Using Ultrasound Imaging to Motivate Physics Learning as Part of the Humanized Physics Project[1,2]

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Physics Concepts Taught With Ultrasound Imaging:

- Sound propagation: material and temperature effects on speed, absorption/attenuation effects.
- Spherical wave intensity as function of distance from source .
- Geometrical optics: law of reflection, law of refraction.
- Doppler effect.

Motivation for Physics:

- How do the physical properties of biological tissues relate to sound propagation?
- How do A-scan and B-scan ultrasound instruments work?
- How does a Doppler ultrasound instrument create an image?

Curriculum:

- Current module has about 6 hours of activities.
- Written for studio (Workshop Physics) environment. Most can be used in a large class using interactive demonstrations.
- Each activity follows the learning cycle model: exploration, invention, application.
- Most activities use multimedia: digital video or computer animations (Macromedia Flash applications).

Activity Titles:

- How can we use sound to "see" inside ourselves?
- Do muscle, fat, and bone sound the same?
- How can the body make sound bend?
- Give me an A(-scan). Give a B-(scan). What does that spell?
- How can you turn a C into a B?
- Just how fast is your blood traveling?

Physical properties of biological tissue:

Acoustic Impedance: $Z=\rho v$

muscle: 1.7×10^6 [kg/m^{2}s]

fat: 1.4×10^6 [kg/m^{2}s]

bone: 7.8×10^6 [kg/m^{2}s]

Reflection Coefficient: $R = \frac{|Z_1 - Z_2|}{|Z_1 + Z_2|}$

Tissue	v [m/s]	ρ [kg/m^3]
muscle (along fibers)	1576	1.058×10^3
muscle (across fibers)	1592	1.058×10^3
liver	1570	1.055×10^3
kidney	1560	1.055×10^3
brain	1520	1.032×10^3
fat	1476	0.928×10^3
bone	3360	2.32×10^3
air	343	1.205

Table 1. from *Diagnostic Ultrasound*, Matthew Hussey, Blackie & Son Limited (London, 1975).

Figure 2. Screen shots for A-scan, B-scan multimedia activity.

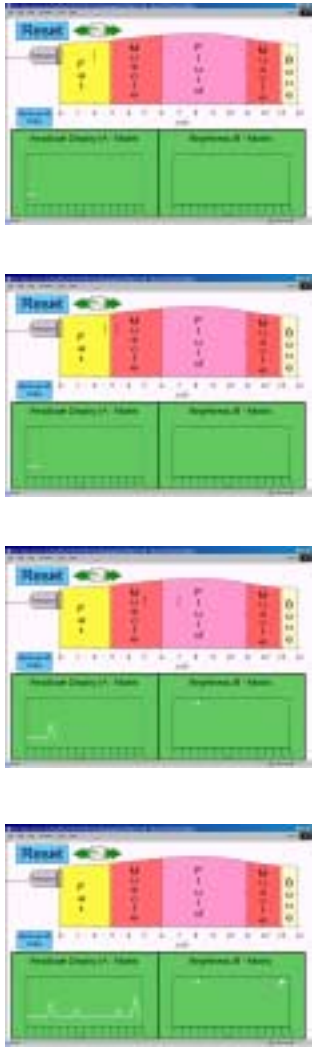

Figure 1. Law of reflection using ripple tank waves.

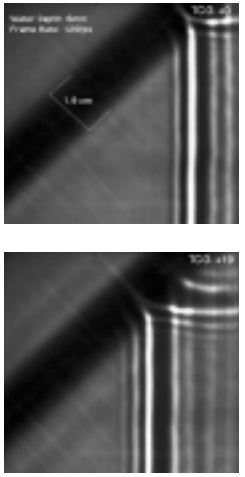

Figure 3. Screen shots for Doppler ultrasound activity.

Curriculum materials and multimedia available at project website:
www.doane.edu/hpp/