Chapter 11 Waves Lecture Notes

Objectives

- **Distinguish** local particle vibrations from overall wave motion.
- **Differentiate** between pulse waves and periodic waves.
- **Interpret** waveforms of transverse and longitudinal waves.
- **Apply** the relationship among wave speed, frequency, and wavelength to solve problems.
- **Relate** energy and amplitude.

**Fill-in the yellow printed words in your note packet**

Section 3 Properties of Waves

Wave Motion

- A _______ is the motion of a disturbance.
- A _______ is a physical environment through which a disturbance can travel. For example, water is the medium for ripple waves in a pond.
- Waves that require a medium through which to travel are called ______________. Water waves and sound waves are mechanical waves.
- _______________ such as visible light do not require a medium.
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Wave Types

• A wave that consists of a single traveling pulse is called a _________.

• Whenever the source of a wave’s motion is a periodic motion, such as the motion of your hand moving up and down repeatedly, a ___________ is produced.

• A wave whose source vibrates with simple harmonic motion is called a _________. Thus, a sine wave is a special case of a periodic wave in which the periodic motion is simple harmonic.

Relationship Between SHM and Wave Motion

As the sine wave created by this vibrating blade travels to the right, a single point on the string vibrates up and down with simple harmonic motion.
Wave Types, \textit{continued}

- A \underline{\text{transverse}} wave is a wave whose particles vibrate \underline{perpendicularly} to the direction of the wave motion.
- The \underline{crest} is the \underline{highest} point above the equilibrium position, and the \underline{trough} is the \underline{lowest} point below the equilibrium position.
- The \underline{wavelength} is the distance between two adjacent similar points of a wave.
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Wave Types, continued

- A ________________ is a wave whose particles vibrate parallel to the direction the wave is traveling.
- A longitudinal wave on a spring at some instant \( t \) can be represented by a graph. The ______ correspond to compressed regions, and the ______ correspond to stretched regions.
- The _____ are regions of ___________________ (relative to the equilibrium density or pressure of the medium), and the _____ are regions of ___________________.

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Longitudinal Waves

Particles move parallel to the direction in which the wave is moving.
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Section 3 Properties of Waves

Period, Frequency, and Wave Speed

• The ______________ describes the number of waves that pass a given point in a unit of time.

• The ______________ describes the time it takes for a complete wavelength to pass a given point.

• The relationship between period and frequency in SHM holds true for waves as well; the period of a wave is ______________ to its frequency.

Characteristics of a Wave

Amplitude

Wavelength $\lambda$

Period

Frequency $f$

End of slide
Period, Frequency, and Wave Speed, \textit{continued}

- The \underline{\text{period}} is constant for any given medium.
- The \underline{\text{frequency}} is given by the following equation:

- This equation applies to both mechanical and electromagnetic waves.

Waves and Energy Transfer

- Waves \underline{\text{transport}} energy by the vibration of matter.
- Waves are often able to transport energy efficiently.
- The rate at which a wave transfers energy depends on the \underline{\text{amplitude}}.
  - \underline{\text{amplitude}}
  - \underline{\text{amplitude}}
  - \underline{\text{amplitude}}
- The amplitude of a wave gradually diminishes over time as its energy is dissipated.
Multiple Choice, continued

Base your answers to questions 11–13 on the graph.

11. What kind of wave does this graph represent?
   A. transverse wave  
   B. longitudinal wave  
   C. electromagnetic wave  
   D. pulse wave

12. Which letter on the graph represents wavelength?
   F. A  
   G. B  
   H. C  
   J. D
13. Which letter on the graph is used for a trough?
A. A  C. C
B. B  D. D

16. Two successive crests of a transverse wave 1.20 m apart. Eight crests pass a given point 12.0 s. What is the wave speed?
F. 0.667 m/s
G. 0.800 m/s
H. 1.80 m/s
J. 9.60 m/s
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**Fill-in the yellow printed words in your note packet**

Objectives

• **Apply** the superposition principle.

• **Differentiate** between constructive and destructive interference.

• **Predict** when a reflected wave will be inverted.

• **Predict** whether specific traveling waves will produce a standing wave.

• **Identify** nodes and antinodes of a standing wave.

Section 4  Wave Interactions

Wave Interference

• Two different material objects can never occupy the same space at the same time.

• Because mechanical waves are not matter but rather are displacements of matter, __________________________

• The combination of two overlapping waves is called __________________________
In ________________, individual displacements on the _______ of the equilibrium position are added together to form the resultant wave.
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Comparing Constructive and Destructive Interference

Section 4 Wave Interactions

Reflection

• What happens to the motion of a wave when it reaches a boundary?
• At a ______ boundary, waves are ________.
• At a ______ boundary, waves are _________ _________

Free boundary           Fixed boundary
Standing Waves

• A __________ is a wave pattern that results when two waves of the same frequency, wavelength, and amplitude travel in opposite directions and interfere.

• Standing waves have nodes and antinodes.
  – A ______ is a point in a standing wave that maintains ____________________.
  – An ______ is a point in a standing wave, halfway between two nodes, at which the ________ ____________ occurs.
Standing Waves, continued

- Only __________ produce standing wave patterns.
- The ______ of the string must be _______ because these points cannot vibrate.
- A standing wave can be produced for any wavelength that allows both ends to be nodes.
- In the diagram, possible wavelengths include __ (b), __ (c), and _____ (d).

Standing Waves

This photograph shows four possible standing waves that can exist on a given string. The diagram shows the progression of the second standing wave for one-half of a cycle.
Multiple Choice, continued

Base your answers to questions 14–15 on the passage.

A wave with an amplitude of 0.75 m has the same wavelength as a second wave with an amplitude of 0.53 m. The two waves interfere.

14. What is the amplitude of the resultant wave if the interference is constructive?
   F. 0.22 m
   G. 0.53 m
   H. 0.75 m
   J. 1.28 m

15. What is the amplitude of the resultant wave if the interference is destructive?
   A. 0.22 m
   B. 0.53 m
   C. 0.75 m
   D. 1.28 m
18. What kind of wave does not need a medium through which to travel?

19. List three wavelengths that could form standing waves on a 2.0 m string that is fixed at both ends.
20. A visitor to a lighthouse wishes to find out the height of the tower. The visitor ties a spool of thread to a small rock to make a simple pendulum. Then, the visitor hangs the pendulum down a spiral staircase in the center of the tower. The period of oscillation is 9.49 s. What is the height of the tower? Show all of your work.

21. A harmonic wave is traveling along a rope. The oscillator that generates the wave completes 40.0 vibrations in 30.0 s. A given crest of the wave travels 425 cm along the rope in a period of 10.0 s. What is the wavelength? Show all of your work.