FACULTY OF HEALTH SCIENCES

DEGREE IN ENVIRONMENTAL HEALTH SCIENCES

(FINAL EXAMINATION –DECEMBER 2014)

TITLE OF PAPER : ACOUSTICS AND HEALTH

COURSE CODE : EHS 401

TIME : 3 HOURS

TOTAL MARKS : 100

INSTRUCTIONS:

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

DO NO 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) Measuring noise levels and worker's noise exposures helps identify work locations where there are noise problems, employees who may be affected, and where additional noise measurements need to be made.

b) 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.

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) The risk of hearing loss from high noise environments depends on both the level of noise and the length of time an individual is exposed to that level.

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) Hearing conservation programs are designed to prevent noise induced hearing loss

h) The far field is an area beyond the near field and is made up of the free field and the reverberant field.

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 above 20 000 Hz is called infrasound.

(20 marks)

II.

Briefly describe a sound level meter and its functions.

(5 marks)

QUESTION 2

a) Describe a hearing conservation program.

(18 marks)

b) If a pure tone acoustic wave has a S.I.L of 90 dB (re 10^{-12} W/m^2) what is the peak value of acoustic pressure?

(7 marks)

QUESTION 3

a) Describe measurement of workplace noise under the following headings:

i. Why measure noise

(2 marks)

ii. How is workplace noise measured

(3 marks)

iii. How noise problems are identified in the workplace

(6 marks)

iv. Types of instruments used for measuring noise

(7 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?

(7 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:

$P_{rms}(1) = 2.5 \times 10^{-2}$ Pa $\quad P_{rms}(2) = 3.1 \times 10^{-2}$ Pa

$P_{rms}(3) = 1.95 \times 10^{-2}$ Pa $\quad P_{rms}(4) = 3.8 \times 10^{-2}$ Pa

The dimensions of areas 1, 2, 3 and 4 of the duct are 0.8m x 0.8m each.

1	2
3	4

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

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

(5 marks)

b) The background sound pressure level at a point is 90 dB. Sound from a fan increases this to 96 dB. What would be the sound pressure level due to the fan alone?

(7 marks)

c) An office is separated by a partition wall of area 100 m^2 having a sound reduction index of 40 dB. A door of area 2.5 m^2 having a sound reduction index of 30 dB is added to the partition. If the room adjoining the office has sound pressure level of 75 dB, find the sound pressure level in the office when the door is closed and when it is open.

(7 marks)

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

88 dBA for 3hours
93 dBA for 2hours
86 dBA for 1.5hours

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

(6 marks)

QUESTION 5

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

NB: The specific surface density for the brick is 21kg/m^2/cm and for glass are 24.7 kg/m^2/cm.

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

(6 marks)

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

(4 marks)

b) A 5 m x 10 m x 3m room has a 1 microwatt (1 $\mu W = 10^{-6}$ 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.

(10 marks)

c) Describe the elements of the basic plan for determining compliance with Occupational Safety and Health Administration noise survey.

(5 marks)

FORMULAE- ACOUSTIC AND HEALTH

1. $W = \sum_{i=1}^{4} \frac{p^2_{rms}(1)S_i}{\rho C}$, 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. $SPL_t = 10 \log_{10} [\Sigma 10^{SPL/10}]$
5. $L_W = 10 \log W/W_0$
6. $I = \frac{W}{A}$
7. $I = \frac{p^2_{rms}}{\rho C}$ or $p_{rms} = (I \rho C)^{1/2}$
8. $S.I.L = 10 \log_{10} (I/I_{ref})$
9. $R = \frac{S\bar{\alpha}}{1-\bar{\alpha}}$
10. $\bar{\alpha} = \frac{S_i \bar{\alpha}_i + S_2 \bar{\alpha}_2 + \ldots.}{S_i + S_2}$
11. $SPLt = SWL + 10 \log_{10} \{ \frac{Q}{4\pi r^2} + \frac{4}{R} \}$
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. $TL_{brick} = 10 \log_{10} \{ \frac{1}{T} \}$
16. $L_p = 10 \log (p_1/p_0)^2$ Or $(p_1/p_0)^2 = 10^{Lp/10}$
17. $SPL_t = 10 \log_{10} [\Sigma 10^{SPL/10}]$
18. $kr = \frac{2\pi f r}{C}$
19. $I = \frac{p^2_{rms}}{\rho_0 C}$
20. $I = p^2_{max}/2 \rho C$