ME413 HW 08

Benjamin Masters

TOTAL POINTS

95 / 100

QUESTION 1

1 Q1 **25 / 30**

- **0 pts** Correct

- **5 Point adjustment**

QUESTION 2

2 Q2 **40 / 40**

- **0 pts** Correct

+ **1 Point adjustment**

QUESTION 3

3 Q3 **30 / 30**

- **0 pts** Correct

+ **1 Point adjustment**

1 Q1 **25 / 30**

- **0 pts** Correct

- **5** **Point adjustment**

2 Q2 40 / 40

- **0 pts** Correct

+ **1 Point adjustment**

3 Q3 30 / 30

- **0 pts** Correct

+ **1** **Point adjustment**

Question 1 (30 points)

Suppose that at an open-air concert the sound is radiated from an arrangement of loudspeakers. At a distance of 8 m from the speakers the noise level is a stimulating 105 (SPL). What is the mean power output of the speakers? You may assume all sound waves incident on the ground are absorbed and that the sound field is omni-directional, *i.e.* the same in all direction. Take the acoustic impedance, ρc to be 413 rayls. You may also assume the sound radiated from the loudspeakers may be treated as plane waves, i.e. the pressure (rms) and particle velocity (rms) are related by $p_{rms} = \rho c u_{rms}$.

Benjamin Masters

$r = 8m \quad L_p = 105\,dB \quad \rho c = 413\,rayls$

$\bar{W} = ?$ $\quad p^2 = 10^{105/10} \cdot (2\times10^{-5}\,Pa)^2 \Rightarrow P_{rms} = 3.56\,Pa$

$W = \bar{P}^2 \cdot A / z \;;\; z = 413\,rayls \quad A = 4\pi(8)^2 = 804.25\,m^2$

$\bar{P} = \sqrt{2} \cdot P_{rms} = 5.03\,Pa$

$$\bar{W} = \frac{(5.03\,Pa)^2 \cdot 804.25\,m^2}{413\,Rayls} = \boxed{49.27\,W = \bar{W}}$$

Question 2 (40 points)

The sound pressure level of a noise source is measured on a hard asphalt car park (empty of cars) outdoors. The sound pressure level measured at 3 m is 70 dB.

(a) What is the sound power level?

(b) What is its sound pressure level if the noise source is measured at 1 m from the source in an anechoic chamber (free space)?

(c) If the source is now placed behind a tall building above a hard ground, what is the corresponding sound power level of the source?

a) $L_p = 70\,dB$ $r = 3m$ $-3dB$ from ground

free space assumption:

$L_{wf} = L_p + 11 + 20\log(r) = 81 + 20\log(3) = 90.54\,dB$

knowing hard ground, $w' = 2w \Rightarrow \Delta W = +3dB$

so $L_w = 93.54\,dB$

b) $L_p = 90.54\,dB - 11\,dB - 20\log(1) = 79.54\,dB = L_p$

c) knowing 2^n $n = 2$ $10\log(4w/w) = 10\log 4 = 6\,dB$

so $L_w = 96.54\,dB$

Question 3 (30 points)

Back to the Krakatoa volcanic eruption question again. Suppose the sound pressure level was measured to be 180 dB at 1 km from the volcano. Using the linear acoustics/continuum mechanics for modeling the propagation of sound,

(a) estimate the radiated sound power and the sound power level of the volcanic eruption.

(b) Calculate the sound pressure level of the eruption sound waves arriving at Hawaii and continental US at (San Diego). You may take Hawaii and San Diego to be located at about 6000 and 13600 miles, respectively, from Krakatoa?

(c) Do you think the eruption sound can be heard by the residences living in Hawaii and San Diego? Give your reasons.

$6000mi = 9656km$

$13600mi = 21887km$

$L_p = 180\,dB$ at $r = 1000m$

$L_w = 180\,dB + 11\,dB + 20\log(1000m) = \boxed{251\,dB = L_w}$

$L_w = 10\log(W/W_{ref}) \Rightarrow 10^{L_w/10} \cdot W_{ref} = W$

$10^{251/10} \cdot 1\times10^{-12}\,W = \boxed{W = 1.26\times10^{13}\,W}$

b) Hawaii: $L_{pH} = 251\,dB - 11 - 20\log(9656\times10^3\,m)$

$\boxed{L_{pH} = 100.3\,dB}$

SD: $L_{pSD} = 251\,dB - 11 - 20\log(21887\times10^3\,m)$

$\boxed{L_{pSD} = 93.2\,dB}$

c) Using assumptions of linear acoustics it should have been heard by the residents. However I do not think this assumption is realistic due to the difference from the mean free path of air. So I do not think the residents in either place could hear the eruption.