ME413 HW12

Benjamin Masters

TOTAL POINTS

250 / 250

QUESTION 1

1 Q1 **40 / 40**

- **- 0 pts** Correct
- **+ 1 Point adjustment**

QUESTION 2

2 Q2 **30 / 30**

- **- 0 pts** Correct
- **+ 1 Point adjustment**

QUESTION 3

3 Q3 **30 / 30**

- **- 0 pts** Correct
- **+ 1 Point adjustment**

QUESTION 4

4 Q4 **50 / 50**

- **- 0 pts** Correct
- **+ 1 Point adjustment**

QUESTION 5

5 Q5 **50 / 50**

- **- 0 pts** Correct
- **+ 1 Point adjustment**

QUESTION 6

6 Q6 **50 / 50**

- **- 0 pts** Correct
- **+ 1 Point adjustment**

1 Q1 **40 / 40**

- **- 0 pts** Correct

+ 1 Point adjustment

2 Q2 **30 / 30**

- **- 0 pts** Correct

+ 1 Point adjustment

3 Q3 **30 / 30**

- **- 0 pts** Correct

+ 1 Point adjustment

4 Q4 **50 / 50**

- **- 0 pts** Correct

+ 1 Point adjustment

5 Q5 **50 / 50**

- **- 0 pts** Correct

+ 1 Point adjustment

6 Q6 **50 / 50**

- **- 0 pts** Correct

+ 1 Point adjustment

Question 1 (40 points)

At a site on which it is proposed to build a housing estate, the noise levels arise mainly from trains on a nearby railway line. There are three types of train using the line, fast express trains, slower sub-urban trains and freight trains. It is proposed to predict the equivalent continuous noise level at the site over a 24 hour period from sample noise measurements of each of the three noise events. The results of these measurements are:

for fast trains : $L_{Aeq} = 85$ dB for 12 seconds
for slow trains: $L_{Aeq} = 78$ dB for 18 seconds
for freight trains: $L_{Aeq} = 76$ dB for 24 seconds

During the 24 hour period there are 120 fast trains, 200 slow trains and 80 freight trains.

(a) Calculate the equivalent noise level for a 24 hour period.
(b) Calculate the corresponding noise exposure level, L_{AE}.
(c) Suppose 20 of the fast trains and 30 of the slow trains and 10 of the freight trains run in the night period (10:00 pm to 7:00 am). The rest of the trains run between 7:00am and 10:00 pm, what is the equivalent L_{DN} ?

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a) $T = 24hr = 86400 sec$

$$L_{eq} = 10\log\left[\frac{120 \cdot 12 \cdot 10^{8.5} + 18 \cdot 200 \cdot 10^{7.8} + 80 \cdot 24 \cdot 10^{7.6}}{86400}\right]$$

$$\boxed{L_{eq} = 69.4 dBA}$$

b) $L_{Ae} = L_{eq} + 10\log(86400)$

$$= 69.4 + 49.4 = \boxed{118.8 dB = L_{AE}}$$

c) $$L_D = 10\log\left[\frac{100 \cdot 12 \cdot 10^{8.5} + 170 \cdot 18 \cdot 10^{7.8} + 70 \cdot 24 \cdot 10^{7.6}}{15 \cdot 3600\ s}\right]$$

$L_D = 70.7 dB$

$$L_N = 10dB + 10\log\left[\frac{20 \cdot 12 \cdot 10^{8.5} + 30 \cdot 18 \cdot 10^{7.8} + 10 \cdot 24 \cdot 10^{7.6}}{9 \cdot 3600 s}\right]$$

$L_N = 75.7 dB$

$L_{DN} = L_D \oplus L_N$

$$L_{DN} = 10\log\left(\frac{9 \cdot 10^{7.57} + 15 \cdot 10^{7.07}}{24}\right)$$

$$\boxed{L_{DN} = 73.3 dBA}$$

Question 2 (30 points)
The background noise level of 50 dB(A) in a certain workplace is sometimes interrupted by 2-minute bursts of 70 dB(A). Calculate the hourly L_{A10}, L_{A90}, L_{Aeq} values when:

(a) there are no such interruptions;
(b) there are 2 bursts every hour
(c) there are 4 bursts every hour;
(d) there are 28 bursts every hour.

Comments on whether there is any relationship between L_{A10}, L_{A90}, and L_{Aeq} in general.

a) $L_{10} = L_{eq} = L_{90} = 50\,dBA$

b) 2 at 70 dB and 28 at 50 dB

$L_{10} = 50\,dBA$ $L_{90} = 50\,dBA$ $L_{AEq} = 10\log\left(\frac{28\ 10^{50/10} + 2 \cdot 10^7}{30}\right)$

$L_{AEq} = 58.6\,dBA$

c) 4 at 70 dB 26 at 50 dB

$L_{10} = 70\,dBA$ $L_{90} = 50\,dBA$ $L_{Aeq} = 10\log\left(\frac{26 \cdot 10^5 + 4 \cdot 10^7}{30}\right)$

$L_{AEq} = 61.5\,dBA$

d) 28 at 70 dB 2 at 50 dB $L_{eq} = 10\log\left(\frac{28 \cdot 10^7 + 2 \cdot 10^5}{30}\right)$

$L_{10} = 70\,dBA$ $L_{90} = 70\,dBA$ $L_{eq} = 69.7\,dBA$

L_{Aeq} is the average over the whole time interval so it is related to L_{10} and L_{90} because they are include in the total time

Question 3 (30 points)
A two-storey building is under construction and has only the structural columns in place. A 37 kW excavator and a 3 tonne dumper are being used. The sound power level of the excavator is 108 dB(A) and that of the dumper is 94 dB(A).

Calculate the $L_{Aeq,1\ hour}$, at 1 m from the façade of a dwelling that is 43 m from the excavator and 39 m from the dumper;
(i) with only the dumper working constantly,
(ii) with both dumper and excavator working simultaneously but for 45 minutes in the hour.

$SWL_E = 108\ dB(A)$ $\quad$ $SWL_D = 94\ dB(A)$

due to façade .. increase of 6dB (so 11−6 = $\underline{5}$)

$$SPL = SWL - 5 - 20\log(r)$$

i) $L_D = 94\,dB - 5 - 20\log(39) = 57\,dBA$

$L_{Aeq} = L_D$ (since constantly running) $= \boxed{57\,dBA = L_{Aeq}}$

ii) $L_E = 108 - 5 - 20\log(43) = 70\,dBA = L_E$ and $L_D = 57\,dBA$

$$L_{AEQ} = 10\log\left(\frac{45 \cdot 10^7 + 45 \cdot 10^{5.7}}{60}\right) = 69\,dBA$$

$$\boxed{L_{Aeq} = 69\,dBA}$$

Question 4 (50 points)

Boston has commissioned the largest (to-date) and most complex infrastructure construction in the United Sates. It was known as the Central Artery/Tunnel (CA/T) project. It took nearly 10 years to define the scope of the project, 6 years to design and an estimated 12 years' construction process.

Read the article entitled "Construction noise control program and mitigation strategy at the Central Artery Tunnel," by E Thalheimer published at the Noise Control Engineering, Journal, **45**, 157-165 (2000) and answer the following questions:

(a) What are the specifications for the CA/T Construction Noise Control?
(b) What is the policy on the noise control of the project?
(c) What are the durations and noise limits specified in the specifications?
(d) What are the equipment classification as "Impact" equipment and their respective noise limit?
(e) What techniques are used for noise control? Give two examples for each technique.
(f) Explain the meaning of the window treatment cost-benefit index (windex)?
(g) List two policies for the off-site noise mitigation used in CA/T.
(h) What is greatest single source of noise complaints during the period of construction?

a) Producing environmental impact report, developing criteria for noise emission limits, operational restrictions, preventing noise issues before community is affected, developing noise mitigation programs.

b) Commitment to minimizing impact on residents while maintaining construction operations 24/7, summary of criteria for success, willingness to develop noise mitigation techniques, commitment to providing qualified noise personnel to asses levels.

c)

	Daytime L_{10}	Daytime L_{max}	Night L_{10}	Night L_{max}
residences	75 dB	85	baseline+5	80
commercial	80	none	none	none
Industrial	85	none	none	none

d) Blasting, $L_{max} = 94dB$ | Clam Shovel, $L_{max} = 93dB$
Hydra Break Ram, $L_{max} = 90dB$ | Impact Piledriver, $L_{max} = 95dB$
Jackhammer, $L_{max} = 85dB$ | Impact hammer, $L_{max} = 90dB$

e) Source Controls : Substitute method, Scheduling
Path controls : Noise barriers, noise curtains
Receptor Controls : Window treatment, Noise complaints

f) Windex requires a 10dB noise level improvement before and after treatment.

g) Noise must be adequately mitigated by source and path.
Resident must be in close proximity to the construction.

h) loud backup vehicle alarms at night.

Question 5 (50 Points)

At night a car wash has caused complaints from occupiers of the nearest dwelling which is 60 m away due east (see Figure 1(a)). Passing vehicles cause typical peak levels of 45 dB(A) at the nearest dwelling. The background level has been measured during lulls between vehicle arrivals and operation of the wash. Typical measurements of $L_{A90,5\ min.}$ are 33 dB at night. During a dry day, with a gentle south-westerly breeze, a typical value of $L_{A90,\ 5\ min.}$ is 42 dB. The owners wish to replace the car wash with a new model in a slightly different location 75 m from the nearest dwelling. The operating cycle of the new car wash is 30 minutes long and consists of two distinct phases: a washing phase lasting 14 minutes and a drying phase which lasts for 16 minutes.

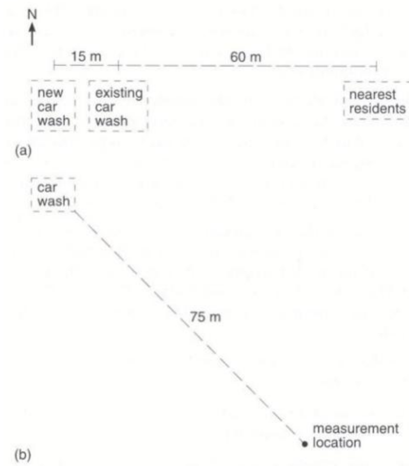

Figure 1: Sketch for Question 5

Measurements have been made at an equivalent source at another site (see Figure 1(b) below) 75 m south east of the source during a gentle westerly breeze and dry conditions at night when the background level (L_{A90}) is 29 dB(A). The sound level measured during the drying phase is a steady 38 dB(A). During the washing phase the level is highly variable with irregular clunks and clicks. Equivalent continuous level measurements made with an integrating sound level meter having an analogue read-out show that the needle becomes steady at 43 dB(A) after 4 minutes and remained at this value while the measurement was continued for 10 minutes. Measurements of the equivalent continuous level from the washing phase have been repeated over three cycles and have given 43 dB(A) after four minutes each time.

Question A

Give an appraisal of the situation and the character of the source noise and the ambient noise with and without the source operating.

Question B

Define residual noise and background noise and distinguish between them in this case.

Question C

Calculate specific noise level and the Rating Level and make an assessment of the noise from the new car wash in the location of interest at night. Set out your answer in the way used for the worked examples, making explicit any assumptions that you have made.

A) The noise is intermittent, unclear if there is tonal component. Noise level seems constant within each phase of wash cycle. With 5dB variation between phases. 4min time intervals, 3 measurements of each cycle. Ambient noise is quiet, except for passing cars.

B) Residual noise is the ambient noise at the location. Background noise is the noise level if the source is not in operation. Background noise in this case would not include passing cars, but residual noise would.

C) $L_{A90} = 29$ dB(A) $\quad L_D = 38$ dBA [16 min] $\quad L_W = 43$ dB [14 min]

Over the 30 minutes: $L_{Aeq} = 10\log\left[\frac{16\cdot 10^{3.8} + 14\cdot 10^{4.3}}{30}\right]$

$L_{AEQ} = 41$ dBA Since $L_{AEQ} - L_{A90} > 9$ correction $= 0$

Correction of $+5$ dB due to non continous operation as an irregularity

Rating level $= L_{Aeq} + 5\,dBA = \boxed{46\,dBA = \text{Rating level}}$

Since Rating level − Background is

$46\,dBA - 29\,dBA = 17\,dBA$

Complaints are very likely

Question 6 (50 points)
Read the extracts from an article by a consultant, R.D. Bines, see Appendix. After you have read the article and thought about its contents answer the following Questions.
(a) What did the consultant gain by measuring octave band levels from each of the contributory sources? Comment on the octave band analysis.
(b) What factors contributed to the consultant's decision to implement the 5 dB correction for the character of the noise being assessed?
(c) What background level did the consultant use in his assessment and what was his justification for so doing?
(d) In his article, the consultant does not specify his final BS4142 assessment for this plant nor the amount of noise reduction that he advised his clients to achieve. On the basis of the information given, (i) make your own BS4142 assessment of the likelihood of complaints, (ii) offer advice on what sources to control and by how much?

a) The octave band analysis allows for easier finding of pure tones, which are known to be particularly noisy and annoying. For example, a pure tone was found in the 250Hz octave band analysis of the Booster pump.

b) The 5dB correction was added to the air compressors due to a significant variation in noise due to an on demand pressure switch.

c) Due to no measurements being available of background noise before the opening of the new bypass. So the consultant considered the provisions of the BATNEEC system to make his determination. He used the components that run throughout the year such as the cooling towers, as part of the background noise level.

d) By looking at the table, and including cooling towers as background noise it can be seen that noise reduction needs to take place in the fast cooling towers, specifically in the 63-500 Hz octave bands, due to being much higher than that component A rated level, these are likely to cause complaints, reduction of 5-10dB needs to happen.