Diploma of Medical Ultrasonography (DMU)

Physical Principles of Ultrasound and Instrumentation
Syllabus
Candidates are expected to cover all of the content of this syllabus when preparing for both the Part 1 and Part 2 DMU assessments. Candidates are will need to refer to the recommended reading list whilst studying this program. The most appropriate textbooks and articles for this program are those which demonstrate the connection between theory and the practical implications of the theory.

The DMU is a professional qualification that is awarded to candidate’s who have demonstrated an ability to apply a wide range of theoretical and practical knowledge in the profession of sonography.

When preparing for this assessment candidate’s need to consider how principles and facts and their implications relate to how these influence clinical practice.

The Part 2 assessment, acknowledges that the candidate will gained clinical experience in sonography and therefore places a higher degree of emphasis on the influence of physical principles on the clinical information acquired.

To be successful in the assessments candidates must demonstrate:
- An understanding of the principles and practical application of the syllabus content
- An ability to apply specific formulae in a practical way to demonstrate their usage
- An understanding of the effect of alterations in parameters used in a particular formula and the consequent effect this may have in practical terms
- The correct use of units of measure as applicable to various formulae and calculations.

Candidates should take particular care in understanding the correct use of units of measurement.

**Physical Principles of Ultrasound**

To be successful candidates must be able to demonstrate an understanding of the fundamental physical principles of ultrasound and the interactions of the various features of wave physics. Candidates must be able to apply the correct formulae to demonstrate understanding which includes:
- The wave nature of ultrasound
- Frequency, wavelength and propagation speed as applicable to wave physics
  - Amplitude, power and intensity
- Mechanisms of attenuation, including the effect of a change in frequency
- Characteristic impedance of tissue
- Reflection and scattering of the sound wave
- Refraction, including principles, practical features and factors affecting refraction
  - Critical angle of incidence and total reflection
- Concept of pulsed mode of operation

Candidates are must be able to define and quote typical approximate values met in clinical applications for the following:
- Propagation speed
- Frequency
- Wavelength
- Characteristic impedance of tissue
- Attenuation coefficient
The candidate is expected to be able to define and carry out simple calculations involving:

- Relationship between velocity, frequency and wavelength
- Snell’s law of refraction
- Ultrasonic attenuation in a path given the attenuation coefficient and ultrasonic frequency

**Transducer And Beamforming Concepts**
Candidates must have a thorough understanding of the:

- Principles of transducer construction
- Different types of transducers
- Characteristics of transducer design that affect beam formation
- Practical application of the theoretical principles
- Concept and purpose of a transducer
- Piezoelectric effect and piezoelectric elements
- Basic principles of transducer construction, including:
  - Materials used
  - Division of elements
  - Matching and backing layers
  - Transducer damping
- Construction and purpose of a lens
- Different types of probes and their major features and characteristics for example
  - Linear array
  - Curved array
  - Phased array
  - Special purpose transducers such as intracavity
- Transmit beamforming such as focusing, steering, scanning patterns and multiple transmit foci
- Receive beamforming such as dynamic focusing, apodization and dynamic aperture
- Basic knowledge of the beam shape, including the factors that affect the beam shape
- Definition of near field, far field and transition distance
- Principles of production of side lobes and grating lobes and their practical effect
- Concept of slice thickness and the practical effect of this
- Factors affecting choice of probe for a given application, including type, frequency and other features

**Imaging Principles And Technology**
An appreciation of the principles of image formation is essential when performing an ultrasound examination and a detailed understanding of the purpose and application of basic equipment functions and controls is essential for a sonographer.

Candidates must be able to demonstrate a thorough understanding of the principles and practical applications of image formation methods and basic equipment functions and controls including:

- Pulse-echo concept
- Image formation, including B-mode imaging and M-mode
- Image processing block diagram
• Principles and practical application of basic equipment functions and controls such as:
  o transmitter, power control
  o transmit focus, depth
  o receive focus
  o amplification of the signal (gain controls)
  o digital scan conversion
  o dynamic range/signal compression
  o time/depth gain compensation (TGC)
  o image storage and display methods
  o image recording methods
  o pre and post-processing concepts
• Simple calculations involving the trade-off between frame rate, image line content and penetration distance

Defining Equipment Performance
An appreciation of the importance of quality assurance and those elements of the ultrasound instrumentation that can be assessed in a quality assurance program is essential for a sonographer in order to ensure that equipment is operating correctly. Candidates must be able to explain a range of elements that define equipment performance and relate these to the practical aspects of ultrasonic imaging including:
• The use of test objects, such as the AIUM 100mm test object, to assess performance
• Technical characteristics of tissue equivalent phantoms
• Principle of the Doppler string and flow phantoms
• Being able to define and calculate simple calculations involving the following:
  o axial resolution
  o lateral resolution
  o slice thickness

Candidates is must be able to describe and to conduct performance assessments of ultrasonic imaging equipment, including:
• measurement calibration
• axial resolution
• lateral resolution
• contrast resolution
  → penetration

Imaging Artifacts
Sonographers must have an understanding of the means of production and appearance of imaging artifacts in ultrasonic imaging in order to produce an effective diagnostic image. Candidates must be able to:
• describe the mechanisms for production
• recognize and analyse the major types of image artifact, including those caused by inappropriate control settings.

Doppler Principles
The uses of Doppler ultrasound techniques is widespread in nearly every clinical application of ultrasound imaging. It is essential that sonographers have an understanding of the principles, instrumentation and relevance to ultrasonic imaging of Doppler ultrasound.

Candidates must have a thorough understanding of the:
• Doppler effect
• Doppler equation and the various elements of the equation
• Principles of continuous wave Doppler
• Principles of pulsed (range gated) Doppler
• Principles of colour Doppler
• Elements of the Doppler spectral display

Candidates are expected to define and carry out simple calculations involving the following:
• Doppler equation
• Pulse repetition frequency (PRF) in pulsed Doppler measurements

Doppler Instrumentation
Candidates must to be able to discuss the:
  o principles of operation
  o performance limitations and effect on the imaging and measurement displays
  o performance of:
    → pulsed (spectral) Doppler controls
    → colour Doppler controls
  o inappropriate control settings

Doppler Artifacts
Candidates must be able to describe the mechanisms of production and recognise the appearance of Doppler information. They must also be able to analyse potentially artifactual Doppler information including:
• Visible effects of inappropriate control settings
• Frequency aliasing in all Doppler modes
• Intrinsic spectral broadening
• Mirror image artifacts
  o spectral mirror artifact
• Range ambiguity artefacts
• Wall thump artifact

Bioeffects And Safety
Candidates must have a thorough knowledge of current practice that relates to bioeffects and the safety of ultrasound techniques.

Candidates must be able to discuss factors that potentially affect the bioeffects and safety performance of diagnostic ultrasound including:
• The difference between a biohazard and a bioeffect
• The use of epidemiological studies in assessing safety
• Known bioeffects:
  o thermal
  o mechanical
• The difference between spatial peak and spatial average intensities
• The difference between temporal peak and temporal average intensities
• The potential safety implications of different exposure regimes in B-mode imaging, M-mode imaging, colour Doppler imaging and pulsed Doppler examinations
• Practical approaches to minimizing risk

Candidates must be able to discuss current ‘best practice’ guidelines such as the:
• Current guidelines as outlined in the ASUM statements on safety
• Clinical use of Mechanical Index and Thermal Index displays
• ALARA (as Low As Reasonably Achievable) principle

Candidates must be able to explain how the following values are calculated and the importance of equipment settings in determining their values:

• The Thermal Index display
• The Mechanical Index display

**New And Evolving Techniques**

Ultrasound imaging is a rapidly changing field of technology. Candidates are expected to have an understanding and appreciation of the basic principles of newer technologies.

Candidates are required to have an understanding of the main concepts, current state of technology and typical application for:

• Multiple beamforming
• Extended field of view
• Contrast agents
• Contrast harmonic imaging
• Spatial compound scanning
• Three dimensional (and 4D) scanning
• Coded signals
• Doppler tissue imaging

**NOTE:** It is each candidate's responsibility to ensure that they have covered all the areas in this syllabus using all the resources available to them.