Unit 14: Waves and Optics – Physical Optics

OBJECTIVES

Big Idea 6: Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena.

Enduring Understanding 6.B: A periodic wave is one that repeats as a function of both time and position and can be described by its amplitude, frequency, wavelength, speed and energy.

Essential Knowledge 6.B.3: A simple wave can be described by an equation involving one sine or cosine function involving the wavelength, amplitude, and frequency of the wave.

Learning Objective 6.B.3.1: The student is able to construct an equation relating the wavelength and amplitude of a wave from a graphical representation of the electric or magnetic field value as a function of position at a given time instant and vice versa, or construct an equation relating the frequency or period and amplitude of a wave from a graphical representation of the electric or magnetic field value at a given position as a function of time and vice versa.

Enduring Understanding 6.C: Only waves exhibit interference and diffraction.

Essential Knowledge 6.C.2: When waves pass through an opening whose dimensions are comparable to the wavelength, a diffraction pattern can be observed.

Learning Objective 6.C.2.1: The student is able to make claims about the diffraction pattern produced when a wave passes through a small opening and to qualitatively apply the wave model to quantities that describe the generation of a diffraction pattern when a wave passes through an opening whose dimensions are comparable to the wavelength of the wave.

Essential Knowledge 6.C.3: When waves pass through a set of openings whose spacing is comparable to the wavelength, an interference pattern can be observed. Examples should include monochromatic double-slit interference.

Learning Objective 6.C.3.1: The student is able to qualitatively apply the wave model to quantities that describe the generation of interference patterns to make predictions about interference patterns that form when waves pass through a set of openings whose spacing and widths are small, but larger than the wavelength.

Essential Knowledge 6.C.4: When waves pass by an edge, they can diffract into the "shadow region" behind the edge. Examples should include hearing around corners, but not seeing around them, and water waves bending around obstacles.

Learning Objective 6.C.4.1: The student is able to predict and explain, using representations and models, the ability or inability of waves to transfer energy around corners and behind obstacles in terms of the diffraction property of waves in situations involving various kinds of wave phenomena, including sound and light.

Enduring Understanding 6.F: Electromagnetic radiation can be modeled as waves or as fundamental particles.

Essential Knowledge 6.F.1: Types of electromagnetic radiation are characterized by their wavelengths, and certain ranges of wavelength have been given specific names. These include (in order of increasing wavelength spanning a range from picometers to kilometers) gamma rays, x-rays, ultraviolet, visible light, infrared, microwaves, and radio waves.

Learning Objective 6.F.1.1: The student is able to make qualitative comparisons of the wavelengths of types of electromagnetic radiation.

Essential Knowledge 6.F.2: Electromagnetic waves can transmit energy through a medium and through a vacuum.

a. Electromagnetic waves are transverse waves composed of mutually perpendicular electric and magnetic fields that can propagate through a vacuum.

b. The planes of these transverse waves are both perpendicular to the direction of propagation.

Learning Objective 6.F.2.1: The student is able to describe representations and models of electromagnetic waves that explain the transmission of energy when no medium is present.

PROCEDURE

I. Lesson 1: Introduction and Diffraction through a Single Slit

- Notes: Roman numeral I – III
- Homework 1: Chapter 27 Conceptual Questions 13, 18 and Problems 19 – 23

II. Lesson 2: Double-Slit Interference

- Notes: Roman numeral IV
- Homework 2: Chapter 27 Conceptual Questions 1 – 5 and Problems 1, 2 (sketch pattern to scale once calculated), 4, 5

IV. Lesson 3: Thin-Film Interference (optional)

- Notes: Finish
- Homework 4: Chapter 27 Check Your Understanding 3 (p. 864) with explanations and Conceptual Questions 7 (index of refraction of soap film > water), 8 – 11 and Problems 10 - 11 (Tip for problems: The wavelength in film is equal to the vacuum wavelength divided by the index of refraction.)