

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

**TITLE OF PAPER : ACOUSTICS AND HEALTH 1**  
**COURSE CODE : EHS 569**  
**TIME : 3 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) Noise-induced hearing loss involves damage to the cochlea.
- b) The organ of Corti is the centre of the sense of hearing.
- c) Frequency is the number of vibration cycles per second.
- d) Sound with a frequency above 20 000 Hz is called infrasound.
- e) In audiometry, the further a person's threshold is below the zero line of the audiogram, the lesser is the loss of hearing.
- f) Refraction occurs when an obstacle's dimensions are larger than the wavelength of the sound.
- g) Diffraction occurs when an obstacle's dimensions are of the same order or less than the wavelength of the sound
- h) When hearing thresholds are measured, essentially it is a person's ability to hear pure tones that is measured.
- i) The incidence of noise-induced hearing loss is directly related to total exposure time.
- j) 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.

**(20 Marks)**

**II.**

Show that the ratio of the acoustic powers of two sounds expressed in dB is equal to the difference of their power levels.

**(5 marks)**

## QUESTION 2

- a) Two sound sources are radiating sound waves of different frequencies and the individual sound pressure levels recorded are 75 and 80 dB. Determine the total sound pressure level.  
**(6 marks)**
- b) The background sound pressure level at a point is 65dB. Sound from a fan increases this to 78dB. What would be the sound pressure level due to the fan alone?  
**(6 marks)**

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

Frequency	Hz	63	125	250	500	1000	2000	4000	8000
Sound Pressure level	dB	64	85	70	60	56	53	53	50

**(13 marks)**

### QUESTION 3

- a) Describe the effects of noise exposure under the following headings:
- i) Temporary threshold shift **(3 marks)**
  - ii) Permanent threshold shift **(5 marks)**
  - iii) Noise-induced hearing loss **(5 marks)**
- b) Describe the communication problems of people with noise-induced hearing loss under the following headings:
- i. Hearing versus understanding.
  - ii. Loudness
  - iii. Clarity
  - iv. Speech sound

**(12 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:

$$P_{\text{rms}}(1) = 3.2 \times 10^{-2} \text{ Pa} \quad P_{\text{rms}}(2) = 4.0 \times 10^{-2} \text{ Pa}$$

$$P_{\text{rms}}(3) = 2.52 \times 10^{-2} \text{ Pa} \quad P_{\text{rms}}(4) = 2.82 \times 10^{-2} \text{ Pa}$$

The dimensions of areas 1, 2, 3 and 4 of the duct are 0.5m x 0.5m 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) A simple spherical sound source radiates sound into whole space with 10 acoustic watts of power at frequency of 700 Hz. Find the acoustic intensity and sound pressure at radial distances of 1m and 2m from the source.
- c) If a pure tone acoustic wave has a S.I.L of 95dB what is the peak value of acoustic pressure?

**(10 marks)**

**(10 marks)**

#### QUESTION 5

- a) 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?
- b) Describe the hearing process.
- c) When measured at the same location four noise sources have sound pressure levels of 89, 87, 78, and 81 dB, respectively. What would the sound pressure level at this location be if all four sources were running concurrently?

**(6 marks)**

**(10 marks)**

**(9 marks)**

## FORMULAE- ACOUSTIC AND HEALTH

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

$$2. L_p = 10 \log (p_1/p_0)^2$$

$$3. NR = 10 \log_{10} = \frac{TA_2}{TA_1}$$

$$4. SPL_t = 10 \log_{10} [ \sum 10^{SPL/10} ]$$

$$5. L_W = 10 \log W/W_0$$

$$6. I = \frac{W}{A}$$

$$7. I = \frac{p_{rms}^2}{\rho C} \text{ or } p_{rms} = (I \rho C)^{1/2}$$

$$8. S.I.L = 10 \log_{10} (I/I_{ref})$$

$$9. R = \frac{S \bar{\alpha}}{1 - \bar{\alpha}} = \frac{19.8}{0.1} = 22.10$$

$$10. \bar{\alpha} = \frac{S_1 \bar{\alpha}_1 + S_2 \bar{\alpha}_2 + \dots}{S_1 + S_2}$$

$$11. SPL_t = SWL + 10 \log_{10} \left\{ \frac{Q}{4\pi r^2} + \frac{4}{R} \right\}$$

$$12. T = \frac{0.161 V}{S \bar{\alpha}}$$

$$13. T = \frac{0.161 V}{-S [\ln (1 - \bar{\alpha})] + 4mV}$$

$$14. \tau = \frac{p_t^2 / \rho C^2}{p_i^2 / \rho C^2}$$

$$15. TL_{brick} = 10 \log_{10} \left\{ \frac{1}{\tau} \right\}$$