

## Warm-Up

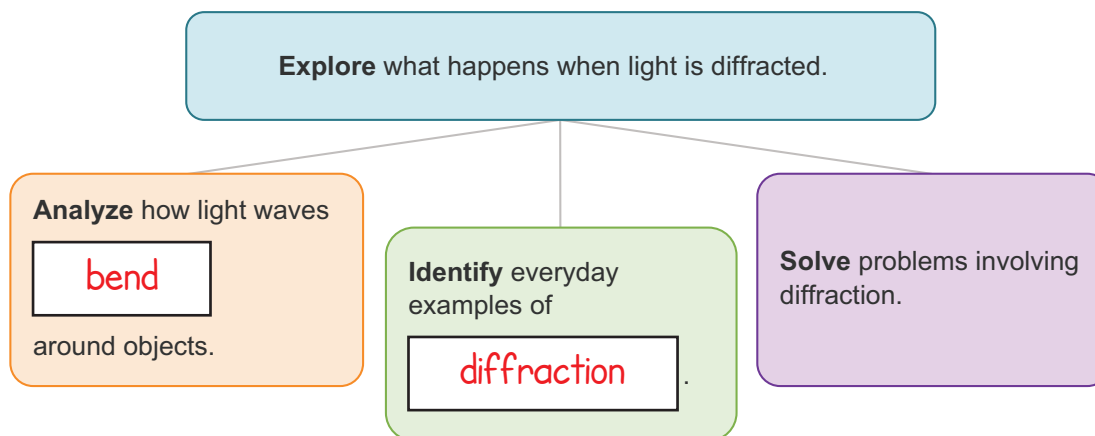
## Diffraction



## Lesson Question

What happens when light is diffracted?

## Lesson Goals



## Words to Know

Write the letter of the definition next to the matching word as you work through the lesson. You may use the glossary to help you.

- |                              |  |
|------------------------------|--|
| <u>B</u> path difference     | A. a surface with many parallel grooves that is used to bend light                     |
| <u>C</u> wavelets            | B. the difference in the distances traveled by two interfering waves                   |
| <u>A</u> diffraction grating | C. the secondary waves formed from source points on the wave front                     |
| <u>F</u> monochromatic       | D. the angle between the direction of an incident wave and a resulting diffracted wave |
| <u>D</u> diffraction angle   | E. a line in which waves that are moving together are all in the same phase            |
| <u>E</u> wave front          | F. having just one wavelength or color   |



**Diffraction**

- Diffraction is the bending of a wave as it encounters a barrier or passes through an opening.

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**Wave Fronts**

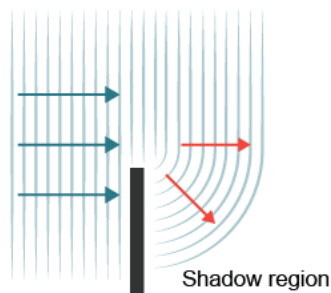
- A **wave front** is a line in which waves that are moving together are all in the same **phase**.
- The waves travel **perpendicular** to the wave fronts.

**Wavelets**

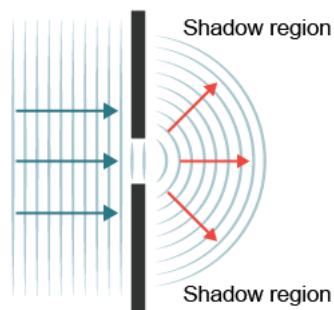
- Wave fronts are made of points that may be a **source** of wavelets (secondary waves).

**Change of Direction**

- Light changes direction during diffraction.



Light bends when it encounters an object.



Light **spreads out** when it goes through an opening.

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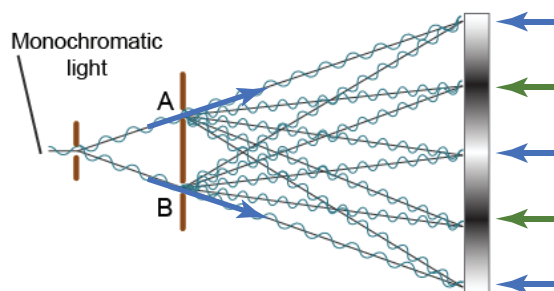
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### Diffraction Grating

- **Diffraction grating** is a surface with many parallel **grooves**; it is used to bend light.
  - These grooves cause different wavelengths of light to bend at different **angles**.
    - Diffracted wavelengths reach the eyes; the eyes see the colors.

### Diffraction and Interference

- When **monochromatic** light encounters a barrier or passes through openings, the diffracted waves **interfere** with each other, resulting in a pattern of bright and **dark** bands on a screen.
  - Waves that interfere constructively form bright bands.
  - Waves that interfere destructively form dark bands.

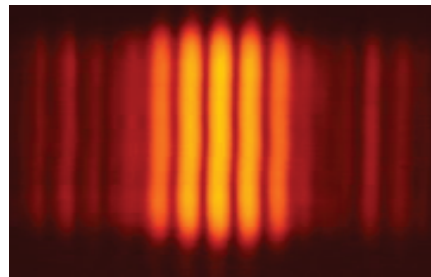
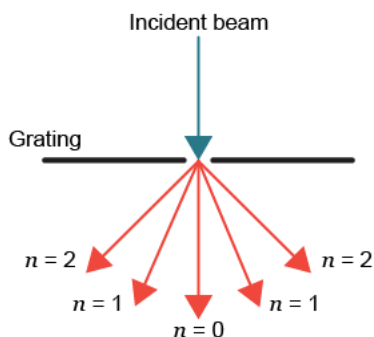


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### Orders

- Bands are designated orders.

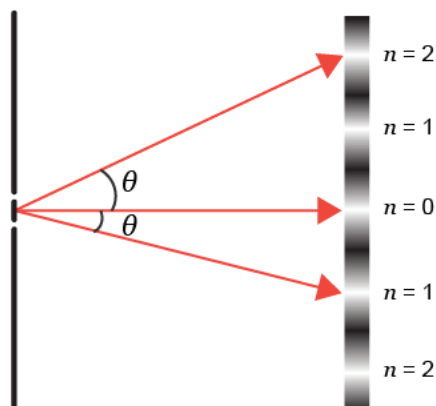


- The bright band that's a result of light passing through the slit traveling on a straight path is designated the **zero order**.
- The first and second order bands on either side of the zero order band are slightly **less** bright, but they're still very visible.

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### Diffraction Angle

- Diffraction angle** is the angle between the direction of an incident wave and a resulting **diffracted** wave.



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### Interference and Path Difference

- The difference in the **distance** traveled by two interfering waves is known as the **path difference**.
  - The path difference between any two waves can be found by  $d \sin \theta$ .
    - $d$  is the distance between the **slits**.
    - $\theta$  is the diffraction angle.
- The path difference determines whether waves will be in phase (constructive) or out of phase (destructive).
  - A path difference of zero or any whole number indicates **constructive** interference.
  - A path difference of an odd multiple of half of the wavelength indicates destructive interference.

### Constructive and Destructive Interference Formulas

- The path difference between two interfering waves is:
  - equal to an **integer** multiple of the wavelength for constructive interference.  $d \sin \theta = n\lambda$
  - equal to an odd number of half wavelengths for destructive interference.  $d \sin \theta = \left(n + \frac{1}{2}\right)\lambda$ 
    - $n$  is the **order** number.
    - $\lambda$  is the wavelength.

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**Determining Wavelength****EXAMPLE**

What is the wavelength of a light whose second order dark band forms a diffraction angle of  $25^\circ$  if the diffraction grating has 250.0 lines per mm?

- Given:

$$d = \frac{1}{250 \text{ lines per mm}} = \boxed{0.004 \text{ mm}}$$

$$= 4000 \text{ nm}$$

- $n = 2$

- $\theta = 25.0^\circ$

- Unknown:  $\lambda$

- Formula to be used:  $d \sin \theta = \left( n + \frac{1}{2} \right) \lambda$

$$\lambda = \frac{d \sin \theta}{n + \frac{1}{2}}$$

$$= \frac{4000 \text{ nm} \cdot \boxed{\sin 25^\circ}}{2.5}$$

$$= \boxed{676} \text{ nm}$$

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**Diffraction in Nature**

- The fuzziness of the sides of shadows and the different colors of the exoskeleton of some beetles are the result of diffraction.

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**Diffraction in Technology**

- Holograms are created from **interference** and diffraction.
  - A hologram is visible because light diffracts off the interference patterns created by **lasers**.

**Diffraction in Technology**

- Spectrometers have diffraction gratings that are used to **separate** light into different wavelengths and colors.
  - Each element has its own pattern, which allows scientists to determine the **composition** of objects.

## Summary

## Diffraction

?

## Lesson Question

What happens when light is diffracted?

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## Answer

(Sample answer) When light encounters a barrier or an opening, wavelets travel perpendicular to the new wave front that moves into the shadow regions of the barrier or opening.

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## Review: Key concepts

- Wave fronts are made of wavelets that move perpendicular to the movement of the wave fronts. This causes light to bend into the **shadow** regions of barriers and openings.
- Diffracted waves interfere and cause **diffraction** patterns.
  - Waves that interfere constructively form bright bands.
    - $d \sin \theta = n\lambda$
  - Waves that interfere destructively form dark bands.
    - $d \sin \theta = \left(n + \frac{1}{2}\right)\lambda$
- Diffraction can be observed in nature and is used in technology.

*Use this space to write any questions or thoughts about this lesson.*