11 PHYSICS

Unit 5: Light + Sound

Booklet 3

June 16th – June 19th

NAME: Filled

THE LAST BOOKLET EVER 😊

(adapted from www.physicsclassroom.com)

U5:L5 Light Theories

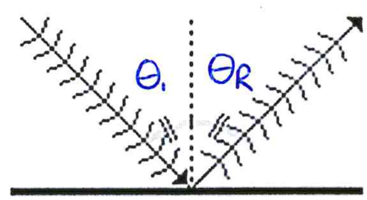
An age-old debate that has persisted among scientists is related to the question, "Is light a wave or a stream of particles?" Very noteworthy and distinguished physicists have taken up each side of the argument, providing a wealth of evidence for each side. The fact is that light exhibits behaviors that are characteristic of both waves and particles.

Light exhibits certain behaviors that are characteristic of any wave and would be difficult to explain with a purely particle-view.

- ✓ Light **reflects** in the same manner that any wave would reflect.
- ✓ Light **refracts** in the same manner that any wave would refract.
- ✓ Light **diffracts** in the same manner that any wave would diffract.
- ✓ Light undergoes **interference** in the same manner that any wave would interfere.
- ✓ And light exhibits **the Doppler effect** just as any wave would exhibit the Doppler effect.

Reflection

All waves are known to undergo **reflection** or the bouncing off of an obstacle. The reflection of light waves off of a mirrored surface results in the formation of an image.



Light waves follow the "law of wave reflection."

$\theta_i = \theta_R$ One characteristic of wave reflection is that the angle at which the wave approaches a flat reflecting surface is equal to the angle at which the wave leaves the surface.

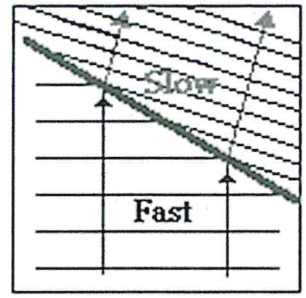
This characteristic is observed for water waves and sound waves. It is also observed for light waves. Light, like any wave, follows the law of reflection when bouncing off surfaces. ★ Like reflections on water!

$\theta_{incident} = \theta_{Reflection}$

(adapted from www.physicsclassroom.com)

Refraction

All waves are known to undergo refraction when they pass from one medium to another medium. That is, when a wavefront crosses the boundary between two media, the direction that the wavefront is moving undergoes a sudden change; the path is "bent."



The refractive behavior of light reveals that light is very wave-like.

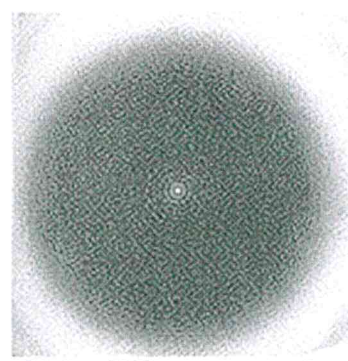
The direction of "bending" is dependent upon the relative speed of the two media. A wave will bend one way when it passes from a medium in which it travels slowly into a medium in which it travels fast; and if moving from a *fast medium* to a *slow medium*, the wavefront will bend in the opposite direction.

The amount of bending is dependent upon the actual speeds of the two media on each side of the boundary. ☆like a pencil bending in water!

Diffraction

Diffraction involves a change in direction of waves as they pass through an opening or around an obstacle in their path. Water waves have the ability to travel around corners, around obstacles and through openings. Sound waves do the same. But what about light?

When light encounters an obstacle in its path, the obstacle blocks the light and tends to cause the formation of a shadow in the region behind the obstacle. Light does not exhibit a very noticeable ability to bend around the obstacle and fill in the region behind it with light. Nonetheless, light does diffract around obstacles. In fact, if you observe a shadow carefully, you will notice that its edges are extremely fuzzy.



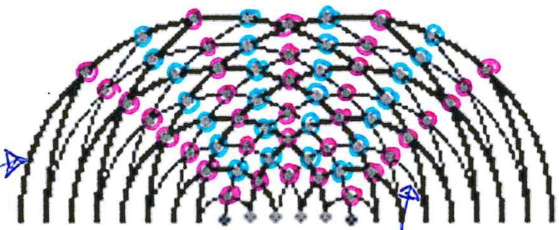
Light diffracts around a penny - observe the light spot in the center of pattern.

Interference effects occur due to the diffraction of light around different sides of the object, causing the shadow of the object to be fuzzy.

Similar to what we have seen before!

U5:L6 Young's Experiment

The interference of two sets of periodic and concentric waves with the same frequency produces an interesting pattern in a ripple tank. The diagram at the right depicts an interference pattern produced by two periodic disturbances.

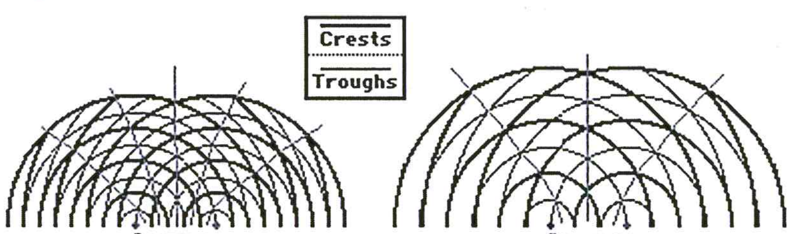


The crests are denoted by the thick lines and the troughs are denoted by the thin lines.

- **Constructive interference** occurs wherever a thick line meets a thick line or a thin line meets a thin line; this type of interference results in the formation of an antinode. The antinodes are denoted by a red dot.
- **Destructive interference** occurs wherever a thick line meets a thin line; this type of interference results in the formation of a node. The nodes are denoted by a blue dot.

The pattern is a standing wave pattern, characterized by the presence of nodes and antinodes that are "standing still" - i.e., always located at the same position on the medium.

The antinodes (points where the waves always interfere constructively) seem to be located along lines - called antinodal lines. The nodes also fall along lines - called nodal lines.



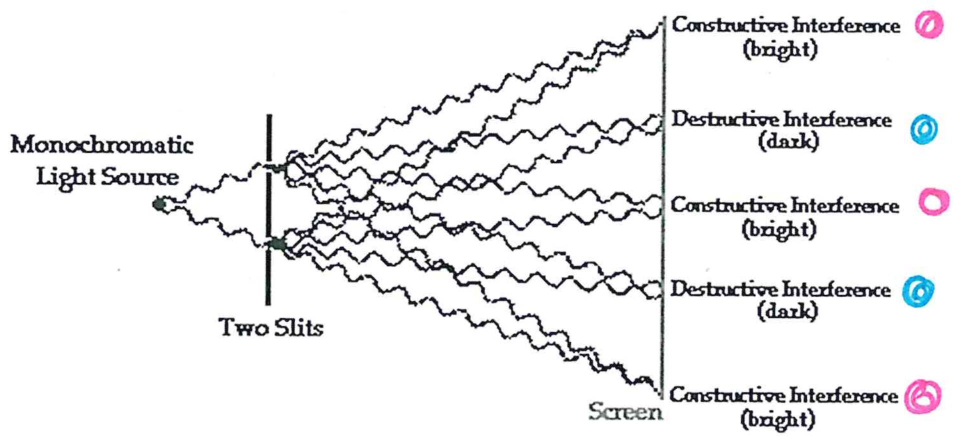
The proximity of the anti-nodal lines in a two-point source interference pattern is dependent upon the wavelength of the waves.

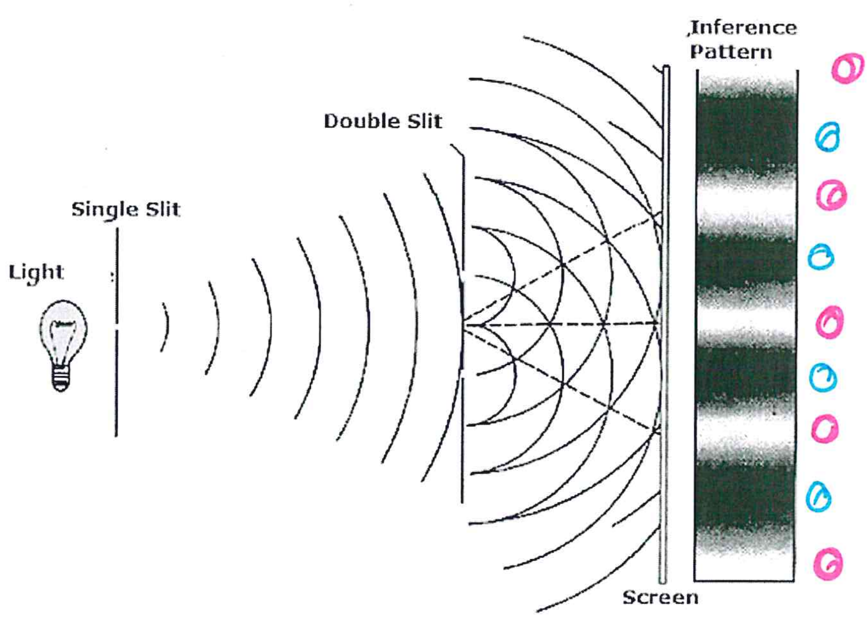
Whenever light **constructively interferes** (such as when a crest meeting a crest or a trough meeting a trough), the two waves act to reinforce one another and to produce a "super light wave."

On the other hand, whenever light **destructively interferes** (such as when a crest meets a trough), the two waves act to destroy each other and produce no light wave.

Thus, the two-point source interference pattern would still consist of an alternating pattern of antinodal lines and nodal lines.

However for light waves, the antinodal lines are equivalent to bright lines and the nodal lines are equivalent to dark lines. If such an interference pattern could be created by two light sources and projected onto a screen, then there ought to be an alternating pattern of dark and bright bands on the screen.



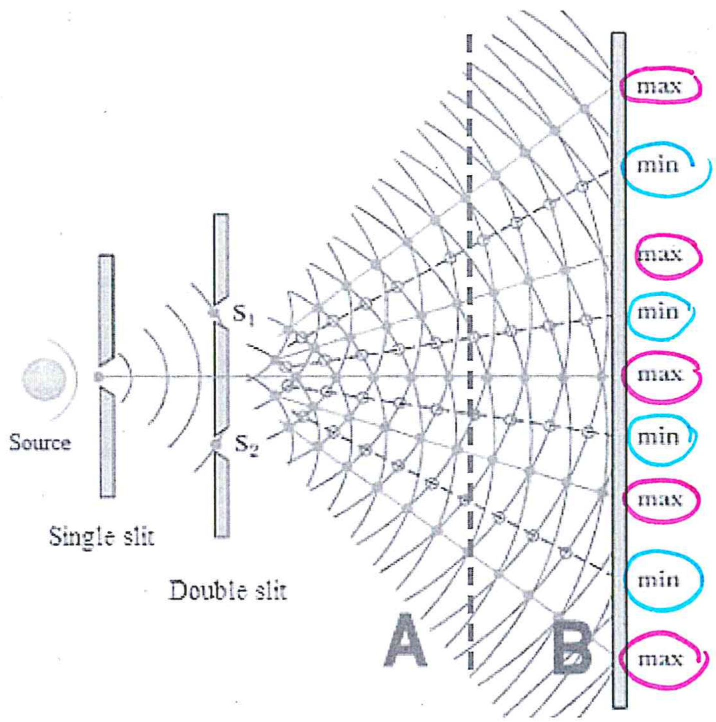


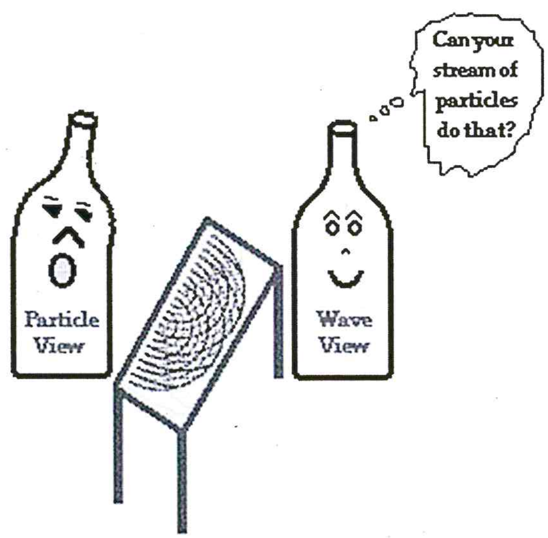
(adapted from www.physicsclassroom.com)

In 1801, **Thomas Young** successfully showed that light does produce a two-point source interference pattern.

In order to produce such a pattern, **monochromatic** light must be used. Monochromatic light is light of a single color; by use of such light, the two sources will vibrate with the same frequency.

It is also important that the two light waves be vibrating **in phase** with each other; that is, the crest of one wave must be produced at the same precise time as the crest of the second wave.





(adapted from www.physicsclassroom.com)