Physics of Sound Review for Exam II

I) Standing waves and overtones (Chapter 3).
- A) Waves trapped by reflections: standing waves as the sum of two traveling waves.
- B) Mersenne's Laws
- C) Frequencies in the overtone series of strings, pipes (straight and conical).
- D) "Intervals" and frequency ratios of overtones.
- E) Modes and the analogy to simple harmonic motion. Resonance of modes.

II) Analysis and synthesis of complex waves (Chapter 4).
- A) Representations of sound.
  - 1) Time domain: Pressure verses time.
  - 2) Frequency domain (Power Spectrum): Power verses frequency
  - 3) Spectrogram: Power as a function of both time and frequency; the compromise of resolving both.
- B) Analysis of a complex periodic sound in terms of the overtones.
- C) Modes in higher dimensions (cymbals, bells, and drums are 2-D).
- D) Effects that influence tone quality
  - 1) Attack-decay transients.
  - 2) Inharmonicities.
  - 3) Formants (filtering).
  - 4) Vibrato.
  - 5) Tremolo.
  - 6) Chorus effect.
- E) Resonance curves
- F) Helmholtz oscillators.

III) Electronic music synthesis (chapter 5).
- A) Addition of waveforms.
- B) Voltage controlled oscillators. Frequency Modulation (FM).
- C) Voltage controlled amplifiers.
  - 1) Envelope generator
  - 2) Ring modulation (balanced modulation).
  - 3) Amplitude modulation (AM).
- D) Voltage controlled filters (formants).
- E) Noise generation.

IV) The human ear and voice (chapter 6).
- A) Basic parts of the ear and vocal tract and their function.
- B) Sound detection and the cochlea (place theory of hearing).
  - 1) Critical band.
  - 2) JND
- C) Peculiarities of the ear.
  - 1) Masking.
  - 2) Combination tones, aural harmonics.
  - 3) Amplitude and frequency response of the ear.
- D) Linear (watts/m^2) and log (decibel) scales of Intensity- (SIL).

Some useful equations and numbers:

Typical speed of sound in air: 340m/s

Overtone series for an open tube or for a string:

$f_n = \frac{n \cdot S}{2 \cdot L}$ n=1,2,3,... (the *mode* number is equal to the overtone (or harmonic) number.

Overtone series for a closed tube (like a clarinet or a krumhorn):

$f_n = \frac{(n - \frac{1}{2}) \cdot S}{2 \cdot L}$ In this equation the *mode* number n=1, 2, 3, correspond to harmonic numbers 1,3,5,... So there are only odd multiples of the fundamental and the fundamental frequency is half as big as it is for the open tube.

L is the tube length and S is the speed of sound (for a tube this is the speed of sound in air and for a string you need to put in the speed of sound on the string).

$S = \sqrt{\frac{F}{W}}$ Speed of sound on a string. The linear mass density is the total mass of the string divided by the length of the string. W=M/L (kg/m) , F is the string tension (in Newtons).

Relation between frequency and wavelength of a wave: $S = f * \lambda$

Approximate table of logarithms (or you can use a calculator).

n	$Log_{10}(n)$
1	0
2	0.3
5	0.7
8	0.9
10	1

$SIL = 10 \log_{10}(I/I_0)$ $I = I_0 * 10^{(SIL/10)}$

$I_0 = 10^{-12} (W/m^2)$

$T = \frac{1}{f}$