ME413 HW 11

Benjamin Masters

TOTAL POINTS

100 / 100

QUESTION 1

1 Q1 **25 / 25**

- **0 pts** Correct

+ **1 Point adjustment**

QUESTION 2

2 Q2 **25 / 25**

- **0 pts** Correct

+ **1 Point adjustment**

QUESTION 3

3 Q3 **25 / 25**

- **0 pts** Correct

+ **1 Point adjustment**

QUESTION 4

4 Q4 **25 / 25**

- **0 pts** Correct

+ **1 Point adjustment**

gradescope

1 Q1 **25 / 25**

- **0 pts** Correct

+ **1 Point adjustment**

gradescope

2 Q2 25 / 25

- **0 pts** Correct

+ **1 Point adjustment**

gradescope

3 Q3 25 / 25

- **0 pts** Correct

+ **1 Point adjustment**

gradescope

4 Q4 25 / 25

- **0 pts** Correct

+ **1 Point adjustment**

gradescope

Ben Masters

Question 1 (25 points)
Explain in your own words (use diagrams if appropriate) the following terms:
(a) (i) Aural reflect and (ii) the mechanism in reducing the impact of intense noise levels higher than 140 dB.
(b) (i) Presbycusis, (ii) & (iii) temporary and permanent threshold shift.
(c) What is the difference between Minimum Audible Field (MAF) and Minimum Audible Pressure in audibility tests?
(d) List other non-acoustical factors that may be used to improve speech intelligibility in a noisy environment.

a)

i) aural reflect is a mechanism that exists to decrease the transmission of energy from the tympanic membrane to the cochlea. ii) this mechanism works by stiffening the muscles in the ossicles to decrease transmission efficiency, they also move side to side instead.

b) Presbycusis is hearing loss that occurs with age due to the cilia closest to the oval window experiencing more deflection over time than the others. For this reason it usually occurs in the higher frequencies first.

ii) Temporary threshold shift is a non-permanent change in intensity that can be heard.

iii) Permanent threshold shift is permanent change in the lowest intensity signal that can be identified by someone.

c) MAF uses speakers to measure audibility.
MAP uses headphones to measure audibility.

d) Limiting vocabulary used and being able to see peoples facial expressions and mouth movements.

Question 2 (25 points)

An octave band analysis of a machine yields the following results:

Band Center Frequency (Hz)	SPL (dB)	dB(A)	dB(B)	dB(C)
31.5	80	40.6	62.9	77
63	76	49.8	66.7	75.2
125	77	60.9	72.8	76.8
250	72	63.4	70.7	72
500	69	65.8	68.7	69
1000	92	92	92	92
2000	83	84.2	82.9	82.8
4000	80	81	79.3	79.2
8000	78	76.9	75.1	75

(a) Find the total A-weighted, B-weighted, C-weighted sound levels. What is the overall SPL?

(b) Use ISO Method A to determine the total loudness level for the octave bands levels.

a) $dB(A)_{tot}$ = log sum of dB(A) column

$$L_A = 10\log\left(10^{4.06} + 10^{4.98} + 10^{6.09} + 10^{6.34} + 10^{6.58} + 10^{9.2} + 10^{8.42} + 10^{8.1} + 10^{7.69}\right)$$

$$L_A = 93 \text{ dBA}$$

$$L_B = 10\log\left(10^{6.29} + 10^{6.67} + 10^{7.28} + 10^{7.07} + 10^{6.87} + 10^{9.2} + 10^{8.29} + 10^{7.93} + 10^{7.51}\right)$$

$$L_B = 92.8 \text{ dB}$$

L_C = same formula as before $\therefore$ $L_C = 93.1$ dB

b)

Band Center Frequency (Hz)	SPL (dB)	index
31.5	80	4.3
63	76	5.0
125	77	7.8
250	72	7.0
500	69	7.0
1000	92	38
2000	83	24.7
4000	80	24.7
8000	78	26.5

$k = .3$

$I_{max} = 38$

$$I_t = 38 + (0.3)\left[4.3 + 5.0 + 7.8 + 7.0 + 7.0 + 24.7 + 24.7 + 26.5\right]$$

$$I_t = 70.1$$

Question 3 (25 points)
Given a 65 dB tone at 40 Hz, a 65 dB tone at 300 Hz, and a 65 dB tone at 4 kHz,

(a) Estimate the loudness and loudness level of each tone.
(b) Which tone is louder to the human ear?
(c) How many times louder is the loudest tone perceived compared to the other two tones?
(d) Calculate the loudness and loudness level of the three tones combined.

a) Using loudness contours

$L_{40} \approx 30$ Phon $L_{300} \approx 68$ Phon

$L_{4k} \approx 75$ Phon

$S_{40} = 2^{((30-40)/10)} = 0.5$ Sone $= S_{40}$

$S_{300} = 2^{((68-40)/10)} = 6.96$ Sone $= S_{300}$

$S_{4k} = 2^{((75-40)/10)} = 11.3$ Sone $= S_{4k}$

b) 4000Hz is the loudest to human ears.

c) $11.3/6.96 = 1.6$ times louder than 300Hz

$11.3/.5 = 22.6$ times louder than 40Hz

d) Adding Sone, since linear

$S_{total} = 11.3 + 6.96 + .5 = 18.8$ Sone $= S_t$

$P_t = 33.3 \log(18.8) + 40 = 82.43$ Phone $= P_t$

Question 4 (25 points)
In a workshop, the following one-third background noise levels have been recorded:

a)

Center Frequency/Hz	Noise Level/dB	dBA
200	42	31.1
250	39	30.4
315	44	37.4
400	46	41.2
500	48	44.8
630	38	36.1
800	30	29.2
1000	26	26
1250	20	20.6
1600	23	24
2000	18	19.2
2500	15	16.3
3150	14	15.2
4000	10	11
5000	10	10.5

(a) What is the A-weighted background noise levels?
(b) What is the preferred speech interference level (PSIL) in the workshop?
(c) Due to the operation of a machine in the workshop, the PSIL has now been increased to 60 dB. (i) Would communication between the speaker (with the normal voice) and listener be possible if they are separated by a distance of 4 ft? (ii) Estimate the maximum separation between them if the speaker uses very loud voice in their communication.
(d) Find the articulation index for a male speaker at a normal level 1 m from a listener in the workshop.

b) finding noise level in 500, 1000, 2000 1/1 bands

500: $L_{500} = 10\log(10^{46/10} + 10^{48/10} + 10^{38/10}) = 50.58\,dB$

1000: $L_{1K} = 10\log(10^{30/10} + 10^{26/10} + 10^{20/10}) = 31.8\,dB$

2000: $L_{2K} = 10\log(10^{22/10} + 10^{18/10} + 10^{15/10}) = 24.7\,dB$

$PSIL = (50.58 + 31.8 + 24.7)/3 = \boxed{35.6\,dB = PSIL}$

c) Yes it would be possible, it would be about equal to the expected voice level.
ii) The max distance would be about 12ft.

d)

Center Frequency/Hz	Noise Level/dB
200	42
250	39
315	44
400	46
500	48
630	38
800	30
1000	26
1250	20
1600	23
2000	18
2500	15
3150	14
4000	10
5000	10

Center Frequency (Hz)	Speech Level (+12 dB)	Weighting factor
200	67	4
250	68	10
315	69	10
400	70	14
500	68	14
630	66	20
800	65	20
1000	64	24
1250	62	30
1600	60	37
2000	59	37
2500	57	34
3150	55	34
4000	53	24
5000	51	20

SIL − N

200: 67 − 42 = 25
250: 68 − 39 = 29
315: 69 − 44 = 25
400: 70 − 46 = 24
500: 68 − 48 = 20
630: 66 − 38 = 28
800: 65 − 30 = 35 ⇒ 30
1000: 64 − 26 = 38 ⇒ 30
1250: 62 − 20 = 42 ⇒ 30
1600: 60 − 23 = 37 ⇒ 30
2000: 59 − 18 = 41 ⇒ 30
2500: 57 − 15 = 42 ⇒ 30
3150: 55 − 14 = 41 ⇒ 30
4000: 53 − 10 = 43 ⇒ 30
5000: 51 − 10 = 41 ⇒ 30

W.F. · Diff:

$25.4 + 29.10 + 26.10 + 24.14 + 20.14 + 26.20 + 30.20 + 30.24 + 30.30 + 30.37 + 30.37 + 30.34 + 30.34 + 30.24 + 30.20 = 961.6$

$\text{Articulation index} = \frac{961.6}{1000} \times 100\% = \boxed{96.16\%}$