UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATIONS, DECEMBER, 1997

Fourth Year - Programs 5, 7

ECE446F - ELECTROACOUSTICS

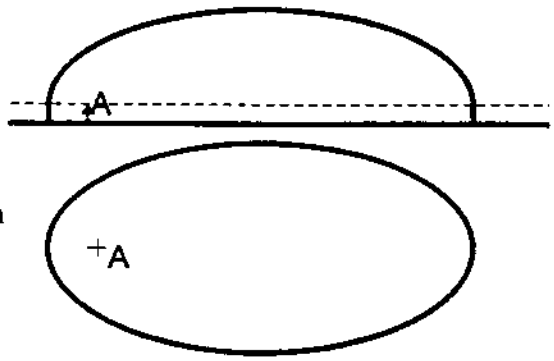
Examiner: H. Kunov

Examination Type: A
(Non-programmable calculator allowed)

There are 8 problems with a total of 12 questions. The 12 questions carry equal weight.
Some useful information is appended on Page 4.

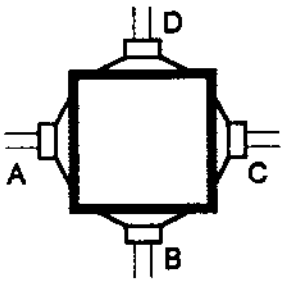
1 Broad band white noise is passed through a 1/3-octave filter with variable centre frequency. If the level after a filter with a 1 kHz centre frequency is 45.6 dB, what is the level when the centre frequency is changed to 8 kHz?

2 The roof of a sports arena has the shape of an ellipsoid, as shown on the right. A represents a person with his head at a focus of the ellipsoid. The vertical walls and the floor are acoustically highly absorbent, while the ceiling is not. Show representative rays of sound (in both views) when A speaks. Does this present a problem? If so, what would you suggest to overcome it?



3 In a certain plant, the noise level increases by 0.1 dB(A) per minute starting at 80.0 dB(A) a 8 am, and leveling off at 98 dB(A) at 11 am, at which time it remains constant for the rest of the day. If someone works in this plant between 8 am and 12 noon, what noise exposure (in terms of a 4-hour L_{eq}) would he be exposed to?

4 A small air-tight box shown to the right has identical speakers mounted in four walls as shown. Speaker A is connected to a true RMS voltmeter, while the other three speakers are connected to identical amplifier output terminals. We have two signal sources: S_1 which is a 150 Hz sinusoid, and S_2 which is a pink noise signal between the cut-off frequencies of 20 Hz and 200 Hz. When S_1 is connected by itself to B, the voltmeter at A reads 35 mV, and when S_2 is connected by itself, the reading is 45 mV.



When the same signal is connected to two of the speakers, they may be connected in phase (both speaker cones moving inward at the same time), or out-of-phase.

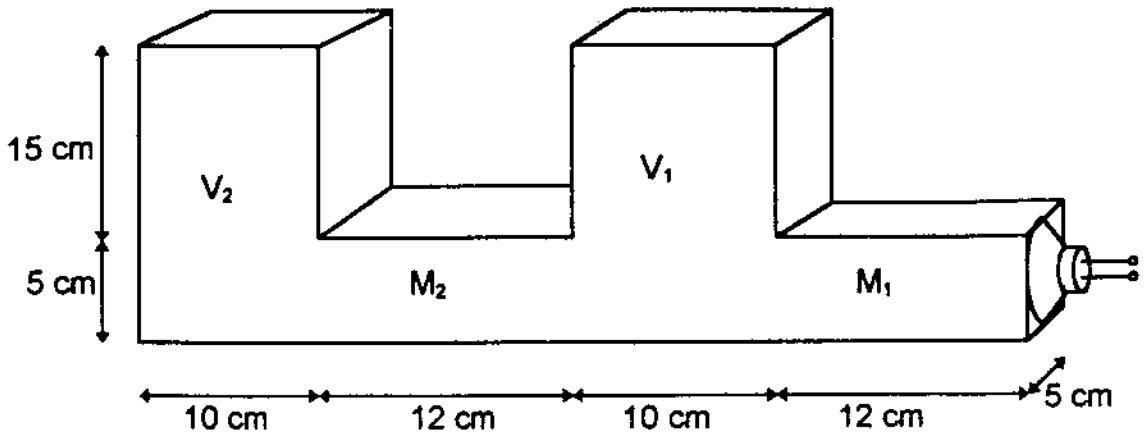
What will the voltmeter connected to speaker A read, with the following signal combinations on the three remaining speakers?

Question	Signal to B	Signal to C	Signal to D
(a)	S_1	S_1	none
(b)	S_1	S_2	S_2
(c)	S_1	S_2	$S_{2,\text{ out-of-phase}}$

5 A 250 Hz pure tone signal appears in short bursts once a second. Each burst is 150 ms long. With a sound level meter set at A-weighting and "slow" response we measure 76.5 dB(A) at a certain location. What would we measure if the sound level meter instead had been set for "fast" response and linear frequency weighting?

6 A narrow-band noise centered on 150 Hz has a loudness level of 80 sones. It is generated by a 13.7 V_{RMS} electrical signal to a loudspeaker. What should the voltage be set to, in order to reduce the loudness to 10 sones?

7



The acoustic system shown above consists of a loudspeaker connected to a ducted system with two acoustic masses and two acoustic compliances. The speaker has a voice coil of length $l = 3.5$ m in a magnetic field $B = 0.55$ T. The resistance of the voice coil is 10 Ω, and the effective area of the speaker cone is 18 cm^2. Assume the frequency of the signal in this problem to be low enough so that the acoustical part can be approximated by the four lumped components mentioned above. With a 120 Hz sinusoidal voltage source applied to the speaker, there is a sound pressure level of 35 dB (SPL) in V_1.

(a) Draw a formal acoustical diagram of the complete system, with all components referred to the acoustical side. Include numerical values and units.

(b) What is an upper frequency below which the assumption stated is valid? Justify your choice.

(c) What is the sound pressure level in V_2?

8 There is a desire to acoustically "brighten" up a rather "dead" room. The dimensions of the room are 7 m · 10 m · 4.5 m (width · length · height). The reverberation time is 0.86 s, and we would like to increase it to 1.2 s. The material covering all walls has an absorption coefficient of 0.28, and a portion of the wall covering can be replaced by a harder material with an absorption coefficient of 0.11. What fraction of the area (in percent) of the wall covering must be replaced to achieve the desired reverberation time?