

Contents

Preface	page xi
1 Introduction	1
What Is Music?	4
What Is Physics?	5
Describing Quantities	7
Prefixes and Scientific Notation	8
Summary	12
Additional Reading	13
Problems	13
2 Frequency and Rates	15
Frequency	15
Rates	17
Musical Intervals	20
The Notes on a Musical Keyboard	21
Logarithms and the Log Scale	23
Summary	25
Additional Reading	26
Problems	26
3 The Notes We Use	28
Scales	28
Chords	31
Pythagoras's Monochord	32
Beats	33
Temperaments	37
Nice Chords	41
Summary	42
Additional Reading	42
Problems	43
4 The Frequency Domain and Pitch	45
The Fourier Series	46

Spectra	49
How a Fourier Transform Works (Optional)	57
Spectral Resolution and Range	59
Pitch	59
Summary	65
Additional Reading	65
Problems	65
5 Harmonic Oscillators and Resonance	67
Newton's Laws and Gravity	67
Gravity Near the Surface of the Earth	70
Hooke's Law for Springs	71
The Harmonic Oscillator	73
The Driven Harmonic Oscillator – Resonance	81
Quality Factor	85
Sympathetic Resonances	87
Fictitious Forces and Physics Demonstrations (Optional)	89
Summary	91
Additional Reading	92
Problems	92
6 String Theory	94
The Frequency of Vibration for a String Under Tension	94
String Resonances	98
Standing Waves	101
The Plucked String	104
End Conditions	106
Quality Factor	109
Summary	110
Additional Reading	111
Problems	111
7 Normal Modes	114
Indexing the Modes	114
Chimes	117
Vibrations in Two Dimensions	127
Degeneracies	131
Bells and Other Shapes	137
Torsional Modes	138
Visualizing Node Lines	139
Summary	140

Additional Reading		140
Problems		141
8 Traveling Waves		143
Motion of a Pulse		144
Mathematical Description of Traveling Waves		145
Traveling and Standing Waves		151
Polarization		154
Traveling Waves Transport Energy		155
Dispersion		156
Summary		157
Additional Reading		158
Problems		158
9 The Uncertainty Principle		161
Wave Pulses		162
Attack and Release		165
ADSR – a Model		166
Spectrographs		166
Phase Shifts and Transients		167
Summary		168
Additional Reading		169
Problems		169
10 Nonlinear Physics		171
Linear Problems		171
What Makes a Problem Nonlinear?		172
Friction		174
The Stick–Slip Mechanism		176
Back to the Swing		178
Reed Instruments Simplified		180
Playing in Tune		184
Mode Locking		185
Chaos (Optional)		186
Summary		188
Additional Reading		188
Problems		188
11 Classical Gases		190
The Elements		191
Isotopes		194

	Molecules	196
	States of Matter	197
	Air	198
	Temperature and Kinetic Energy	199
	Impulse	201
	Pressure	203
	Ideal Gas Law Examples	206
	Pressure for Wind Instruments	208
	Summary	209
	Additional Reading	210
	Problems	210
	12 The Speed of Sound in a Gas	212
	Measured Values	212
	Adiabatic Processes	214
	The “Springiness” of a Gas	217
	The Adiabatic Exponent	221
	Speed of Sound	223
	Summary	228
	Additional Reading	228
	Problems	228
	13 Sounds We Hear	230
	Fluid Mechanics	230
	Sound Waves Are Longitudinal	232
	The Amplitude of Sound	233
	Combining Signals	238
	Summary	240
	Additional Reading	240
	Problems	241
	14 Sound in Pipes	242
	Impedance	243
	Sound in Air-Filled Pipes	245
	Pipes with Holes	254
	More Complicated Pipe Resonances	259
	Losses	265
	Derivation of R and T (Optional)	265
	Summary	266
	Additional Reading	267
	Problems	267

15 Sound in Three Dimensions	269
Isotropic and Point Sources	269
More Complicated Sources	270
The Inverse Square Law	278
Echoes and Reverberation	280
Room Features of Note	287
The Cocktail Party Effect	289
Summary	292
Additional Reading	293
Problems	293
16 Interference, Diffraction, and Diffusion	295
Interference	295
Diffraction	299
Diffusion	301
Summary	307
Additional Reading	308
Problems	308
17 Faraday's Laws of Induction	310
Properties of Magnets	310
The Magnetic Field	312
Magnetic Materials	314
Nonmagnetic Materials	318
Electromagnets	319
The Electric Guitar Pickup	324
Transformers (Optional)	326
Summary	327
Additional Reading	328
Problems	328
18 RC Time Constants	330
Electric Fields	330
Conductors and Insulators	333
Electrostatic Discharge (Optional)	334
Capacitors	335
Resistors	338
Circuit Diagrams	339
RC Time Constants	339
Condenser and Electret Microphones	344

Microphone Sensitivity (Optional)	345
Summary	347
Additional Reading	348
Problems	348
19 Physics and Recording Technology	350
Physical Media	351
Magnetic Recording	355
Optical Media	361
Digital Storage and Playback	367
Summary	374
Additional Reading	375
Problems	375
20 Electronics and Music	376
Electronic Effects	376
Making Music with Electronics	380
Electronic Synthesis	384
Interfaces	386
Concluding Remarks	387
Summary	387
Additional Material	388
Problems	388
Appendices	390
Appendix A Mathematics	390
I. Exponents and Standard International (SI) Unit Prefixes	390
II. Some Mathematical Properties	392
III. The Summation Symbol	397
Appendix B Greek Alphabet	398
Appendix C Note Frequencies	399
Appendix D Answers to Selected Problems	401
Index	405