Name _____ Date _____ Period _____

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Honors Physics Unit 9 Study Guide

Waves

Show equations, substitutions, units, and vector directions. Explain your reasoning. Use sensible rounding.

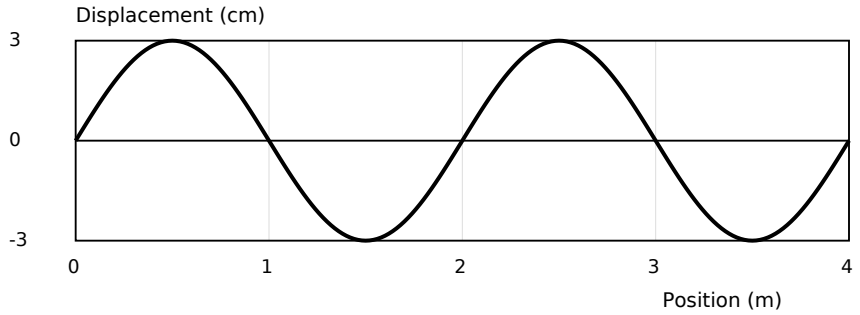
Constants	$c = 3.00 \times 10^{8}$ m/s | $h = 6.63 \times 10^{-34}$ J·s | 1 nm = 10^{-9} m
Equations	$f = 1/T$ | $v = f\lambda$ | $\lambda_n = 2L/n$ (string fixed at both ends) $c = f\lambda$ | $\theta_i = \theta_r$ | $n_{index} = c/v$ | $n_1 \sin\theta_1 = n_2 \sin\theta_2$ $E_{photon} = hf = hc/\lambda$

Measure optical angles from the normal. n means harmonic number or refractive index as labeled.

9.1 Wave Basics

1. Classify each wave as mechanical or electromagnetic and transverse or longitudinal: sound in air, a wave on a stretched rope shaken sideways, and visible light. What do waves transfer?

2. Read the wave snapshot. Find amplitude and wavelength. Mark one crest, one trough, and the equilibrium line. Explain why the crest-to-trough vertical distance is not the amplitude.



Snapshot at one instant.

9.2 Frequency, Period, and Wave Speed

3. A buoy completes 15 full oscillations in 30 s. Find frequency and period. If neighboring crests are 8.0 m apart, find wave speed.

4. Sound travels at 343 m/s and has frequency 490 Hz. Find wavelength. For a nondispersive medium under unchanged conditions, what happens to wavelength when frequency doubles?

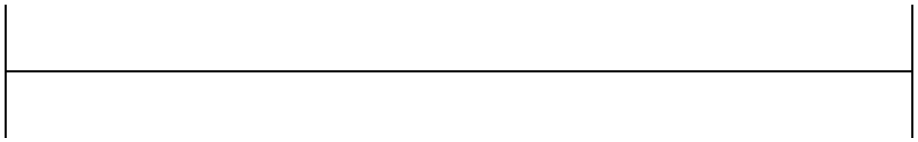
9.3 Interference

5. Find the displacement during overlap for (a) +4.0 cm and +2.0 cm pulses, (b) +4.0 cm and −2.0 cm pulses, and (c) +4.0 cm and −4.0 cm pulses. Name each interference type.

6. Two equal and opposite pulses cancel at one instant on an ideal rope. Have they disappeared permanently? Describe what happens after they pass and how this relates to noise-cancelling headphones.

9.4 Standing Waves

7. A 1.50 m string is fixed at both ends and vibrates in its third harmonic. Sketch the pattern, label nodes and antinodes, and find wavelength. Count endpoint nodes.



L = 1.50 m

8. For the string in Question 7, wave speed is 60 m/s. Find the third-harmonic frequency and fundamental frequency. Explain resonance.

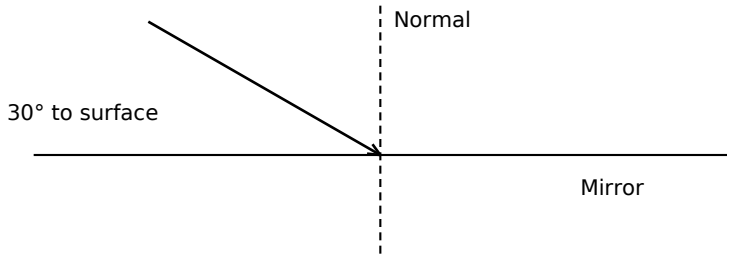
9.5 The Electromagnetic Spectrum

9. List radio, microwave, infrared, visible, ultraviolet, X-ray, and gamma radiation in order of increasing frequency. Which has the longest wavelength? Compare their speeds in a vacuum.

10. Light has wavelength 600 nm in vacuum. Find its frequency. Compare its photon energy with 400 nm light and explain your reasoning without calculating either photon energy.

9.6 Reflection and Mirrors

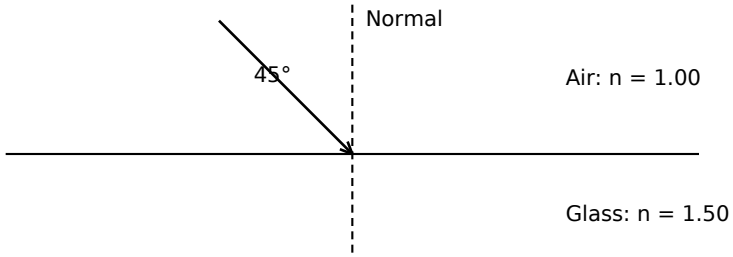
11. A ray meets a plane mirror at 30° to its surface. Draw the normal and reflected ray. Find incidence and reflection angles measured from the normal.



12. A student stands 2.0 m in front of a plane mirror. Locate the image and find the student-image distance. State image size and whether it is real or virtual. Compare smooth and rough-surface reflection.

9.7 Refraction

13. Light passes from air (n = 1.00) into glass (n = 1.50) at 45.0° from the normal. Find the refracted angle and light speed in glass. Sketch the refracted ray.



14. Light moves from water into air at an angle that permits transmission. Does it bend toward or away from the normal? What happens to speed, frequency, and wavelength? What if it enters along the normal?

9.8 The Photoelectric Effect

15. Calculate the energy of a photon with frequency 8.0×10^{14} Hz. A metal needs at least 4.0×10^{-19} J to release an electron. Can this photon release one?

16. For the same metal, determine whether 700 nm light can release electrons. Would making that light much brighter change your conclusion in the single-photon model? Explain.

Unit 9 Review

17. A 2.0 m string fixed at both ends has wave speed 24 m/s. Find wavelength and frequency for the first and fourth harmonics. Compare the number of nodes in each.

18. Light travels through a transparent material at 2.4×10^8 m/s. Find its refractive index. If its frequency is 6.0×10^{14} Hz, find its wavelength in the material and in vacuum.

19. A metal already emits electrons under monochromatic light. Predict the effects of (a) greater intensity at the same frequency and (b) greater frequency at the same photon arrival rate. Assume all photons still exceed the threshold.

20. Give one observation supporting the wave model of light and one supporting the photon model. Explain why a single classical wave model cannot explain the photoelectric threshold frequency.