UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATIONS, DECEMBER, 2001

Fourth Year - Programs 5, 7

ECE446F - ELECTROACOUSTICS

Examiner: H. Kunov

Examination Type: A
(Non-programmable calculator allowed)

There are 6 problems with a total of 15 questions. The 15 questions carry equal weight.
Some useful information is appended on Page 4.

1. A loudspeaker produces an acoustic signal consisting of two pure tones, namely a 47 Hz tone and a 985 Hz tone. At a certain location in front of the loudspeaker, the sound levels of the tones, when measured individually, are: 78 dB(SPL) for the 48 Hz tone, and 80.5 dB(SPL) for the 980 Hz tone.

   a. What sound pressure level do you expect to measure when both signals are present together?

   b. Suppose you decide to measure the signal in dB(A) instead. What do you expect to measure when both signals are present?

   c. You are being asked to increase the level of the combined signal so that each of the two tones individually is subjectively "twice as loud" at the location mentioned above. What sound pressure level do you expect from the combined signal?

2. Octave-band sound-pressure-level data on the noise generated by an electric shaver at a distance of 40 cm are measured as follows:

Hz	63	125	250	500	1k	2k	4k	8k
dB(SPL)	58	60	55	66	62	64	60	54

Estimate the single, overall (that is, without the octave filters) A-weighted sound level under the same circumstances.

3. Given a loudspeaker with the following properties:

Total mass of diaphragm and voice coil, m = 10 g

Radius of the diaphragm, a = 10 cm

Stiffness of the diaphragm suspension, k = 2000 N/m

Mechanical damping of the diaphragm, D = 1 N·s/m

Inductance of the voice coil, L = 0.2 mH

Resistance of the voice coil, R = 5 Ω

Length of wire in the voice coil, l = 5 m

Magnetic field, B = 0.9 T

a. Draw a formal diagram of the transducer, showing an electrical side, a mechanical section, and an acoustical side, and all relevant components with their values and units. Assume an acoustic load on the diaphragm of Z = 12000 Pa·s/m^3

b. Draw a new diagram, with all components transferred to the electrical side. Include values and units.

c. Determine the electrical driving-point impedance of the loudspeaker at a frequency of 200 Hz.

d. The loudspeaker cone is now mechanically clamped so it cannot move. What is the force experienced by the clamp when a 10 V dc signal is applied to the electrical terminals?

4. The reverberation time in a given reverberation chamber of dimensions 3 x 4 x 5 metres is 4.0 seconds.

a. What is the average absorption coefficient of the surfaces of the chamber?

b. When 15 m^2 of one wall is covered with acoustic tile, the reverberation time is reduced to 1.3 second. What is the absorption coefficient of the tile?

c. What would be the reverberation time if all surfaces of the chamber are covered with this acoustic tile?

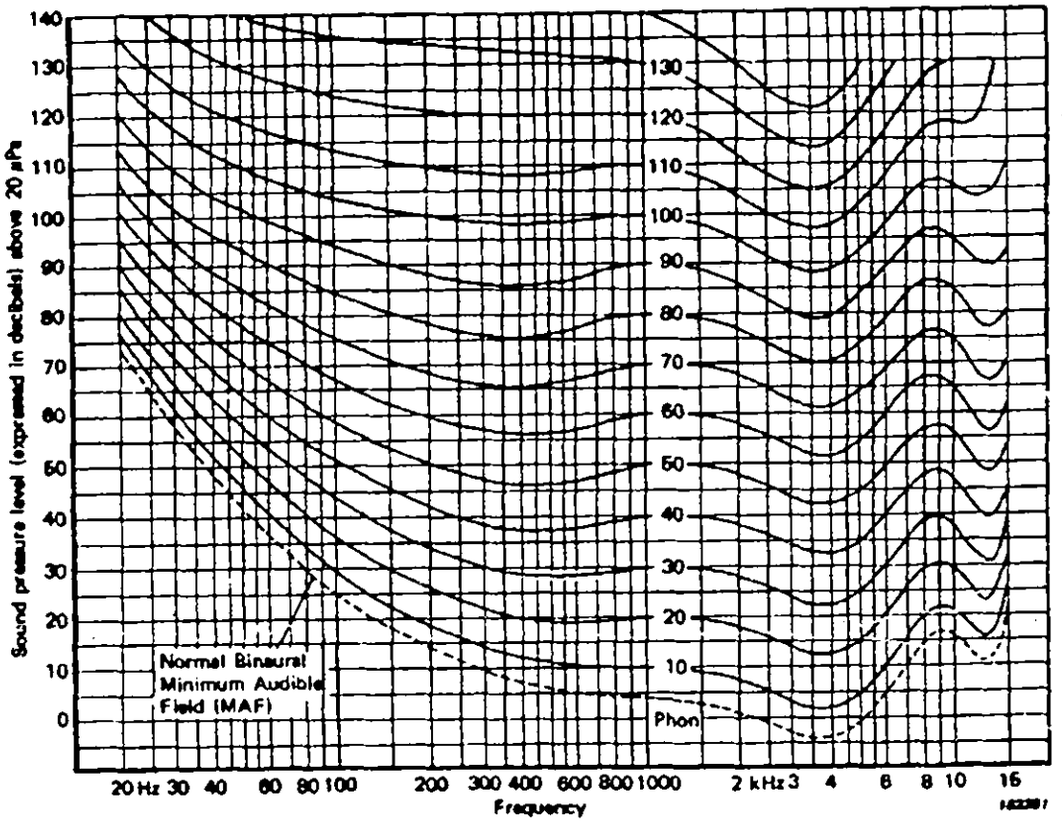
5. Out of an eight-hour work day, a certain worker spends n hours at a work station where he is exposed to noise at 93.5 dB(A), and (8 – n) hours at another work station with noise at 82 dB(A). Make a graph of the worker's noise exposure L_{eq} versus n, for n between 0 and 8 hours.

6. The air pressure at a certain point in space varies sinusoidally around the mean value which is the atmospheric pressure. The amplitude of the variable pressure is 0.010% of atmospheric pressure, and the frequency is 1000 Hz.

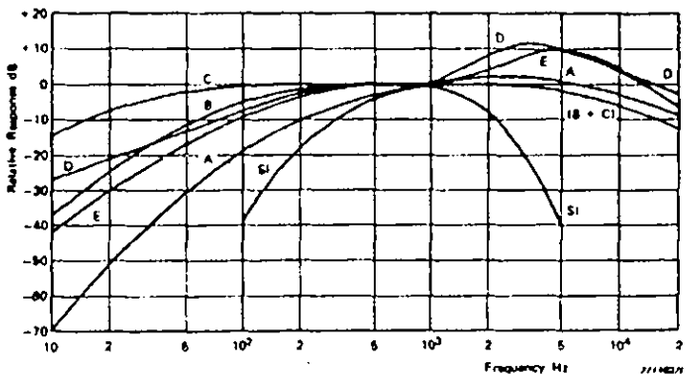
   a. What is the sound pressure level expressed in dB(SPL)?

   b. How many sones does this correspond to?

   c. If the frequency had been 40 Hz instead of 1000 Hz, how many sones would the signal represent?



Normal Equal Loudness Contours for pure tones



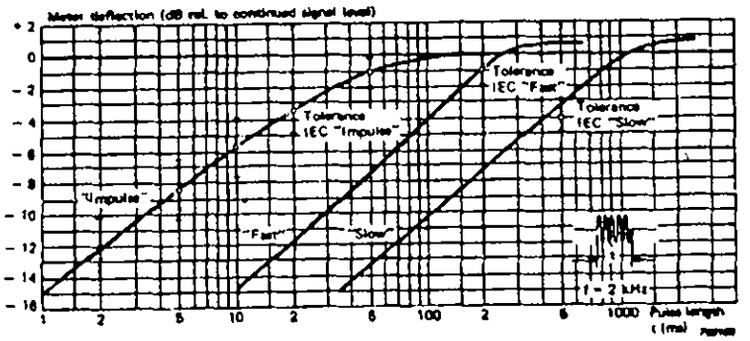
The internationally standardized weighting curves for sound level meters and recently suggested E and SI weighting

1 atmosphere (normal) = 1.0133 x 10^5 Pa

Ratio of specific heats for an ideal gas: = c_p/c_v = 1.4

Reference acoustic pressure = 20 µPa in air (1 µPa in other media)

Speed of sound in air: 344 m/s. In fresh water: 1480 m/s



Response of meter to tone bursts of varying duration

Density of air (normal) = 1.18 kg/m^3