Applied Physics for Engineers

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Diffraction, polarization

Diffraction

When plane light waves pass through a small aperture in an opaque barrier, the aperture acts as if it were a point source of light, with waves entering the shadow region behind the barrier. This phenomenon, known as diffraction can be described only with a wave model for light.

A diffraction pattern occurs when the light from an aperture is allowed to fall on a screen .

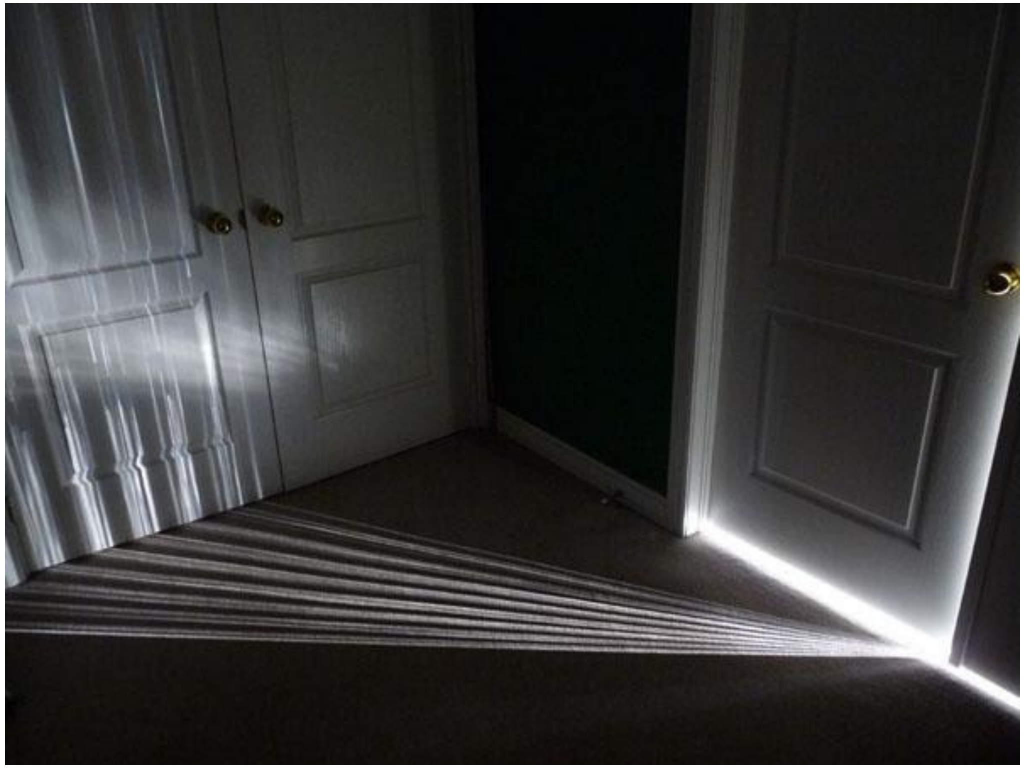
- The features of this diffraction pattern can be investigated.

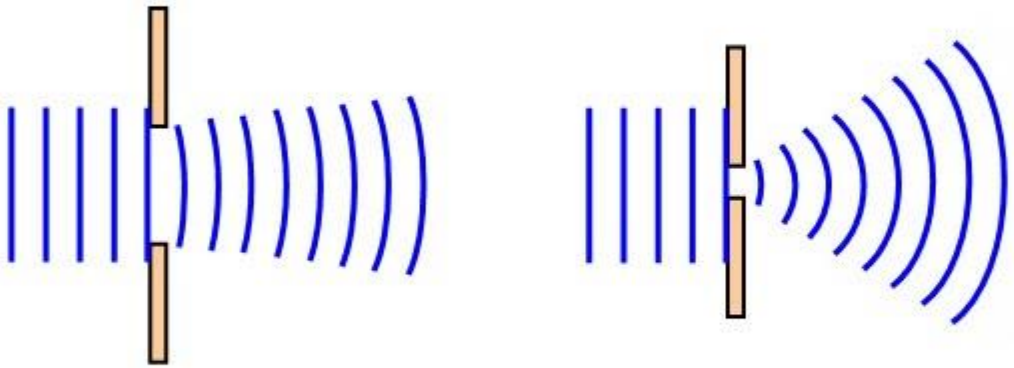
Diffraction

Light of wavelength comparable to or larger than the width of a slit spreads out in all forward directions upon passing through the slit.

This phenomena is called *diffraction.*

- This indicates that light spreads beyond the narrow path defined by the slit into regions that would be in shadow if light traveled in straight lines.





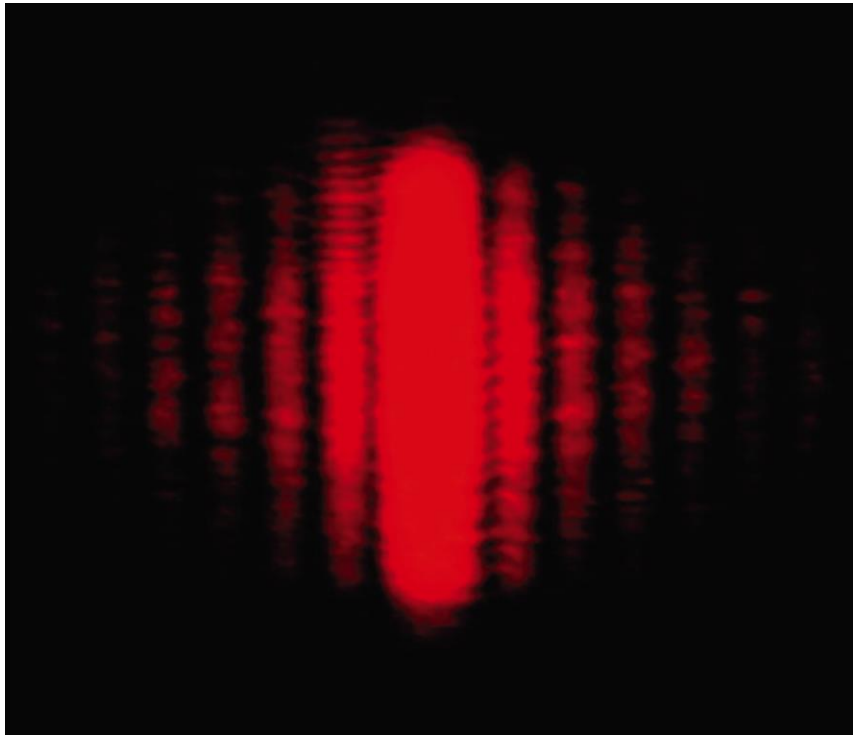
Diffraction Pattern

A single slit placed between a distant light source and a screen produces a **diffraction pattern.**

- It will have a broad, intense central band, called the **central maximum**
- The central band will be flanked by a series of narrower, less intense secondary bands, called **side maxima** or **secondary maxima**
- The central band will also be flanked by a series of dark bands, called **minima**

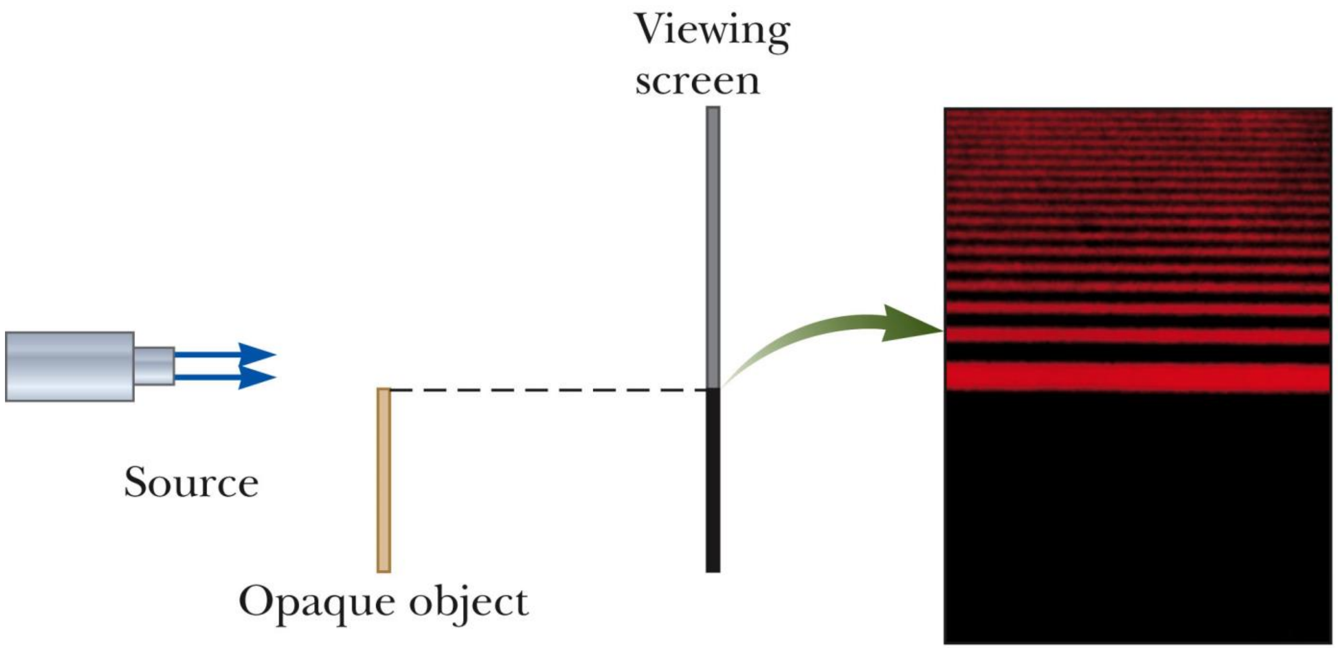
Diffraction Pattern, Single Slit

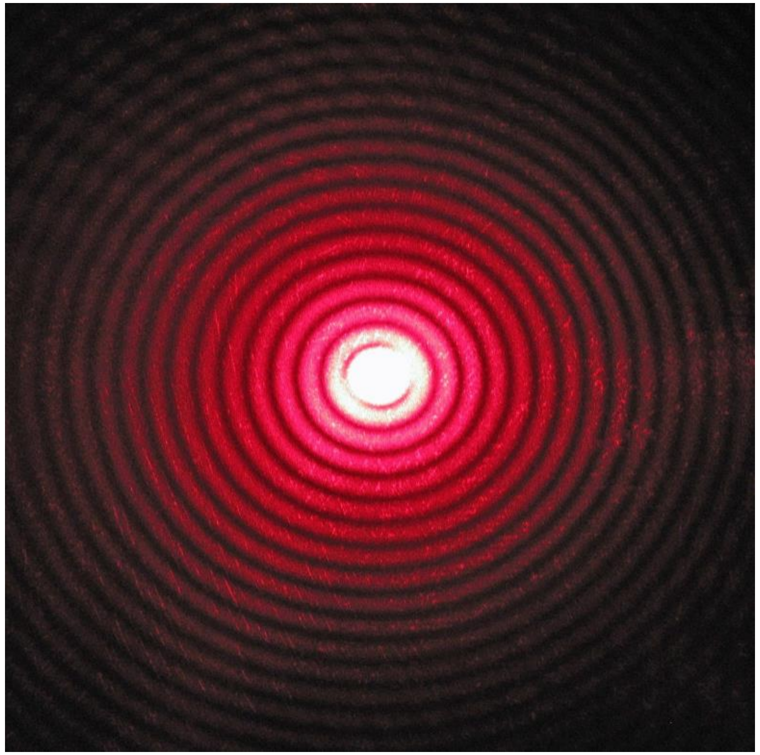
- The diffraction pattern consists of the central maximum and a series of secondary maxima and minima.
- The pattern is similar to an interference pattern.



Diffraction Pattern, Object Edge

- This shows the upper half of the diffraction pattern formed by light from a single source passing by the edge of an opaque object.
- The diffraction pattern is vertical with the central maximum at the bottom.





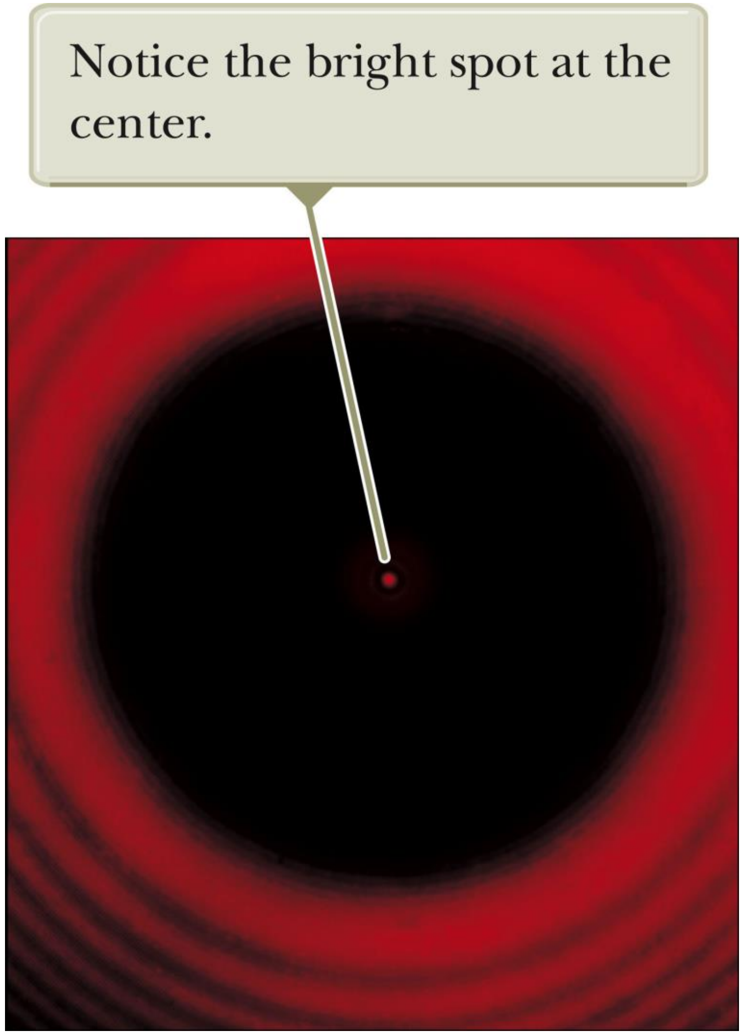
Confirming Wave Nature

Ray optics would predict a dark spot in the center.

Wave theory predicts the presence of the center spot.

There is a bright spot at the center which confirms wave theory

The circular fringes extend outward from the shadow's edge.



Single-Slit Diffraction

The finite width of slits is the basis for understanding Fraunhofer diffraction.

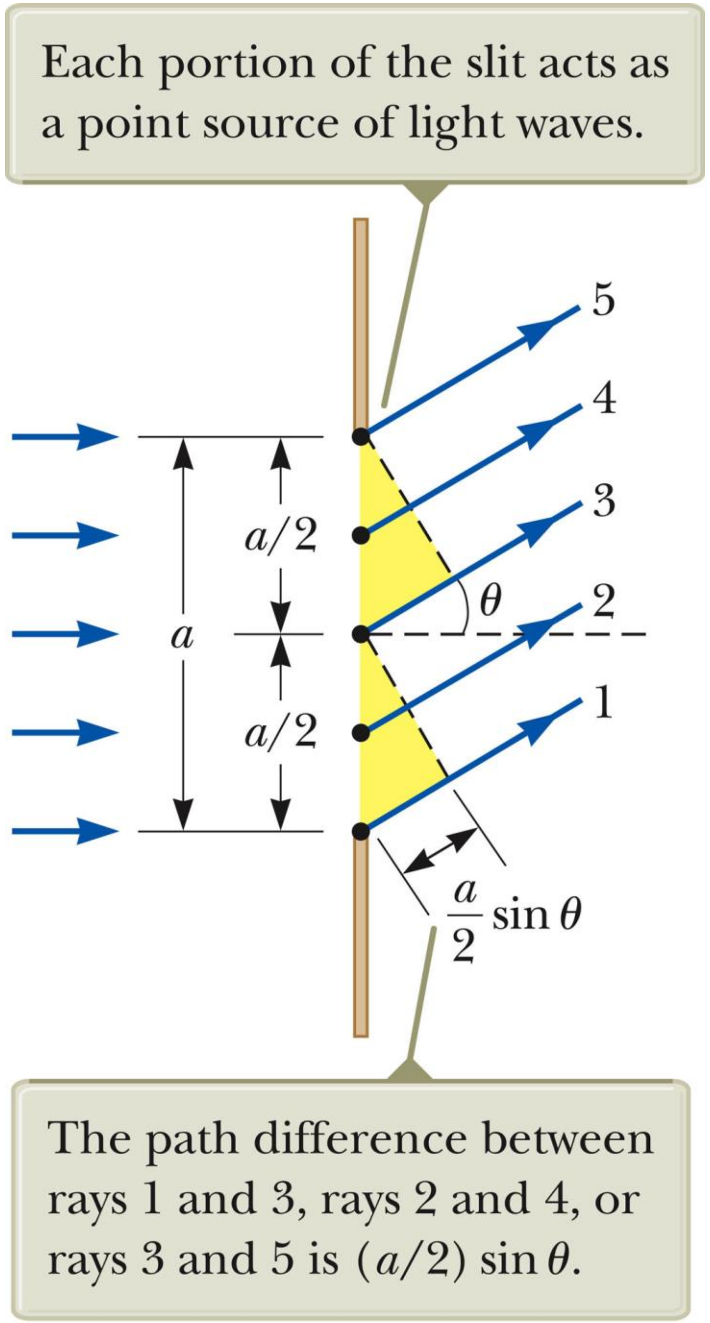
According to Huygens's principle, each portion of the slit acts as a source of light waves.

Therefore, light from one portion of the slit can interfere with light from another portion.

The resultant light intensity on a viewing screen depends on the direction θ.

The diffraction pattern is actually an interference pattern.

- The different sources of light are different portions of the single slit.



Single-Slit Diffraction, Analysis

All the waves are in phase as they leave the slit.

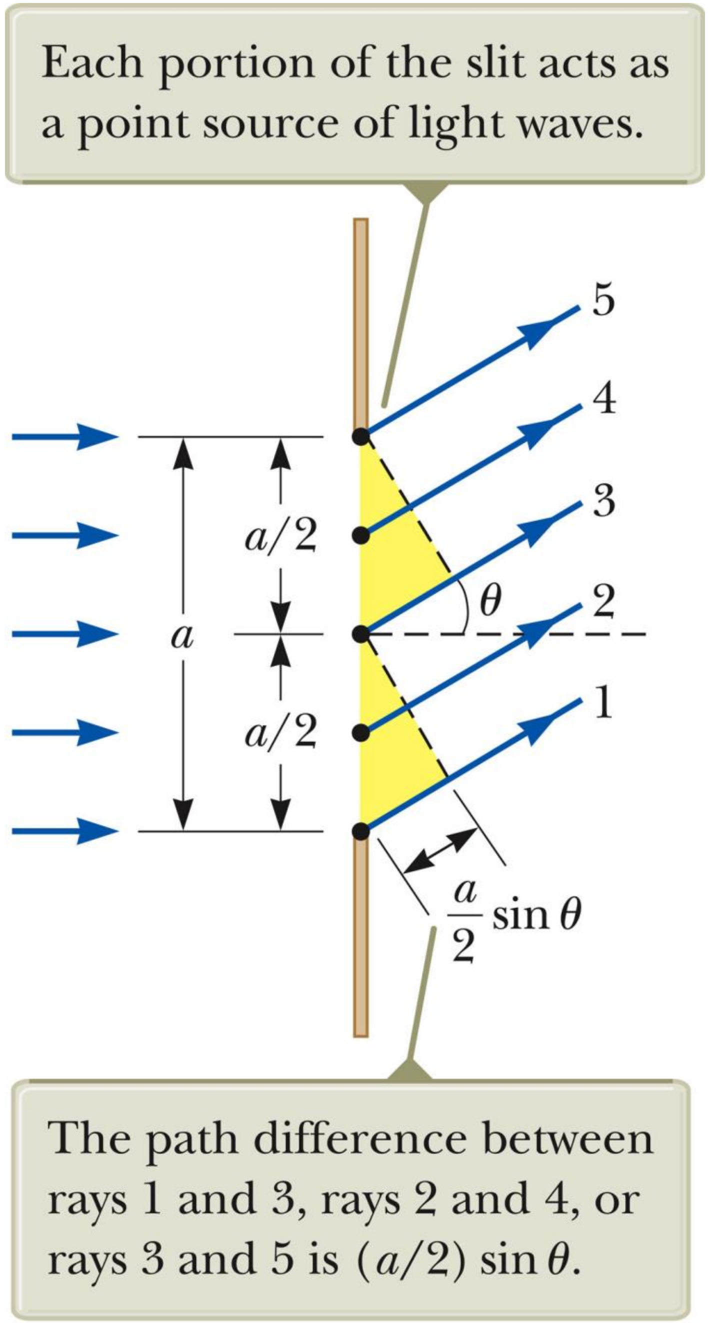
Wave 1 travels farther than wave 3 by an amount equal to the path difference.

- $(a/2) \sin \theta$

If this path difference is exactly half of a wavelength, the two waves cancel each other and destructive interference results.

In general, destructive interference occurs for a single slit of width ‘a’ when $\sin \theta_{dark} = m\lambda / a$.

- $m = \pm 1, \pm 2, \pm 3, \ldots$



Single-Slit Diffraction, Intensity

The general features of the intensity distribution are shown.

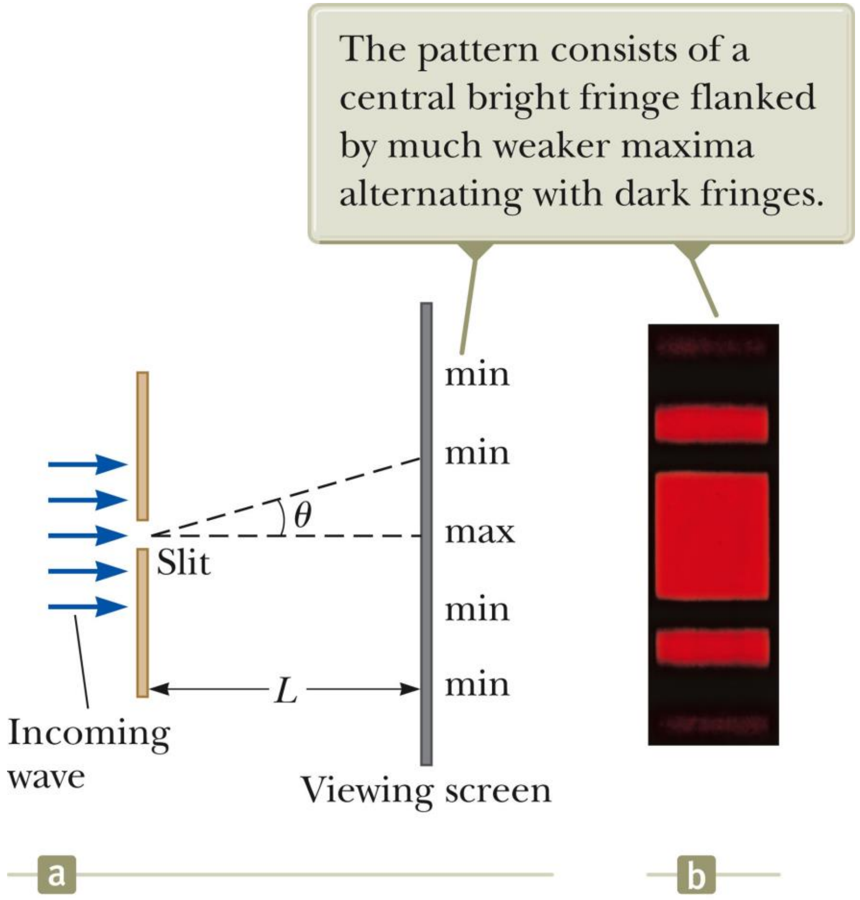
A broad central bright fringe is flanked by much weaker bright fringes alternating with dark fringes.

Each bright fringe peak lies approximately halfway between the dark fringes.

The central bright maximum is twice as wide as the secondary maxima.

There is no central dark fringe.

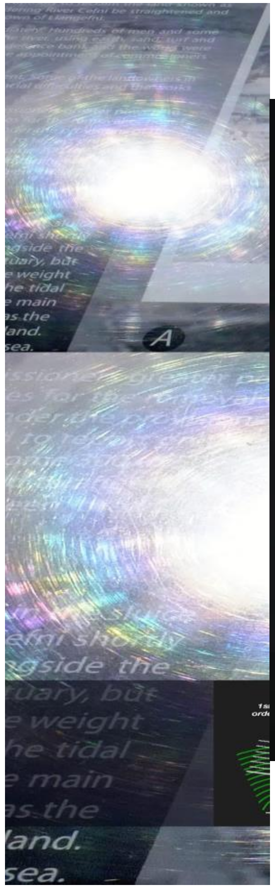
- Corresponds to no m = 0 in the equation

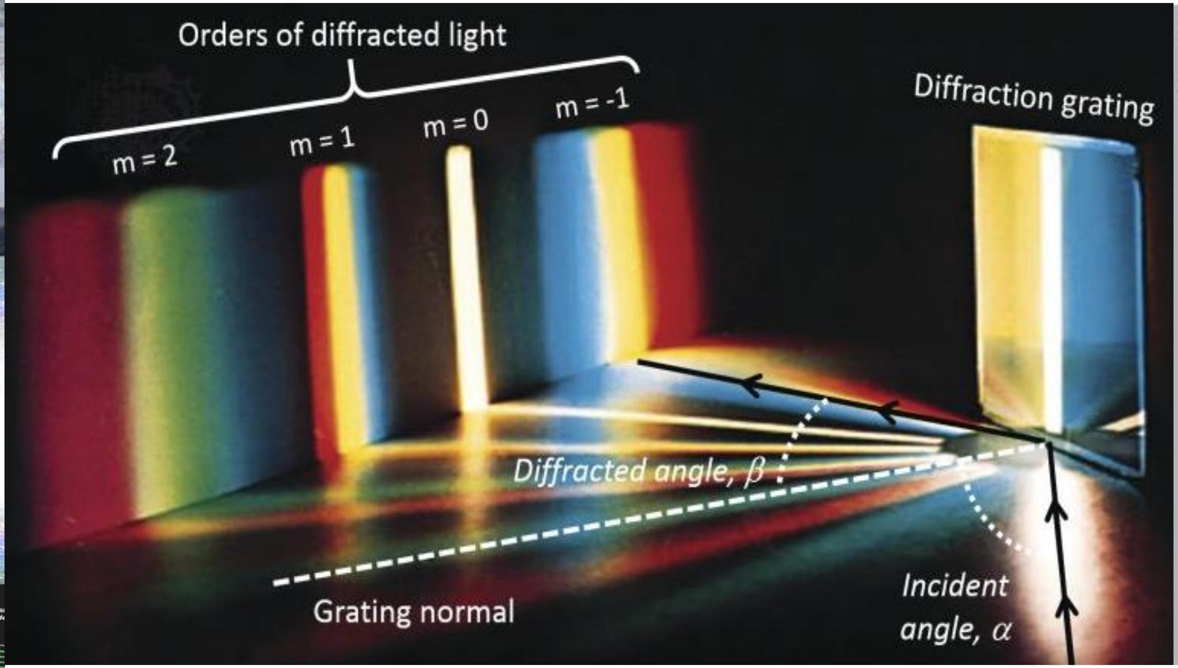


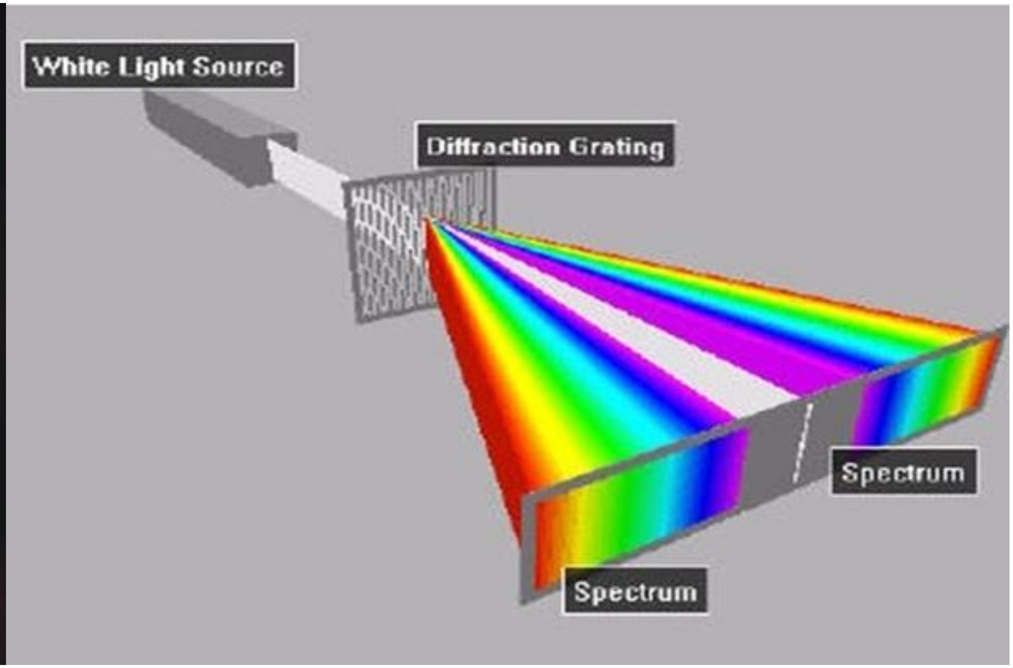
Diffraction Grating

The diffracting grating consists of a large number of equally spaced parallel slits..

- A diffraction grating is an optical component with a periodic structure that splits and diffracts light into several beams travelling in different directions.
- A typical grating contains several thousand lines per centimeter





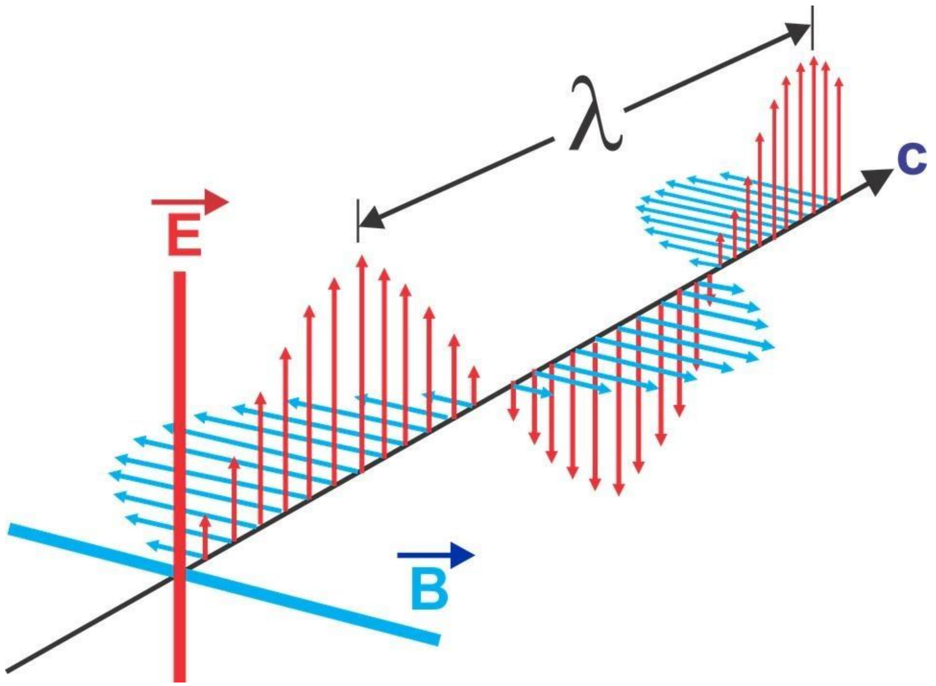


Polarization

Electromagnetic waves

Electromagnetic waves are the waves that are propagated by simultaneous periodic variations of electric and magnetic field intensity

- EM waves are transverse waves
- Non-mechanical waves
- **E** travels ⊥ direction of propagation of wave
- **B** travels ⊥ direction of propagation of wave
- **E** oscillates ⊥ to **B**
- **E** and **B** waves are in phase

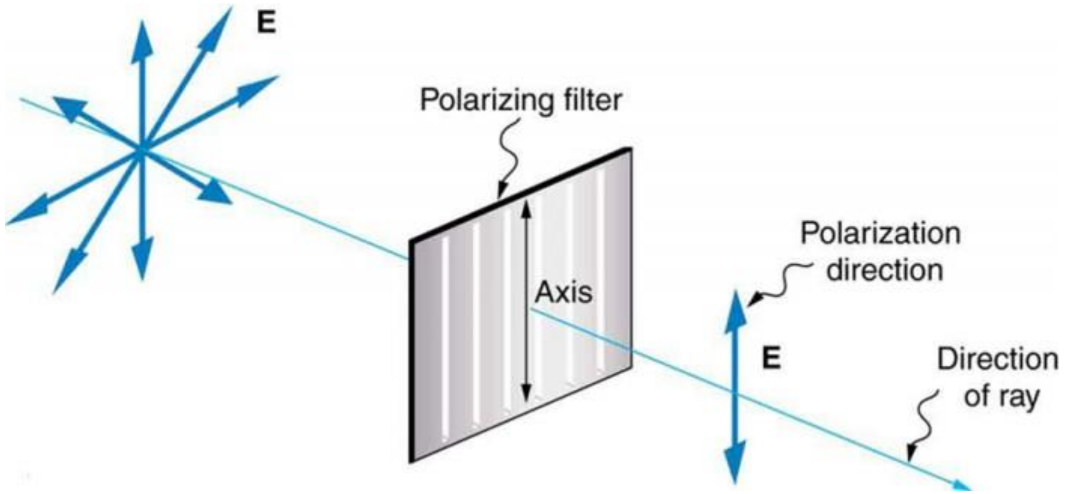


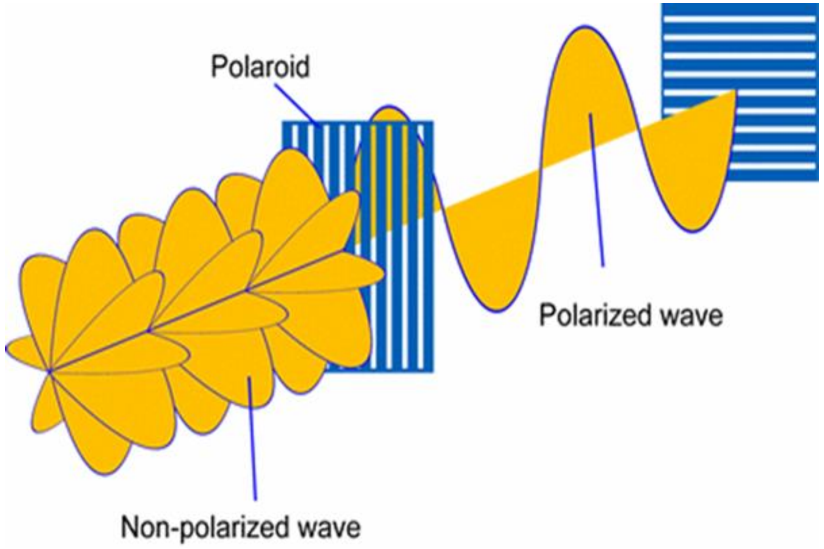
Polarization of light

- Electromagnetic waves are polarized if their electric field vectors are all in a single plane, called the plane of oscillation. Light waves from common sources are not polarized; that is, they are unpolarized, or polarized randomly.
- When a polarizing sheet is placed in the path of light, only electric field components of the light parallel to the sheet's polarizing direction are transmitted by the sheet; components perpendicular to the polarizing direction are absorbed. The light that emerges from a polarizing sheet is polarized parallel to the polarizing direction of the sheet.

Tourmaline crystal, Nicol prism are examples of polaroid

Intensity:





- f the original light is initially unpolarized, the transmitted intensity I is half the original intensity I_0:

$$I = \frac{1}{2} I_0.$$

- If the original light is initially polarized, the transmitted intensity depends on the angle u between the polarization direction of the original light and the polarizing direction of the sheet:

$$I = I_0 \cos^2 \theta.$$

Sample problem 33.02

Sample problem 36.01

(FUNDAMENTALS OF PHYSICS)