Physics 115 Lecture 18

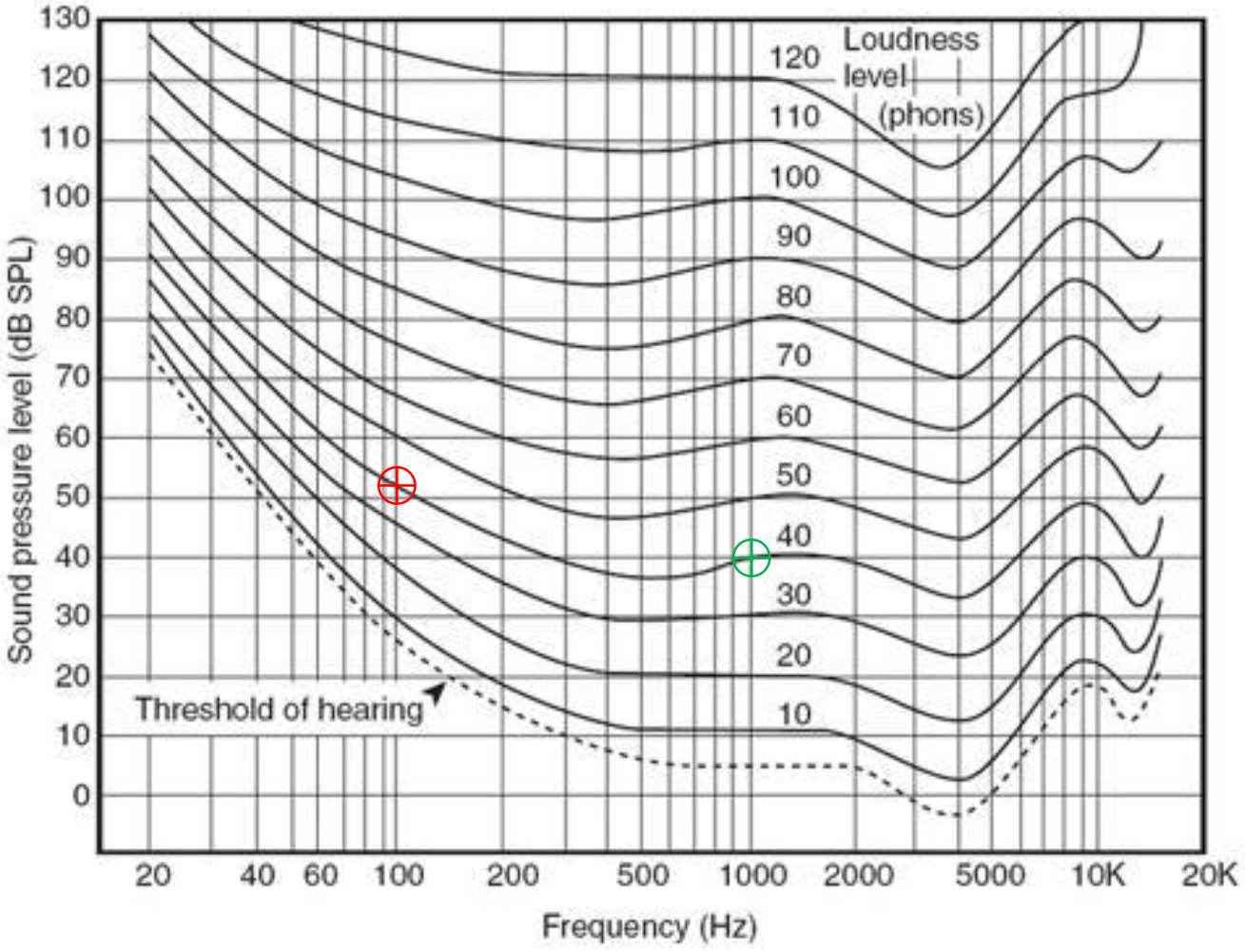
Decibels part III

March 6, 2018

Human Hearing and decibels

- Our perception of loudness depends on frequency

A 52-dB sound at 100 Hz has 16 times the intensity of a 40-dB sound at 1000 Hz, but the human ear perceives them to have the same loudness

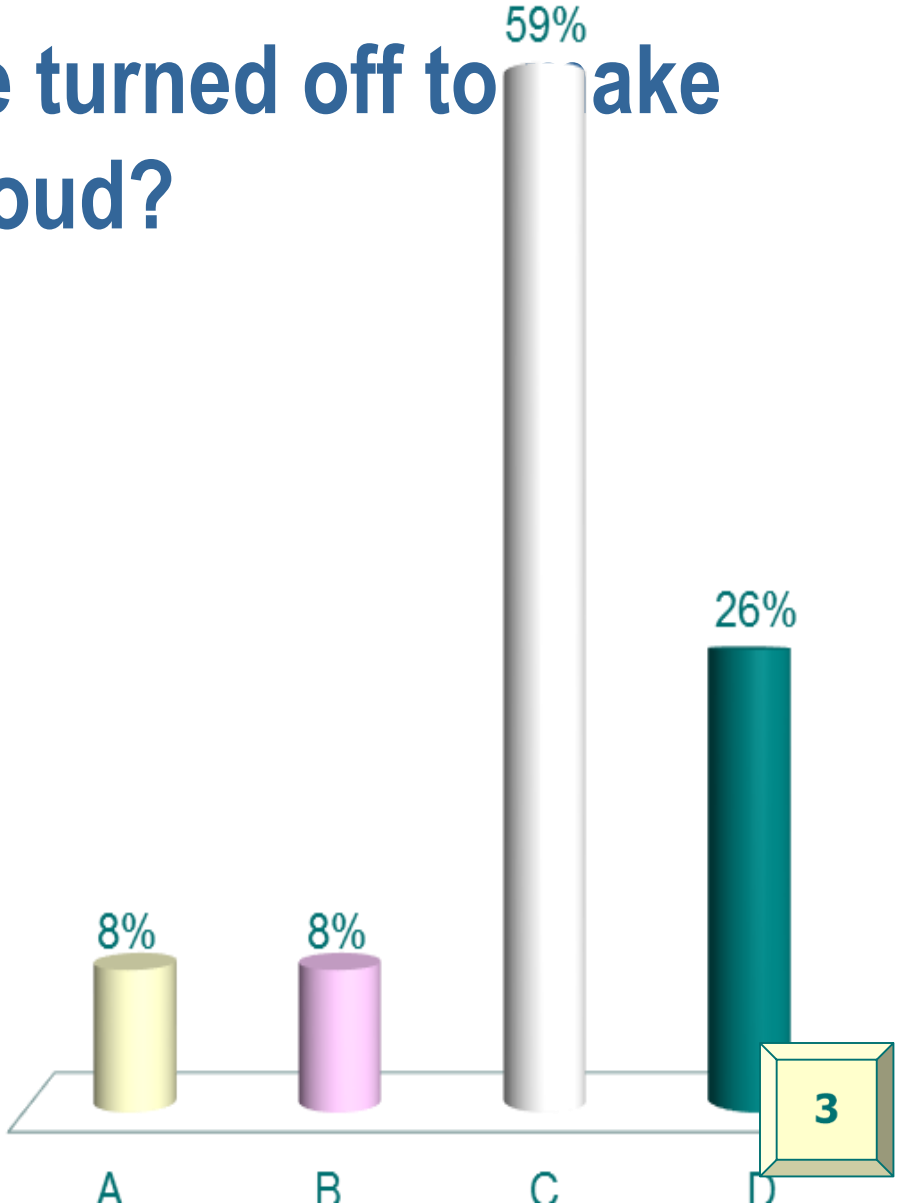


Human Hearing and decibels

- If the sound level increases by 10 dB, it is perceived to be about twice as loud to the human ear. (See chapter 12 … more on this later in the course)
- Thus a 100-dB sound level seems twice as loud as a 90-dB sound level, and four times louder than an 80-dB sound level.

120 noisy machines in a factory generate a nerve-wracking 95-dB sound level. How many machines must be turned off to make the noise seem half as loud?

A. 60 machines
B. 80 machines
C. 12 machines
D. 108 machines



120 noisy machines in a factory generate a nerve-wracking 95-dB sound level. How many machines must be turned off to make the noise seem half as loud?

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Quick way: intensity must be reduced by factor of ten to reduce sound level by 10 dB and perceived loudness by a factor of 2. That means $120/10 = 12$ machines remain, or $\boxed{108 \text{ machines}}$ were turned off.

Detailed calculation on the next slide

Detailed calculation

Need to reduce 95-dB sound down to 85 dB

in order to reduce perceived loudness by half.

$$I_{95} = I_r 10^{L/10} = \left(1.0\times10^{-12}\ \text{W/m}^2\right)10^{95/10} = 3.16\times10^{-3}\ \text{W/m}^2$$

$$I_{85} = I_r 10^{L/10} = \left(1.0\times10^{-12}\ \text{W/m}^2\right)10^{85/10} = 3.16\times10^{-4}\ \text{W/m}^2$$

$$\frac{I_{85}}{I_{95}} = \frac{3.16\times10^{-4}\ \text{W/m}^2}{3.16\times10^{-3}\ \text{W/m}^2} = \frac{1}{10} = \frac{\#\ \text{machines ON}}{120\ \text{machines}}$$

So with 12 machines on, $120 - 12 = \boxed{108\ \text{machines}}$

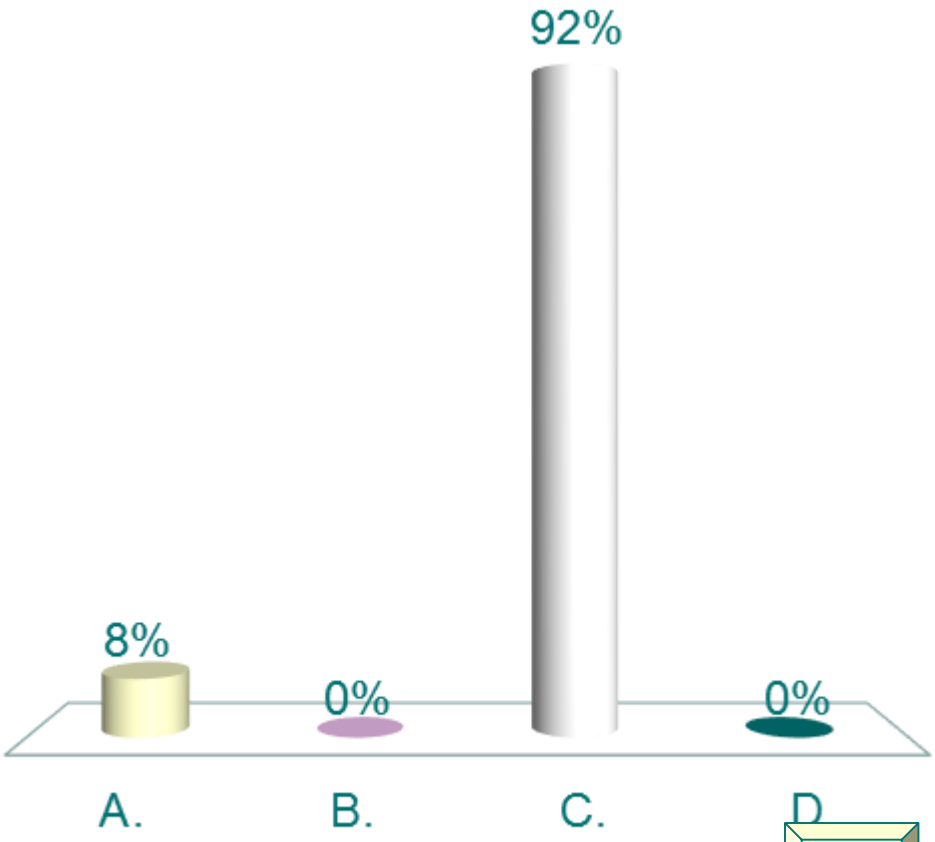
must be turned off.

Summary Example:

	initial		final		
	value	**level**	**value**	**level**	**ratio**
pressure	p_1	$20\log\left(\frac{p_1}{p_r}\right)$	p_2	$20\log\left(\frac{p_2}{p_r}\right)$	$\frac{p_2}{p_1}$
pressure	0.252 Pa	82 dB SPL	2.52 Pa	102 dB SPL	10
intensity	I_1	$10\log\left(\frac{I_1}{I_r}\right)$	I_2	$10\log\left(\frac{I_2}{I_r}\right)$	$\frac{I_2}{I_1}$
intensity	158 μW/m^2	82 dB IL	15.8 mW/m^2	102 dB IL	100
loudness	loud		four times louder		4.0

Class Quiz: A 116-dB sound encounters a wall with sound insulation that decreases the sound intensity by a factor of 400. What is the sound level on the other side of the wall?

A. 76 dB
B. 26 dB
C. 90 dB
D. 114 dB



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Class Quiz: A 116-dB sound encounters a wall with sound insulation that decreases the sound intensity by a factor of 400. What is the sound level on the other side of the wall?

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D. 114 dB

$$I_1 = I_r 10^{L/10} = \left(1.0\times10^{-12}\ \text{W/m}^2\right)10^{11.6}$$

$$= 0.3981\ \text{W/m}^2$$

$$I_2 = I_1/400 = 9.953\times10^{-4}\ \text{W/m}^2$$

$$L_2 = 10\log\left(\frac{I_2}{I_r}\right) = \boxed{90.0\ \text{dB}}$$

Or, the sound loses 20 dB when the intensity drops by a factor of 100 and 6 dB when it drops by a factor of 4, so 116 dB − 26 dB = 90 dB