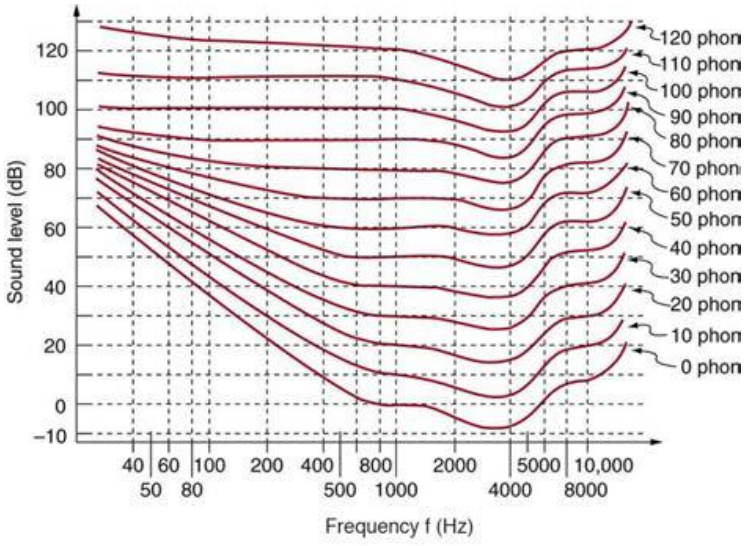
Physics 07-08 Hearing and Ultrasound Name: _____

## *Hearing*

- Pitch
  - Perception of _____
  - 20 Hz – 20000 Hz
  - Most sensitive to _____ Hz
  - Can distinguish between pitches that vary by at least _____
- Loudness
  - Perception of _____
  - Range $10^{-12}$ W/m$^2$ – $10^{12}$ W/m$^2$
  - Most people can discern an intensity level difference of _____




## *Ultrasound*

- Used in _____ to examine a fetus, used to examine some _____, and _____ flow
- High _____ sound aimed at target
- Sound reflects at _____ of tissues with different _____ impedances
- _____compiles picture from where _____ come from
- Acoustic impedance
  $Z = \rho v$
  - See table
- Intensity reflection coefficient
  $a = \frac{(Z_2 - Z_1)^2}{(Z_1 + Z_2)^2}$
  - Higher coefficient, more reflection

Table 17.5 The Ultrasound Properties of Various Media, Including Soft Tissue Found in the Body

| Medium | Density (kg/m$^3$) | Speed of Ultrasound (m/s) | Acoustic Impedance $(\text{kg}/(\text{m}^2 \cdot \text{s}))$ |
|---|---|---|---|
| Air | 1.3 | 330 | 429 |
| Water | 1000 | 1500 | $1.5\times10^6$ |
| Blood | 1060 | 1570 | $1.66\times10^6$ |
| Fat | 925 | 1450 | $1.34\times10^6$ |
| Muscle (average) | 1075 | 1590 | $1.70\times10^6$ |
| Bone (varies) | 1400–1900 | 4080 | $5.7\times10^6$ to $7.8\times10^6$ |
| Barium titanate (transducer material) | 5600 | 5500 | $30.8\times10^6$ |

- Can't see detail smaller than _____
- Can only penetrate to depth of _____

Calculate the intensity reflection coefficient of ultrasound when going from water to fat tissue (like a baby in the womb)

## *Cavitron Ultra Surgical Aspirator*

- Used to remove inoperable _____ tumors
- Tip of instrument vibrates at _____kHz
- Shatters _____ tissue that comes in contact
- Better _____ than a knife

## *High-Intensity Focused Ultrasound*

- Sound is _____ on a region of the body.

- The waves entering the body don't do _____
- Only damage done where _____ (like sun and magnifying glass)
- The focused energy at target causes _____ which kills abnormal cells

## *Doppler Flow Meter*

- _____ and _____ placed on skin
- High _____ sound emitted
- Sound _____ off of blood cells
- Since cells are moving, _____ effect exists
- Computer can find rate of flow by counting the returned _____
- Used to find areas of _____ blood vessels
- Narrowest area → _____ flow

## *Homework*

1. Why can a hearing test show that your threshold of hearing is 0 dB at 250 Hz, when the figure on the front side implies that no one can hear such a frequency at less than 20 dB?
2. If audible sound follows a rule of thumb similar to that for ultrasound, in terms of its absorption, would you expect the high or low frequencies from your neighbor's stereo to penetrate into your house? How does this expectation compare with your experience?
3. Elephants and whales are known to use infrasound to communicate over very large distances. What are the advantages of infrasound for long distance communication?
4. Suppose you read that 210-dB ultrasound is being used to pulverize cancerous tumors. You calculate the intensity in watts per centimeter squared and find it is unreasonably high ($10^5$ W/cm$^2$). What is a possible explanation?
5. What are the closest frequencies to 500 Hz that an average person can clearly distinguish as being different in frequency from 500 Hz? The sounds are not present simultaneously. (OpenStax 17.57) **498.5 Hz and 501.5 Hz**
6. Can the average person tell that a 2002-Hz sound has a different frequency than a 1999-Hz sound without playing them simultaneously? (OpenStax 17.58) **No**
7. If your radio is producing an average sound intensity level of 85 dB, what is the next lowest sound intensity level that is clearly less intense? (OpenStax 17.59) **82 dB**
8. Can you tell that your roommate turned up the sound on the TV if its average sound intensity level goes from 70 to 73 dB? (OpenStax 17.60) **Yes**
9. Based on the graph on the front side, what is the threshold of hearing in decibels for frequencies of 60, 400, 1000, 4000, and 15,000 Hz? *Note that many AC electrical appliances produce 60 Hz, music is commonly 400 Hz, a reference frequency is 1000 Hz, your maximum sensitivity is near 4000 Hz, and many older TVs produce a 15,750 Hz whine.* (OpenStax 17.61) **48 dB, 9 dB, 0 dB, -7 dB, 20 dB**
10. What is the sound intensity level in decibels of ultrasound of intensity $10^5$ W/m$^2$, used to pulverize tissue during surgery? (OpenStax 17.72) **170 dB**
11. Find the sound intensity level in decibels of $2.00 \times 10^{-2}$ W/m$^2$ ultrasound used in medical diagnostics. (OpenStax 17.74) **103 dB**
12. The time delay between transmission and the arrival of the reflected wave of a signal using ultrasound traveling through a piece of fat tissue was 0.13 ms. At what depth did this reflection occur? (OpenStax 17.75) **10 cm**
13. In the clinical use of ultrasound, transducers are always coupled to the skin by a thin layer of gel or oil, replacing the air that would otherwise exist between the transducer and the skin. (a) Using the values of acoustic impedance given in Table 17.5 calculate the intensity reflection coefficient between transducer material and air. (b) Calculate the intensity reflection coefficient between transducer material and gel (assuming for this problem that its acoustic impedance is identical to that of water). (c) Based on the results of your calculations, explain why the gel is used. (OpenStax 17.76) **1.00, 0.823**
14. (a) How far apart are two layers of tissue that produce echoes having round-trip times (used to measure distances) that differ by 0.750 μs? (b) What minimum frequency must the ultrasound have to see detail this small? (OpenStax 17.80) $\mathbf{5.78 \times 10^{-4}}$ **m,** $\mathbf{2.67 \times 10^{6}}$ **Hz**
15. A diagnostic ultrasound echo is reflected from moving blood and returns with a frequency 500 Hz higher than its original 2.00 MHz. What is the velocity of the blood? (Assume that the frequency of 2.00 MHz is accurate to seven significant figures and 500 Hz is accurate to three significant figures.) (OpenStax 17.83) **0.192 m/s**