13.9: Propagation of Electromagnetic Waves (Summary)

Key Terms

corner reflector	object consisting of two (or three) mutually perpendicular reflecting surfaces, so that the light that enters is reflected back exactly parallel to the direction from which it came
constructive interference	when two waves arrive at the same point exactly in phase; that is, the crests of the two waves are precisely aligned, as are the troughs
destructive interference	hen two identical waves arrive at the same point exactly out of phase; that is, precisely aligned crest to trough
geometric optics	part of optics dealing with the ray aspect of light
Huygens's principle	every point on a wave front is a source of wavelets that spread out in the forward direction at the same speed as the wave itself; the new wave front is a plane tangent to all of the wavelets
index of refraction	for a material, the ratio of the speed of light in a vacuum to that in a material
interference	overlap of two or more waves at the same point and time
law of reflection	angle of reflection equals the angle of incidence
law of refraction	when a light ray crosses from one medium to another, it changes direction by an amount that depends on the index of refraction of each medium and the sines of the angle of incidence and angle of refraction
ray	straight line that originates at some point
refraction	changing of a light ray's direction when it passes through variations in matter
superposition	phenomenon that occurs when two or more waves arrive at the same point
wave optics	part of optics dealing with the wave aspect of light

Key Equations

Speed of light	$c = 2.99792458 \times 10^8 m/s \approx 3.00 \times 10^8 m/s$
Index of refraction	$n = \frac{c}{v}$
Law of reflection	$\theta_r = \theta_i$
Law of refraction (Snell's law)	$n_1 sin\theta_1 = n_2 sin\theta_2$

Summary

Ray and Wave Models of Propagation

- The speed of light in a vacuum is $c = 2.99792458 \times 10^8 m/s \approx 3.00 \times 10^8 m/s$.
- The index of refraction of a material is $n = c/v$, where v is the speed of light in a material and **c** is the speed of light in a vacuum.
- The ray model of light describes the path of light as straight lines. The part of optics dealing with the ray aspect of light is called geometric optics.

- Light can travel in three ways from a source to another location: (1) directly from the source through empty space; (2) through various media; and (3) after being reflected from a mirror.

Reflection of Rays

- When a light ray strikes a smooth surface, the angle of reflection equals the angle of incidence.
- A mirror has a smooth surface and reflects light at specific angles.
- Light is diffused when it reflects from a rough surface.

Refraction of Rays

- The change of a light ray's direction when it passes through variations in matter is called refraction.
- The law of refraction, also called Snell's law, relates the indices of refraction for two media at an interface to the change in angle of a light ray passing through that interface.

Application: Line-of-Sight Transmission

- Using the ray model, there is a maximum distance of transmission of a ray due to the curvature of the earth.

Diffraction of Waves

- According to Huygens's principle, every point on a wave front is a source of wavelets that spread out in the forward direction at the same speed as the wave itself. The new wave front is tangent to all of the wavelets.
- A mirror reflects an incoming wave at an angle equal to the incident angle, verifying the law of reflection.
- The law of refraction can be explained by applying Huygens's principle to a wave front passing from one medium to another.
- The bending of a wave around the edges of an opening or an obstacle is called diffraction.

Interference of Waves

- Superposition is the combination of two waves at the same location.
- Constructive interference occurs from the superposition of two identical waves that are in phase.
- Destructive interference occurs from the superposition of two identical waves that are 180° (π radians) out of phase.
- The wave that results from the superposition of two sine waves that differ only by a phase shift is a wave with an amplitude that depends on the value of the phase difference.

Double-Slit Interference

- Young's double-slit experiment gave definitive proof of the wave character of light.
- An interference pattern is obtained by the superposition of light from two slits.
