

**FACULTY OF HEALTH SCIENCES
DEGREE IN ENVIRONMENTAL HEALTH SCIENCES
(FINAL EXAMINATION)**

TITLE OF PAPER : ACOUSTICS AND HEALTH 1
COURSE CODE : EHS 569
TIME : 2 HOURS
TOTAL MARKS : 100

INSTRUCTIONS:

- QUESTION 1 IS COMPULSORY
- ANSWER ANY OTHER THREE QUESTIONS
- ALL QUESTIONS ARE WORTH 25 MARKS EACH
- FORMULAE AND OTHER DATA IS PROVIDED
- NO FORM OF PAPER SHOULD BE BROUGHT IN OR OUT OF THE EXAMINATION ROOM
- BEGIN THE ANSWER TO EACH QUESTION IN A SEPARATE SHEET OF PAPER.

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

QUESTION 1

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

I.

- (a) When sound spreads out from a point source in a free space, the wave fronts are spherical and the sound pressure level will decrease 3 dB for each doubling of distance.
- (b) To be able to deal with problems of noise, one must first have an understanding of the nature of sound and its physical properties.
- (c) The word sound is used to describe an auditory sensation in the ear and the disturbance in a medium which can cause this sensation.
- (d) When a sound wave strikes an obstacle, part of it is reflected, part is absorbed within the obstacle and part is transmitted through to become a sound wave in air again on the other side.
- (e) White noise is noise having frequencies unevenly distributed throughout the audible range, and it sounds rather like rushing water.
- (f) Most sounds encountered in noise control problems are continuous spectrum sounds in which acoustic energy is not distributed over the whole range of audible frequencies.
- (g) The characteristics of an octave band are such that the upper frequency limit is thrice the lower limit, and the audible range is then represented by 10 contiguous bands.
- (h) The pressure changes produced by a sound wave are known as the sound pressure.
- (i) Noise is damaging sound, that is, sound which interferes with what people are trying to do, or sound which has an adverse effect on health or safety.
- (j) Sound with a frequency below 20 Hz is called ultrasound.

(20 marks)

II.

If the r.m.s value of acoustic pressure of a plane wave is 6.5 N/m^2 at standard temperature and pressure, what is the sound intensity level of the wave? At standard temperature and pressure, $\sigma = 1.2 \text{ kg/m}^3$ and $C = 344 \text{ m/s}$

(5 marks)

QUESTION 2

- (a) An octave band analysis of the noise present within a sports hall is given below. Determine the overall sound pressure level of the noise in dBA.

O/B centre frequency	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2 kHz	4 k Hz	8 kHz
O/B SPL(A)dB	84	73	60	58	55	50	45	40	32
"A" weight(B)dB	-40	-26	-16	-9	-3	0	+1	+1	-1

- (b) Two sound sources are radiating sound waves of different frequencies and the individual sound pressure levels recorded are 88 and 85 dB. Determine the total sound pressure level. **(13 marks)**
- (c) If a pure tone acoustic wave has a S.I.L of 95 dB (re 10^{-12} W/m²) what is the peak value of acoustic pressure? **(5 marks)**
- (7 marks)**

QUESTION 3

- (a) A simple spherical sound source radiates sound into whole space with 10 acoustic watts of power at a frequency of 800 Hz. Find the acoustic intensity and sound pressure at radial distances of 1m and 2m from the source. **(10 marks)**
- (b) 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? **(5 marks)**
- (c) Describe the communication problems of people with noise-induced hearing loss under the following headings:
- i. Loudness **(2 marks)**
 - ii. Clarity **(5 marks)**
- (d) Describe temporary threshold shift as applied in acoustics and health **(3 marks)**

QUESTION 4

- a) The sound pressures of the sound propagating in a duct were measured in the indicated areas and were found to be:

$$P_{\text{rms}}(1) = 2.12 \times 10^{-2} \text{ Pa} \quad P_{\text{rms}}(2) = 2.1 \times 10^{-2} \text{ Pa}$$

$$P_{\text{rms}}(3) = 1.92 \times 10^{-2} \text{ Pa} \quad P_{\text{rms}}(4) = 1.8 \times 10^{-2} \text{ Pa}$$

The dimensions of areas 1, 2, 3 and 4 of the duct are 0.7m x 0.7m each.

1	2
3	4

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

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

(5 marks)

- b) The 1/1 octave band sound pressure levels of the noise from a garbage disposal are given below. Determine the overall noise level of the garbage disposal.

Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Sound Pressure Level (dB)	70	81	75	65	53	48	47	46

(13 marks)

- c) The background sound pressure level at a point is 75 dB. Sound from a fan increases this to 78 dB. What would be the sound pressure level due to the fan alone?

(7 marks)

QUESTION 5

- a) Describe the hearing process and the types of hearing loss. **(15 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 89 dB, with only the second running it is 85 dB, and with only the third source running it is 83 dB. What will the sound pressure level at the point be with all three sources running concurrently?

(10 marks)

FORMULAE- ACOUSTIC AND HEALTH

1. $W = \sum_{i=1}^4 \frac{p_{rms(i)}^2 S_i}{\rho C}$, where $\rho C = 420$ RAYLS.
2. $L_p = 10 \log (p_1/p_0)^2$
3. $NR = 10 \log_{10} = \frac{TA_2}{TA_1}$
4. $SPL_t = 10 \log_{10} [\sum 10^{SPL/10}]$
5. $L_w = 10 \log W/W_0$
6. $I = \frac{W}{A}$
7. $I = \frac{p_{rms}^2}{\rho C}$ or $p_{rms} = (I \rho C)^{1/2}$
8. $S.I.L = 10 \log_{10} (I/I_{ref})$
9. $R = \frac{S \square}{1 - \square} = 19.8 = 22.10$
10. $\square = \frac{S_1 \square_1 + S_2 \square_2 + \dots}{S_1 + S_2}$
11. $SPL_t = SWL + 10 \log_{10} \left\{ \frac{Q}{4\pi r^2} + \frac{4}{R} \right\}$
12. $T = \frac{0.161 V}{S \square}$
13. $T = \frac{0.161 V}{-S [\ln (1 - \square)]} + 4mV$
14. $\tau = \frac{p_i^2 / \rho C^2}{p_i^2 / \rho C^2}$
15. $TL_{brick} = 10 \log_{10} \left\{ \frac{1}{\tau} \right\}$