# Part I: Point of Care Musculoskeletal Ultrasound Physics

## eCourse

## Summary

This eight module course builds the foundation for understanding and learning Point of Care (POC) Musculoskeletal (MSK) Ultrasound Physics for sonographers, physicians, and health care professionals with a need to practice MSK ultrasound. The modules teach physics from a unique perspective with direct clinical application to ultrasound using many analogies, animations, ultrasound images, and ultrasound videos. The modules cover ultrasound and wave fundamentals, imaging fundamentals, ultrasound system controls, image artifacts, basic Doppler theory, PW spectral Doppler, color Doppler, and ultrasound bioeffects and safety. The instructor for this course, Frank Miele, is a dynamic, world-renown lecturer who holds many patents and trade secrets in diagnostic ultrasound, with a unique ability to make seemingly very difficult concepts come to life and comprehensible.


## Instructor Biography

**Frank Miele, MSEE**

*President, Pegasus Lectures, Inc., Dallas, Texas*

Frank graduated cum laude from Dartmouth College with a triple major in physics, mathematics, and engineering. While at Dartmouth, he was a Proctor Scholar and received citations for academic excellence in comparative literature, atomic physics and quantum mechanics, and real analysis. After co-teaching a course in digital electronics at Dartmouth, Frank was a research and design engineer and project leader, designing ultrasound equipment and electronics for more than ten years at Hewlett Packard Company. Frank also served as the chief scientist and Vice President of Research and Development for a small medical company designing non-invasive hemodynamic based measurements. As a designer of ultrasound, he has lectured across the country to sonographers, physicians, engineers, and students on myriad topics.

Frank has authored multiple texts on ultrasound physics, produced multiple educational videos, designed exam simulation programs, as well as created the patented analysis algorithm method and apparatus for evaluating educational performance. Frank has recently produced multiple online ultrasound seminars, focusing on making high quality educational programs affordable and accessible to the domestic and international ultrasound community. He is credited with several ultrasound and medical device patents, trade secrets, and publications.

## Module Descriptions

**Module 1: Ultrasound & Sound Wave Fundamentals**
Module 1, Ultrasound and Sound Wave Fundamentals, lays the foundation for all of the subsequent modules. Unlike most introductory physics modules, this module directly connects the physics concept to the ultrasound application, making clear not only the concept, but how the concept applies clinically and why it matters. The module uses myriad ultrasound images, demonstrations, and analogies to simplify the underlying physics concepts on which ultrasound is based. Specifically, this module answers the questions: what is ultrasound?, how does ultrasound work?, what parameters characterize a wave?, and how do sound waves interact with tissues in the body?

***Core Concepts: 1 hr 18 min***
***Focus Session: 1 hr***

**Module 2: Ultrasound Imaging Fundamentals**
Module 2, Transducers and Image Generation, develops the foundation for understanding the practical and logistical aspects of scanning. The module begins by discussing transducer basics including functionality, transducer types, and image formats. This is followed by multiple animations which demonstrate how ultrasound images are actually generated – including transducer movements (translation, angulation, and rotation), scan planes, image planes, correlation with anatomical planes, and transducer orientation requirements. In the second part of the module, reflection from tissue is discussed as relates to sonographic appearance. Again, ultrasound images are used to reinforce the concepts being taught.

***Core Concepts: 48 min***
***Focus Session: 36 min***

**Module 3: Ultrasound System Controls: Musculoskeletal Ultrasound**
The third of eight modules, Ultrasound System Controls: Musculoskeletal Ultrasound Imaging reviews the function of the ultrasound system controls, relating each control back to the underlying physic concept taught in the previous two modules. The module covers choosing the appropriate transmit frequency, transmit power, receiver gain, imaging depth, image width, focal depth, compression (dynamic range), presets, screen brightness, and the use of the harmonics, automated optimization, and cine loop. Ultrasound images and video loops are used throughout to illustrate the functionality of each control.

***Core Concepts: 1 hr 11 min***
***Focus Session: 54 min***

**Module 4: Image Artifacts: Musculoskeletal Ultrasound**
With ultrasound, not everything is as it appears to be. Sometimes, structures appear that do not exist, sometimes structures do not appear that do exist, and sometimes structures appear differently than they really are. When any of these situations occur, artifacts exist in the image. In this module, you will learn what an artifact is as well as the most common artifacts, their causes, and how you recognize these artifacts in the image. Most importantly, by understanding the mechanisms that cause the artifacts, you will recognize the existence of artifacts when they occur and understand what the artifact tells you about the structures in the body that are causing the artifact.

***Core Concepts: 42 min***
***Focus Session: 32 min***

**Module 5: Introduction to Doppler Fundamentals**
Module 5, Introduction to Doppler Fundamentals, teaches Doppler theory and serves as the foundation for the following two modules on spectral Doppler and color Doppler. Whereas 2D ultrasound images provide grayscale representation of tissues, fluids, and structures, the use of Doppler techniques allows for appreciation and quantification of blood flow. Learning the specific techniques and system controls of Doppler is greatly facilitated by first learning the underlying principles employed in Doppler assessments. Concepts taught in this module include the Doppler Effect, reflection of ultrasound waves from red blood cells, and the principles of spectral Doppler and of color Doppler.

***Core Concepts: 41 min***
***Focus Session: 31 min***

**Module 6: Introduction to PW Spectral Doppler: MSK Ultrasound**
Building on the concepts taught in the previous module, this module develops an understanding of the specifics of Pulsed Wave (PW) spectral Doppler. Because of the limited role of PW in MSK, this module focuses on the basics required to make sure that a PW spectrum can be obtained. The module begins with an illustration of the information contained in a Doppler spectrum. From here, you will learn how PW Doppler is performed, the importance of the PW Doppler sample volume, and the angle dependence of the spectral Doppler. Once you have learned the fundamentals of PW spectral Doppler, the module reviews the Doppler system controls related to spectral brightness and signal strength, velocity display, low velocity flow, and sweep speed. As with the system controls module, the controls will be taught through direct application on actual Doppler spectrums. Finally, the module concludes with examples of the application of pulsed wave Doppler in Musculoskeletal Ultrasound.

***Core Concepts: 28 min***
***Focus Session: 21 min***

**Module 7: Introduction to Color Doppler: MSK Ultrasound**
The color Doppler module begins with the basics of color Doppler and how color Doppler images are generated. Once the basics are understood, the color Doppler system controls are reviewed to improve your ability to employ color Doppler in your ultrasound exams. As with 2D and PW Doppler, ultrasound images are used throughout this section to make evident the effects of each color Doppler control. The last part of the module focuses on the application of color Doppler and the use of color Power Doppler in Musculoskeletal Ultrasound.

***Core Concepts: 52 min***
***Focus Session: 39 min***

**Module 8: Ultrasound Bioeffects and Safety**
The official statement by the AIUM regarding the safety of ultrasound is that ultrasound is a very safe modality but that there are some risks. Module 8, Ultrasound Bioeffects and Safety, reviews the concepts of ultrasound safety, bioeffects, and transducer care so that you can minimize the risks as much as possible. Topics discussed include AIUM statements on safety, mechanisms of bioeffects (thermal and mechanical), the ALARA principle, and specifics of transducer care.

***Core Concepts: 18 min***
***Focus Session: 15 min***

**Ultrasound Physics MSK POC Summary:**

***Viewing Time:*** *6.5 hours*
***Focus Sessions:*** *5.5 hours*
***CME:*** The Institute for Medical Studies designates this activity for a maximum of 12 *AMA PRA Category 1 credit(s)*™. Physicians should claim credit commensurate with the extent of their participation in the activity.

**For more information:**

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