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Conceptual Physics Review (Chapters 25, 26 & 27)

Chapter 25

- Describe the period of a pendulum.
- Describe the characteristics and properties of waves.
- Describe wave motion.
- Describe factors that affect the speed of a wave.
- Distinguish between transverse and longitudinal waves, and be able to give an example of each.
- Distinguish between constructive and destructive interference.
- Describe how a standing wave occurs.
- Describe the Doppler effect for sound.
- Describe bow waves.
- Describe sonic booms.
- Be able to define all vocabulary words in bold from the chapter.

Chapter 26

- Describe the relationship between a sound wave's frequency and pitch.
- Describe the movement of sound through air.
- Compare the transmission of sound through air with that through solids, liquids, and a vacuum.
- Describe factors that affect the speed of sound.
- Describe loudness and sound intensity.
- Determine the relative intensities of two sounds from their respective decibel levels.
- Describe natural frequency.
- Describe resonance.
- Describe beats.
- Be able to define all vocabulary words in bold from the chapter.

Chapter 27

- Describe the dual nature of light.
- What produces light (electromagnetic waves)?
- Define photons and identify which theory of light they provide evidence for.
- Explain why it is difficult to measure the speed of light.
- Explain Roemer's method of measuring the speed of light.
- Explain Michelson's method of measuring the speed of light.
- Know the different portions of the electromagnetic spectrum and how they each relate to each other in terms of wavelength and frequency.
- Describe opaque materials.
- Describe solar and lunar eclipses.
- Distinguish between umbra and penumbra.
- Describe polarization and how Polaroid filters work.
- Know the speed of light in meters per second and kilometers per second.
- Explain why sound waves move faster through steel than through air, while light waves travel more slowly in any medium than through a vacuum.

Labs

- Review the Pendulum Lab.
- Review the Mechanical Waves Lab.
- Review the Speed of Sound Lab.

Homework Assignments

- Review all written assignments out of your textbook.
- Review all reading quizzes.
- Review all worksheets.
- Review all class notes and challenge problems worked during class.

Sample Calculations

$f = \frac{1}{T}$

1. What is the frequency, in hertz, that corresponds to each of the following periods?

a) 0.10 sec $\frac{1}{0.10} = \boxed{10\ Hz}$

b) 5 secs $\frac{1}{5} = \boxed{0.2\ Hz}$

c) $\frac{1}{60}$ sec $\frac{1}{\frac{1}{60}} = \boxed{60\ Hz}$

d) 24 hours $\frac{1}{86400} = \boxed{0.00001\ Hz}$

e) 12 mins $\frac{1}{60(12)} = \boxed{0.0014\ Hz}$

2. What is the period, in seconds, that corresponds to each of the following frequencies?

$T = \frac{1}{f}$

a) 10 Hz $\boxed{0.1\ sec}$

b) 0.2 Hz $\frac{1}{0.2} = \boxed{5\ sec}$

c) 60 Hz $\frac{1}{60} = \boxed{0.017\ sec}$

d) 1.1574 x 10^{-5} Hz $\frac{1}{1.1574e{-5}\ Hz} = \boxed{86400\ sec}$ (1 day)

e) 2.3 MHz $\frac{1}{2.3e6} = \boxed{4.3 \cdot 10^{-7}\ sec}$

3. A metronome is set so that it makes ten complete vibrations in 12 seconds. Find the frequency of the metronome.

$\frac{10\ \text{cycles}}{12\ \text{seconds}} = \boxed{0.83\ Hz}$

4. While sitting on a pier, Carlos notices that incoming waves are 2.0 m between crests. If the waves lap against the pier every 5.0 s, find the

a) frequency of the waves

$T = 5\ sec$

$f = \frac{1}{T} = \frac{1}{5} = \boxed{0.2\ Hz}$

b) speed of the waves

$v = \lambda f \quad \lambda = 2m$

$v = 2m(0.2\ Hz) = \boxed{0.4\ m/s}$

5. Light travels at a speed of 3 x 10^8 m/s in a vacuum, and for practical purposes, through air as well. The wavelength of a shade of yellow light is 5.80 x 10^{-11} m. Find the frequency of this light.

$v = \lambda f \qquad f = \frac{v}{\lambda}$

$v = 3 \cdot 10^8\ m/s$

$\lambda = 5.8 \cdot 10^{-11} \qquad f = \boxed{5.17 \cdot 10^{18}\ Hz}$

6. A gamma ray is high-frequency light. Find the wavelength of a gamma ray with a frequency of 10^{22} Hz.

$v = \lambda f$ $\quad \lambda = \frac{v}{f} = \frac{3 \cdot 10^8}{10^{22}} = 3 \cdot 10^{-14}$ m

$v = 3 \cdot 10^8$ m/s

$f = 10^{22}$ Hz

7. If the speed of a longitudinal sound wave is 340 m/s, and the frequency is 1000 Hz, what is the wavelength of the wave?

$v = \lambda f$ $\quad \lambda = \frac{v}{f}$

$v = 340$ m/s $\quad \lambda = \frac{340}{1000} = 0.34$ m

$f = 1000$ Hz

8. The Sears Building in Chicago sways back and forth at a frequency of about 0.1 Hz. What is its period of vibration?

$f = 0.1$ Hz

$T = \frac{1}{f}$ $\quad T = \frac{1}{0.1} = 10$ sec

9. If a train of freight cars, each 10 m long, rolls by you at the rate of 2 cars each second, what is the speed of the train?

$\lambda = 10$ m $\quad v = \lambda f$

$f = 2$ Hz $\quad v = 10$ m $(2$ Hz$) = 20$ m/s

10. If a wave with wavelength 10 m has a frequency of 2 Hz, what is the wave speed?

$\lambda = 10$ m $\quad v = \lambda f$

$f = 2$ Hz $\quad v = 10$ m $(2$ Hz$) = 20$ m/s

11. If a water wave vibrates up and down two times each second and the distance between wave crests is 1.5 meters, find each of the following:

a) the frequency of the wave

$f = 2$ Hz

b) the wavelength of the wave

$\lambda = 1.5$ m

c) the speed of the wave

$v = \lambda f$

$v = 1.5$ m $(2$ Hz$) = 3$ m/s

12. Is it possible for one wave to cancel another wave so that the combined amplitude is zero? Explain your answer.

Yes, it is. For example, this property of destructive interference is used in sound-canceling headphones and mass damper systems. It is also seen in the double-slit experiment, where the dark areas are nulls of interference.

13. Is the Doppler effect an apparent change in speed or frequency of a wave, due to the motion of the source relative to the receiver?

The Doppler effect is an apparent change in frequency due to the source's relative motion to the receiver.

14. Find the frequency of a sound wave that has a wavelength of 1.5 meters. Could you hear this sound?

$V = 331 + 0.6C = 343 m/s$ (room temp: 20°C) $V = \lambda f$

$\lambda = 1.5m$ $f = \frac{V}{\lambda}$

$f = \frac{343}{1.5} = 228.7 Hz$ Yes I can hear it.

15. Your teacher says "Hello" to you from across the gym, 34 m away. How long does it take the sound to reach you?

$V = 343 m/s$

$t = \frac{d}{V}$ $d = 34m$

$t = \frac{34m}{343 m/s} = 0.1s$

16. Imagine a hiker camping in the mountains. Just before going to sleep he yells "WAKE UP", and the sound echoes off the nearest mountain, returning 8 hours later. How far away is that mountain?

$d = vt$ $t = \frac{8 hr}{1} \cdot \frac{60 min}{1 hr} \cdot \frac{60 sec}{1 min} = 28800s$

$V = 343 m/s$

$d = 343 m/s (28800s) = 9878400 m$ round trip $= 4939200 m$ one way

17. Suppose that you put your left ear down against a railroad track, and your friend one kilometer away strikes the track with a hammer. How much sooner will the sound get to your left ear than to your right ear? The speed of sound is about 5950 m/s in steel and 340 m/s in air.

$t = \frac{d}{V}$ $d = 1000m$ $t_1 = \frac{1000}{340} = 2.94s$

$V_1 = 340 m/s$

$V_2 = 5950 m/s$ $t_2 = \frac{1000}{5950} = 0.17s$

It reaches the left ear nearly 2.77s earlier.

18. Radio station WKLB in Boston broadcasts at a frequency of 99.5 MHz. What is the wavelength of the radio waves emitted by WKLB?

$V = \lambda f$ $\lambda = \frac{V}{f}$

$V = 3 \cdot 10^8 m/s$

$f = 99.5 \cdot 10^6 Hz$ $\lambda = \frac{3 \cdot 10^8}{99.5 \cdot 10^6} = 3.02m$

19. A pendulum's natural frequency is one full back-and-forth swing every 2 seconds. For maximum amplitude, how often should the pendulum bob be pushed? Express your answer in terms of time and also as a frequency, in Hz.

It should be pushed every 2 seconds, or 0.5 Hz.

a) Would the pendulum continue to swing at this natural frequency if it were pushed only half as frequently?

Yes, it would — the lack of a push does not interfere with its swinging ability.

b) What about if it were pushed with twice the frequency?

If it were pushed at twice the frequency, it would not be efficient, and in the worst case scenario, would instead result in no swinging at all.

20. In order to create beats, should two sound waves be of the same frequency or of different frequencies? Why?

Beats are created by "waves" of constructive and destructive interference — in order to set that up, the two waves should have different frequencies.

21. Two notes of frequencies of 110 Hz and 140 Hz are sounded together. What is the resulting beat frequency? Would you be able to hear the beats? If not, why not? If so, what would they sound like?

The beat frequency is the same as the difference between the two: 30 Hz. You might be able to hear them (I would) as [illegible] if the tones were loud enough.

22. If you owe me \$50, and you only pay me \$45, by how much money were you short? What percentage is this of the amount you owed me? This percentage is equivalent to a percent error.

I was short \$5. This is 10% of \$50.

23. Assume that the actual speed of sound at a given temperature is 340 m/s and that you do an experiment to calculate the speed of sound using echo reflection. If your experimentally determined speed of sound is 335 m/s, what is your percent error in the experiment? Show your work!!!

$$\% \text{ error} = \frac{|\text{real} - \text{experiment}|}{\text{real}} = \frac{|340-335|}{340} = \frac{5}{340} = 1.47\%$$

24. For each of the following pairs, identify which has the longer wavelength and identify which has the higher frequency:

a. radio waves vs. gamma rays

longer wave higher frequency

b. ultraviolet radiation vs. microwaves

higher frequency longer wave

c. microwaves vs. X-rays

longer wave higher frequency

d. visible light waves vs. infrared radiation

higher frequency longer wave

e. gamma rays vs. visible light waves

higher frequency longer wave

f. X-rays vs. radio waves

higher frequency longer wave

25. How long does it take for light from the sun to reach Earth if the sun is 1.50×10^{11} m away? Show your calculation!!

$t = \frac{d}{v}$ $d = 1.5 \cdot 10^{11}$ m

$v = 3 \cdot 10^8$ m/s

$t = \frac{1.5 \cdot 10^{11} \text{ m}}{3 \cdot 10^8 \text{ m/s}} = $ **500 seconds**

26. When you look at a distant star or planet, you are looking back in time. How far back in time are you looking when you observe Pluto through the telescope from a distance of 5.91×10^{12} m?

$t = \frac{d}{v}$ $d = 5.91 \cdot 10^{12}$ m

$v = 3 \cdot 10^8$ m/s

$t = \frac{5.91 \cdot 10^{12} \text{ m}}{3 \cdot 10^8 \text{ m/s}} = $ **19700 seconds** into the past

27. If a person could travel at the speed of light, it would still take 4.3 years to reach the nearest star, Proxima Centauri. How far away, in meters, is Proxima Centauri? (Ignore any relativistic effects.)

$\frac{4.3 \text{ years}}{1} \cdot \frac{365 \text{ days}}{1 \text{ year}} \cdot \frac{24 \text{ hrs}}{1 \text{ day}} \cdot \frac{60 \text{ min}}{1 \text{ hr}} \cdot \frac{60 \text{ s}}{1 \text{ min}} \cdot \frac{3.0 \cdot 10^8 \text{ m}}{1 \text{ s}} = $ **$4.07 \cdot 10^{17}$ m**

28. The wavelength of green light is about 500 nm. What is the frequency of this light?

$v = \lambda f$

$\lambda = 500 \cdot 10^{-9}$ m

$v = 3 \cdot 10^8$ m/s

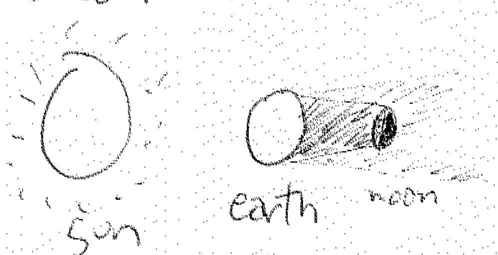
$f = \frac{v}{\lambda} = \frac{3 \cdot 10^8 \text{ m/s}}{500 \cdot 10^{-9} \text{ m}} = 6 \cdot 10^{14}$ Hz

29. When electromagnetic waves travel through a medium such as glass, what happens to the speed of the waves? What happens to the frequency? What happens to the wavelength?

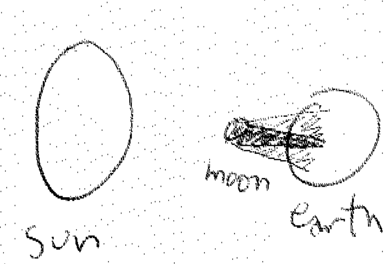
The waves slow down, and the frequency remains constant — but the wavelength gets shorter to account for the slower velocity.

30. Draw a sketch (not necessarily to scale) of the sun, moon, and Earth in their relative positions for a solar eclipse. Then draw a sketch with the relative positions for a lunar eclipse. Throughout your life, which type of eclipse would you probably be able to see more often? Explain why.

Lunar eclipse:



Solar eclipse:



I would see a lunar eclipse more often because it is viewable by all of dark Earth (those in shadow) whereas solar eclipses can be viewed only from a very specific tiny tract of land.