Box 2.3
Sound Waves

Sound waves are described using three properties: wavelength, frequency, and amplitude (see figure B2.5). (The fourth, velocity [velocity = wavelength × frequency] is typically the same for all sound waveforms and so is not discussed here.)

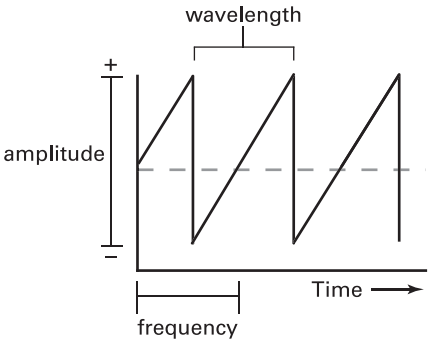

Figure B2.5
Anatomy of a sound wave.

Wavelength is the distance from one peak of a wave to the next, or the distance between maximum compressions. *Frequency*, the technical name for pitch, is a measure of the number of pulses (waves) in a given space of time. It is measured in Hertz, or CPS (cycles per second). For example, a note with a frequency of 440 Hz (A), means that in one second, 440 pulses occur. Shorter wavelengths result in higher frequencies. *Amplitude* is the measure of the amount of energy in a wave (technically, the amount of compression the wave is under), typically described as intensity, or loudness. The more energy a sound has, the more intense, or loud, the sound that results. Loudness is measured in decibels (dB).

Regular, or *periodic*, waveforms are considered pleasing to the ear, and can take several forms, including:

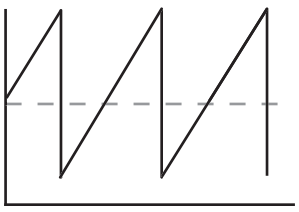

Figure B2.6

BOX 2.3
(continued)

Sine waves have only one frequency associated with them—they are ''pure'' in that they have no harmonics. They are also referred to as ''pure tones.'' In games, sine waves are often used for certain sound effects (laser, alarm), or for flute-like melodic parts.

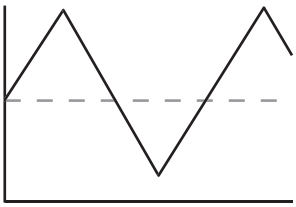

FIGURE B2.7

Sawtooth waves are so named because they resemble the teeth on a saw. They are also sometimes referred to as *ramp waves*. Sawtooth waves typically ramp upward and then drop sharply, although the opposite are also found (inverse/reverse sawtooth waves). Sawtooth waves contain both odd and even harmonics. Sawtooth waveforms in games are used to create bass parts, as it resembles a warm, round sound.

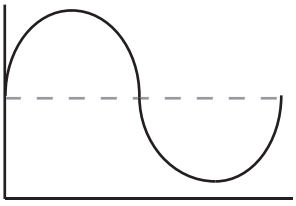

FIGURE B2.8

Pulse waves contain only odd harmonics, and are rectangular waveforms with ''on'' and ''off'' slopes, known as the *duty cycle*. When the duty cycle is of equal length in its ''on'' and ''off'' period, it is known as a square wave. Changing the duty cycle options (changing the ratio of the ''on'' to ''off'' of the waveform), alters the harmonics. At 50 percent (square wave), the waveform is quite smooth, but

Box 2.3
(continued)

with adjustments can be ''fat,'' or thin and ''raspy''). Square waves are often referred to as ''hollow'' sounding.

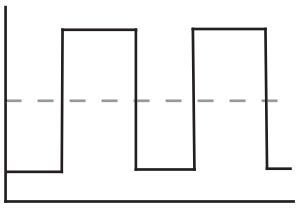

Figure B2.9

Triangle waves contain only odd harmonics, like pulse waves; however, in triangle waves, harmonics finish much faster, and so the resultant sound is much smoother, sounding similar to a sine wave.

Figure B2.10

White noise is a sound that contains every frequency within the range of human hearing in equal amounts. In games, it is commonly used for laser sounds, wind, surf, or percussion sounds. Pink noise is a variant of white noise. Pink noise is white noise that has been filtered to reduce the volume at each octave. It is also commonly used for rain or percussion sounds in games, sounding like white noise with more bass.