(TW.L3.4-212.sols) 212 Mastery Stage Solutions

Tuesday, February 18, 2020 6:01 PM

TW.L3.4 | Energy and Intensity, Sound Intensity Level | Challenge Homework

Submit a digital copy (PDF, jpg, etc.) to gradescope.com. Every page should be labeled on the top left with the question code (e.g. GR.L1.4-01) and there should be only be one solution per page. The questions should be in order. If a solution takes more than one page, be sure to label that it is a continuation of the previous page's solution (e.g. GR.L1.4-01 continued). One question will be randomly selected and graded. Challenge homework for a given week are due the following week by Tuesday at midnight. If data is needed to complete a problem, be sure to cite the source you've acquired your data from. See the course website for further details.

You will be asked to apply sense-making in most problems. Use the list below as a reference to the different sense-making techniques. More information about sense-making can be found on the BoxSand menu under Math Tools => Sense-making.

- *Sign:* Check the **sign** of each quantity makes sense.
- *Dimensionality:* Check the **dimensionality** and units of each quantity makes sense.
- *Order of Magnitude:* Check the **order of magnitude** of the final answer and other important quantities is within a a factor of 10 of what you think it should be.
- *Graphical Analysis:* Use a **graph** to see if the behavior of a solution makes sense.
- *Proportionality:* Using a symbolic solution, check the behavior of the answer when you change a given quantity on which it is dependent. Does the answer vary **proportionally** to what you expect?
- *Special Cases:* Check the behavior of a derived equation in limiting (**special**) cases makes sense, e.g. as x goes to 90 degrees in sin(x).
- *Self-consistency:* Check derived equations, functions, or values, are **self-consistent**, e.g. check that the slope of a derived position plot matches the values of the given velocity plot
- *Known Values:* Compare given or derived quantities with common well **known values**.
- *Related Quantities:* Compare the relative magnitude of two **related quantities**.

TW.L3.4-01

You are convinced the opera is almost over because of the large woman singing a loud vibrato.

(a) If the sound intensity level (dB) increases from one note to the next by 1 dB, what is the percent increase in the intensity?

(b) The singer comes over to your side of the stage, only 10 m away, and your phone applet tells you the sound intensity level is 85 dB. What is the power coming from her voice?

(c) All of a sudden 4 more identical women come out of nowhere and join her – you think to yourself, will it ever end. Three of them are standing next to her and the forth is on the other side of the stage, twice as far away from you as the group of singers. What is the sound intensity level now?

a) $\Delta\beta = 1 \text{ dB}$

$$\Delta\beta = 10\left(\log_{10}\left(\frac{I_f}{I_0}\right) - \log\left(\frac{I_i}{I_0}\right)\right)$$

$$\Delta\beta = 10\log_{10}\left(\frac{I_f}{I_i}\right)$$

$$1 = 10\log_{10}\left(\frac{I_f}{I_i}\right)$$

$$\frac{1}{10} = \log_{10}\left(\frac{I_f}{I_i}\right)$$

$$10^{1/10} = \frac{I_f}{I_i}$$

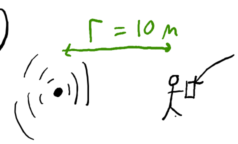
$$I_f = 10^{1/10} I_i$$

$$\% \text{ INCREASE} = \frac{\text{FINAL} - \text{INITIAL}}{\text{INITIAL}} \times 100$$

$$\% \text{ INCREASE} = \frac{10^{1/10} I_i - I_i}{I_i} \times 100$$

$$\boxed{\% \text{ INCREASE} \approx 25.9\%}$$

b)



$\beta = 85 \text{ dB}$

$$\beta = 10\log_{10}\left(\frac{I}{I_0}\right)$$

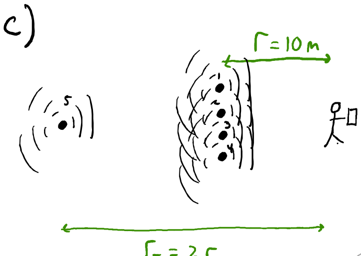
$$\beta = 10\log_{10}\left(\frac{P}{A I_0}\right)$$

$$\frac{\beta}{10} = \log_{10}\left(\frac{P}{4\pi r^2 I_0}\right)$$

$$10^{\beta/10} = \frac{P}{4\pi r^2 I_0}$$

$$P = 4\pi r^2 I_0 10^{\beta/10} \approx \boxed{0.397 \text{ W}}$$

c)



$$\beta = 10\log_{10}\left(\frac{\Sigma I}{I_0}\right)$$

$$\Sigma I = I_1 + I_2 + I_3 + I_4 + I_5$$

* $r_1 = r_2 = r_3 = r_4 \equiv r$

$P_1 = P_2 = P_3 = P_4 = P_5 \equiv P$

$$\Sigma I = \frac{P}{\pi r^2} + \frac{P}{4\pi(2r)^2}$$

$$\Sigma I = \frac{17P}{16\pi r^2}$$

$$\beta = 10\log_{10}\left(\frac{17P}{16\pi r^2 I_0}\right) \approx \boxed{91.3 \text{ dB}}$$

$$\beta = 10\log_{10}\left(\frac{I}{I_0}\right)$$

$$\beta = 10\log_{10}\left(\frac{17P}{16\pi r^2 I_0}\right) \approx \boxed{91.3 \text{ dB}}$$

$$\Sigma I = I_1 + I_2 + I_3 + I_4 + I_5$$

SEE *

$$\Sigma I = \frac{P_1}{A_1} + \frac{P_2}{A_2} + \frac{P_3}{A_3} + \frac{P_4}{A_4} + \frac{P_5}{A_5}$$

$$\Sigma I = \frac{4P}{4\pi r^2} + \frac{P}{4\pi r_5^2}$$