The Science of Music

Exercises for Chapter 8

8.1 When CDs were first developed there was a debate over whether to use 16-bit resolution or 14-bit.

a) By how many decibels would the dynamic range be reduced if it had been decided to use 14-bit resolution?

b) Would this have made a practical difference to the sound?

8.2 Dogs can hear frequencies up to about 50 000 Hz.

a) If you wanted to record music for dogs, what sampling frequency would you need to use to reproduce the sound faithfully? Explain briefly how you got your answer.

b) There are, it turns out, quite a number of albums of music for dogs that you can stream online. Based on your answer for part (a), what problems do you anticipate with these albums?

8.3 One of the first commercial uses of digital sound was in early video game consoles. For example, the Nintendo NES, released in 1985, played digital sound at 7-bit resolution and a sampling frequency of 15 746 samples per second.

a) What is the highest frequency of sound that could be faithfully reproduced using the digital audio on the NES?

b) For high quality music reproduction, how high should the frequencies actually go?

c) What is the dynamic range in decibels between the loudest and quietest sounds that could be reproduced on the NES?

d) For high quality music reproduction, how large a dynamic range is desirable?

e) Based on your answers, comment on what deficiencies you might expect to hear in the sound from the NES.

8.4 In professional music recording studios, music is often recorded digitally at a sample rate of 96 000 samples per second and 24-bit resolution.

a) What approximately is the highest frequency of sound that can be captured by such a recording? Why is your answer only approximate?

b) What is the dynamic range in decibels between the loudest and quietest sounds that can be captured?

c) How much computer disk space would it take to record 5 minutes of music at these rates? (You can assume the recording is monophonic—just a single track—not stereo.)

d) Finished recordings are normally downsampled to the industry standard of 44 100 samples per second and 16 bits, then compressed, which reduces the amount of data by about a factor of 10. How much disk space would the same 5 minutes of music then require for its storage?

8.5   One hour of music in digital stereo is recorded at 44 100 samples per second and 16-bit resolution.

a) How much disk space would it take to store this recording, uncompressed, on a computer?
b) The same recording is compressed using MP3 at 192 kbits/s. Now how much space will it take?
c) If it is compressed at 64 kbits/s how much space will it take? Would you recommend doing this?

8.6   What is the compression ratio you achieve if you take digital audio at the industry standard 44 100 samples per second and 16-bit resolution and compress it to a bit rate of (a) 160 kbits/s, (b) 384 kbits/s?

8.7   Four example files were given in Section 8.3.3 that all contain the same sample of music but with different levels of compression. File uncompressed.wav is uncompressed digital audio and files compressed64.mp3, compressed128.mp3, and compressed192.mp3 are compressed at 64, 128, and 192 kbits/s.

a) How big is each of these files in bytes?
b) Hence what is the compression ratio for each of the three compressed files?
c) How do these numbers compare with the theoretical values given in Table 8.1?