size: Smaller

(D) Type: Real

Size: Larger



(E) Type: Real

Size: Smaller

---

2. A concave mirror with a radius of curvature of 1.0 m is used to collect light from a distant star. The distance between the mirror and the image of the star is most nearly



## Optics Practice

---

(A) 0.25 m

(B) 0.50 m



(C) 0.75 m

(D) 1.0 m

(E) 2.0 m

---

3. A converging lens is used to form a real image of an object placed outside the focal point of the lens. Which of the following would increase the size of the real image?

(A) Moving the object closer to the lens but keeping it outside the focal point



(B) Moving the object to a position inside the focal point

(C) Moving the lens farther from the object

(D) Replacing the lens with one in the same position with the same focal length but a greater diameter

(E) Replacing the lens with one in the same position with the same diameter but a smaller focal length

---

4. A physics student places an object 6.0 cm from a converging lens of focal length 9.0 cm. What is the magnitude of the magnification of the image produced?



**Optics Practice**

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(A) 0.6

(B) 1.5

(C) 2.0

(D) 3.0



(E) 3.6

---

5. A student is doing an experiment in which monochromatic light passes through a double slit, creating a pattern of dark and bright lines on a nearby screen. The student has a red light and a green light. The student also has two sets of slits, one with a small separation between the slits and one with a large separation. Which of the following lists the color and slit separation that will create the pattern with the greatest separation between the bright lines?

(A)

Color Slit Separation  
Green Large

(B)

Color Slit Separation  
Green Small

(C)

Color Slit Separation  
Red Large

(D)

Color Slit Separation  
Red Small



## Optics Practice

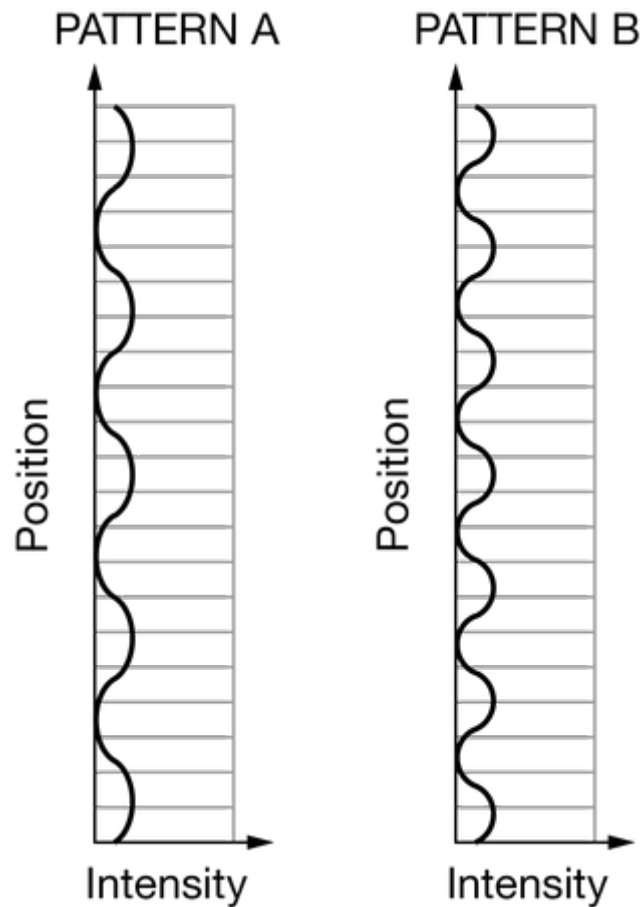
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6. A student is given a loudspeaker with a square opening and asked to make a change in the dimensions of the opening so that the sound wave is more spread out vertically and narrowed horizontally. Which of the following is the correct use of the principle of diffraction to accomplish the desired result?
- (A) The task is impossible since diffraction affects only electromagnetic radiation and very short wavelengths.
- (B) Make the opening into a rectangle with a longer vertical dimension and a shorter horizontal dimension.
- (C) Make the opening into a rectangle with a longer horizontal dimension and a shorter vertical dimension. ✓
- (D) Keep the opening in the shape of a square, but reduce both the horizontal and vertical dimensions.
- 



## Optics Practice

7.



An interference pattern is formed on a distant screen when monochromatic laser light is incident on two closely spaced slits. Initially, interference pattern A is created. A change is made to the setup, and then interference pattern B is created. Which of the following indicates a possible change to the setup?

- ☒ (A) The wavelength of the laser light decreased.
- ☐ (B) The spacing of the slits decreased.
- ☐ (C) The distance from the slits to the screen increased.
- ☐ (D) The width of the slits increased.



## Optics Practice

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8. A student shines a laser at a diffraction grating and observes a pattern of dots on a wall behind the grating. The student then puts a second laser at the same location as the first and shines it at the diffraction grating. A new pattern of dots is observed on the wall behind the grating. The second laser emitted light of equal brightness, and shorter wavelength. How will the pattern of dots on the wall generated by the second laser compare to that generated by the first laser?

- (A) The distance between adjacent dots would decrease. ✓
- (B) The distance between adjacent dots would remain the same.
- (C) The distance between adjacent dots would increase.
- (D) The difference cannot be known without knowing the wavelengths of the light used.
- 

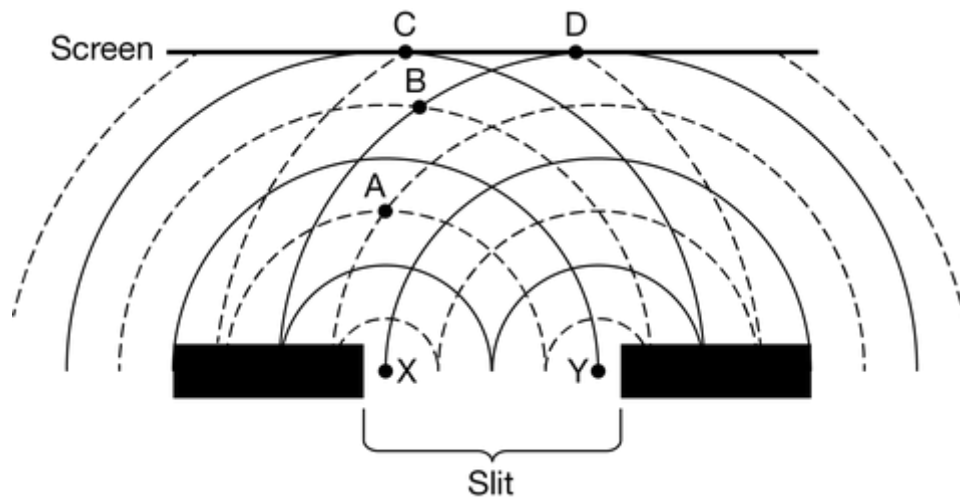
9. A red laser beam ( $\lambda = 675 \text{ nm}$ ) is incident on two very narrow slits that are spaced  $10 \text{ mm}$  apart. The interference pattern is observed on a distant screen. A green laser ( $\lambda = 500 \text{ nm}$ ) is then used instead. Which of the following claims correctly compares characteristics of the dark fringes observed with the green laser to those observed with the red laser?

- (A) Narrower and farther apart
- (B) Narrower and closer together ✓
- (C) Broader and farther apart
- (D) Broader and closer together
- 



## Optics Practice

10.



Light incident on a single slit forms an interference pattern on a distant screen. Each point on the wave front moving through the slit acts like a point source. The crests and troughs for waves originating from two points, X and Y, are shown by solid and dashed lines, respectively. Which of the following statements about the diagram is true?

- (A) Destructive interference will occur at point A.
- (B) Constructive interference will occur at point B.
- (C) A bright fringe will be formed at point C on the screen.

(D) A dark fringe will be formed at point D on the screen.



## Optics Practice

11.

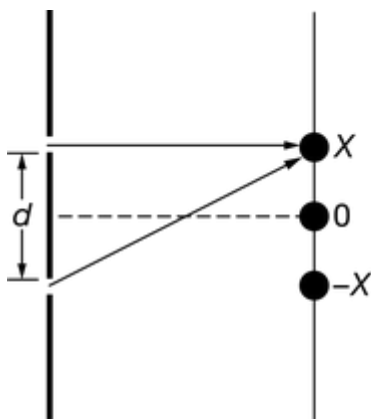


Figure 1

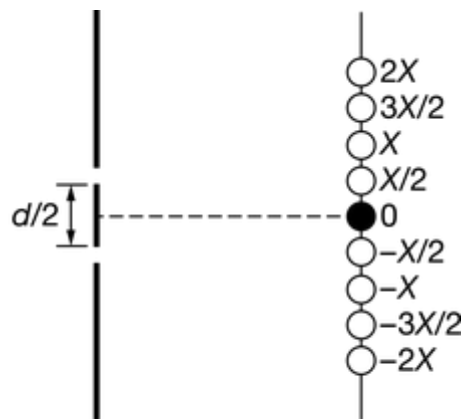


Figure 2

Light from a coherent source passes through a pair of narrow slits spaced a distance  $d$  apart and produces a diffraction pattern with bright spots that are spaced a distance  $X$  apart, as shown in Figure 1. The slits are then replaced by a pair that are spaced a distance  $d/2$  apart, as shown in Figure 2. Which of the following most accurately describes the spacing of the bright spots in the interference pattern produced by the new slits?

(A)  $2X$



(B)  $3X/2$

(C)  $X$

(D)  $X/2$

12. Which of the following types of waves is most likely to diffract as it passes through a window with width  $1.0 \text{ m}$ ? Assume the speed of light is  $3 \times 10^8 \text{ m/s}$  and the speed of sound is  $300 \text{ m/s}$ .





**Optics Practice**

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(A) Visible light waves ( $f = 6 \times 10^{14} \text{ Hz}$ )

(B) Microwaves ( $f = 6 \times 10^{10} \text{ Hz}$ )

(C) Radio waves ( $f = 6 \times 10^6 \text{ Hz}$ )

(D) Sound waves ( $f = 6 \times 10^2 \text{ Hz}$ )



---

13. Light from a source that produces a single frequency passes through a single slit A. The diffraction pattern on a screen is observed. Slit A is then replaced by slit B, and the new pattern is observed to have fringes that are more closely spaced than those in the first pattern. Which of the following is a possible explanation for why the spacings are different?

(A) Slit A is wider than slit B.

(B) Slit B is wider than slit A.



(C) The distance between the light source and the slit is greater for slit A than for slit B.

(D) The distance between the light source and the slit is greater for slit B than for slit A.

---

14. Light from a laser shines on a diffraction grating, creating an interference pattern on a screen. The grating is then moved farther from the screen. How does the spacing between maxima in the interference pattern for the farther distance compare to that for the closer distance?

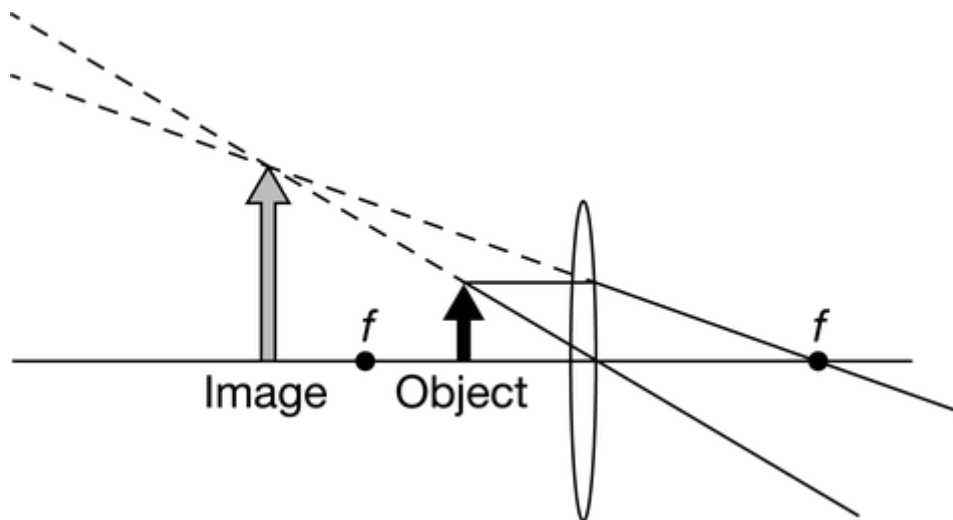


**Optics Practice**

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- (A) The spacing is the same.
- (B) The spacing is smaller for the farther distance.
- (C) The spacing is larger for the farther distance. ✓
- (D) The spacing cannot be compared without knowing the wavelength of the laser light.
- 

15.



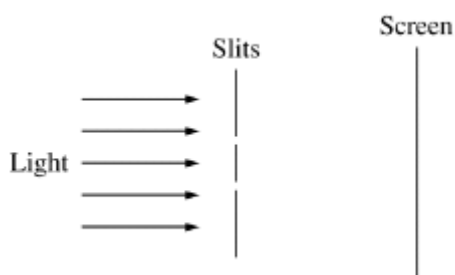
Using the diagram as a guide, a group of students place an object near a lens and place a screen at the location where the image is shown on the diagram. They intend to measure the distance from the object to the lens and the distance from the location of the image to the lens and calculate the focal length of the lens. However, they cannot find a screen location where there is a clear image on the screen. Which of the following follow-up questions would help refine the procedure?



**Optics Practice**

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- (A) Is the lens converging or diverging?
- (B) Is the image in the diagram real or virtual? ✓
- (C) Is the image upright or inverted?
- (D) Is the focal length the same on both sides of the lens?
- 

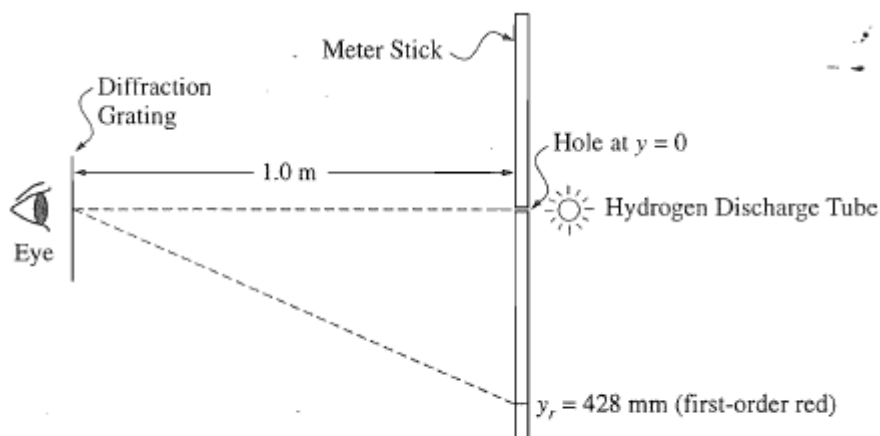
**16.**

At separate times, red light and blue light pass through the same two narrow slits, and each forms an interference pattern on the screen represented above. How do the spacings of the bright fringes in the two patterns compare?

- (A) The red fringes are spaced farther apart than the blue fringes are. ✓
- (B) The blue fringes are spaced farther apart than the red fringes are.
- (C) The fringes have the same spacing in both patterns.
- (D) The patterns cannot be compared without knowing the slit separation.
- (E) The patterns cannot be compared without knowing the distance from the slits to the screen.
- 

**17.**

## Optics Practice



Note: Figure is drawn to scale.

A transmission diffraction grating with 600 lines/mm is used to study the line spectrum of the light produced by a hydrogen discharge tube with the setup shown above. The grating is 1.0 m from the source (a hole at the center of the meter stick). An observer sees the first-order red line at a distance  $y_r = 428$  mm from the hole.

- (a) Calculate the wavelength of the red line in the hydrogen spectrum.
- (b) According to the Bohr model, the energy levels of the hydrogen atom are given by  $E_n = -13.6 \text{ eV}/n^2$ , where  $n$  is an integer labeling the levels. The red line is a transition to a final level with  $n = 2$ . Use the Bohr model to determine the value of  $n$  for the initial level of the transition.
- (c) Qualitatively describe how the location of the first-order red line would change if a diffraction grating with 800 lines/mm were used instead of one with 600 lines/mm.



Please respond on separate paper, following directions from your teacher.

## Part A

## 4 Points

Using the expression for the location of lines in the different pattern  $d \sin$

$$\theta = m\lambda$$



## Optics Practice

One point is earned for using the correct value for  $d$ .

$$d = \frac{1}{600 \text{ lines/mm}} = 1.67 \times 10^{-6} \text{ m}$$

One point is earned for finding the value of  $\theta$ , the angle between the two dashed lines in the figure

$$\tan \theta = \frac{y}{L} = \frac{428 \text{ mm}}{1.0 \text{ m}}$$

$$\theta = 23^\circ$$

One point is earned for the correct substitutions into the first equation

$$(1.67 \times 10^{-6} \text{ m}) \sin 23^\circ = (1)\lambda$$

One point is earned for the correct answer

$$\lambda = 657 \text{ nm or } 6.57 \times 10^{-7} \text{ m}$$



0	1	2	3	4
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The student earns all of the following points.

Using the expression for the location of lines in the different pattern  $d \sin$

$$\theta = m\lambda$$

One point is earned for using the correct value for  $d$ .

$$d = \frac{1}{600 \text{ lines/mm}} = 1.67 \times 10^{-6} \text{ m}$$

One point is earned for finding the value of  $\theta$ , the angle between the two dashed lines in the figure

$$\tan \theta = \frac{y}{L} = \frac{428 \text{ mm}}{1.0 \text{ m}}$$

$$\theta = 23^\circ$$

One point is earned for the correct substitutions into the first equation

$$(1.67 \times 10^{-6} \text{ m}) \sin 23^\circ = (1)\lambda$$



**Optics Practice**

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One point is earned for the correct answer

$$\lambda = 657\text{nm or } 6.57 \times 10^{-7}\text{m}$$

**Part B****4 Points**

One point is earned for using the correct equation(s) relating energy and wavelength.

$$E = \frac{hc}{\lambda} \quad \text{OR} \quad E = h\nu \quad \text{and} \quad c = \nu\lambda$$

Substituting

$$E = \frac{(1.24 \times 10^3 \text{ eV} \cdot \text{nm})}{657 \text{ nm}} \quad \text{OR} \quad E = \frac{(1.99 \times 10^{-25} \text{ J} \cdot \text{m})}{657 \text{ nm}}$$

One point is earned for the correct photon energy

$$E = 1.89\text{eV} \quad \text{OR} \quad 3.03 \times 10^{-19} \text{ J}$$

One point is earned for some indication that this photon energy is the difference between two energy levels. For example, a statement on conservation of energy, an energy level diagram, a statement saying the photon energy is the energy released when an electron drops to a lower energy level or an equation involving the appropriate energies

Using the energy level equation



## Optics Practice

$$\begin{aligned}
 E &= E_n - E_2 \\
 1.89 \text{ eV} &= (-13.6 \text{ eV}) \left( \frac{1}{n^2} - \frac{1}{2^2} \right) \\
 -0.14 &= \left( \frac{1}{n^2} - \frac{1}{4} \right) \\
 0.11 &= \frac{1}{n^2} \\
 n^2 &= 9.1
 \end{aligned}$$

One point is earned for the correct answer

$$n = 3$$



0	1	2	3	4
---	---	---	---	---

The student earns all of the following points.

One point is earned for using the correct equation(s) relating energy and wavelength.

$$E = \frac{hc}{\lambda} \quad \text{OR} \quad E = h\nu \quad \text{and} \quad c = \nu\lambda$$

$$\begin{aligned}
 &\text{Substituting} \\
 E &= \frac{(1.24 \times 10^3 \text{ eV} \cdot \text{nm})}{657 \text{ nm}} \quad \text{OR} \quad E = \frac{(1.99 \times 10^{-25} \text{ J} \cdot \text{m})}{657 \text{ nm}}
 \end{aligned}$$

One point is earned for the correct photon energy

$$E = 1.89 \text{ eV} \quad \text{OR} \quad 3.03 \times 10^{-19} \text{ J}$$

One point is earned for some indication that this photon energy is the difference between two energy levels. For example, a statement on conservation of energy, an energy level diagram, a statement saying the photon energy is the energy released when an electron drops to a lower energy level or an equation



## Optics Practice

involving the appropriate energies

Using the energy level equation

$$\begin{aligned}
 E &= E_n - E_2 \\
 1.89 \text{ eV} &= (-13.6 \text{ eV}) \left( \frac{1}{n^2} - \frac{1}{2^2} \right) \\
 -0.14 &= \left( \frac{1}{n^2} - \frac{1}{4} \right) \\
 0.11 &= \frac{1}{n^2} \\
 n^2 &= 9.1
 \end{aligned}$$

One point is earned for the correct answer

$$n = 3$$

### Part C

#### 2 Points

Two points are earned for any reasonable indication that the line would move farther away from the principal axis.



0	1	2
---	---	---

The student earns all of the following points.

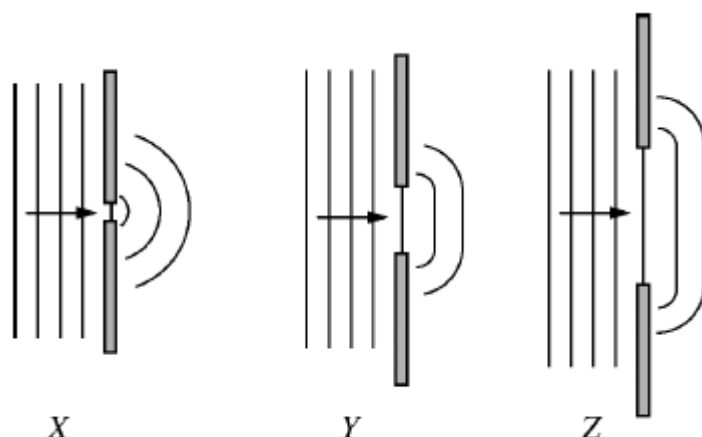
Two points are earned for any reasonable indication that the line would move farther away from the principal axis.

18.



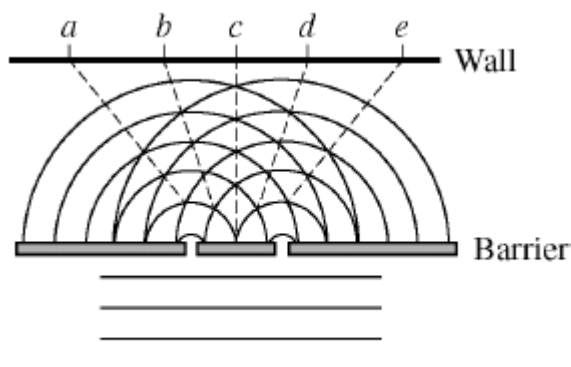


## Optics Practice



The figures above labeled X, Y, and Z represent plane waves of the same wavelength incident on barriers that have openings of different sizes. Also shown are the shapes of the wave fronts beyond the barriers.

(a) One model of waves treats every point on a wave front as a point source. Give a clear, coherent, paragraph-length description of how this model can be used to explain the shape of the wave fronts beyond the barriers.



The figure above represents another plane wave incident on a barrier with two identical openings, creating an interference pattern on the wall. Some positions in the pattern on the wall are labeled.

(b) In a few sentences, describe how the point-source model described in part (a) and the figure above can be used to explain the formation of the interference pattern on the wall.

(c) On the axes below, sketch the intensity of the waves that are incident on the wall. The

## Optics Practice

labels correspond to the positions noted in the figure above.



Please respond on separate paper, following directions from your teacher.

### Part A

**1 point is earned:** For a correct description of X as essentially a point source

**1 point is earned:** For demonstrating understanding that wider openings can be treated as multiple point sources

**1 point is earned:** For demonstrating understanding that interference of wave fronts creates the pattern on the far side of the opening

**1 point is earned:** For demonstrating understanding of the lack of interference at the edges

**1 point is earned:** For coherently connecting the above ideas in a logical explanation

For example: In X, the size of the slit is comparable to the wavelength of the plane waves, so it acts most like a single point source and produces essentially spherical wave fronts. As the slit gets wider in Y and Z, it acts like an increasing number of point sources. Away from the edges, the spherical wave fronts interfere and the points of constructive interference result in the planar sections that reproduce the incident plane waves. Near the edges, there are no waves on one side to interfere, so the spherical fronts propagate.



0	1	2	3	4	5
---	---	---	---	---	---

The student response earns five of the following points:



## Optics Practice

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**1 point is earned:** For a correct description of X as essentially a point source

**1 point is earned:** For demonstrating understanding that wider openings can be treated as multiple point sources

**1 point is earned:** For demonstrating understanding that interference of wave fronts creates the pattern on the far side of the opening

**1 point is earned:** For demonstrating understanding of the lack of interference at the edges

**1 point is earned:** For coherently connecting the above ideas in a logical explanation

For example: In X, the size of the slit is comparable to the wavelength of the plane waves, so it acts most like a single point source and produces essentially spherical wave fronts. As the slit gets wider in Y and Z, it acts like an increasing number of point sources. Away from the edges, the spherical wave fronts interfere and the points of constructive interference result in the planar sections that reproduce the incident plane waves. Near the edges, there are no waves on one side to interfere, so the spherical fronts propagate.

### Part B

**1 point is earned:** For demonstrating understanding that the figure shows a set of wave fronts for each opening

**1 point is earned:** For demonstrating understanding that maxima in the resulting interference pattern occur where the fronts intersect

**1 point is earned:** For demonstrating understanding that the dashed lines lead to points of maxima in the resulting interference pattern on the wall

For example: Each opening creates a set of spherical wave fronts as shown. Assuming the wave fronts denote maximum amplitude, where they cross are points of maximum constructive interference. The dashed lines connect these points, and indicate where the maxima of the pattern on the wall are located.



0	1	2	3
---	---	---	---

The student response earns three of the following points:

**1 point is earned:** For demonstrating understanding that the figure shows a set of wave fronts for each



## Optics Practice

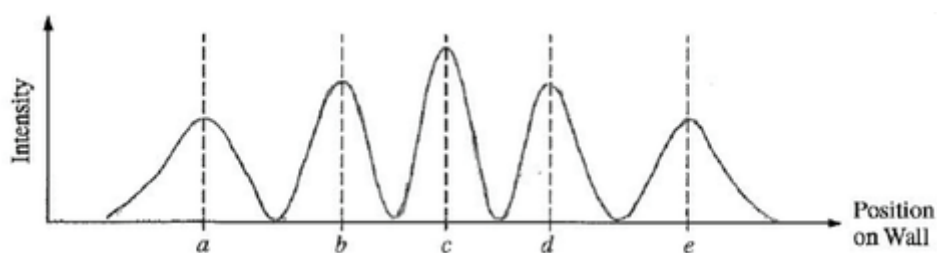
opening

**1 point is earned:** For demonstrating understanding that maxima in the resulting interference pattern occur where the fronts intersect

**1 point is earned:** For demonstrating understanding that the dashed lines lead to points of maxima in the resulting interference pattern on the wall

For example: Each opening creates a set of spherical wave fronts as shown. Assuming the wave fronts denote maximum amplitude, where they cross are points of maximum constructive interference. The dashed lines connect these points, and indicate where the maxima of the pattern on the wall are located.

### Part C



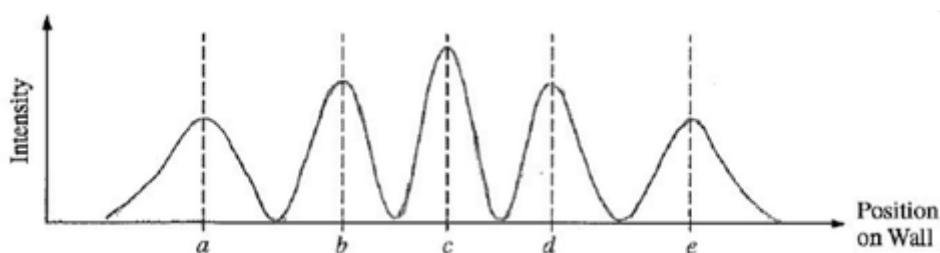
**1 point is earned:** For maxima at the labeled positions on the wall and minima in between

**1 point is earned:** For showing a decrease in the height of the maxima as position moves away from the central point c



0	1	2
---	---	---

The student response earns two of the following points:



## Optics Practice

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**1 point is earned:** For maxima at the labeled positions on the wall and minima in between

**1 point is earned:** For showing a decrease in the height of the maxima as position moves away from the central point  $c$

---

19. Two waves from the same source travel different distances to point  $P$ . One wave has amplitude  $A$  and the other has amplitude  $0.50A$ . The resultant amplitude from the superposition of the two waves at point  $P$  CANNOT be

(A)  $0.25A$



(B)  $0.5A$

(C)  $0.75A$

(D)  $A$

(E)  $1.25A$

---

20. Young's double-slit experiment is performed with a pair of slits separated by a distance  $d$ . A screen is a distance  $L$  away from the slits, and the distance from the central maximum to the  $n$ th bright fringe is  $x$ . What is the wavelength of this light?



## Optics Practice

(A)  $n\lambda dL$

(B)  $\frac{\lambda d}{nL}$



(C)  $\frac{nL}{\lambda d}$

(D)  $\frac{L}{n\lambda d}$

(E)  $\frac{n\lambda d}{L}$

21. A diffraction pattern is formed by passing monochromatic light through a single slit. If the width of the single slit is reduced, which of the following is true?

(A)

Width of the Central Maximum	Intensity of the Central Maximum
Decreases	Decreases

(B)

Width of the Central Maximum	Intensity of the Central Maximum
Increases	Increases

(C)

Width of the Central Maximum	Intensity of the Central Maximum
Increases	Decreases



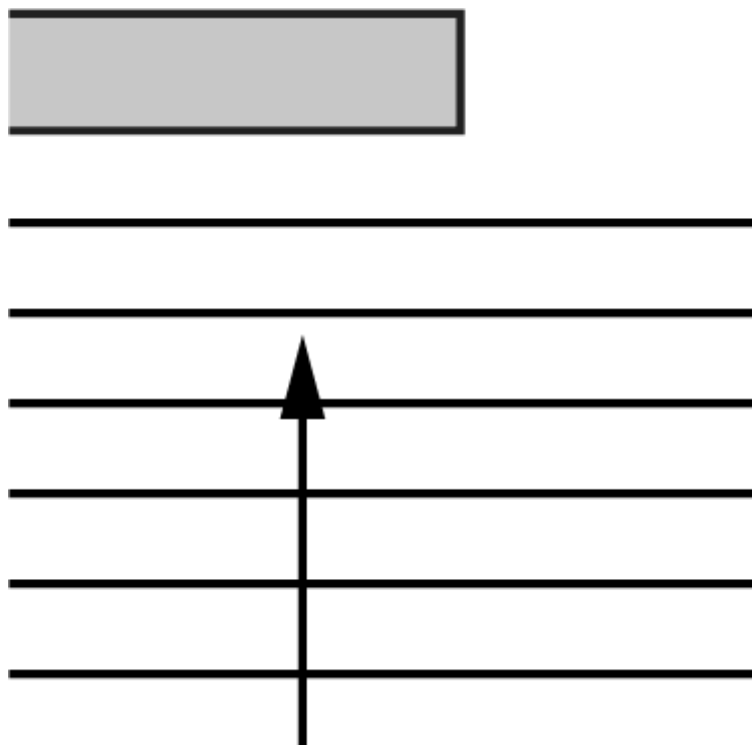
(D)

Width of the Central Maximum	Intensity of the Central Maximum
Decreases	Increases



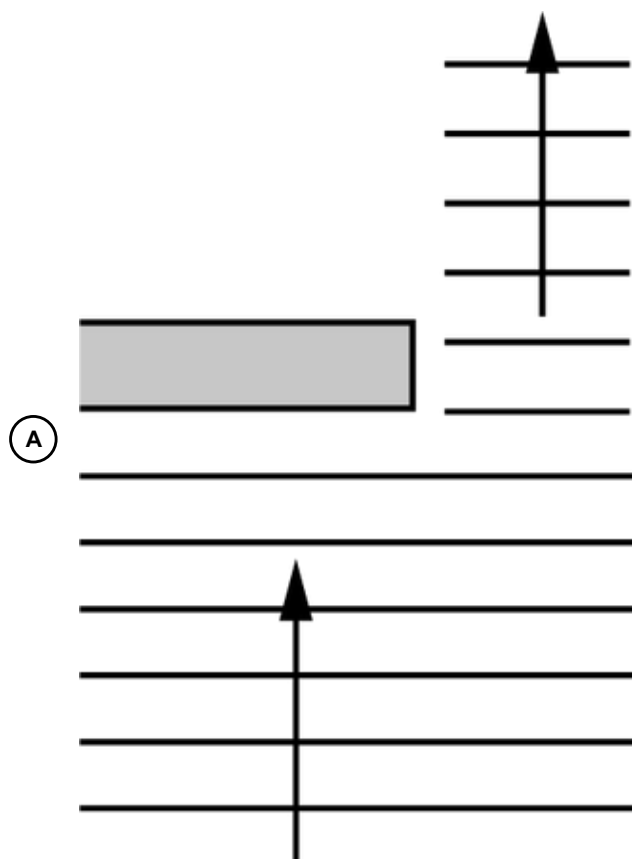
## Optics Practice

22.



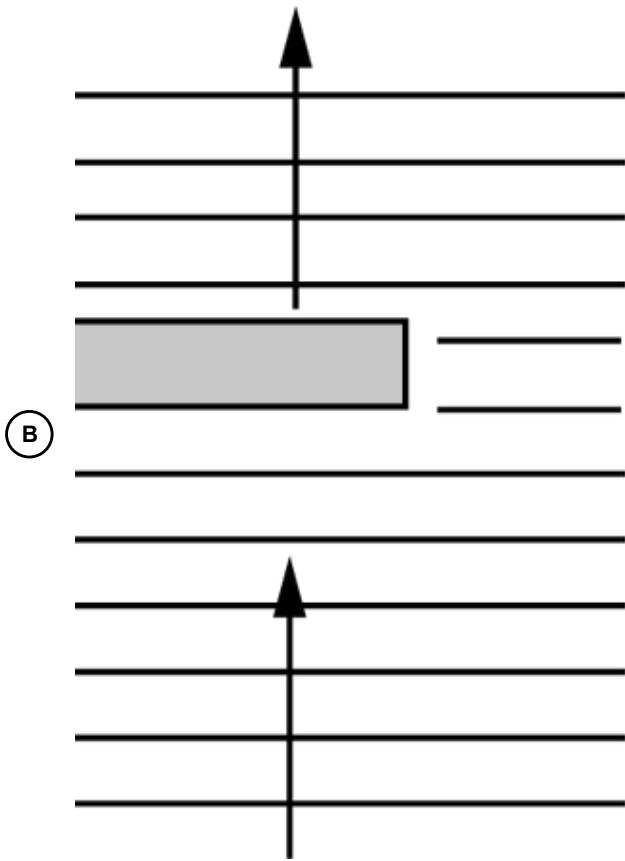
The figure represents the wave fronts for a wave traveling perpendicular to the end of a barrier. Which of the following best represents the waves as they travel past the barrier?

## Optics Practice

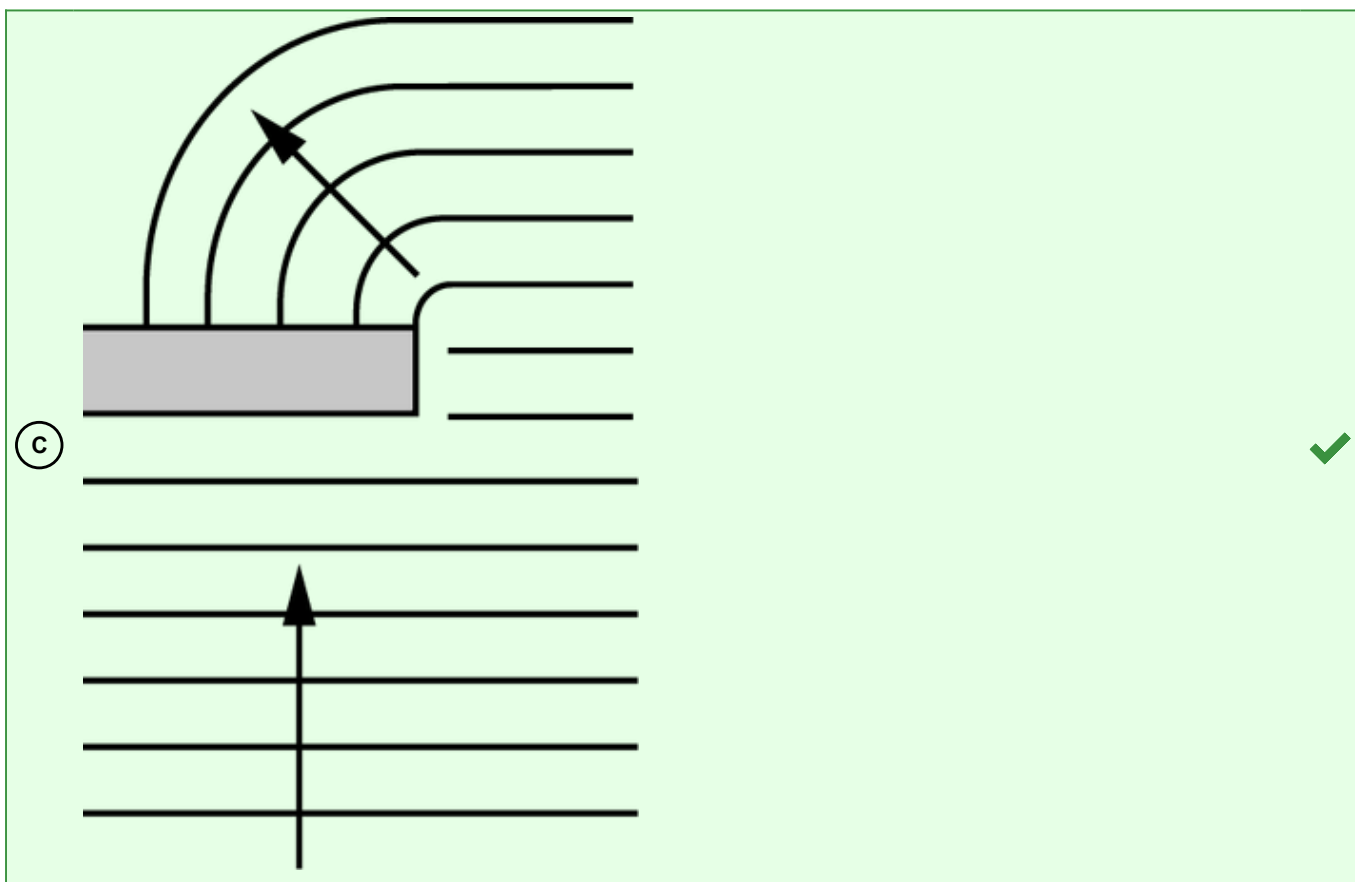




## Optics Practice



## Optics Practice



## Optics Practice

