UNIVERSITY OF SWAZILAND

Faculty of Health Science

Department of Environmental Health Sciences

Final Examination 2007

TITLE OF PAPER	:	ACOUSTICS
COURSE CODE	:	EHS 535
DURATION	:	3 HOURS
MARKS	:	100
INSTRUCTIONS	:	READ THE QUESTIONS & INSTRUCTIONS CAREFULLY
	:	ANSWER FIVE QUESTIONS: QUESTION 1 AND 2 ARE MULTIPLE CHOICE
	:	EACH QUESTION CARRIES 20 MARKS
	:	NO PAPER SHOULD BE BROUGHT INTO NOR OUT OF THE EXAMINATION ROOM
	:	BEGIN EACH QUESTION ON A SEPARATE SHEET OF PAPER

DO NOT OPEN THE QUESTION PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE INVIGILATOR.

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QUESTION 1

Multiple choice: Write True or False against each letter corresponding to the following statements as they apply to acoustics.

a) The minimum Audible Sound Pressure is approximately 0.0002×10^{-6} of the atmospheric pressure.

b) In acoustic measurement, the magnitude of a sound wave can be determined in a number of different ways. It is usually more convenient to measure the acoustic velocity and not parameters such as pressure or particle displacement.

c) The plane, progressive wave propagates away from the source in one direction only.

d) For a perfect gas, the velocity of sound, C depends on the absolute temperature, T, density or pressure.

e) $\frac{P}{U} = \rho_0 C$= the characteristic impedance of the medium(kg/m^{2}s/RAYLS)

f) The more intense the sound from the audiometer must be for a person to hear it, the lesser is that individual's hearing loss.

g) Disease can impair hearing through fixation and interruption of the ossicles.

h) The A, B and C weighting curves were originally intended to approximate human ear responses at low, medium and high sound levels respectively.

i) Measurements of noise may be made to determine areas where a hearing risk may occur.

j) Noise control investigations to determine the characteristics of noise sources so that control measures may be taken do not require more accurate and sophisticated instruments capable of octave band frequency analysis and continuous recording.

QUESTION 2

Multiple choice: Write True or False against each letter corresponding to the following statements as they apply to acoustics.

a) For a sinusoidal pressure wave it is found that $P_{rms} = \frac{P_{max}}{\sqrt{2}}$

b) $I = \frac{P^2_{rms}}{\rho_0 C}$

c) For a spherical wave, radiating evenly in all directions, $I = \frac{W}{A} = \frac{W}{4\pi r^2}$

d) The intensity of a sound is an important quantity and is easy to measure.

e) The time average of the sound power per unit area is known as the sound intensity of the wave.

f) For most noise problems encountered in industry, the sound level meter and octave-band analyzers do not provide ample information.

g) If the wavelength of the sound is small in comparison with the size of an obstacle, the sound is reflected or scattered in many directions.

h) The Occupational Safety and Health Administration regulations neither require the control of noise exposures, nor employee protection against the effects of noise exposures, and the initiation of comprehensive and effective hearing conservation programs.

i) The effectiveness of a hearing conservation program depends only on t he cooperation of employees.

j) The audiometric testing program should indicate whether hearing loss is being prevented by the employer's hearing conservation program.

[20 Marks]

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QUESTION 3

a) Two sources are radiating noise in a free field. One source has a sound power level of 120 dB and the other has a sound power level of 118 dB. What is the combined sound power level of the two sources?

[6 marks]

b) Suppose the sound pressure level of each of three individual noise sources is measured at a point such that with only the first source running, the sound power level is 86 dB, with only the second running it is 84 dB, and with only the third source running it is 89 dB. What will the sound pressure level at the point be with all three sources running concurrently?

[6 marks]

c) A hydraulic pump driven by a 2kW electric motor has a sound power level of 90 dB. What percentage of the electrical energy consumed by the pump is emitted as noise?

[4 marks]

d) The background sound pressure level at a point is 56 dB. Sound from a fan increases this to 58 dB. What would be the sound pressure level due to the fan?

[4 marks]

QUESTION 4

a) A 5 m wide x 10 m long x 3.5 m high room has a 10 microwatt (1 μW= 10^{-6} watts) sound source located in the centre of the 5 m wall where the floor and the wall meet. The absorption coefficients associated with the room are: walls $\alpha = 0.02$, floor $\alpha = 0.1$ and ceiling $\alpha = 0.26$.

Find the sound pressure level at the centre of the room first taking into account the presence of the reverberant field and then assuming only direct sound radiation from the sound source.

[10 marks]

b) A 2.4m x 6m, 10.2cm thick brick wall has 0.3175cm thick 0.9m x 1.5m windows in it.

N.B The specific surface density for brick is 21 kg/m^2/cm and for glass is 24.7 kg/m^2/cm.

ii) Compute the normal incidence transmission loss for the brick wall and windows individually and at a frequency of 500 Hz.

[6 marks]

iii) Compute the normal incidence transmission loss of the composite barrier composed of the brick wall and two windows.

[5 marks]

QUESTION 5

a) The sound pressures of the sound propagating in a duct were measured in the indicated areas and were found to be:
P_{rms} (1) = 2.2 x 10^{-2} Pa P_{rms} (2) = 3.0 x 10^{-2} Pa

P_{rms} (3) = 3.52 x 10^{-2} Pa P_{rms} (4) = 2.82 x 10^{-2} Pa

The dimensions of areas 1, 2, 3 and 4 of the duct are 0.55m x 0.55m each.

1	2
3	4

Determine the acoustic sound power of the sound that is propagating in the duct.

N.B: $W = \sum_{i=1}^{4} \frac{p^{2rms(1)}}{\rho C} S_i$, where ρC = 420 RAYLS.

[4 marks]

b) A simple spherical sound source radiates sound into whole space with15 acoustic watts of power at frequency of 600 Hz. Find the acoustic intensity and sound pressure at radial distances of 1m and 2m from the source.

[16 marks]

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QUESTION 6.

a) Use the following results to carry out an audiogram evaluation.

Frequency (Hz)	Baseline Audiogram Threshold (dB)	Annual Audiogram Threshold (dB)	Change
500	5	5	
1000	5	5	
2000	0	10	
3000	5	20	
4000	10	35	
6000	10	15	

Calculate the Standard Threshold Shift (STS) and stipulate your conclusion.

[6 marks]

b) An employee is exposed to the following noise levels during the workday:

85 dBA for 3.75 hours
90 dBA for 2 hours
94 dBA for 2 hoours
95 dBA for 0.25 hours

Calculate the daily dose and give your conclusion about the exposure.

[4 marks]

c) A worker in an engineering workshop is exposed to the following noise levels:

88 dB (A) for 4 hours
93 dB (A) for 1 hour
86 dB (A) for 3 hours

Determine the $L_{EP,d}$ for this individual.

[6 marks]

d) What are the purposes of a detailed noise survey?.

[4 marks]

FORMULARS

1. $Cd = 0.61$ and $T = \int dt = \frac{ZA\,(H_1^{1/2} - H_2^{1/2})}{Cda\sqrt{2g}}$

2. $Q = 2/3\ Cd\ \sqrt{2g}\quad b(H_1^{3/2} - H_2^{3/2})$

3. $Y_i = Y_S/2\ (\sqrt{1+8\beta f_S^2} - 1)$

4. $F_{S=} V_S/\sqrt{g Y_S}$

5. $(Y + V/2g) - (Y + V/2g)$

6. $\rho g y^2/2 + \rho q(V_1 - V_2) - \rho g Y_2^2/ F_X = 0$

7. $Y_G = Y_s\ \sqrt{1+2F_s^2}\ (1 - Y_S/ Y_2)$
8. $Q = AV$

9. $Q = A/n\ R^{2/3}\ S_0^{1/2}$
10. $Y_i = Y_S/2\ (\sqrt{1+8\beta f_S^2} - 1)$

11. $F_{S=} V_S/\sqrt{g Y_S}$

12. $10 \log_{10} [W/W_0]$
13. $W/W_0 = 10^{LW/10}$

14. L_W (Total) $= 10 \log (W_1/W_0 + W_2/W_0)$

15. $L_p = 10 \log (p_1/p_0)^2$
16. $L_p(\text{total}) = 10 \log (p_{\text{total}}/p_0)^2$

17. $W = \sum_{i=1}^{4} \frac{p^{2rms(1)}}{\rho C} S_i$, where $\rho C = 420$ rayls.

18. $I = \frac{W}{4\pi r^2}$
19. $I = \frac{p^2_{rms}}{\rho C}$ or $p_{rms} = (I\ \rho C)^{1/2}$
20. $\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P}{\rho g} + \frac{V_2^2}{2g}$

21. $h = \frac{2\sigma \cos\theta}{r\rho g}$

22. $W = \rho g Q$