ME413 HW 09

Benjamin Masters

TOTAL POINTS

150 / 160

QUESTION 1

1 1 **30 / 30**

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

QUESTION 2

2 2 **30 / 30**

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

QUESTION 3

3 3 **15 / 20**

- **- 0 pts** Correct
- **- 5 Point adjustment**

  please also give the calculation results

QUESTION 4

4 4 **20 / 20**

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

QUESTION 5

5 5 **20 / 20**

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

QUESTION 6

6 6 **20 / 20**

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

QUESTION 7

7 7 **15 / 20**

- **- 0 pts** Correct
- **- 5 Point adjustment**

1 1 **30 / 30**

- **- 0 pts** Correct

+ **+ 1 Point adjustment**

2 2 **30 / 30**

- **- 0 pts** Correct

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3 3 **15 / 20**

- **0 pts** Correct

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please also give the calculation results

4 4 **20** / **20**

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- **- 0 pts** Correct

+ 1 Point adjustment

7 7 **15 / 20**

- **- 0 pts** Correct

- 5 Point adjustment

Question 1 (30 points)

(a) Name three key elements for noise control. Discuss briefly the main strategy in each of these three elements.

(b) When air flows past an object, a pure tone can be produced at a certain frequency. Briefly explain reasons for its generation and give an example for its reduction.

(c) Briefly explain the formation of jet noise and give an example for reducing it.

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a)
Three key elements:

Source: reducing the noise before it is created (flow/vibration)

Propogation: reducing the spread of the noise (absorption/isolation)

Reception: reducing the noise level before it is heard (hearing protection)

b) The tone is caused by a regular vortex coming off the object, adding turbulence can reduce this.

c) Jet noise comes from the difference between outlet and ambient velocities generating turbulance. It can be reduced by introducing a lower speed air stream before the outlet.

Question 2 (Factory Noise – 30 points)

(a) Estimate the sound power of a "quiet" 100-hp electric motor operating at 1200 rpm.

Noise Source	Conversion Factor F_n Low	Midrange	High
Compressors, air (1–100 hp)	3×10^{-7}	5.3×10^{-7}	1×10^{6}
Gear trains	1.5×10^{-8}	5×10^{-7}	1.4×10^{-6}
Engines, diesels	2×10^{-7}	5×10^{-7}	2.5×10^{-6}
Motors, electric (1200 rpm)	1×10^{-8}	1×10^{-7}	3×10^{-7}
Pumps, >1600 rpm	3.5×10^{-6}	1.4×10^{-5}	5×10^{-5}
Pumps, <1600 rpm	1.1×10^{-6}	4.4×10^{-6}	1.6×10^{-5}
Turbines, gas	2×10^{-6}	5×10^{-6}	5×10^{-5}

(b) Consider a radial forward-curved fan with 24 blades, having a rotor diameter of 0.8 m, and operating at 750 rpm with a volume flow rate of 18 m3/s and with a total pressure of 1.5 kPa. Find the total sound power at the inlet.

(c) Find the frequency of the blade rate component of a diffuser-type compressor with N_r = 16 and N_s = 24 and operating speed of 6000 rpm.

a) using $F_n = 1 \times 10^{-8}$

$$P = 1\times10^{-8} \cdot 100\,hp \cdot 746 \frac{W}{hp} = 7.46\times10^{-4}\ W$$

$$L_W = 10\log\left(7.46\times10^{-4}\ W / 1\times10^{-12}\ W\right) = \boxed{88.7\,dB = L_W}$$

b) $$f_B = \frac{nN}{60} = \frac{750\,rpm \cdot 24\,blades}{60} = 300\ Hz$$

$250 \cdot \sqrt{2} = 353$ so 300Hz is in 250Hz Octave band

$L_{p,s} = 88$ $\quad \Delta = 10\log(18\,m^3/s) + 20\log(1500\,Pa) = 76\,dB$

$B.F.I = 2\,dB$ $\quad \Delta + B.F.I. = 78\,dB$

since looking at outlet $L_p = 78\,dB - 3\,dB$ $\boxed{L_p = 75\,dB}$

c) $$f_{BRC} = \frac{16 \cdot 24 \cdot 6000\,rpm}{60 \cdot 8} = \boxed{4800\,rpm = f_{BRC}}$$

Question 3 (20 points)
It is known that the preferred 1/1 center octave band frequencies are 31.5, 63, 125, 250, 500, 1000, 2000, 4000, 8000, 16,000 Hz.

(a) Determine the bandwidths of each of these 1/1 frequency bands.
(b) Based on the 1/1 center band frequencies, what are the corresponding center frequency for the one-third octave bands?
(c) What are the corresponding bandwidths for each of these one-third octave bands?

a) $B.W. = \sqrt{2} f - f/\sqrt{2} = f\left(\sqrt{2} - \left(1/\sqrt{2}\right)\right) = .707$

$31.5 \cdot .707 = \boxed{22.3\,Hz}$ $\quad 63 \cdot .707 = \boxed{44.54\,Hz}$ $\quad 125 \cdot .707 = \boxed{88.375\,Hz}$

$250 \cdot .707 = \boxed{176.75\,Hz}$ $\quad 500 \cdot .707 = \boxed{353.5\,Hz}$ $\quad 1000 \cdot .707 = \boxed{707\,Hz}$

$2000 \cdot .707 = \boxed{1414\,Hz}$ $\quad 4000 \cdot .707 = \boxed{2828\,Hz}$ $\quad 8000 \cdot .707 = \boxed{5656\,Hz}$

$16000 \cdot .707 = \boxed{11312\,Hz}$

b) $f_{c_1} = f_c / 2^{(1/3)}$

$f_{c2} = f_c$

$f_{c3} = f_c \cdot 2^{(1/3)}$

c) $\Delta f_1 = f_{c_1} \cdot \left(\sqrt{2} - 1/\sqrt{2}\right) \cdot 1/3$

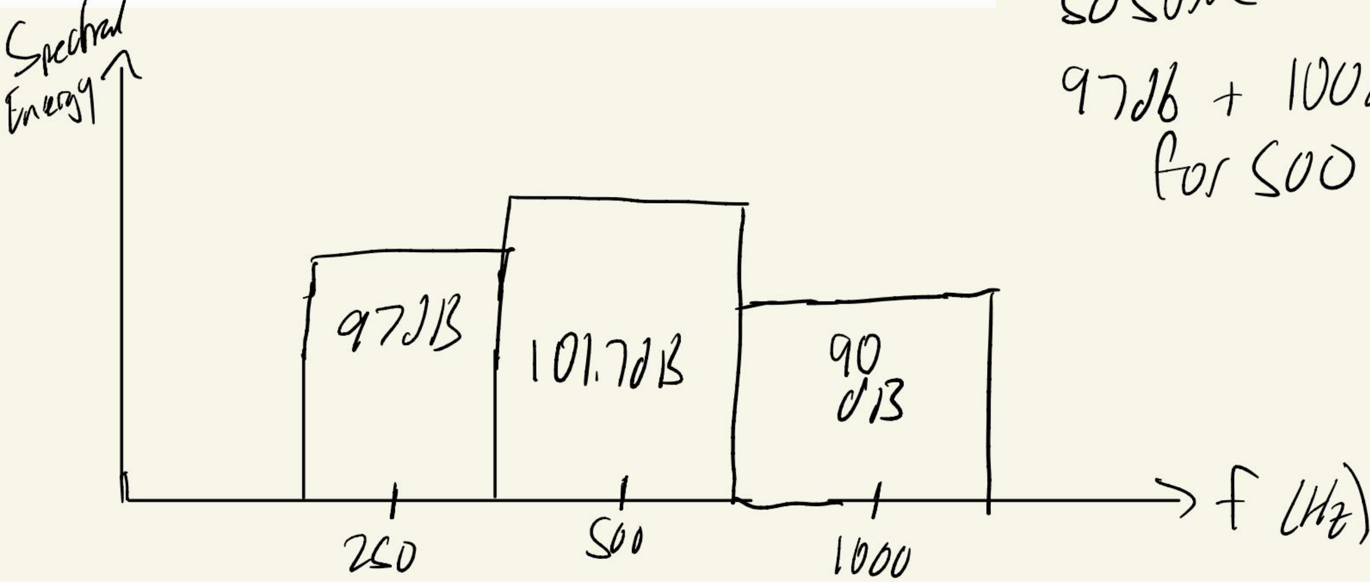
$\Delta f_2 = f_{c2} \cdot \left(\sqrt{2} - 1/\sqrt{2}\right) \cdot 1/3$

$\Delta f_3 = f_{c3} \cdot \left(\sqrt{2} - 1/\sqrt{2}\right) \cdot 1/3$

Question 4 (20 points)
Draw the 250, 500 and 1000 Hz octave band sound pressure levels of a noise source that produces three discrete pure tones, one at 1 kHz having a sound pressure level of 90 dB, one at 353 Hz having a sound pressure level of 100 dB and one at 600 Hz have a sound pressure level of 97 dB.

Explain, in your words, the three pases of data analysis.

353 in both 250 and 500 so sum 97db + 100dB for 500



$$10\log\left(10^{97/10} + 10^{100/10}\right) = 101.7\text{dB}$$

Data Analysis Phases:

1. Collection of data
2. Processing: transforming the data into a useful form
3. Interpretation: extracting meaningful information from the data.

Question 5 (20 points)
A gas furnace produces a uniform spectral density level of 90 dB on a power spectral density plot. Estimate the band sound level of the 1 kHz octave band and each of the 1/3 octave bands within the 1 kHz octave band.

In the classification of random noise data, explain the difference between stationary and non-stationary data.

$$\Delta f_{ref} = 1000\left(\sqrt{2} - 1/\sqrt{2}\right)$$
$$\Delta f_{ref} = 707.1 Hz$$

$$L_{SL} = 90 dB$$

$$L_B = L_{SL} + 10\log(\Delta f) = 90 dB + 10\log(707.1 Hz)$$
$$L_B = 90 dB + 28.5 = \boxed{118.5 dB = L_B}$$

1/3 octave bands of 1kHz: $\Delta f = \frac{707.1 Hz}{3} = 235.7 Hz$

$$118.5 dB + 10\log(235.7/707.1) = \boxed{113.7 dB = L_{B\,1/3}}$$

In stationary data the mean square value is independent from time.
In non-stationary the mean square changes as a function of time.

Question 6 (20 points)
A particular noise consists of a broadband component having a constant band level of 50 dB from 100 Hz to 10 kHz (there is no significant energy outside this band). In addition to the broadband component, there are also contributions from two pure tones: one at 360 Hz with a level of 75 dB and one at 720 Hz with a level of 78 dB. Estimate the 250, 500, and 1000 Hz octave band sound pressure levels.

$\Delta f_1 = 9900 Hz$

$L_B = 50 dB$ $\quad$ $100 Hz \rightarrow 10 kHz$

75dB at 360Hz and 78dB at 720Hz

$250 Hz: L_{B250} = 50 dB + 10\log(176.75/9900)$

$\Delta f_{250} = 250(.707) = 176.75$; $\boxed{L_{B250} = 32.52 dB}$

360Hz is in 500Hz band

$L_5 = 50 dB + 10\log(353.5/9900) = 35.52 dB$

$L_{B500} = 10\log(10^{35.52/10} + 10^{75/10}) = \boxed{75 dB = L_{B500}}$

$L_{10} = 50 dB + 10\log(707.1/9900) = 38.52 dB$

$L_{B1k} = 10\log(10^{38.52/10} + 10^{78/10}) = \boxed{78 dB = L_{B1k}}$

Question 7 (20 points)
Pink noise has a constant level when measured on octave bands or fractional octave bands. Find the overall sound pressure level of pink noise if the level in the 500 Hz octave bands is 85 dB. You may consider octave bands varying from 32 Hz to 16 kHz.

$$\Delta f = 16000 - 32 = 15968\ Hz$$

$$\Delta f_{500} = 353.5\ Hz$$

$$L_{BB} = 85dB + 10\log\left(15968/353.5\right) = 250.5dB$$