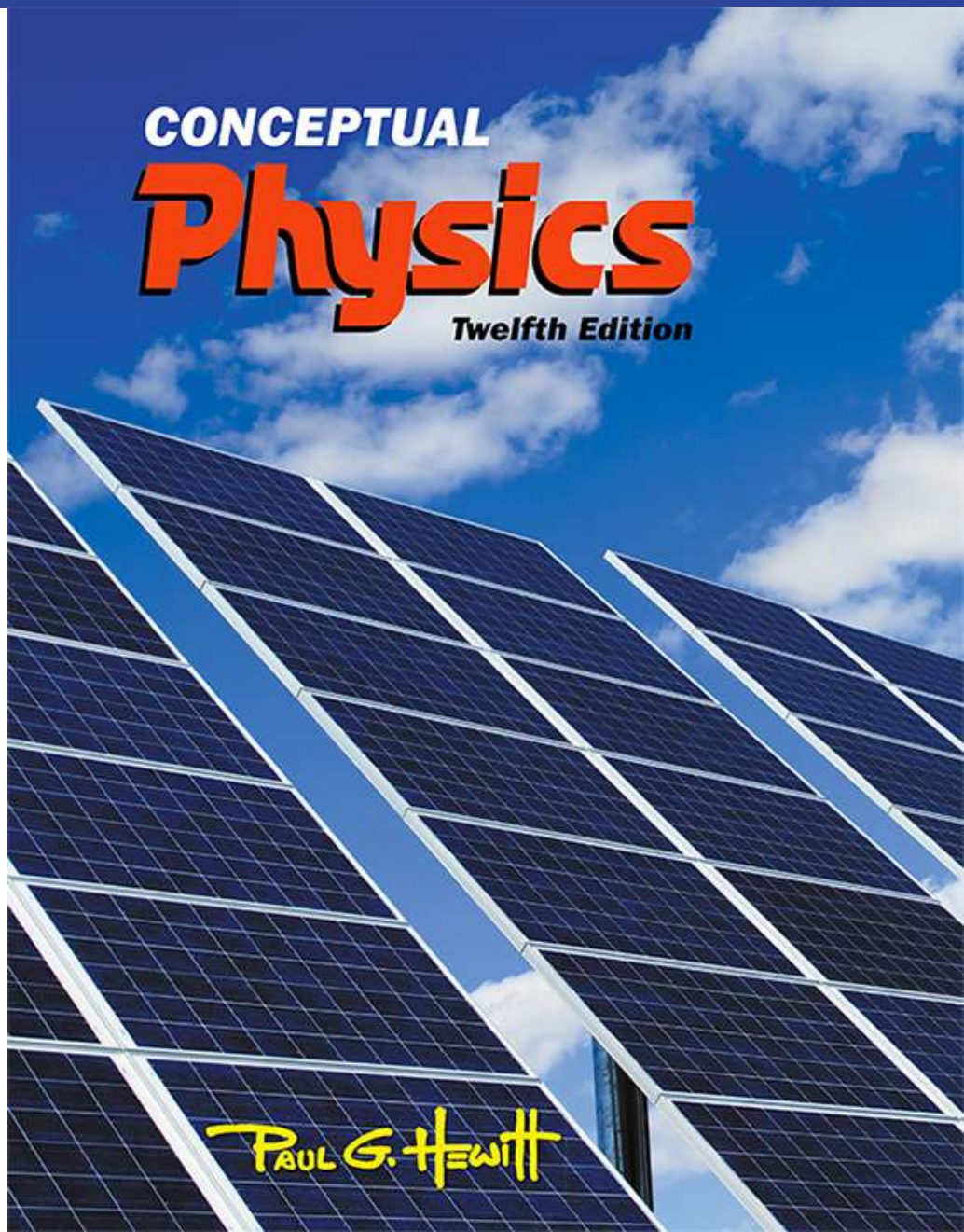
Lecture Outline

Chapter 29: Light Waves



This lecture will help you understand:

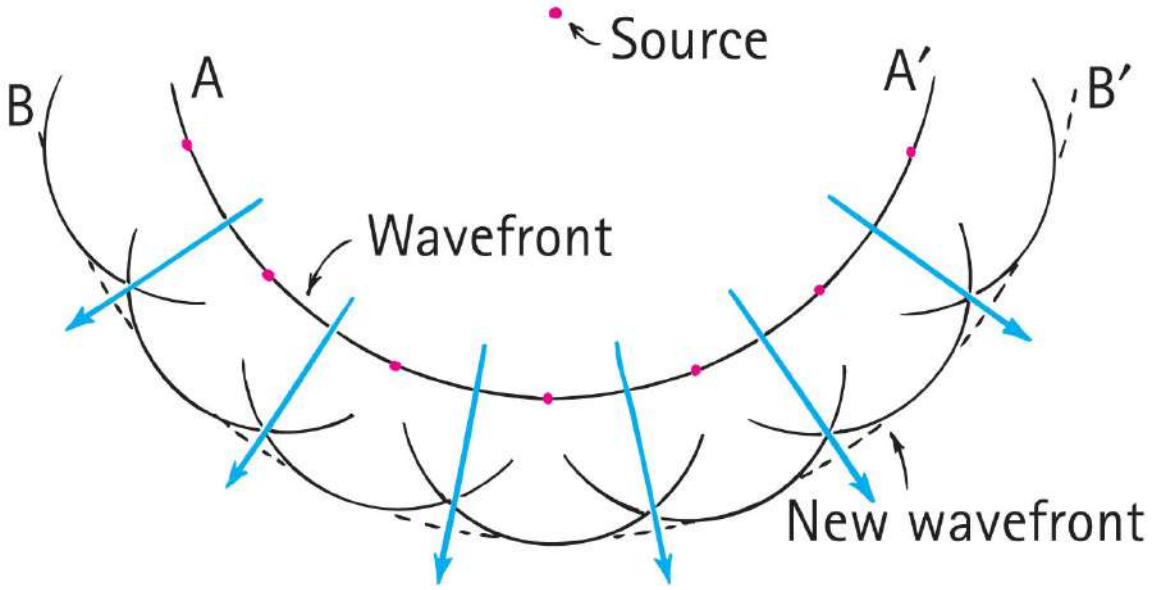
- Huygens' Principle
- Diffraction
- Superposition and Interference
- Polarization
- Holography

Huygens' Principle

- Throw a rock in a quiet pool, and waves appear along the surface of the water.
- Huygens proposed that the wavefronts of light waves spreading out from a point source can be regarded as the overlapped crests of tiny secondary waves.
- Wavefronts are made up of tinier wavefronts—this idea is called **Huygens' principle.**

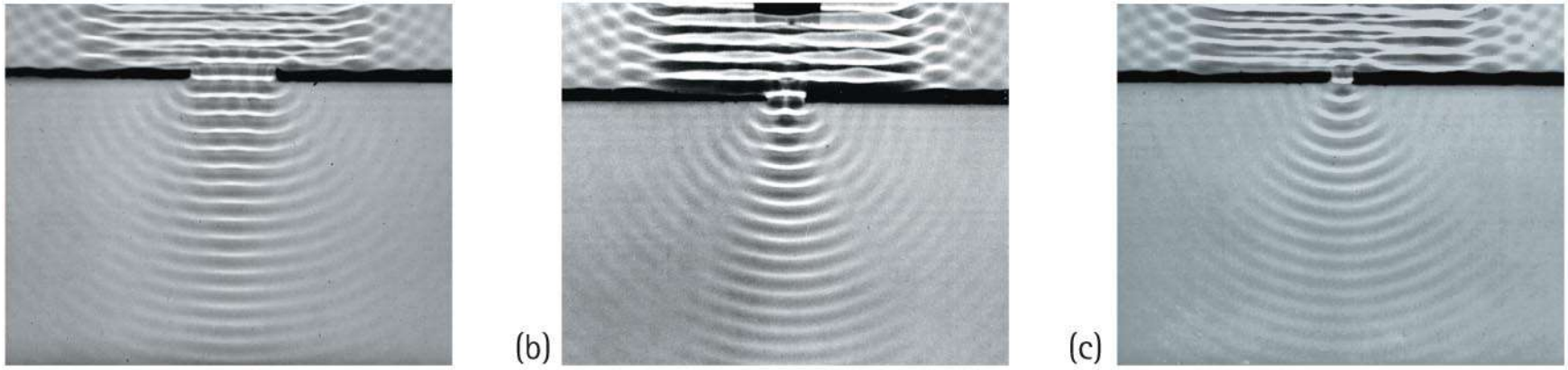
Huygens' Principle, Continued

- Every point of a wavefront may be considered the source of secondary wavelets that spread out in all directions with a speed equal to the speed of propagation of the waves.



Huygens' Principle, Continued-1

- Plane waves can be generated in water by successively dipping a horizontally held straightedge into the surface
- As the width of the opening is narrowed, less of the incident wave is transmitted.
- The spreading of waves into the shadow region becomes more pronounced.

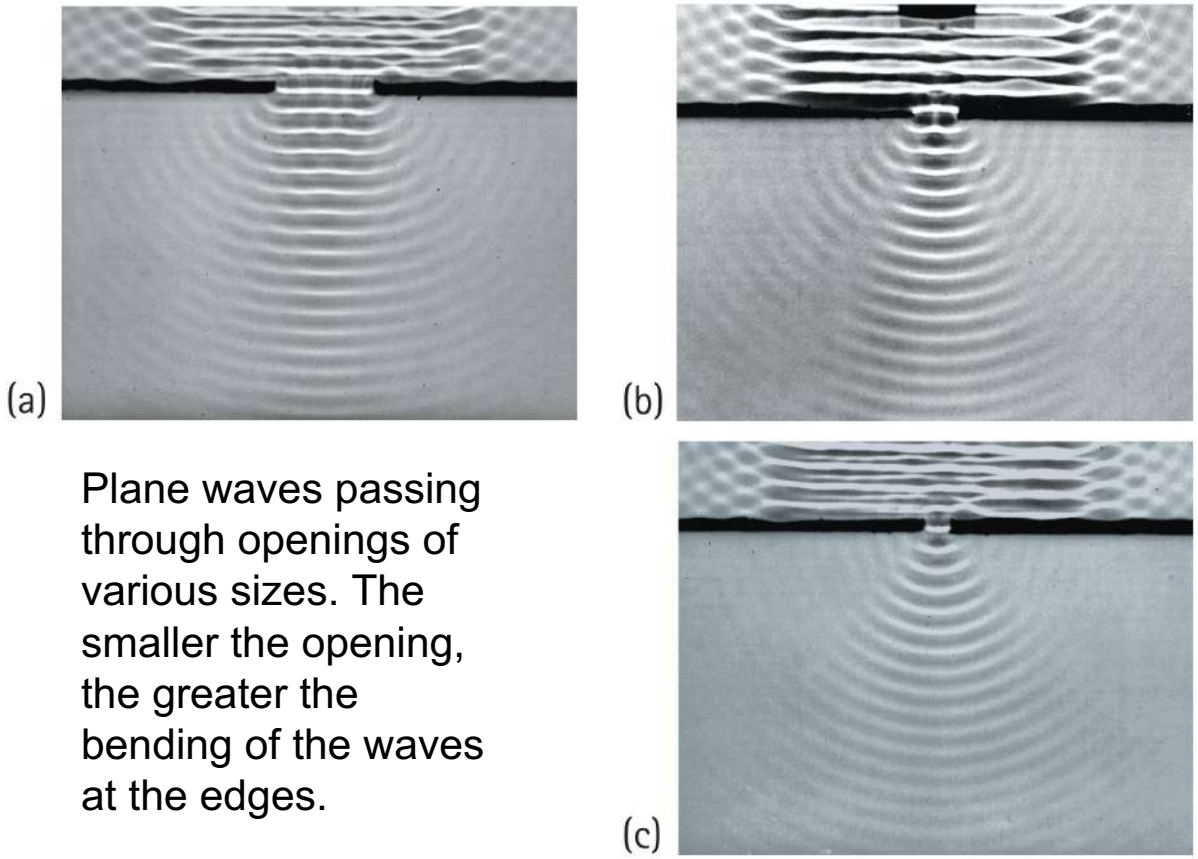


Diffraction

- Diffraction
  - Bending of waves by means other than reflection and refraction
  - Property of *all* kinds of waves
  - Seen around edges of many shadows

Diffraction, Continued

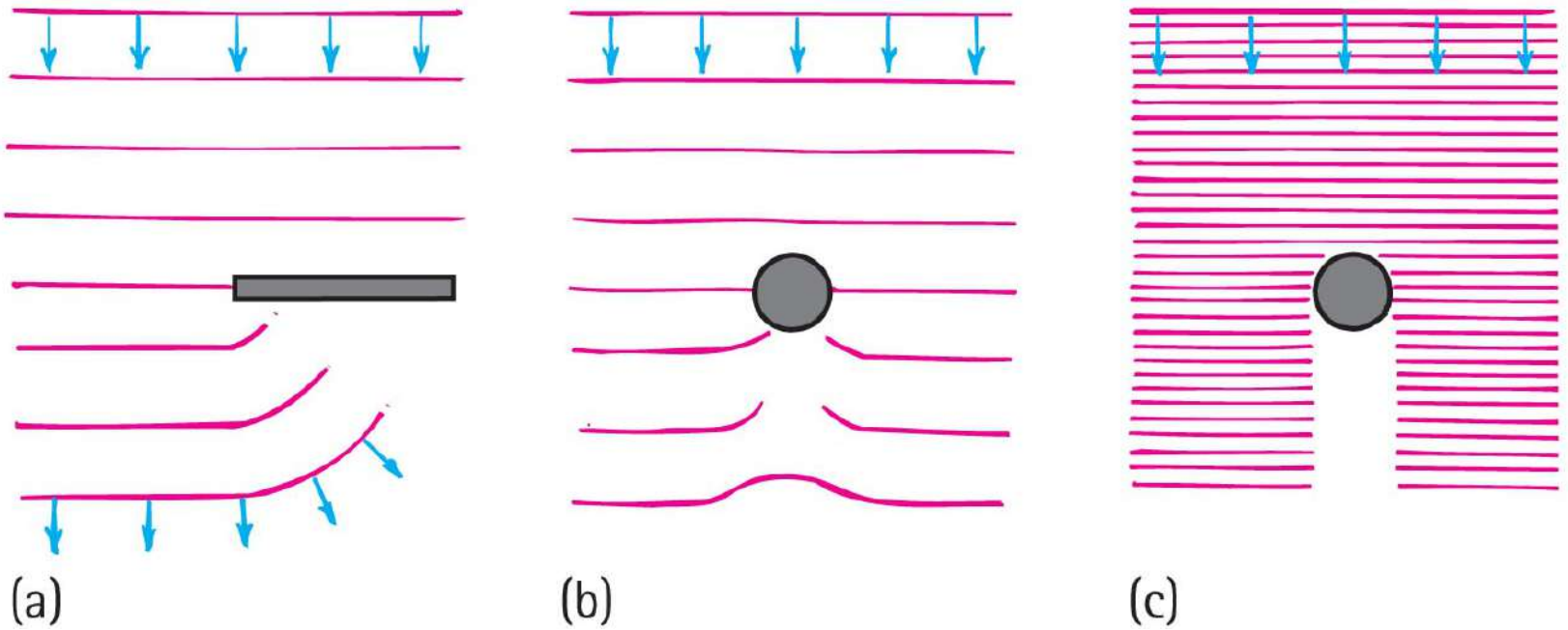
- Waves diffract after passing through a narrow opening.



Plane waves passing through openings of various sizes. The smaller the opening, the greater the bending of the waves at the edges.

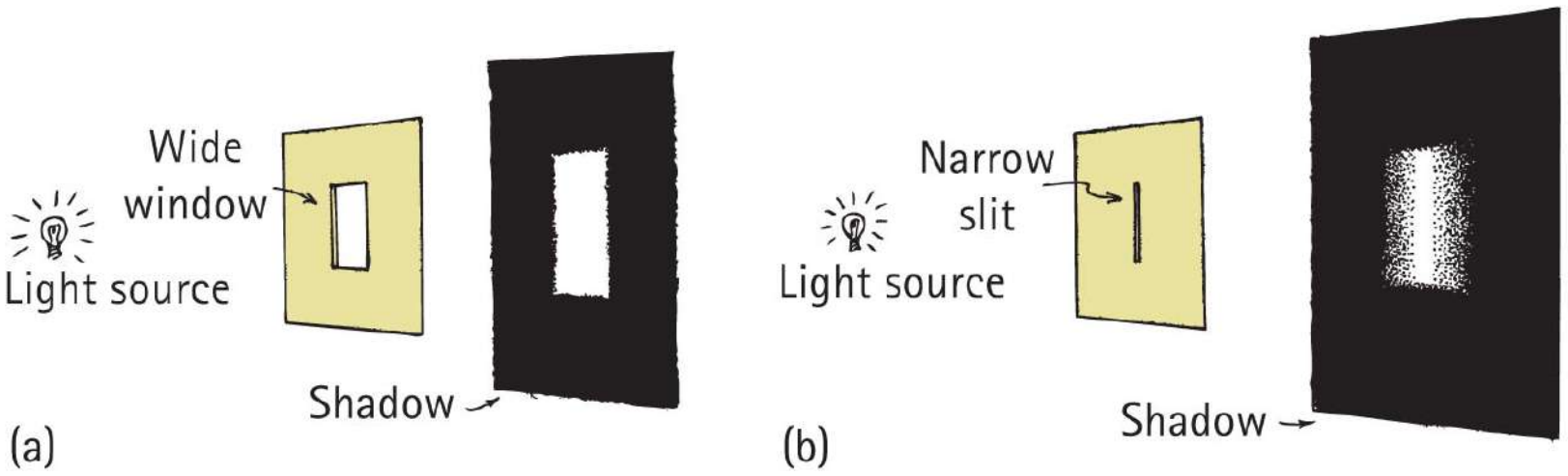
Diffraction, Continued-1

- Amount of diffraction depends on wavelength of the wave compared to the size of the obstruction that casts the shadow.



Diffraction, Continued-2

a. Light casts a sharp shadow with some fuzziness at its edges when the opening is large compared with the wavelength of the light.
b. When the opening is very narrow, diffraction is more apparent and the shadow is fuzzier.



Diffraction, Continued-3

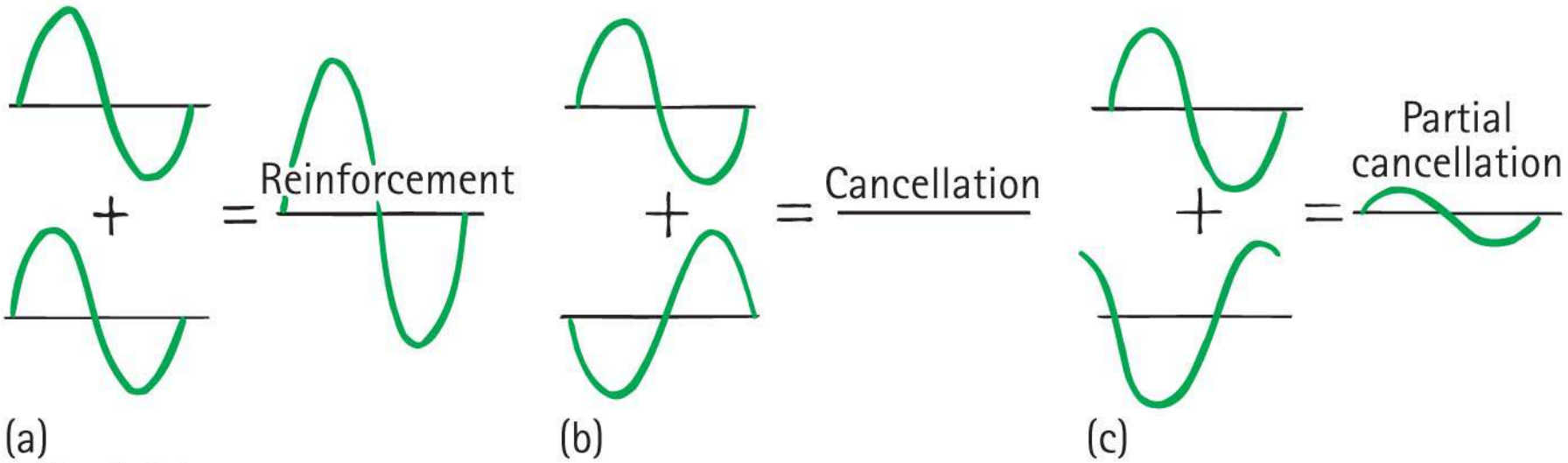
- Features of diffraction
  - Limitations with focusing images in optical instruments
    - object about the same size as wavelength of light, diffraction blurs
    - object smaller than wavelength of light, no image
  - Limitations avoided with an electron beam having extremely short wavelengths

Diffraction, Continued-4

- Features of diffraction (continued)
  - Electron microscopes use electric and magnetic fields to focus and magnify images
  - Better radio reception with long radio waves
  - For dolphins, use of shorter wavelengths gives finer detail—ultrasound

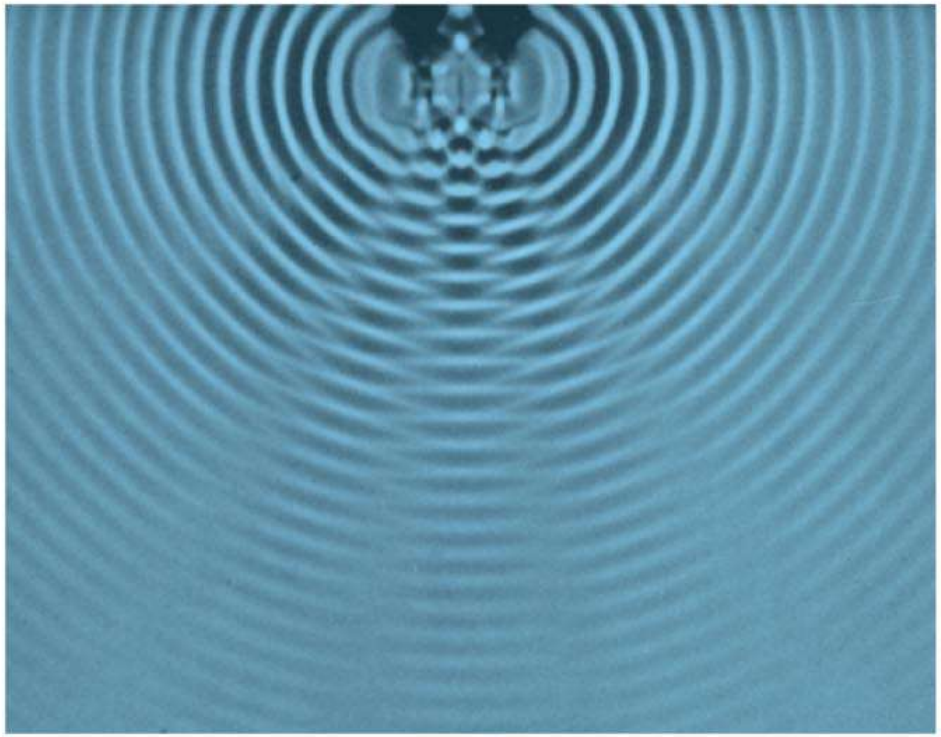
Superposition and Interference

- Superposition of waves



Superposition and Interference, Continued

- Interference patterns of overlapping waves from two vibrating sources



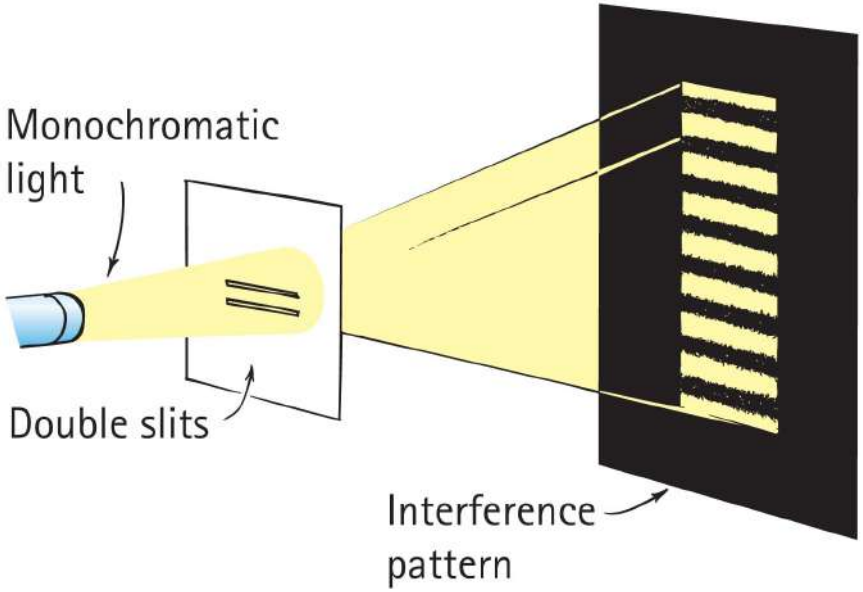
Superposition and Interference, Continued-1

- Interference pattern
  - Caused by interference between a pair of waves

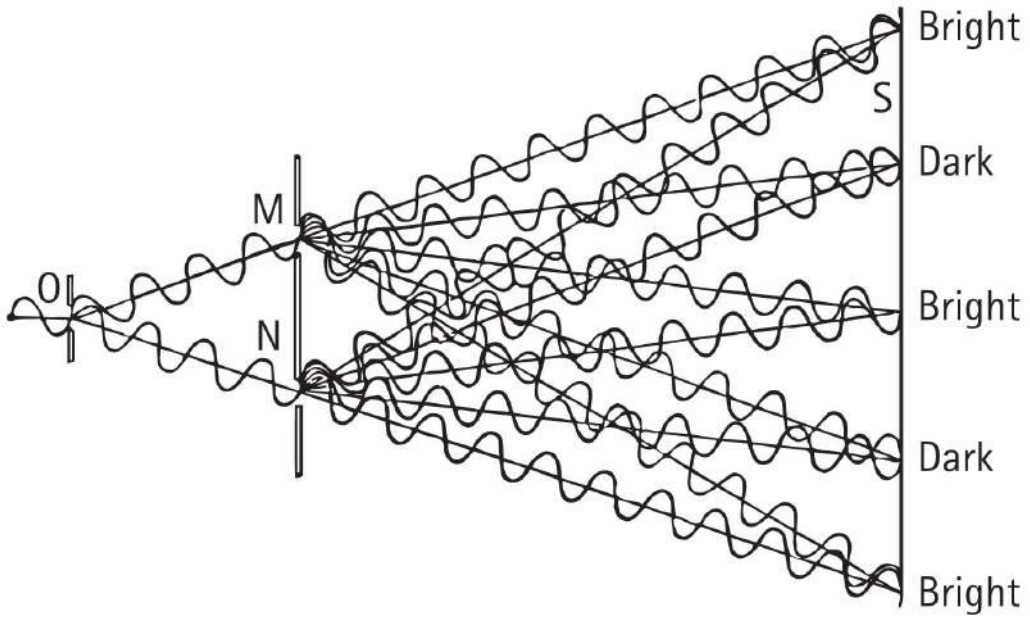
Superposition and Interference, Continued-2

- Interference pattern (continued)
  - Constructive interference produces bright region where waves reinforce each other (waves arriving in phase).
  - Destructive interference produces dark region where waves cancel each other (waves arriving half a wavelength out of phase).

Superposition and Interference, Continued-



Interference Experiment



Detail of Interference Pattern

Interference of Light
CHECK YOUR NEIGHBOR

The phenomenon of interference occurs for

A. sound waves.
B. light waves.
C. Both A and B.
D. Neither A nor B.

Interference of Light
CHECK YOUR NEIGHBOR, Continued

The phenomenon of interference occurs for

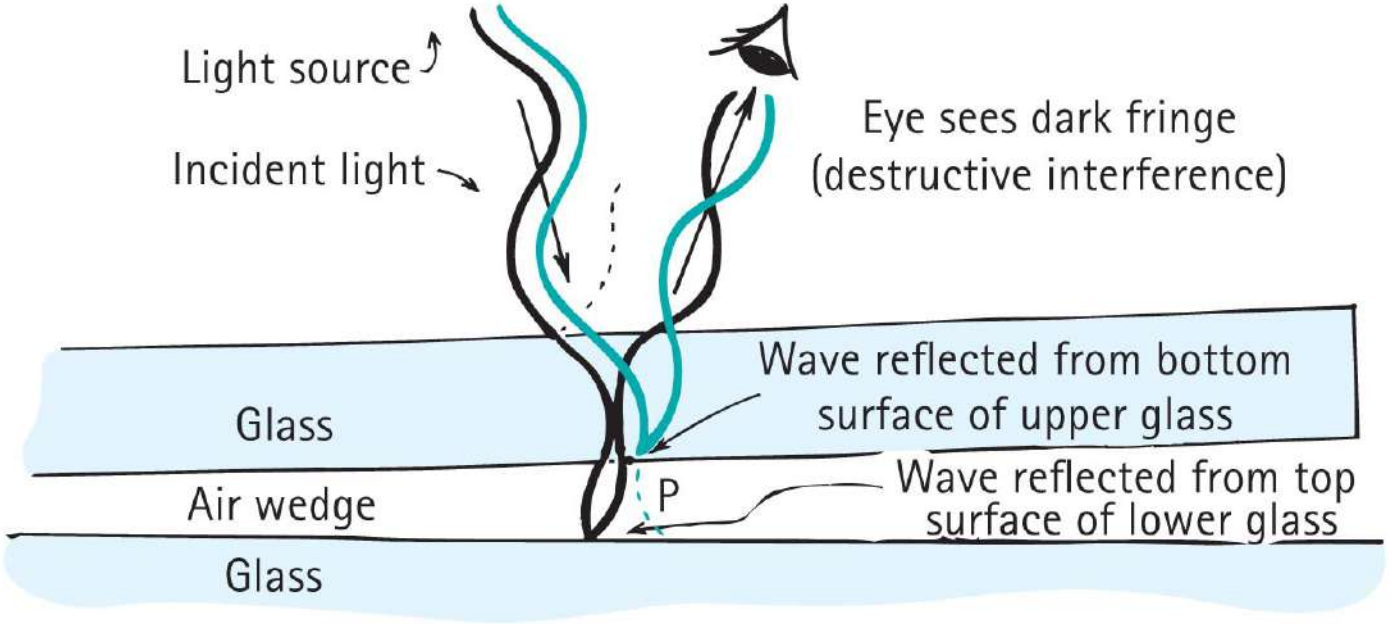
C. Both A and B.

Explanation:

Interference is the property that characterizes waves in general.

Superposition and Interference, Continued-4

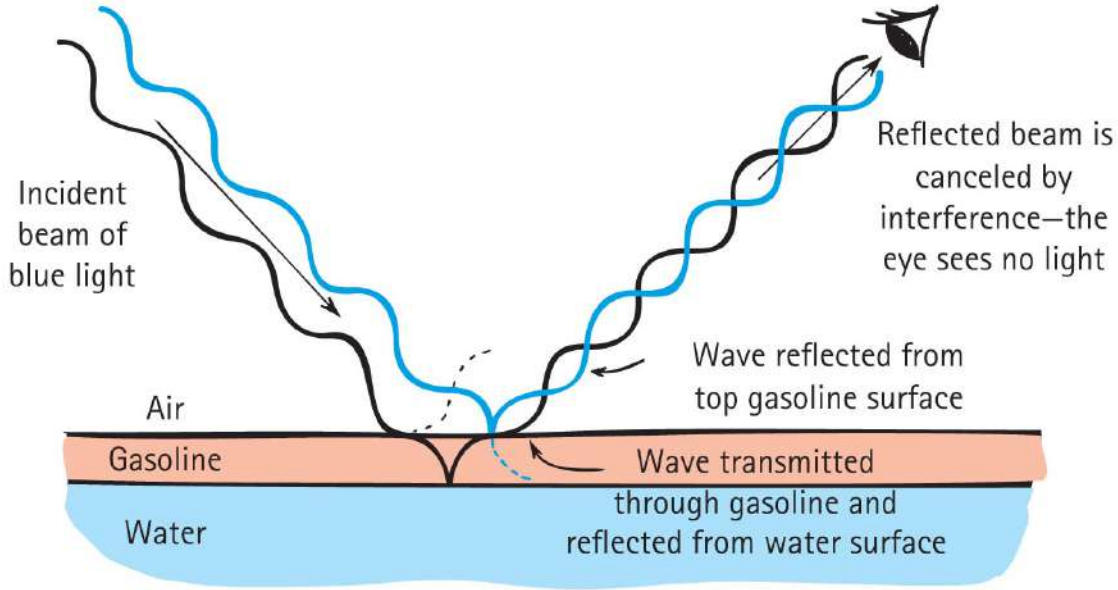
- Single-color thin-film interference



  - Reflection from the upper and lower surfaces of a wedge of air between two glass plates

Superposition and Interference, Continued-5

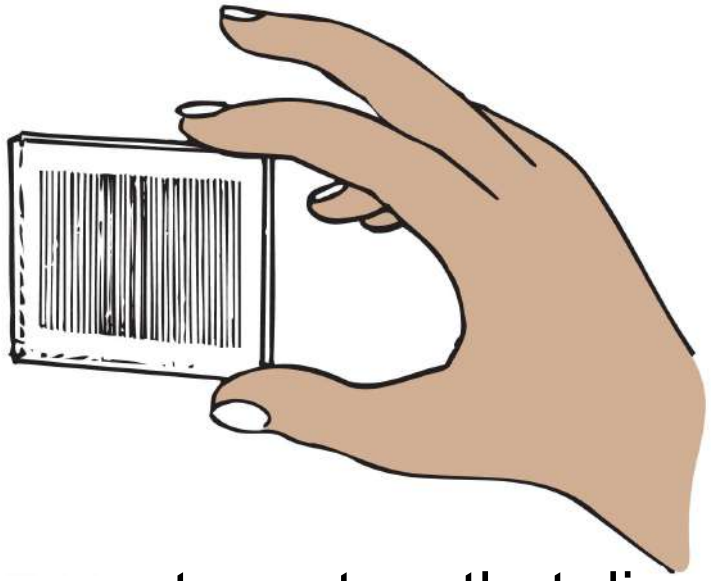
- Interference colors by reflection from thin films.



  - The thin film of gasoline is just the right thickness to result in the destructive interference of blue light.

Superposition and Interference, Continued-6

- Diffraction grating
  - Composed of a large number of close, equally spaced slits for analyzing light source



  - Produced by spectrometers that disperse white light into colors

Superposition and Interference
CHECK YOUR NEIGHBOR

If the thin film of gasoline was a bit thinner, the wavelength to be canceled would be

A. shorter than that of blue.
B. longer than that of blue.
C. white.
D. None of the above.

Superposition and Interference
CHECK YOUR ANSWER

If the thin film of gasoline was a bit thinner, the wavelength to be canceled would be

A. shorter than that of blue.

Superposition and Interference
CHECK YOUR NEIGHBOR, Continued

If violet light were canceled by the double reflection of sunlight from gasoline on a wet surface, the resulting color would likely be

A. red.
B. orange.
C. green.
D. violet.

Superposition and Interference
CHECK YOUR ANSWER, Continued

If violet light were canceled by the double reflection of sunlight from gasoline on a wet surface, the resulting color would likely be

B. orange.

Explanation:

Orange is the complementary color of violet.

Superposition and Interference
CHECK YOUR NEIGHBOR, Continued-1

If you see the color blue reflected in the interference from gasoline on water, and you lower your head so a greater angle from the normal results, you'll likely see a color having a wavelength

A. shorter than that of blue.
B. longer than that of blue.
C. with a white appearance.
D. None of the above.

Superposition and Interference
CHECK YOUR ANSWER, Continued-1

If you see the color blue reflected in the interference from gasoline on water, and you lower your head so a greater angle from the normal results, you'll likely see a color having a wavelength

A. shorter than that of blue.

Explanation:

The path through the gasoline would be longer, and a longer wavelength would be canceled. The result of a long wave being canceled is a shorter wave.

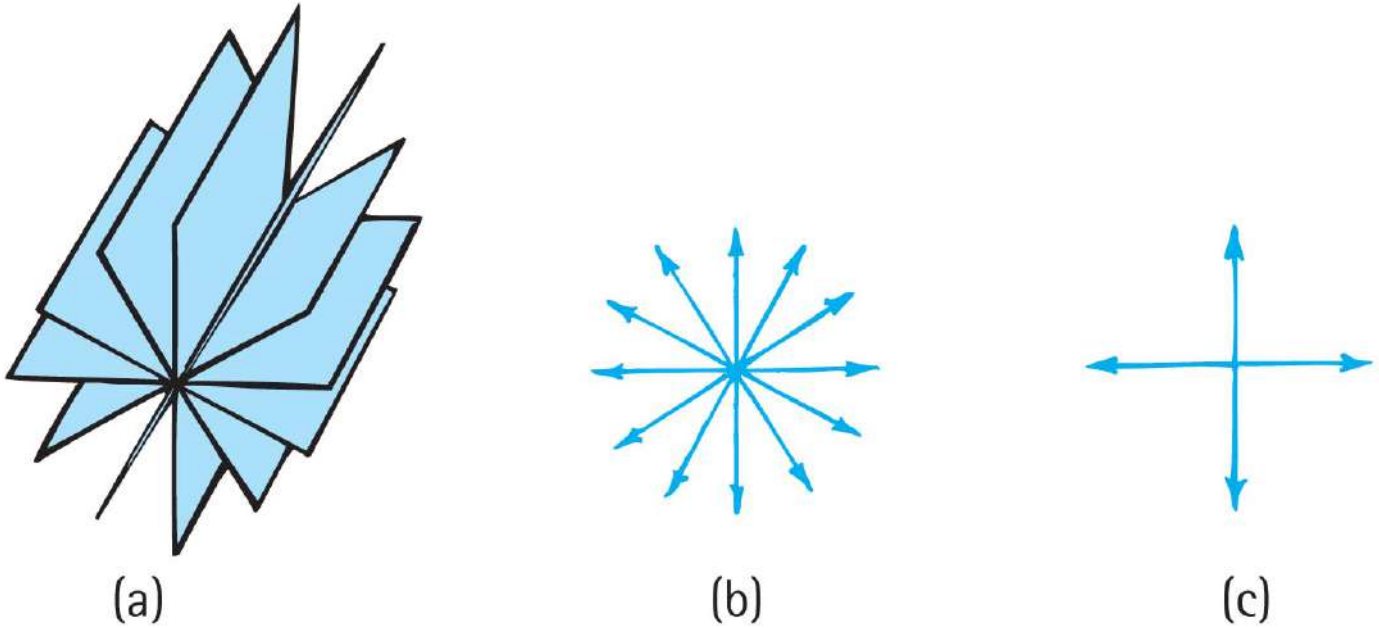
Superposition and Interference, Continued-7

- Interference colors

  - Note the colors in the bubble are subtractive primaries—magentas, yellows, and cyans.

Polarization

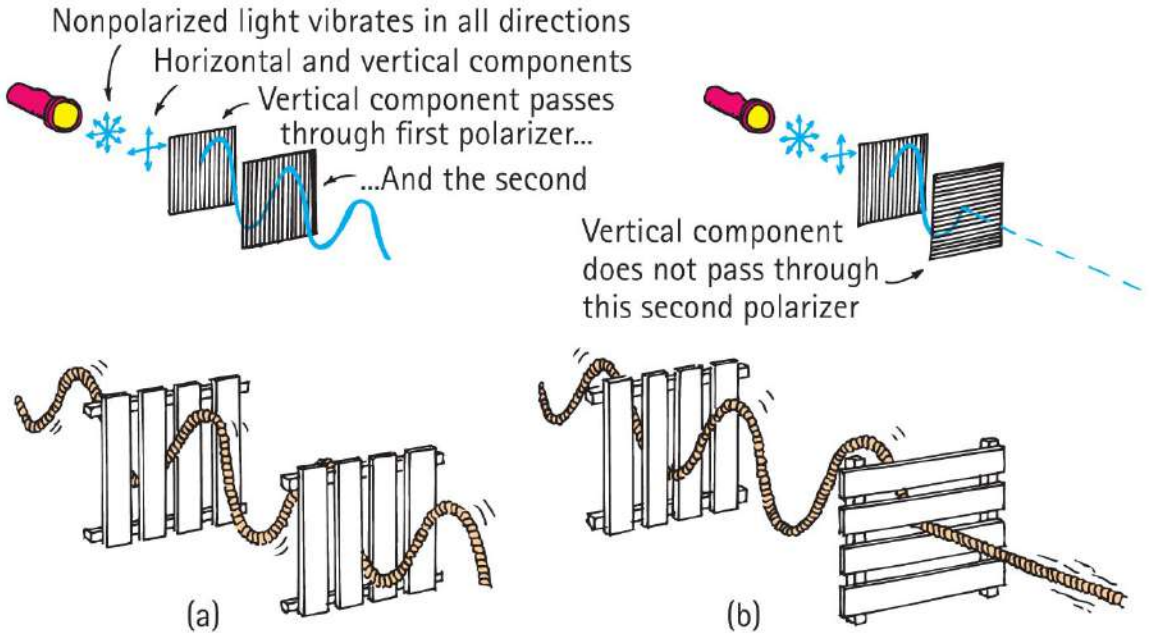
- Unpolarized light
  - Vibrations producing light are in random directions.



  - Example: incandescent lamp, fluorescent lamp, candle flame

Polarization, Continued

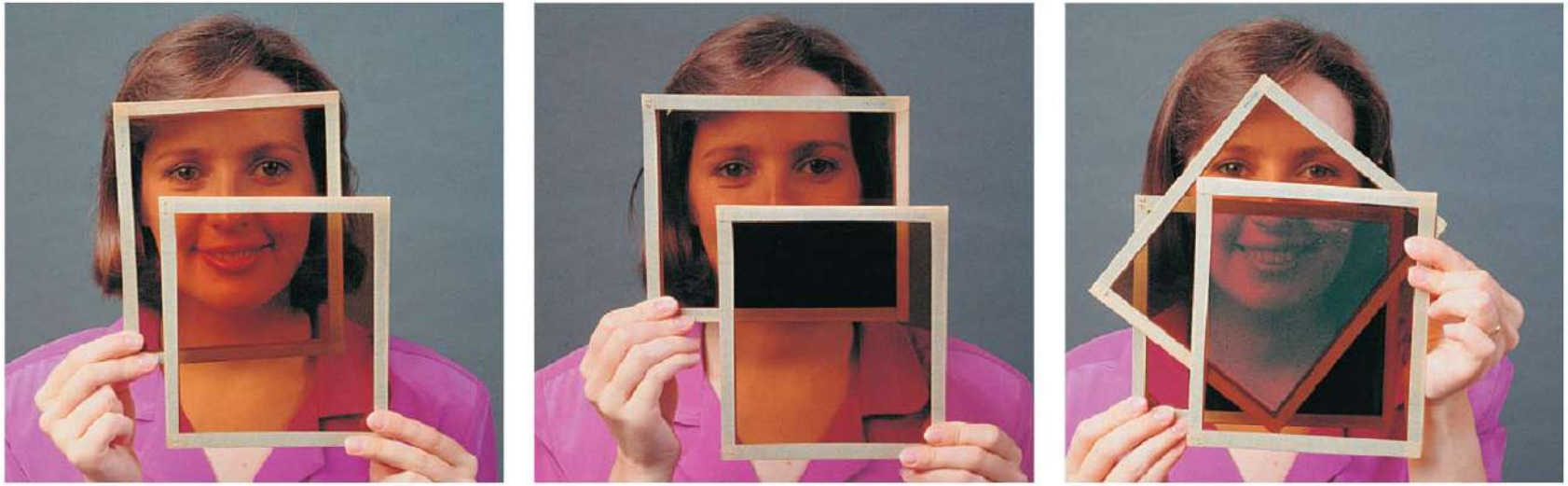
- Polarized light



  - Unpolarized light divided into two internal beams polarized at right angles to each other. One beam is absorbed while the other beam is transmitted.

Polarization, Continued-1

- Polarized light (continued)



  - Use your knowledge of vectors and vector components to explain how light that can't pass through a pair of Polaroids at right angles to each other will pass light when a third Polaroid is sandwiched between them!

Polarization
CHECK YOUR NEIGHBOR

Polarization occurs for waves that are

A. translational.
B. longitudinal.
C. Both A and B.
D. Neither A nor B.

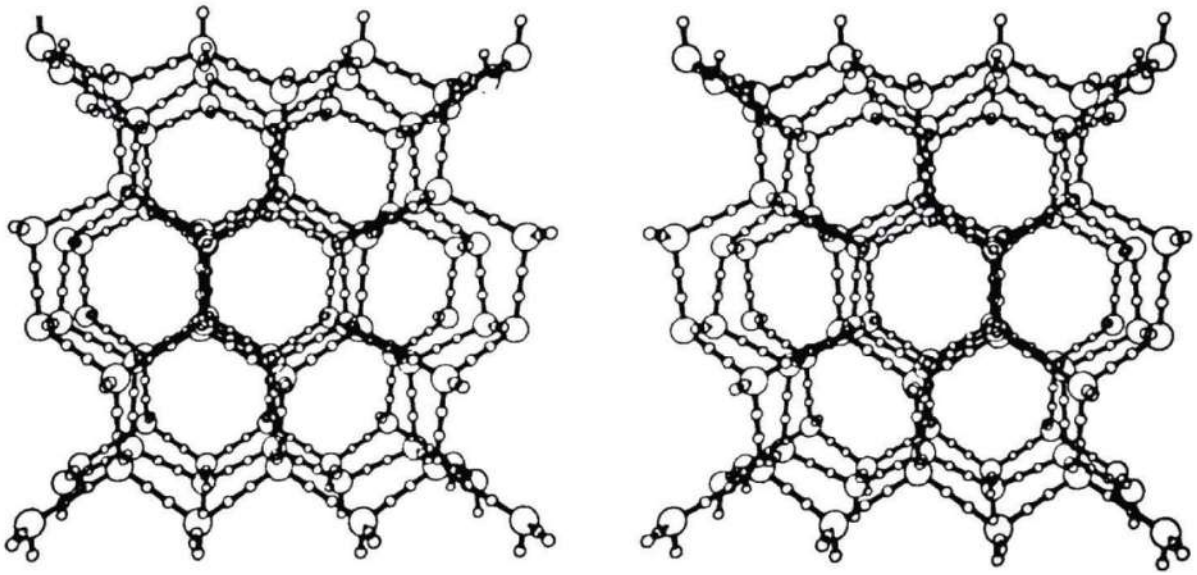
Polarization
CHECK YOUR ANSWER

Polarization occurs for waves that are

A. translational.

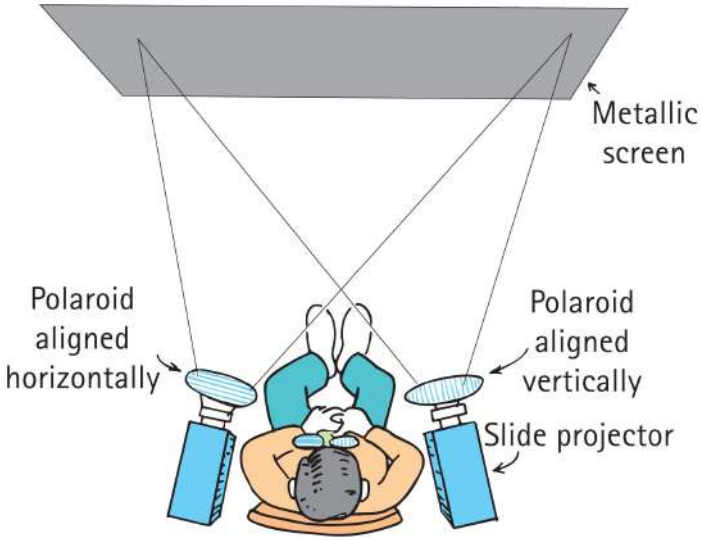
Polarization, Continued-2

- Three-dimensional viewing
  - Vision in three dimensions depends primarily on the fact that both eyes give their impressions simultaneously (or nearly so), each eye viewing the scene from a slightly different angle.



Polarization, Continued-3

- Three-dimensional viewing (continued)
  - If you place the Polaroids in front of the projectors so that they are at right angles to each other, and you view the polarized image with polarized glasses of the same orientation, each eye will see the proper view, as with the stereoscopic viewer.



Holography

- A *hologram*, is a two-dimensional photographic plate illuminated with laser light that allows you to see a faithful reproduction of a scene in three dimensions.
- Each point of the object being "photographed" reflects light to the entire photographic plate, so every part of the plate is exposed with light reflected from every part of the object.
- It is important that the light used to make a hologram be of a single frequency and all parts exactly in phase: It must be *coherent*.