RLP-PHYB · RLP Physics B — Energy, Thermal Physics, Electromagnetism and Waves

Unit 4: Waves, Light and Information

Practice Workbook. The same problems, in the same order, as the Practice sections of the online lessons.

Name _____ Period _____

Lesson 4.1 — Seconds of Warning: Wave Speed and the New Madrid Seismic Zone

FLUENCY

1. A wave has frequency 5 Hz and wavelength 1.3 m. What is its speed?

2. A radio or wireless signal has frequency 101.7 MHz. Using $c = 3.0 \times 10^8$ m/s, find its wavelength.

3. A sound in air (speed 343 m/s) has wavelength 3.43 m. What is its frequency?

4. Sound in air travels at 343 m/s. Find the wavelength for a frequency of 880 Hz.

5. Middle C (262 Hz) travels through air at 343 m/s. Find its wavelength and period.

6. Ocean swells arrive every 4.0 s with crests 60 m apart. Find the frequency and wave speed.

APPLICATION

7. Using P = 6.0 km/s and S = 3.5 km/s, what is the S-minus-P lag at Cape Girardeau, 80 km from an epicenter at New Madrid?

8. With the unit's warning model (alert issued 6.7 s after rupture), how much warning would St. Louis, 236 km from an epicenter at New Madrid, get before the S wave?

9. A seismometer in southeast Missouri records an S-minus-P lag of 12.0 s. How far away was the earthquake?

CHALLENGE

10. Engineers cut the processing-and-delivery latency in the model from 5.0 s to 3.0 s. By how much does the radius of the late-alert zone shrink?

REVIEW

11. A 9 V source is connected across a 10 Ω resistor. What current flows?

12. A 1,200 W hair dryer runs on 120 V. What current does it draw?

Lesson 4.2 — Investigation Lab: Standing Waves on a Stretched String

FLUENCY

1. A sound in air (speed 343 m/s) has wavelength 1.0 m. What is its frequency?

2. A wave on a rope travels at 5 m/s. Find the wavelength for a frequency of 4 Hz.

3. A string 1.20 m long, fixed at both ends, vibrates in 3 loops. What is the wavelength?

4. A 1.5 m string has mass 1.5 g and is under the tension of a 150 g hanging mass. Find μ, the tension and the wave speed.

5. With that string vibrating over 0.90 m, what is the fundamental frequency, and what are the next two harmonics?

6. By what factor must you increase the tension to double the wave speed on a string?

APPLICATION

7. A student finds the fundamental of a 0.90 m vibrating length at 30.5 Hz. What wave speed does that give, and how does it compare with the model value above?

8. What tension would make the fundamental of the 0.90 m string exactly 40 Hz?

9. A friend says: "The standing wave doesn't move, so $v = f\lambda$ doesn't apply." Respond.

CHALLENGE

10. A guitar string's fundamental is 110 Hz. Tightening it raises the tension by 21%. What is the new fundamental?

REVIEW

11. Resistors of 12 Ω and 15 Ω are in parallel across 3 V. Find the equivalent resistance and the total current.

12. A gas occupies 12 L at 200 kPa. At constant temperature, what volume does it occupy at 50 kPa?

Lesson 4.3 — Argument Lab: Is Digital Always Better?

FLUENCY

1. Convert 300 km to m.

2. Convert 300 cm^3 to mL.

3. A recorder takes 48,000 samples/s at 24 bits on 2 channels. Find the bit rate and the storage for one minute in megabytes.

4. How many levels does a 10-bit converter have, and what is the step size on a 0-5 V range?

5. What minimum sample rate captures frequencies up to 12 kHz?

6. How long does a 2.0 GB file take to send at 100 Mbit/s?

APPLICATION

7. A station samples at 100 samples/s. A 60 Hz hum from nearby power lines reaches the sensor unfiltered. At what false frequency does it appear?

8. An analog signal relayed through 10 stations picks up noise at each. A digital signal relayed the same way arrives identical. Explain why, and state one condition for it to work.

9. Evaluate the claim: "An earthquake alert for Missouri would be slow mainly because the signal takes time to travel through fiber." Use light in glass at 2.0×10^8 m/s over 400 km.

10. NOAA Weather Radio sends a tornado warning for New Madrid County as the SAME header ZCZC-WXR-TOR-029143+0030-3092130-KPAH/NWS- (42 characters), each copy preceded by a 16-byte preamble, at 520.83 bits/s with 8 bits per character. How many bits is one copy, and how long do the three required copies take?

CHALLENGE

11. A 3-minute song is stored as CD audio (1,411,200 bit/s) and as a 256 kbit/s file. Find both sizes in MB and the compression ratio. Is the compressed file lossless?

REVIEW

12. A motor does 3000 J of work in 2 s. What is its power output?

13. A device draws 8 A from a 120 V supply. What power does it use, and how much energy in 1 hour?

Lesson 4.4 — Light as Wave and Particle: Refraction, Photons and the Spectrum

FLUENCY

1. A wave has frequency 2 Hz and wavelength 0.5 m. What is its speed?

2. A wave has frequency 256 Hz and wavelength 2 m. What is its speed?

3. Light in air hits water (n = 1.33) at 30° from the normal. Find the refraction angle.

4. Find the critical angle for glass (n = 1.52) to air.

5. Find the energy of a 532 nm green laser photon in joules and eV.

6. Find the speed of light in glass with n = 1.52.

APPLICATION

7. In the refraction lab, a beam at 45° in air bends to 32° in a block. What is the block's index of refraction, and which material could it be?

8. Sodium's work function is about 2.28 eV. Will 400 nm violet light eject electrons? If so, with what maximum kinetic energy? What is the longest wavelength that works?

9. A website claims 5G signals at 3.5 GHz break DNA bonds like ultraviolet light. Compute the photon energy and evaluate the claim.

CHALLENGE

10. Light enters an optical fiber whose core has n = 1.48 and cladding n = 1.46. Find the critical angle at the core-cladding boundary and explain why the fiber must keep light nearly parallel to its axis.

REVIEW

11. Resistors of 15 Ω and 5 Ω are in series across 120 V. Find the total resistance, the current and the voltage across each resistor.

12. Find the kinetic energy of a 2 kg object moving at 5 m/s.

Unit 4 checkpoint

1. A 500 Hz sound in water (1,480 m/s) has a wavelength of _____ m.
2. When a wave passes from air into water, which stays the same?
   A. Speed
   B. Wavelength
   C. Frequency
   D. Amplitude
3. With P at 6.0 km/s and S at 3.5 km/s, the S-minus-P lag 100 km away is _____ s.
4. True or false: On a string fixed at both ends, one loop of a standing wave is one full wavelength.
5. Quadrupling the tension on a string _____ the wave speed.

6. A digital signal can be relayed many times without degrading because
   A. digital signals are not waves
   B. each receiver only decides 0 or 1 and regenerates a clean signal
   C. digital signals have no noise
   D. they travel faster than light
7. A 16-bit sample has _____ possible levels.
8. Light at 30° in air enters glass (n = 1.50). The refracted angle is _____°.
9. Why does bright red light eject no electrons from a metal that dim violet light affects?
   A. Red light is slower
   B. Each red photon has less energy than the work function
   C. Red light has no photons
   D. Violet light is brighter
10. True or false: Making microwaves more intense raises the energy of each microwave photon.
11. A 300 nm UV photon carries about _____ eV.
12. A solar cell uses which wave interaction to capture energy?
   A. Reflection
   B. Photons with energy above the band gap freeing electrons
   C. Sound waves
   D. Aliasing