Contents

CHAPTER 1	THE NATURE OF SOUND	
	1.1 Acoustics and Music 2 Box 1.1 Kinds of Acoustics 2 *Box 1.2 " But Is It Music?" 3	
	 1.2 Organizing Our Study of Sound 3 1.3 The Physical Nature of Sound 5 *Box 1.3 The Value of Wave Analogies 6 	
	1.4 The Speed of Sound 81.5 Pressure and Sound Amplitude 10	
CHAPTER 2	WAVES AND VIBRATIONS	17
	 2.1 The Time Element in Sound 17 2.2 Waveforms 20 Box 2.1 The Ubiquitous Oscilloscope 21 	
	 2.3 Functional Relations 23 2.4 Simple Harmonic Oscillation 27 Box 2.2 Mass and Weight 28 	
	2.5 Work, Energy, and Resonance 31	
CHAPTER 3	SOURCES OF SOUND	38
	3.1 Classifying Sound Sources 383.2 Percussion Instruments 393.3 String Instruments 42	

	3.5 Source Size 47 *Box 3.1 Transposing Instruments 49	
	3.6 Sound from the Natural Environment 50	
CHAPTER 4	SOUND PROPAGATION	
	 4.1 Reflection and Refraction 54 4.2 Diffraction 57 *Box 4.1 The Wave Nature of Matter 59 	54
	4.3 Outdoor Music 61 *4.4 The Doppler Effect 63 4.5 Interference and Beats 64	
CHAPTER 5	SOUND INTENSITY AND ITS MEASUREMENT	70
	 5.1 Amplitude, Energy, and Intensity 72 5.2 Sound Level and the Decibel Scale 74 Box 5.1 The Sound Level Meter 75 Box 5.2 Sound Levels in Music 77 	72
	 5.3 The Inverse-Square Law 78 *5.4 Environmental Noise 79 5.5 Combined Sound Levels and Interference 83 *Box 5.3 Combining Amplitudes, Intensities, and Sound Levels 8 	4
CHAPTER 6	THE HUMAN EAR AND ITS RESPONSE	
	6.1 The Mechanism of the Human Ear 90 6.2 Limits of Audibility and Discrimination 94 *Box 6.1 Hearing Loss 95	89
	 6.3 Characteristics of Steady Single Tones 98 6.4 Loudness and Intensity 99 Box 6.2 The Psychophysical Law 101 	

3.4 Wind Instruments 44

		Pitch and Frequency 102 Pitch and Loudness Together 103 Timbre and Instrument Recognition 107	
CHAPTER 7	ELEN	MENTAL INGREDIENTS OF MUSIC	11;
	7.1 7.2 7.3	Organizing Musical Events in Time 114 Melody and Harmony 118 Scales and Intervals 120 Box 7.1 The Chromatic Scale in Equal Temperament 121	
	7.4	The Harmonic Series 123	
CHAPTER 8	SOU	ND SPECTRA AND ELECTRONIC SYNTHESIS	128
	8.1 8.2 8.3 8.4	Modulated Tones 138	
	0.1	*Box 8.1 Musical Uses of Computers 144	
CHAPTER 9	PER	CUSSION INSTRUMENTS AND NATURAL MODES	148
	9.1 9.2 9.3 9.4 9.5	Natural Modes and Their Frequencies 155	
	9.6 9.7	Striking Points and Vibration Recipes 168 Damped Vibrations 170	
CHAPTER 10	PIAN	O AND GUITAR STRINGS	177
	10.1	Natural Modes of a Thin String 177 Box 10.1 Standing and Traveling Waves 179	

	Box 10.2 The Piano Action 185	
	10.4 Piano Scaling and Tuning 189 Box 10.3 Impedance Matching 191	
OUADTED		
CHAPTER 11	THE BOWED STRING	198
	11.1 Violin Construction 198	700
	11.2 Bowing and String Vibrations 202 11.3 Resonance 208	
	Box 11.1 Energy Flow and Resonance 209	
	11.4 Sound Radiation from String Instruments 213	
CHAPTER 12	BLOWN PIPES AND FLUTES	
	10.1 Air Column Vit. III	225
	Box 12.1 Acoustic Standing Waves 226	
	12.2 Fluid Jets and Edgetones 230 Box 12.2 Examples of Flow Instability 231	
	12.3 Organ Flue Pipes 236 *12.4 Organ Registration and Design 241 12.5 Fingerholes and Recorders 245 12.6 The Transverse Flute 247	
CHAPTER 13		
CHAPIER 13	BLOWN REED INSTRUMENTS	255
	13.1 Organ Reed Pipes 255 13.2 The Reed Woodwinds 260 13.3 The Brass Family 264	
	*Box 13.1 A Chromatic Scale for the Trumpet 268	
	13.4 Playable Notes and Harmonic Spectra 269 13.5 Radiation 278 Box 13.2 The Tacet Horn 278	

10.2 Vibration Recipes for Plucked Strings

10.3 Vibration Recipes for the Piano

181

CHAPIER 14	14.1 The Vocal Apparatus 287 14.2 Sound Production 290 *Box 14.1 The Bernoulli Effect 292	
	14.3 Formants 295 *14.4 Special Problems of the Singing Voice 304	
CHAPTER 15	ROOM ACOUSTICS	310
	15.1 General Criteria for Room Acoustics 310 Box 15.1 Traveling and Standing Waves 314	
	 15.2 Reverberation Time 317 15.3 Reverberation Calculation 322 *15.4 Reverberant Sound Levels 327 15.5 Sound Reinforcement 329 15.6 Spatial Perception 332 Box 15.2 Anechoic Chambers and Reverberation Chambers 32 	332
CHAPTER *16	SOUND REPRODUCTION	341
	16.1 Electric and Magnetic Concepts 341 16.2 Transducers 343 16.3 Microphones 348 16.4 Amplifiers 352 16.5 Recording 355 Box 16.1 Equalization 357 16.6 Loudspeakers 360	
	16.7 Multiphonic Sound Reproduction 364	
CHAPTER 17	THE EAR REVISITED 17.1 Types of Pitch Judgment 372 17.2 Pitch Perception Mechanisms 372 17.3 Modern Pitch Perception Theory 380	371

17.4 Critical Bands 382

	The Chromatic Scale; The Chromatic Series Slider	469
APPENDIX G APPENDIX H	GLOSSARY HINTS AND ANSWERS TO SELECTED EXERCISES Index	459 465
	B.1 Units for Physical Measurements 454B.2 Scientific Notation and Computation 455	453
APPENDIX A APPENDIX B	WRITTEN MUSIC THE METRIC SYSTEM	447
CHAPTER 20	EPILOGUE: SCIENCE AND ESTHETICS	441
0110	19.2 Chords and Harmonic Progressions 42819.3 Consonance and Dissonance 43319.4 Musical Forms and Styles 434	
CHAPTER 19	STRUCTURE IN MUSIC 19.1 Melodies and Modes 425	425
	18.2 Intervals and the Harmonic Series 404 18.3 Musical Scales 406 18.4 The Impossibility of Perfect Tuning 409 18.5 Tuning and Temperament 412 Box 18.1 Moods, Keys, and Transposition 419	
CHAPTER 18	HARMONIC INTERVALS AND TUNING 18.1 Interval Perception 398	398
	17.5 Combination Tones 386 17.6 Loudness and Masking 389 17.7 Timbre 392	
	*Box 17.1 The Uncertainty Principle 385	