Homework 3 Solutions

1) The bass frequency needs to be twice the intensity of the higher frequencies:

$$I_B = 2I_H$$

$$10\log\left(\frac{I_B}{I_0}\right) = 10\log\left(\frac{2I_H}{I_0}\right) = \underbrace{10\log(2)}_{\text{The correction is this term,}} + 10\log\left(\frac{I_H}{I_0}\right)$$

$10\log(2) = \boxed{3.01\ dB}$

* We have used the log rule $\log_a(x\cdot y) = \log_a(x) + \log_a(y)$

2) $I_{ipod} = 100$ dB (in decibels)

$$10\log\left(\frac{I_{ipod}}{I_0}\right) = 100\ dB$$

$$\log\frac{I_{ipod}}{I_0} = 10$$

$$\frac{I_{ipod}}{10^{-12}\ W/m^2} = 10^{10}$$

$$I_{ipod} = (10^{10})(10^{-12}) = 10^{-2}\ W/m^2$$

$I_{concert} = 120$ (in decibels)

$$\frac{I_{concert}}{10^{-12}\ W/m^2} = 10^{12}$$

$$I_{concert} = 1\ W/m^2$$

The concert produces 100 times as much power as the iPod, so you would need 100 iPods to produce the same amount of power.

3)

$$\text{Intensity} = \frac{\text{Power}}{\text{Area}} = \frac{P}{4\pi r^2}$$

Intensity is proportional to $\frac{1}{r^2}$, so $\frac{1}{(2r)^2} = \frac{1}{4}\frac{1}{r^2} \Rightarrow \frac{I}{4}$

$$10\log\left(\frac{I/4}{I_0}\right) = 10\log\left(\frac{1}{4}\cdot\frac{I}{I_0}\right) = \underbrace{10\log\left(\frac{1}{4}\right)}_{\text{This term is } -6.02\ dB} + 10\log\left(\frac{I}{I_0}\right)$$

As the distance doubles, the intensity decreases by 6.02 dB

4)a) Using the results from #3, $80\ dB - 6.02\ dB \approx 74\ dB$

Alice measures the sound intensity level as $\boxed{74\ dB}$

b) No, according to our math, no matter what intensity Bob measures, Alice will always measure 6.02dBless. This has to do with the rules of logarithms and the way the deciBel scale is set up.