# UNIVERSITY OF SWAZILAND

## Faculty of Health Science

## Department of Environmental Health Sciences

## Main Examination 2010

Title of paper: ACOUSTIC AND HEALTH II

Course code: EHS 570

Time allowed: 3 hours

Marks allocation: 100 Marks

Instructions:

1) Question 1(i) is multiple chioce
2) Answer Any FOUR questions
3) Each question is weighted 25 marks
4) Write neatly and clearly
5) Begin each question in a separate sheet of paper

This paper is not to be opened until the invigilator has granted permission

## QUESTION 1

**I.**

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

(a) The effects of noise can be both psychological and physiological. It can lead to a decrease in working efficiency and it can in some cases present a safety risk.
(b) 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.
(c) Most sound level meters provide the option of quantifying the combined sound at all frequencies.
(d) The A-weighted response stimulates the sensitivity of the human ear at high sound levels.
(e) The C-weighted response stimulates the sensitivity of the human ear at high sound levels.
(f) If the source is located directly in the corner of a room, it will radiate sound in a ¼ spherical pattern.
(g) If the dose is greater than 1.0 (100%) (TWA > 90dBA) feasible administrative or engineering controls may be initiated to reduce the TWA to not greater than 90.
(h) For the purpose of evaluating personnel noise exposures, the A-weighted sound level is needed at the ear of the person being monitored.
(i) The sound level meter is the basic instrument for the occupational hygienist or engineer investigating noise levels.
(j) Dosimeters can be used to identify specific noise sources and to determine compliance with purchase specifications.

**(20 marks)**

**II.**

Briefly describe a sound level meter and its functions.

**(5 marks)**

**QUESTION 2**

Describe the five (5) primary reasons for reducing noise levels in an occupational environment.

**(25 marks)**

**QUESTION 3**

a) Using table 20.9 provided determine:

i) The total absorption before treatment at 1000Hz;

**(6 marks)**

ii) The total absorption after treatment at 1000Hz and

**(6 marks)**

iii) The noise reduction;

**(3 marks)**

For a room with the following characteristics.

| | |
|---|---|
| Room | 13m x 14m x 4m |
| Volume | 728 $m^3$ |
| Ceiling | plaster – 182 $m^2$ |
| Floor | concrete – 142 $m^2$ |
| Floor | carpet – 40 $m^2$ |
| Walls | painted brick – 216 $m^2$ |

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

**(10 marks)**

## QUESTION 4

(a) 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.

**(7 marks)**

(b) A 1.5m x 6m door is located in a 3m x 8m wall. The door has a sound reduction index of 15dB while that of the wall is 25dB.
Determine the sound reduction index of the combination.

**(6 marks)**

(c) A wall 15m x 25m with an initial sound reduction index of 50dB has three (3) windows built into it. The area of each window is $5m^2$ and its sound transmission coefficient is 0.01. Determine the new sound reduction index of the wall with windows.

**(6 marks)**

(d) Determine the reverberant times. T, for rooms, 5m x 10m x 3.5m with the following characteristics:

i) $\alpha = 0.1$, $S = 205m^3$, $V = 175m^3$
ii) $\alpha = 0.25$, $S = 205m^3$, $V = 175\ m^3$

**(6 marks)**

## QUESTION 5

a) A 6m x 8m x 4m room has a 10-microwatt ($1\mu W$ = 10 $m^6$ watts) sound source located in the centre of the 6m wall where the floor and wall meet. The absorption coefficient associated with the room are:

Wall: $\alpha = 0.02$;
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.

**(11 marks)**

b) A 2.4m x 6m, 10.2cm thick brick wall has two 0.3175cm thick 0.9m x 1.5m glass windows in it.
**NB**: The specific surface density for the brick is 21kg/m$^2$/cm and for glass is 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.

**(8 marks)**

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

**(6 marks)**

**Table 20.9 — Sound-Absorption Data for Common Building Materials[28-32]**

| Material | Sound-Absorption Coefficient 125 Hz | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz | 4000 Hz |
|---|---|---|---|---|---|---|
| **Walls** | | | | | | |
| Sound-reflecting: | | | | | | |
| Brick, unglazed, unpainted | 0.03 | 0.03 | 0.03 | 0.04 | 0.05 | 0.07 |
| Brick, glazed or painted | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 |
| Concrete block, painted | 0.10 | 0.05 | 0.06 | 0.07 | 0.09 | 0.08 |
| Cork on brick or concrete | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 |
| Glass, typical window | 0.35 | 0.25 | 0.18 | 0.12 | 0.07 | 0.04 |
| Gypsum board, $^1/_2$-in. paneling | 0.29 | 0.10 | 0.05 | 0.04 | 0.07 | 0.09 |
| Metal* | 0.05 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 |
| Plaster, gypsum or lime, on brick or tile | 0.01 | 0.02 | 0.02 | 0.03 | 0.04 | 0.05 |
| Plaster, gypsum or lime, on lath | 0.14 | 0.10 | 0.06 | 0.05 | 0.04 | 0.03 |
| Plywood, $^3/_8$-in. paneling | 0.28 | 0.22 | 0.17 | 0.09 | 0.10 | 0.11 |
| Wood, $^1/_4$-in. paneling, with air space behind | 0.42 | 0.21 | 0.10 | 0.08 | 0.06 | 0.06 |
| Sound-absorbing: | | | | | | |
| Concrete block, coarse, unpainted | 0.36 | 0.44 | 0.31 | 0.29 | 0.39 | 0.25 |
| Medium weight drapery, 14 oz/sq. yd., draped to half area | 0.07 | 0.31 | 0.49 | 0.75 | 0.70 | 0.60 |
| Fiberglass fabric curtain, $8^1/_2$ oz/sq. yd., draped to half area | 0.09 | 0.32 | 0.68 | 0.83 | 0.39 | 0.76 |
| Shredded wood fiberboard, 2-in. thick on concrete | 0.32 | 0.37 | 0.77 | 0.99 | 0.79 | 0.88 |
| Foams: (Acoustical open cell) | | | | | | |
| 1-in., 2 lb/cu. ft. polyester | .23 | .54 | .60 | .98 | .93 | .99 |
| 2-in., 2 lb/cu. ft. polyester | .17 | .38 | .94 | .96 | .99 | .91 |
| Glass fiber: | | | | | | |
| 1-in., 3 lb/cu. ft. | .23 | .50 | .73 | .88 | .91 | .97 |
| 1-in., 6 lb/cu. ft. | .26 | .49 | .63 | .95 | .87 | .82 |
| **Floors** | | | | | | |
| Sound-reflecting: | | | | | | |
| Concrete, terrazzo, marble or glazed tile | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| Cork, rubber, linoleum, or asphalt tile on concrete | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 |
| Wood | 0.15 | 0.11 | 0.10 | 0.07 | 0.06 | 0.07 |
| Wood parquet on concrete | 0.04 | 0.04 | 0.07 | 0.06 | 0.06 | 0.07 |
| Sound-absorbing: | | | | | | |
| Carpet, heavy, on concrete | 0.02 | 0.06 | 0.14 | 0.37 | 0.60 | 0.65 |
| Carpet, heavy, on foam rubber | 0.08 | 0.24 | 0.57 | 0.69 | 0.71 | 0.73 |
| Indoor-outdoor carpet | 0.01 | 0.05 | 0.10 | 0.20 | 0.45 | 0.65 |
| **Ceilings** | | | | | | |
| Sound-reflecting: | | | | | | |
| Concrete | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |
| Gypsum board, $^1/_2$-in. thick | 0.29 | 0.10 | 0.05 | 0.04 | 0.07 | 0.09 |
| Plaster, gypsum or lime, on lath | 0.14 | 0.10 | 0.06 | 0.05 | 0.04 | 0.03 |
| Plywood, $^3/_8$-in. thick | 0.28 | 0.22 | 0.17 | 0.09 | 0.10 | 0.11 |
| Sound-absorbing: | | | | | | |
| Suspended acoustical tile, $^3/_4$-in. thick, 16-in. air space above | 0.76 | 0.93 | 0.83 | 0.99 | 0.99 | 0.94 |
| Thin, porous sound-absorbing material, $^3/_4$-in. thick (mounted to structure) | 0.10 | 0.60 | 0.80 | 0.82 | 0.78 | 0.60 |
| Thick, porous sound-absorbing material, 2-in. thick (mounted to structure) or thin material with 1-in. air space behind | 0.38 | 0.60 | 0.78 | 0.80 | 0.78 | 0.70 |
| Sprayed cellulose fibers, 1-in. thick on concrete | 0.08 | 0.29 | 0.75 | 0.98 | 0.93 | 0.76 |
| **Air Absorption** | | | | | | |
| Air, per 1000 $m^3$–@ 50% RH | 0 | 0 | 0 | 3.0 | 7.5 | 23.6 |

*Absorption coefficients for metal were estimated by the authors of this chapter. Low frequency absorption coefficients will depend on the metal thickness.

**FORMULARS**

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

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. $p_1/\rho g + v_1^2/2g = p_2/\rho g + v_2^2/2g + 0.03\,(p_1/\rho g - p_2/\rho g)$

13. $Q = 1.84BH^{3/2}\,[(1+ \alpha\, v^2/2g\, H)^{3/2} - (\alpha\, v^2/2g\, H)^{3/2}]$

14. $k=[(1+ \alpha\, v^2/2g\, H)^{3/2} - (\alpha\, v^2/2g\, H)^{3/2}]$

15. $h= (v^2/2g)(1+ A_1/A_2)^2 = v^2/2g\,(A_1/A_2 - 1)^2$

16. $W = \sum_{i=1} \dfrac{p^{2rms(1)} S_i}{\rho C}$, where $\rho C = 420$ RAYLS.

17. $S.I.L = 10 \log_{10}(I) + 120$

18. $L_p = 10 \log (p_1/p_0)^2$ or $(p_1/p_0)^2 = 10^{Lp/10}$

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

20. $I = W/A$

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

22. $Q_1 = 1.84\ BH^{3/2}$

23. $Q = Cd\ 8/15\ \sqrt{(2g)}(\tan\square/2)H^{5/2}$

24. $\Delta Q = \dfrac{-\sum h}{2\sum h/Q}$