

# Sonography Tech

Essentials of Physics & Sound, Image Interpretation, Tools, Techniques, Equipment & Terminology

## OVERVIEW

### Scope of Practice

- Ultrasound (a.k.a., **ultrasonography** and/or **sonography**) involves the following aspects of skills, practice and technology:
    - patient care
    - quality control
    - diagnostic procedures
    - computer data acquisition & processing
  - Ultrasound technology is a **multidisciplinary** field, in which medicine is linked to mathematics and quantitative sciences, including:
    - geometry
    - physics
    - computer technology
  - Ultrasound diagnostic imaging technique is used to visualize **subcutaneous** body structures, for possible **pathology** or **lesions**
    - structures best suited to sonographic imaging include:
      - tendons
      - muscles
      - joints
      - vessels
      - internal organs
  - In physics, the term "ultrasound" applies to all acoustic energy with a frequency above human hearing (20,000 hertz [Hz] or 20 kilohertz [kHz])
    - Typical diagnostic sonographic scanners operate in the frequency range of 2-18 megahertz [MHz], hundreds of times greater than the limit of human hearing
  - However, the choice of frequency is a trade-off between spatial resolution of the image and imaging depth.
    - lower frequencies produce less resolution, but image deeper into the body
- (NOTE: See page 6 for a Glossary of Sonographic Terminology)

### How Ultrasound Works

- Sonography is effective for imaging soft tissues of the body
  - superficial structures such as muscles, tendons, testes, breast and the neonatal brain are imaged at a higher frequency (7-18 MHz), which provides better axial and lateral resolution
  - deeper structures such as liver and kidney are imaged at a lower frequency (1-6 MHz), which provides less axial and lateral resolution but greater penetration (i.e., increased imaging depth)
- A general-purpose sonographic machine may be used for most imaging purposes; specialty applications may be imaged by use of a specialty transducer
  - Most ultrasound procedures are done using a transducer on the surface of the body, but improved diagnostic procedures are often possible if a transducer can be placed inside the body
    - for this purpose, specialty transducers (including endovaginal, endorectal and transesophageal transducers) are commonly employed

## PHYSICS & SOUND

### Understanding Sound Waves

- In physics, all waves carry energy from one location to another
- Sound is a mechanical wave in which particles move (i.e., the molecules vibrate back and forth from a fixed position)
- Sound travels in a straight line and sound waves are longitudinal waves
- Sound waves are identified by the following acoustic variables: pressure, particle displacement, density and temperature
- In diagnostic ultrasound, pulses (i.e., sound) travel through tissue
- Reflections arising from structures in the body return to the transducer and are processed into images
- To understand exactly how that happens, let's review how sound waves work.

#### Pressure

- The ratio of force acting on a surface object
  - If there were no forces, or pressure, everything would be in a state of constant rest
  - The Law of Inertia explains that a body in motion will remain in motion; likewise, a body at rest will stay at rest until acted upon by an outside force
  - Ultrasound moves human soft tissue out of its state of rest
- FORMULA**  
 $\text{Pressure} = \text{Force/Area OR } P = F/A$   
 Units of measure: Newtons/Area or N/m<sup>2</sup>

#### Particle Displacement

- The distance the body has moved after being impinged upon by a force (i.e., how far the particles moved from their equilibrium positions)

#### Density

- The property common to all matter and the one property that makes each type of matter unique
- Density is defined as mass per unit volume; the more mass confined to a given volume, the greater the density
- In ultrasound, density is referred to as mass density, which can be defined as the mass of the object divided by its volume

#### FORMULA

$$\text{Density} = \text{Mass/Volume OR } D = M/V$$

Units of measure: Kg/M<sup>3</sup>, g/cm<sup>3</sup>

#### Temperature

- The measurement of relative coolness or warmth of an object
- temperature in ultrasound becomes important because the speed of sound varies with the temperature of the tissue that is being scanned

### 7 Parameters of Sound Waves

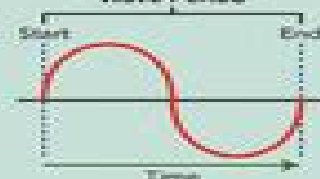
- The seven parameters of sound waves are: period, frequency, amplitude, power, intensity, wavelength and speed
- Period and frequency describe the speed of the wave
- Amplitude, power and intensity describe the strength of the wave (a.k.a., magnitude); these parameters tend to be directly related; when intensity increases so do power and amplitude

#### Period

- Time it takes for a wave to vibrate a single cycle (i.e., from the start of one cycle to the start of the next cycle)

- Reported in units of time (seconds, milliseconds, hours, days)
  - The value of period in diagnostic ultrasound is one tenth to one half of a millionth of one second
  - period determined by the sound source only, not by the tissue being scanned
  - period is **NOT** adjustable by the sonographer
- ultrasound tech with a particular transducer

#### Wave Period



#### Frequency

- Number of events that occur in a specific duration of time
- In diagnostic ultrasound, the frequency of a wave is described as the number of cycles occurring in one second
- Frequency is important in diagnostic ultrasound because it affects penetration and image quality
- Measured in units per second or Hz (1 cycle/second = 1 Hz)
- Frequency ranges are from 2MHz to 10 MHz (2 million to 10 million per second)
- frequency determined by the sound source only, not by the tissue being scanned
- frequency is **NOT** adjustable by the sonographer with a particular transducer

#### Frequency Spectrum of Sound

infrasonic : less than 20 Hz  
 audible : sound between 20 Hz and 20 kHz  
 ultrasound : greater than 20 kHz

#### Wave Frequency



#### Amplitude

- Defined as the "bigness" of the wave, it is the difference between the minimum value and the average value of the acoustic variable
- Measured in units of pressure (pascals), density (g/cm) and particle motion (any distance)
- Amplitude is determined by the sound source, but amplitude decreases as it travels through the body
- decrease in sound depends on the characteristic of the sound and the body tissue the wave is traveling through
- the sonographer can alter the initial amplitude on an ultrasound machine
- Amplitude is measured from the middle value to the maximum value

# Diagnostic Sonography Study Guide

**Jann Dolk, Nancy Smith Miner, Oscar  
del Barco, Monica McCrea, Lisa M. B.  
Simons**

## **Diagnostic Sonography Study Guide:**

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Hedrick, Paul R. Wagner, 2016-06-24 Gain a firm foundation for sonography practice Corresponding to the chapters in Hedrick's Technology for Diagnostic Sonography this study guide focuses on basic concepts to help you master sonography physics and instrumentation It includes laboratory exercises designed to teach you how to operate a scanner and comprehensive review questions allow you to assess your knowledge Not only will you learn the theoretical knowledge that is the basis for ultrasound scanning but also the practical skills necessary for clinical practice Laboratory exercises teach you the function of operator controls and how to optimize image quality and practice ALARA and include step by step instructions for scanner operation for hands on application and practice 250 review questions help you assess your understanding of sonography physics and instrumentation and identify areas of knowledge that may need further study Key Points at the beginning of each chapter emphasize the most important sonography principles that you need to understand and apply

**The Physics and Technology of Diagnostic Ultrasound** Robert Wyatt Gill, 2020-09 Companion to the popular ultrasound physics textbook The Physics and Technology of Diagnostic Ultrasound A Practitioner's Guide Second Edition Contains 125 short questions keyed to the textbook chapters and model answers for each Designed for both students and teachers

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exercises to help you master each objective      **Study Guide and Laboratory Exercises for Technology for Diagnostic Sonography, 1e** Wayne R. Hedrick, 2012-04-26      **ARDMS Ultrasound Physics & Instrumentation Exam Secrets Study Guide: Unofficial ARDMS Test Review for the American Registry for Diagnostic Medical Sonography**, 2018-04-12

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website Technology for Diagnostic Sonography Wayne R. Hedrick, 2012-02-16 Gain a complete understanding of sonography physics and instrumentation related to clinical practice Technology for Diagnostic Sonography provides clear in depth coverage of physics principles ultrasound transducers pulse echo instrumentation Doppler instrumentation clinical safety and quality control It includes the latest information on real time imaging techniques plus a comprehensive discussion of image artifacts With wide ranging online review questions it also offers ample opportunities to assess your learning progress Written by sonography and testing expert Wayne Hedrick Technology for Diagnostic Sonography simplifies this difficult topic and allows you to demonstrate your knowledge of physics and instrumentation on exams with the ultimate goal of preparing you for success in clinical practice A focus on essential physics and instrumentation provides the exact technical content you need to prepare for clinical sonography practice Accessible conversational writing style with real world analogies explains physics concepts and makes this difficult topic less intimidating Examples and sample problems help you make the connection between theory and practical applications The latest information on equipment and scanning methods ensures an understanding of how to competently and safely use ultrasound instrumentation Comprehensive discussion of image artifacts with illustrative examples helps you recognize and eliminate artifacts Detailed description of performance testing with tissue mimicking phantoms allows assessment of the proper operation of B mode scanners Practical guidance on the clinical use of mechanical index and thermal index enables practice of the ALARA principle when scanning patients Full color format shows scans as they appear in the clinical setting Key terms and other learner friendly features focus your study on important information Summaries of essential principles and equations reinforce the most important concepts Extensive review questions on a companion Evolve website allow realistic assessment of your knowledge

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