RLP-PSB · RLP Physical Science B — Forces, Energy and Waves

Unit 4: Waves and Information

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

Name _____ Period _____

Lesson 4.1 — Warning Before the Shaking

FLUENCY

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

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

3. A wave has frequency 10 Hz and wavelength 2 m. What is its speed?

4. A radio or wireless signal has frequency 2400 MHz. Using $c = 3.0 \times 10^8$ m/s, find its wavelength.

5. Using P waves at 6.0 km/s and S waves at 3.5 km/s, find the arrival times of each in St. Louis, about 236 km from an earthquake near New Madrid, and the gap between them.

6. A seismic P wave at 6,000 m/s has frequency 2.0 Hz. What is its wavelength?

7. Does a wave's frequency or its medium set its speed?

APPLICATION

8. A seismograph station records the S wave 8.0 s after the P wave. Using 6.0 km/s and 3.5 km/s, how far away was the earthquake?

9. An alert system needs about 5 s to detect, process and send an alert (illustrative). For a town 60 km from the epicenter, how much warning remains before the S wave arrives? For a town 20 km away?

10. You see lightning and hear the thunder 3.0 s later. Using 343 m/s for sound and treating light as instant, how far away was the strike? Explain why this works the same way as earthquake early warning.

CHALLENGE

11. Show that the gap between P and S arrivals is proportional to distance, and find how many seconds of gap each extra 10 km adds (6.0 km/s and 3.5 km/s).

REVIEW

12. Find the kinetic energy of a 0.15 kg object moving at 3 m/s.

13. Predict the final temperature when 200 g of water at 40 °C is mixed with 200 g at 20 °C.

Lesson 4.2 — Waves on a Spring

FLUENCY

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

2. A wave has frequency 256 Hz and wavelength 3.4 m. What is its speed?

3. A sound in air (speed 343 m/s) has wavelength 1.56 m. What is its frequency?

4. A pulse travels 10.0 m in 1.70 s. What is its speed?

5. A standing wave with one loop on a 5.0 m spring has what wavelength? With two loops?

6. Is a sound wave transverse or longitudinal? An S wave?

APPLICATION

7. You measure 5.9 m/s by pulse timing and gets 12 shakes in 10 s with two loops on a 5.0 m spring. Find the standing-wave speed and the percent difference between the methods.

8. After stretching the spring from 5.0 m to 6.0 m, a pulse's round trip (12.0 m) takes 1.60 s. Compare the new speed with 5.9 m/s and explain the change.

9. A student stands 50 m from a large wall and claps. Using 343 m/s, how long until the echo returns? Explain why timing a single echo by hand gives a poor measurement of the speed of sound.

CHALLENGE

10. On the same spring, you make a standing wave with three loops at 1.8 Hz on a 5.0 m spring. Is this consistent with a speed of 6.0 m/s? Show your reasoning.

REVIEW

11. A net force of 120 N gives an object an acceleration of 2 m/s^2. What is its mass?

12. A device takes in 3600 J and delivers 3210 J of useful energy. What is its efficiency, and where did the rest go?

Lesson 4.3 — Wave or Particle? Light, Photons and Health Claims

FLUENCY

1. A wave has frequency 10 Hz and wavelength 1.3 m. What is its speed?
2. A sound in air (speed 343 m/s) has wavelength 1.56 m. What is its frequency?
3. Rank these by photon energy from lowest to highest: ultraviolet, radio, green light, microwaves, X-rays.
4. Which light charged the glow material: red or blue? Which model explains this?
5. Name one observation that supports the wave model of light.

6. Using E (eV) ≈ 1,240 ÷ wavelength (nm), find the photon energy of green light at 530 nm.

APPLICATION

7. A UV-A photon (365 nm) carries about 3.4 eV and a typical carbon-carbon bond needs about 3.6 eV to break. A UV-B photon (300 nm) carries about 4.1 eV. Which can break such a bond directly, and what does this suggest about why UV-B causes sunburn more than UV-A?

8. A website claims: 'Wi-Fi at 2.4 GHz breaks the DNA in your cells.' Evaluate its validity with photon energy ($h = 6.626 \times 10^{-34}$ J·s; 1 eV = 1.602×10^{-19} J) and name what you would check about its reliability.

9. Why can a microwave oven cook food even though microwave photons cannot break chemical bonds?

CHALLENGE

10. Explain why making the red light brighter and shining it longer (patch 4) still did not charge the glow material, and what the wave model alone would have predicted.

REVIEW

11. Find the gravitational potential energy gained when a 0.5 kg object is lifted 10 m ($g = 9.8\ m/s^2$).

12. A generator produces current only while its coil turns. Which effect from Unit 2 explains this?

Lesson 4.4 — Digital Signals and the Devices That Carry Them

FLUENCY

1. Convert 1250 °C to kelvin.

2. How many different values can 4 bits represent? 10 bits?

3. Write the number 5 in 4-bit binary.

4. A telephone-quality voice signal takes 8,000 samples per second at 8 bits each. What is its bit rate?

5. Light travels in a glass fiber at about 2×10^8 m/s. How long does it take to travel 1,000 km?

6. NOAA Weather Radio broadcasts at 162.475 MHz on one of its seven channels. Using 3.00×10^8 m/s, what is the wavelength?

7. Name two advantages and one limitation of digital transmission.

APPLICATION

8. Calculate the size of a 3-minute stereo song at CD quality (44,100 samples per second, 16 bits per sample, 2 channels) in bits and in megabytes.

9. A 10-minute video streams at 5 megabits per second. How many megabytes of data does it use? Explain one reason compression is essential for streaming.

10. A NOAA Weather Radio warning starts with a digital SAME header sent at 520.83 bits per second (47 CFR 11.31). One header with its 16-byte preamble is 58 bytes. How long does one copy take, and how long do the three required copies take, not counting pauses?

11. Explain how a solar cell and a seismometer each use an interaction between waves and matter to produce an electrical signal.

CHALLENGE

12. An analog signal relayed through 10 stations picks up a little noise at each. A digital signal relayed through the same 10 stations picks up the same noise. Explain why the digital message arrives intact but the analog one does not, and when the digital one would fail.

REVIEW

13. A 1200 kg object moving at 20 m/s collides and sticks to a 1400 kg object moving at 4.0 m/s (same line; positive is the first object's direction). Find the total momentum and the velocity just after the collision.

14. A ball keeps 60% of its energy each bounce. Dropped from 1.0 m, how high is its first rebound?

Unit 4 checkpoint

1. A wave in water travels at 1.5 m/s with frequency 0.50 Hz. Its wavelength is
   A. 0.75 m
   B. 3.0 m
   C. 1.0 m
   D. 2.0 m

2. Why would an earthquake early-warning system give St. Louis more warning than Sikeston during an earthquake near New Madrid?
   A. Earthquakes are weaker far away
   B. The S wave takes much longer to reach St. Louis, while the alert arrives almost instantly
   C. Phones work better in cities
   D. S waves travel faster far away

3. True or false: Increasing a wave's amplitude increases its speed in the same medium.

4. At 90 km, with P at 6.0 km/s and S at 3.5 km/s, the P wave arrives after _____ s.

5. Which observation is best explained by the particle (photon) model of light?
   A. Rainbow colors on a DVD
   B. Light bending into water
   C. Blue light, but not bright red light, charging glow-in-the-dark material
   D. Two-slit interference fringes

6. True or false: Scientists use both a wave model and a particle model for light because each explains evidence the other does not.

7. Ultraviolet light can damage DNA but radio waves cannot because
   A. ultraviolet is louder
   B. each UV photon carries enough energy to break chemical bonds; radio photons carry far too little
   C. radio waves do not travel through the body
   D. ultraviolet travels faster

8. True or false: A claim is reliable if it appears on many websites, even if none cites evidence.

9. Why do digital signals resist noise better than analog signals?
   A. They travel faster
   B. Receivers only distinguish 0 from 1, and relays send clean copies
   C. They carry no energy
   D. They use lower frequencies

10. With 16 bits per sample, a digital recording can represent _____ different levels.

11. Optical fibers keep light inside because of
   A. total internal reflection
   B. diffraction
   C. electromagnetic induction
   D. radioactive decay

12. True or false: A solar cell produces current when absorbed photons give electrons in silicon enough energy to move.

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