The Principles of Medical Ultrasound

Motivations

- Well, this is the field in which I currently use to pay my bills
- I have a project in mind that pertains to the subject
- It is a form of embedded system
- The technology is cool

What's the Purpose of an Ultrasound Machine?

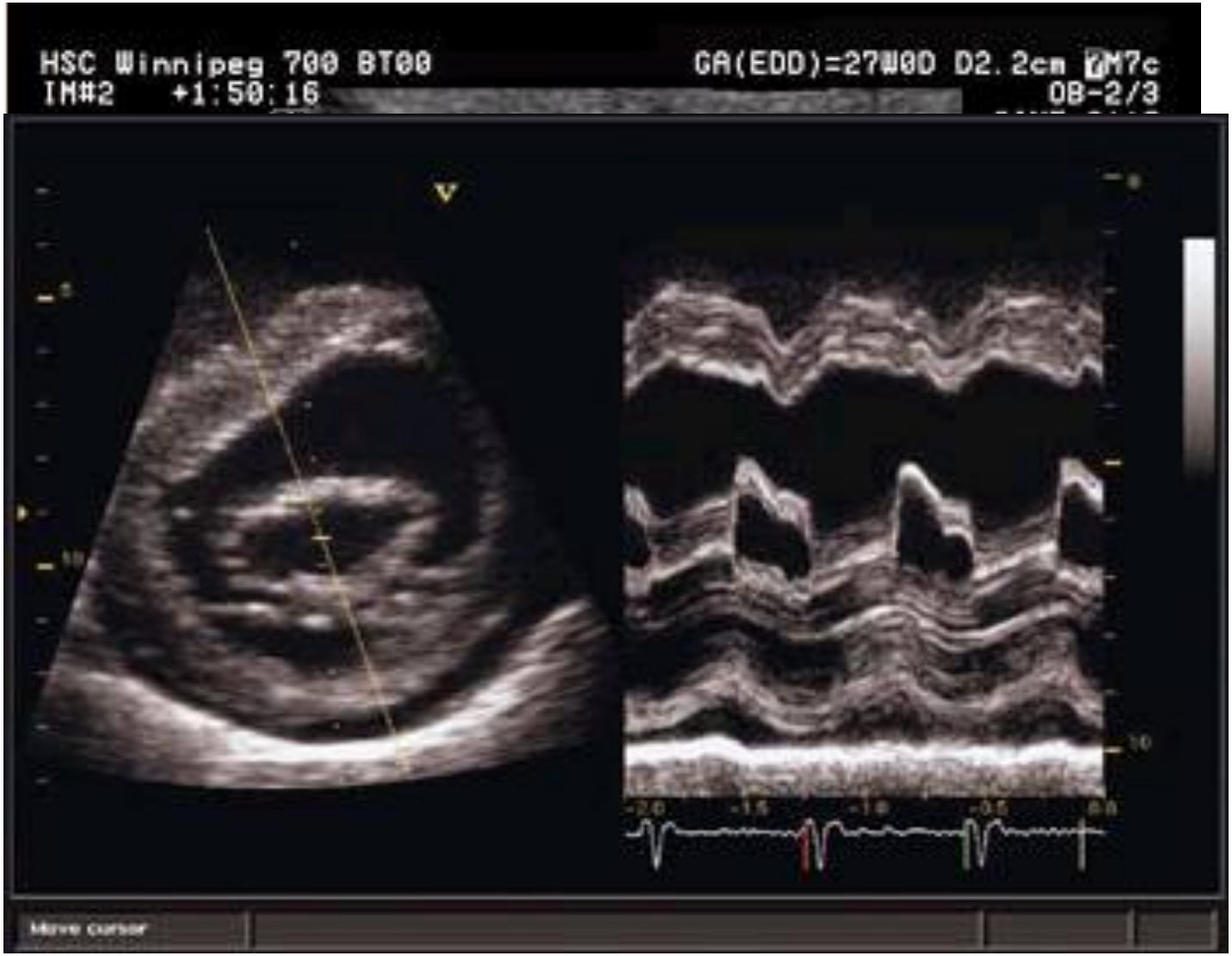
- The main objective of an ultrasound machine is diagnosis of abnormalities within the body and fetal detection

- Modalities of analysis: cardiac, vascular, abdominal, etc. etc. etc.

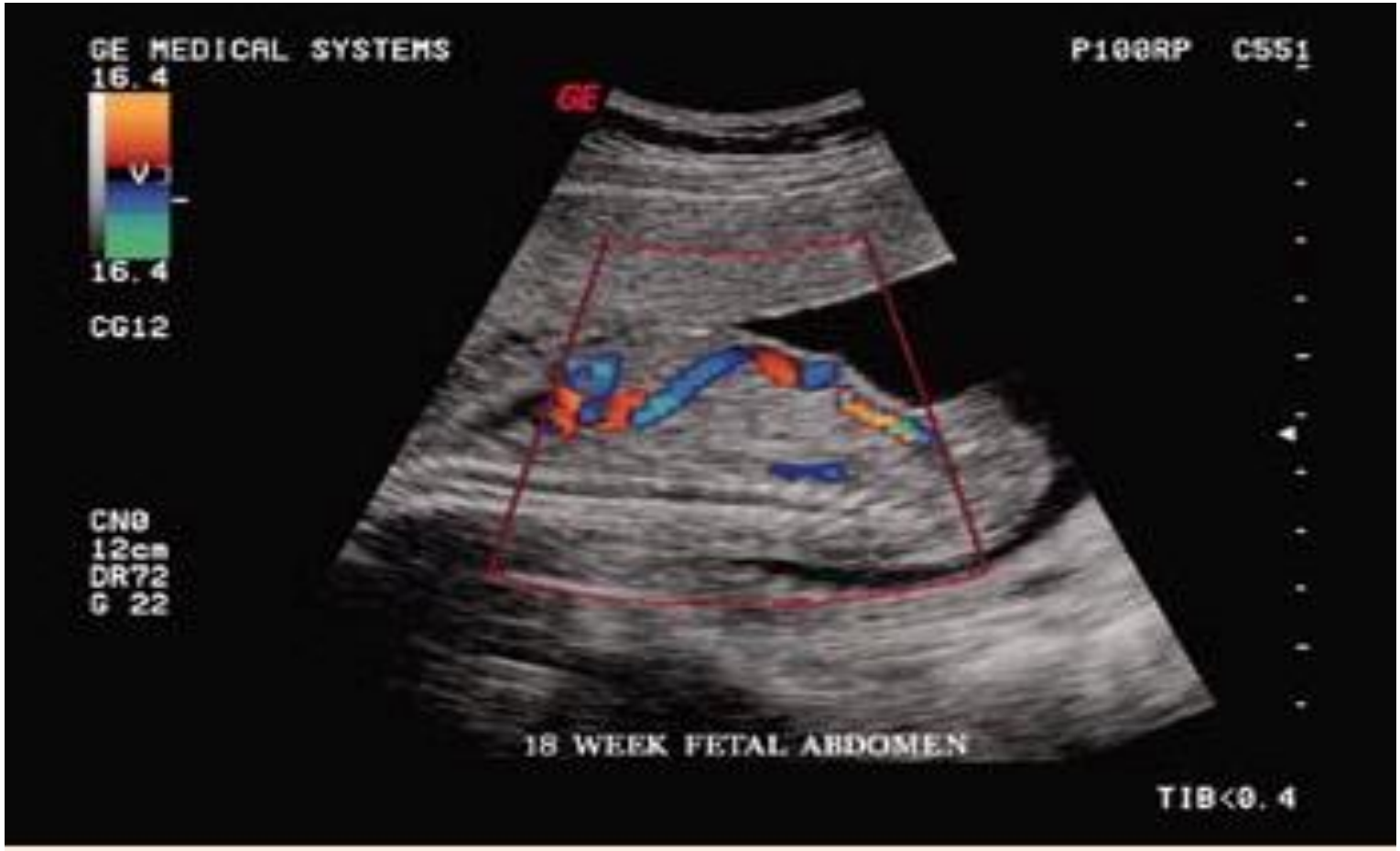
Typical Ultrasound Machines

A Few Pics….2D-Mode

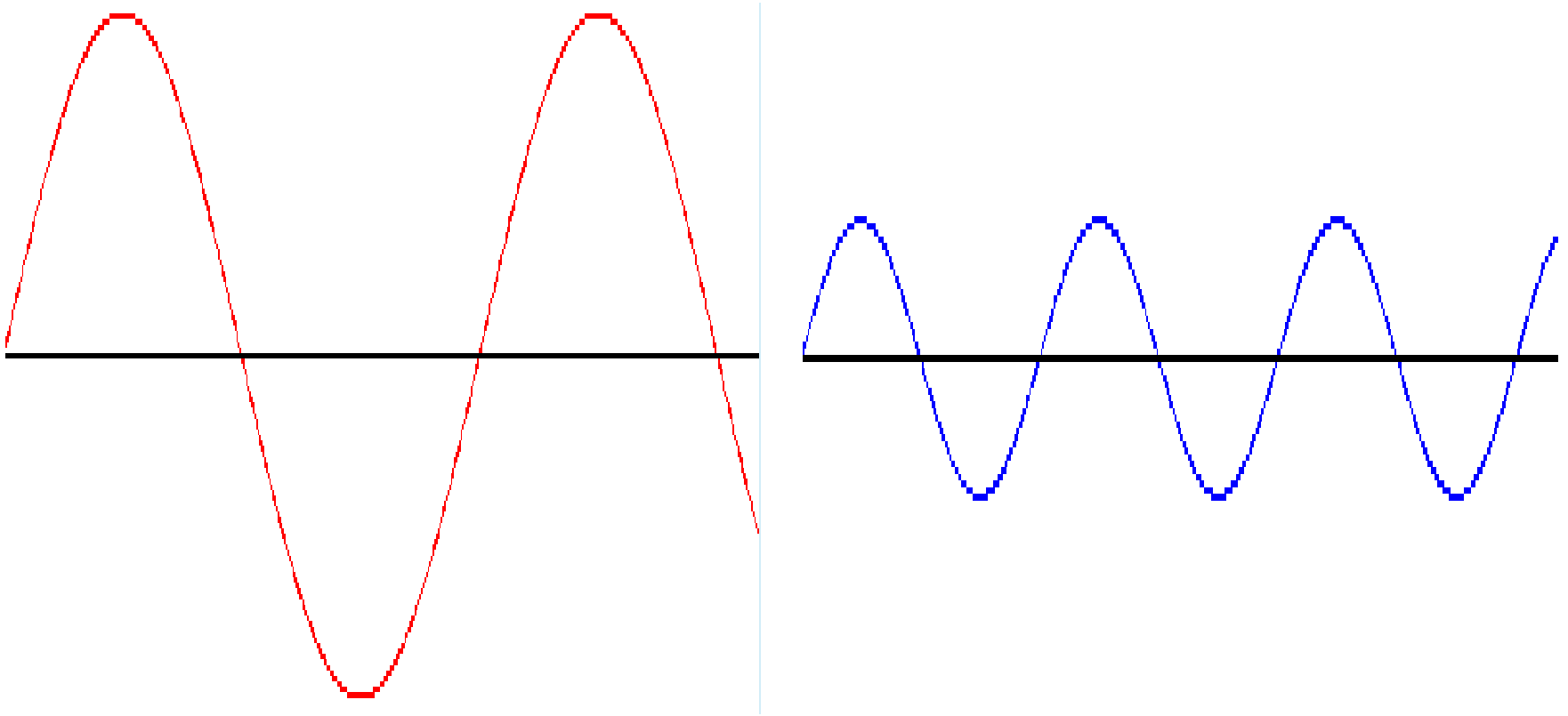
A Few Pics….M-Mode



A Few Pics….Color Doppler



Ultrasound is Sound



What is Sound?

- Sound is defined as mechanical energy that is transmitted by pressure waves in a material's medium

- When sound travels from place to place, it causes slight displacements of molecules or particles in its path

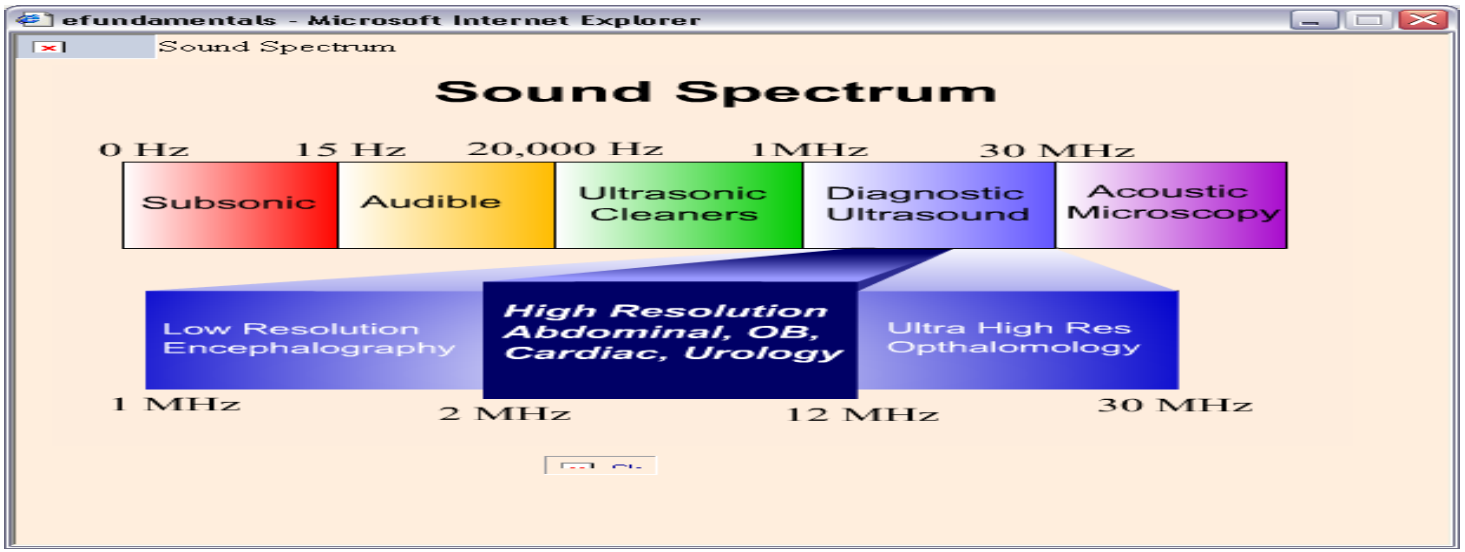
- When sound hits your eardrum, it causes the eardrum to vibrate and give the sensation of hearing

- Cannot Travel in a vacuum

A Couple Properties of Ultrasound Waves

- Range from about 1 – 20 MHz for medical imaging

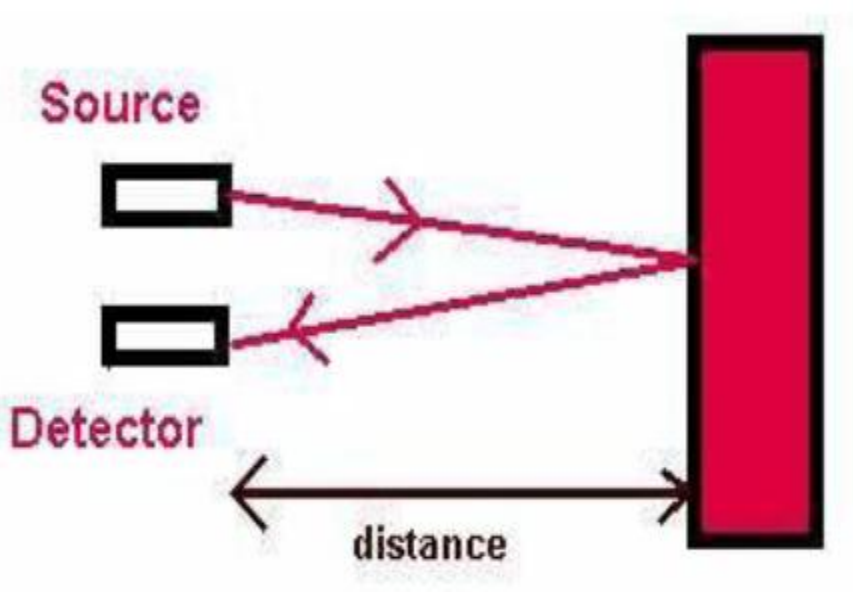
- Inaudible (Human hearing 20 Hz – 20 kHz)



Speed of Sound

*Total Distance Traveled = Speed of Sound * Time*

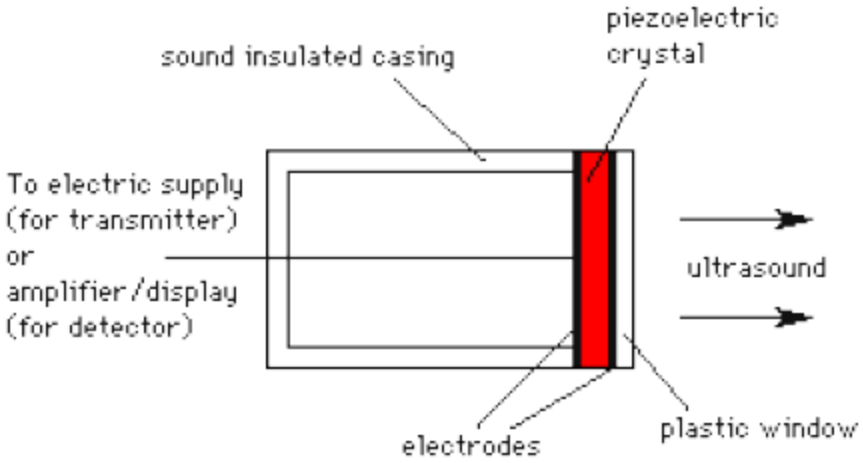
Material	Velocity (m/s)
Air	330
Water	1497
Metal	3000 - 6000
Fat	1440
Blood	1570
Soft tissue	1540



Ultrasound Transducers and Wave Production

Transducer

•Any device which converts one form of energy into another form



Piezoelectric Effect

•When electrical energy is applied to a material, the material expands or contracts.

•Also, when a material contracts or expands, it has the ability to produce electrical energy

•Examples are quartz, tourmaline, and ceramics

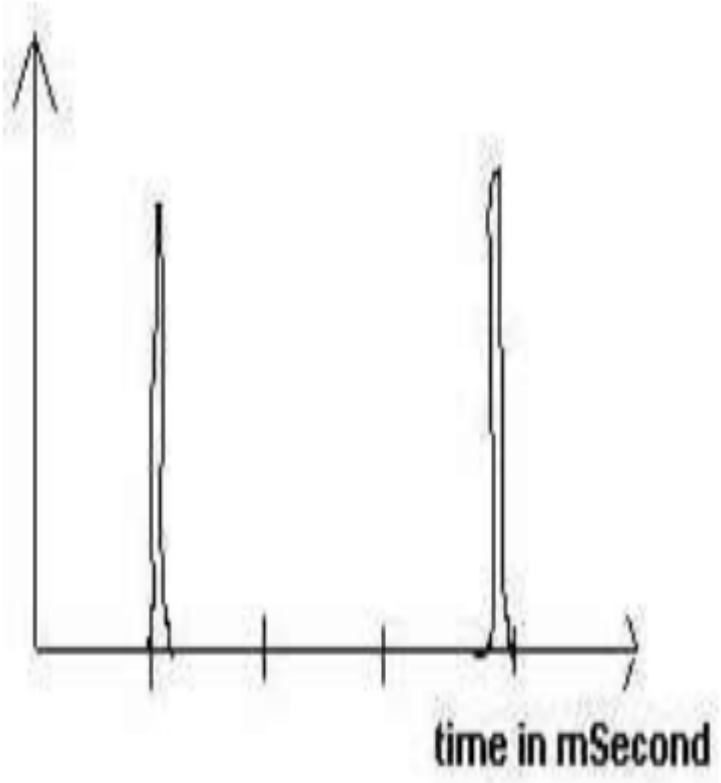
Acoustic Impedance and Echoes

Medium	Impedance (in standard unit)
air	0.000429
water	1.50
blood	1.59
fat	1.38
muscle	1.70
bone	6.50

- Ultrasound machines process reflected sound waves(echoes) to produce images
- Echoes come from sound waves hitting boundaries between materials with different acoustic impedances
- Materials in the body (except bone) are closely related in acoustic impedance (machine relies on this property)

A-Mode (Old School)

- Amplitude of returning echo information displayed in a time-domain form such as an oscilloscope



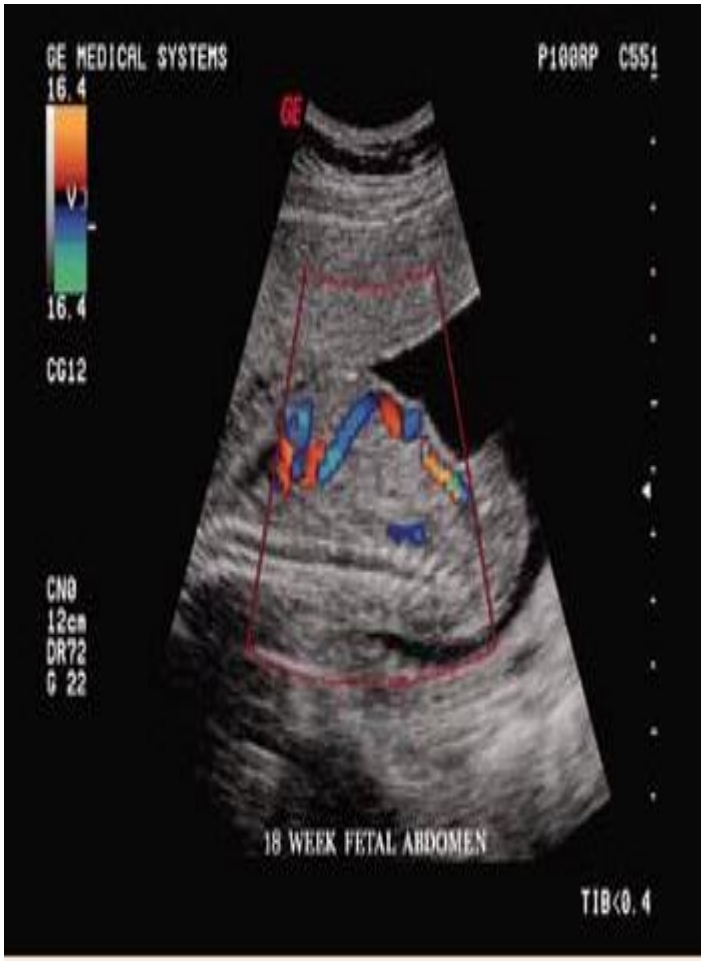
B-Mode (Welcome to the Present)

- Amplitude information is processed and displayed as 2-Dimensional information on a monitor
- Varying shades of gray are used to display amplitude information

Color Doppler Mode

Doppler Effect Properties

- If sound hits a moving surface, the frequency of the echo is altered
- Displays color information on screen which corresponds to direction of motion of tissue or blood within the body using the Doppler effect



Advantages and Disadvantages

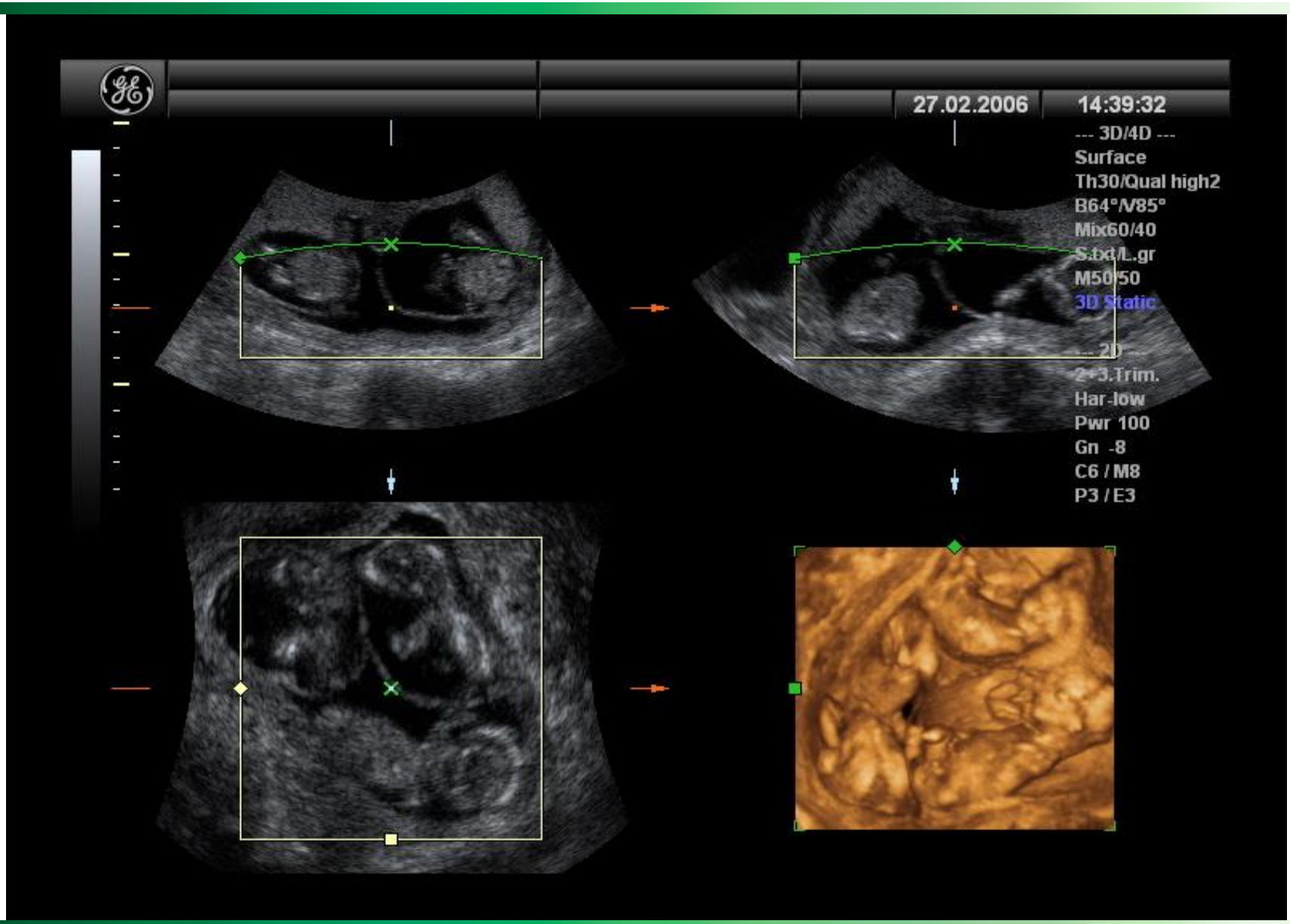
Advantages

- Non-invasive
- Inexpensive and Convenient
- Not harmful (non-ionizing energy)
- Great in soft tissue apps

Disadvantages

- Limited resolution
- Tissue to gas limitations
- Doesn't travel well through bone

Finish it off with a pic!



Fin