Homework 1

*** Please work collaboratively on homework but show your own work. Homework is worth 20 points or double that of a tutorial. You may need to schedule extra time outside of class to complete the homework. Homework is due on Thursday at 11:59pm. You may wish to work out answers on scratch paper first. Tutorials are graded more on effort; homework will be graded for correctness. The TA may take off points if your work is not clear and understandable. ***

CD Quality Sample Size – 74 min
44,100 samples/s x 2 channels x 16 bits x 1 byte / (8 bits) x
74 min x 60 s/min = 783,000,000 bytes

1. What would be the file size in bytes of a 4 min. stereo digital sample with a bit depth of 32 and a sampling rate of 192 kHz?

$$\frac{192000}{s} \cdot 2 \text{ channels} \cdot 32 \text{ bits} \cdot \frac{1 \text{ byte}}{8 \text{ bits}} \cdot 4 \text{ min} \cdot \frac{60 \text{ s}}{\text{min}}$$

$$= 368640000 \text{ bytes}$$

2. In Question 1), what is the maximum frequency that can be resolved?

$$\frac{192000 \text{ Hz}}{2} = 96000 \text{ hz}$$

3. <u>For 16-bit sound, what is the ratio of the largest amplitude sound to the smallest amplitude sound?</u> Hint: 2^{16} =65,536. Remember that we have positive and negative integer values stored for the digital sample. In this case they would range from -32,768 to +32,768. Think about what would be the largest and smallest possible amplitude waveforms. This ratio you are calculating here is a quantitative measure of the dynamic range.

$$\frac{2^{16}}{2} = 32768 \text{ Hz} : 1 \text{ Hz}$$

4. For 8-bit sound, how much bigger can the largest amplitude sound be than the smallest amplitude sound? Hint: $2^8 = 256$.

$\frac{256}{2} = 128 - 1 = 127$ Hz

5. What would be the memory required in bytes to store 74 min. of stereo sound with a sampling rate of 88,200 Hz and a bit depth of 32?

$\frac{88200}{s} \times 2 \times 32\,bit \times \frac{1\ byte}{8\ bit} \times 74\ min \times \frac{60s}{min}$

$= 3132864000$ bytes

6. In Question 5), what is the maximum frequency that can be resolved?

$\frac{88200\ Hz}{2} = 44100\ Hz$

7. Starting from CD quality what would increase the file size of a digital sound sample more?

A) going to a 96,000Hz sample rate $= 2557440000$ greater
B) going to a bit depth of 24 $= 1174824000$ less than
C) none of the above

8. What would be the file size in bytes of a 20 min. mono digital sample with a bit depth of 16 and a sampling rate of 8 kHz?

$\frac{8000}{s} \times 1 \times 16\,bit \times \frac{1\ byte}{8\ bit} \times 20\ min \times \frac{60s}{min}$

$= 19200000$ bytes

9. Define of the following terms. Just use a sentence or two. Discuss your definitions with your group or the instructors.

Sampling Rate:

The number of samples taken each second

Bit Depth:

The range of possible values on the y-axis

Nyquist Frequency:

The highest frequency that can be resolved

Dynamic Range:

the ratio of the ~~largest~~ strongest signal to the weakest

10. Suppose a sound wave has a pressure fluctuation of 0.1 N/m^2. What would be the force exerted on a square surface measuring 8 mm x 8 mm (similar in size to an eardrum)? How does this compare to the weight of a human being (say 62 kg or 608 N)?

Note: The weight in Newtons is the mass in kilograms times the acceleration of gravity. 62 kg x 9.8 m^2/s = 608 N.

$A = 64 m^2$

$P = F/A$

$8\,mm \cdot \frac{1\,cm}{10\,mm} \cdot \frac{1\,m}{100\,cm} = 0.008\,m$

$\frac{0.1}{10}\ N/m^2 = \frac{F}{.000064 m^2}$

$A = 0.008 m \cdot 0.008 m =$

$.000064 m^2$

Sound: $F = P \cdot A = 0.1 \frac{N}{m^2} \cdot .000064 m^2 = 0.0000064\ N$

Man: $F = P \cdot A = 608\ N \cdot .000064 m^2 = 0.038912\ N$