Appendix 3: Hints and Solutions

Answers to Self-Checks

Answers to Self-Checks for Chapter 2

Page 28, self-check A: The horizontal axis is a time axis, and the period of the vibrations is independent of amplitude. Shrinking the amplitude does not make the cyles and faster.

Page 29, self-check B: Energy is proportional to the square of the amplitude, so its energy is four times smaller after every cycle. It loses three quarters of its energy with each cycle.

Page 35, self-check C: She should tap the wine glasses she finds in the store and look for one with a high Q, i.e., one whose vibrations die out very slowly. The one with the highest Q will have the highest-amplitude response to her driving force, making it more likely to break.

Answers to Self-Checks for Chapter 3

Page 51, self-check A: The leading edge is moving up, the trailing edge is moving down, and the top of the hump is motionless for one instant.

Answers to Self-Checks for Chapter 4

Page 77, self-check A: The energy of a wave is usually proportional to the square of its amplitude. Squaring a negative number gives a positive result, so the energy is the same.

Page 77, self-check B: A substance is invisible to sonar if the speed of sound waves in it is the same as in water. Reflections only occur at boundaries between media in which the wave speed is different.

Page 79, self-check C: No. A material object that loses kinetic energy slows down, but a wave is not a material object. The velocity of a wave ordinarily only depends on the medium, not the amplitude. The speed of a soft sound, for example, is the same as the speed of a loud sound.

Page 88, self-check D: 1. No. To get the best possible interference, the thickness of the coating must be such that the second reflected wave train lags behind the first by an integer number of wavelengths. Optimal performance can therefore only be produced for one specific color of light. The typical greenish color of the coatings shows that they do the worst job for green light.

2. Light can be reflected either from the outer surface of the film or from the inner surface, and there can be either constructive or destructive interference between the two reflections. We see a pattern that varies across the surface because its thickness isn't constant. We see rainbow colors because the condition for destructive or constructive interference depends on wavelength.

White light is a mixture of all the colors of the rainbow, and at a particular place on the soap bubble, part of that mixture, say red, may be reflected strongly, while another part, blue for example, is almost entirely transmitted.

Page 89, self-check E: The period is the time required to travel a distance $2L$ at speed v, $T = 2L/v$. The frequency is $f = 1/T = v/2L$.

Page 94, self-check F: The wave pattern will look like this:  . Three quarters of a wavelength fit in the tube, so the wavelength is three times shorter than that of the lowest-frequency mode, in which one quarter of a wave fits. Since the wavelength is smaller by a factor of three, the frequency is three times higher. Instead of $f_o, 2f_o, 3f_o, 4f_o, \ldots$, the pattern of wave frequencies of this air column goes $f_o, 3f_o, 5f_o, 7f_o, \ldots$

Answers to Selected Homework Problems

Solutions for Chapter 4

Page 96, problem 3: Check: The actual length of a flute is about 66 cm.

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Useful Data

Metric Prefixes

M-	mega-	10^6
k-	kilo-	10^3
m-	milli-	10^{-3}
μ- (Greek mu)	micro-	10^{-6}
n-	nano-	10^{-9}
p-	pico-	10^{-12}
f-	femto-	10^{-15}

(Centi-, 10^{-2}, is used only in the centimeter.)

The Greek Alphabet

α	A	alpha	ν	N	nu
β	B	beta	ξ	Ξ	xi
γ	Γ	gamma	o	O	omicron
δ	Δ	delta	π	Π	pi
ϵ	E	epsilon	ρ	P	rho
ζ	Z	zeta	σ	Σ	sigma
η	H	eta	τ	T	tau
θ	Θ	theta	υ	Y	upsilon
ι	I	iota	ϕ	Φ	phi
κ	K	kappa	χ	X	chi
λ	Λ	lambda	ψ	Ψ	psi
μ	M	mu	ω	Ω	omega

Speeds of Light and Sound

speed of light	$c = 3.00 \times 10^8$ m/s
speed of sound	$c = 340$ m/s

Subatomic Particles

particle	mass (kg)	radius (fm)
electron	9.109×10^{-31}	$\lesssim 0.01$
proton	1.673×10^{-27}	~ 1.1
neutron	1.675×10^{-27}	~ 1.1

The radii of protons and neutrons can only be given approximately, since they have fuzzy surfaces. For comparison, a typical atom is about a million fm in radius.

Notation and Units

quantity	unit	symbol
distance	meter, m	$x, \Delta x$
time	second, s	$t, \Delta t$
mass	kilogram, kg	m
density	kg/m^3	ρ
velocity	m/s	$\mathbf{v}$
acceleration	m/s^2	$\mathbf{a}$
gravitational field	J/kg·m or m/s^2	g
force	newton, 1 N=1 kg·m/s^2	$\mathbf{F}$
pressure	1 Pa=1 N/m^2	P
energy	joule, J	E
power	watt, 1 W = 1 J/s	P
amplitude	(varies)	A
period	s	T
frequency	Hz	f
wavelength	m	λ
quality factor	unitless	Q
FWHM	Hz	FWHM

Conversions

Nonmetric units in terms of metric ones:

1 inch	= 25.4 mm (by definition)
1 pound-force	= 4.5 newtons of force
(1 kg) · g	= 2.2 pounds-force
1 scientific calorie	= 4.18 J
1 kcal	= 4.18×10^3 J
1 gallon	= 3.78×10^3 cm^3
1 horsepower	= 746 W

When speaking of food energy, the word "Calorie" is used to mean 1 kcal, i.e., 1000 calories. In writing, the capital C may be used to indicate 1 Calorie=1000 calories.

Relationships among U.S. units:

1 foot (ft)	= 12 inches
1 yard (yd)	= 3 feet
1 mile (mi)	= 5280 feet

Earth, Moon, and Sun

body	mass (kg)	radius (km)	radius of orbit (km)
earth	5.97×10^{24}	6.4×10^3	1.49×10^8
moon	7.35×10^{22}	1.7×10^3	3.84×10^5
sun	1.99×10^{30}	7.0×10^5	—