Preparing for Medical Physics Components of the ABR Core Examination

The ABR core examination for radiologists contains material on medical physics. This content is based on the medical physics that is used in practice by working radiologists in academic and private practice. Thus the best preparation for the exam is to learn to use medical physics in your routine practice. If you do that well you should have no problems with the medical physics on the CORE examination. This material is also included in the certifying and MOC examinations so that this knowledge will be useful both in practice situations and for preparation for the certifying and MOC examinations. It is the position of the ABR and virtually all professional organizations that an understanding of this material is crucial to the safe and effective practice of radiology.

We recognize, however, that candidates would like additional guidance to assist them with preparation for the examination. While it is impossible to provide the detail on the content that many candidates would desire, this document explains how the material is structured and how the candidate should prepare for the examination during their years of residency.

An important disclaimer is that each exam form is a sample of all of the practice areas, so there is some variation from one exam to another in the details of the exam content.

Physics Content

Each column of the grid contains material on basic medical physics, the underlying principles of medical physics that apply to that area of radiology, effective use, safety and artifacts.

Basic Content

The purpose of examining the candidate about fundamentals is to determine that the candidate has knowledge of:

- Medical Imaging Informatics
- Image Perception (Psychophysics)
- Characterization of Medical Images and Basic Image Processing
- Fundamentals of the Generation, Attenuation and Detection of Ionizing Radiation
- Radioactive Materials and Radioactive Decay Processes
- Radiobiology

- Ionizing Radiation Effects
- Fundamentals of the Generation, Transmission and Attenuation of Ultrasound
- Fundamentals of Magnetic Resonance

Questions in the basic section are designed to determine if the candidate understands how these issues affect the everyday practice of radiology. Emphasis is on principles rather that the memorization of facts that are not directly relevant or that could be easily looked up on Google or in the Wikipedia.

For example there would be no questions about the:

$$\lambda \nu = c,$$

relationship as it applies to electromagnetic radiation since there is no practical application in radiology. However, that same relationship, as it applies to ultrasound, is of interest since it affects resolution and penetration of the ultrasound. Fundamental questions make up about 20% of the medical physics questions and are distributed into all of the columns of the matrix. While the exam as a whole is strongly image-rich, some fundamental medical physics questions are not easily expressed in an image-rich form

EXAMPLES of Basic Items

1. **If the x-ray tube voltage is increased from 60 to 70 kVp, how would milliampere-seconds (mAs) need to be adjusted to maintain a similar amount of radiation exposure to the image detector?**

   A. Reduce mAs by ¼
   B. Reduce mAs by ½
   C. Increase mAs by ¼
   D. Increase mAs by ½

2. If the physical half-life and biologic half-life for a radiopharmaceutical are both equal to 6 hours, what is the effective half-life?

A. 1 hour
B. 3 hours
C. 6 hours
D. 12 hours

Modality Based Questions

The rest of the medical physics questions in each of the columns of the matrix are based on the imaging modalities used in that column. These are approximately as shown in Figure 1.

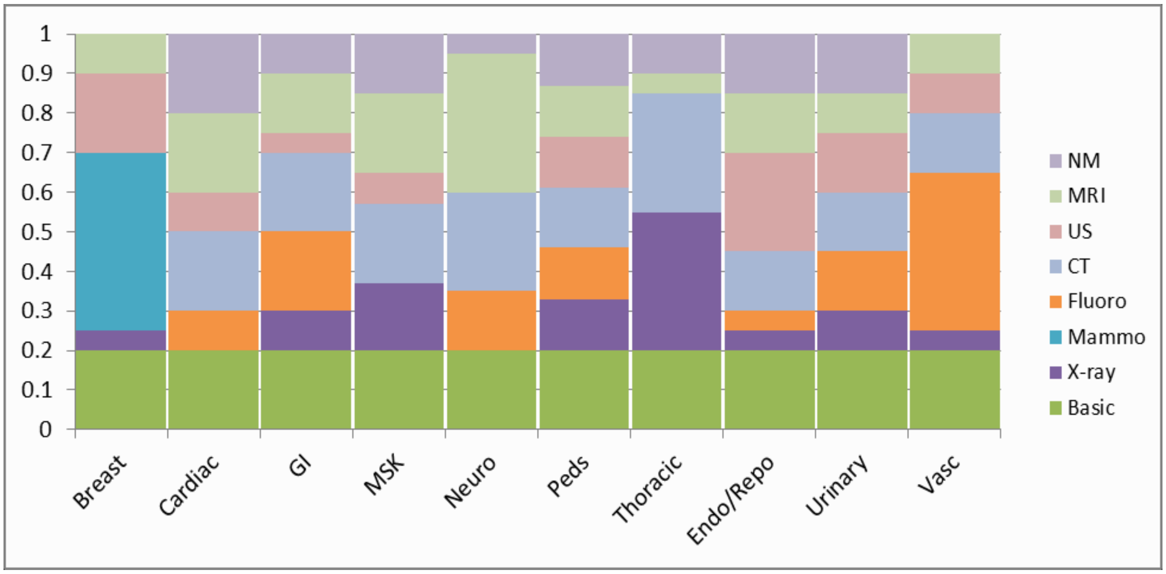


Figure 1: The approximate distribution of medical physics questions by imaging modality in each of the categories.

On the average the distribution of modality questions on the exam is as shown in Fig 2. Please again note that this is a general guide and there is significant variation from exam to exam.

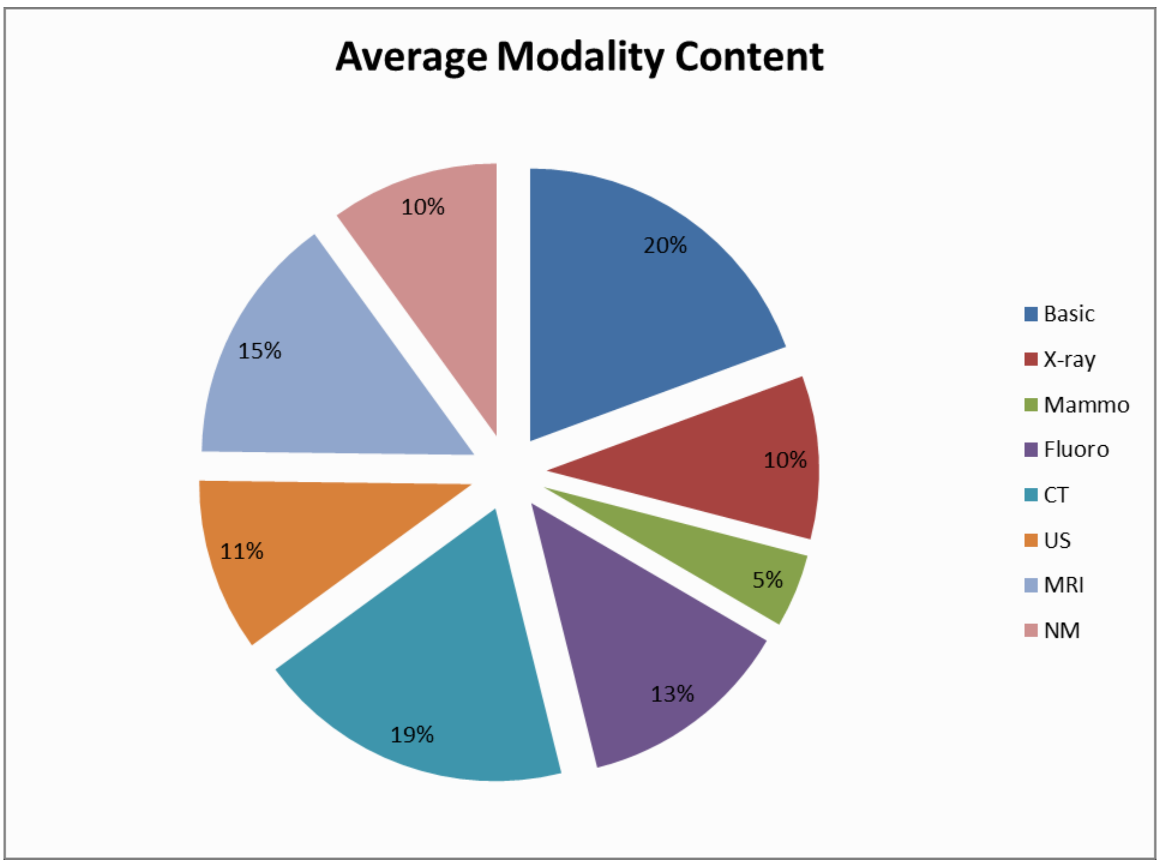


Figure 2: Approximate distribution of medical physics questions by category/modality on the CORE Exam.

Category Based Questions – Major Focus of the Items

These category/modality questions are very image rich and are divided into four main types:

- Underlying medical physics principles for the category/modality in question
- Application of medical physics in the effective use of the category/modality
- Safety related to the particular category/modality
- Understanding the causes and methods to reduce artifacts associated with a particular category/modality

These questions are distributed approximately as shown in Figure 3.

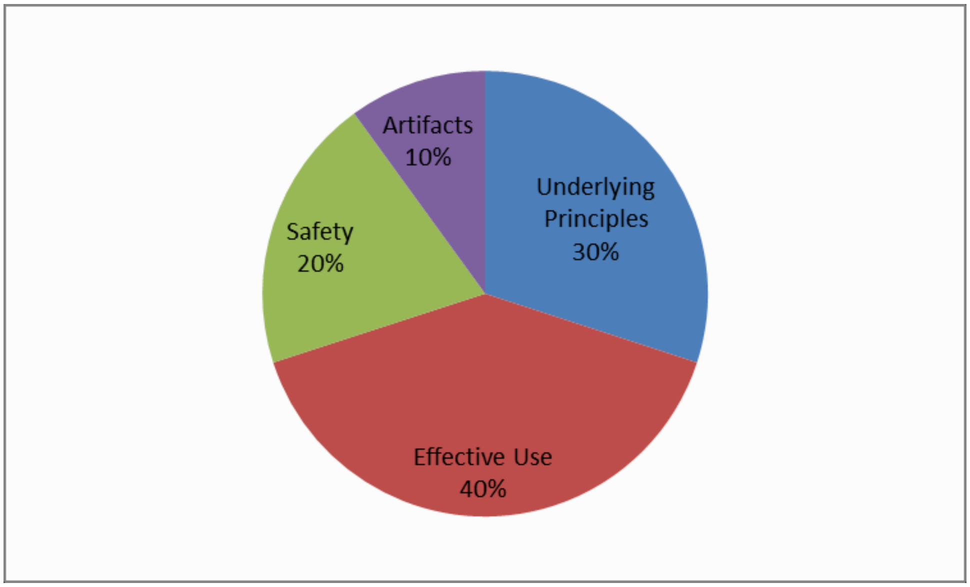


Figure 3: Distribution of the category/modality specific questions

Underlying Technology and Physics Principles

Every imaging modality has underlying technology and physics principles that must be understood by a radiologist so that the radiologist can understand and interpret the images that are produced by the modality. For example a radiologist needs to understand the relationship between radiation attenuation and Hounsfield numbers to understand how CT images are presented. The questions in the underlying technology and physics principle group focus on these areas.

EXAMPLES of Underlying Technology and Physics Principles Items

1. The quality or penetrating power of a diagnostic x-ray beam can be increased by which of the following actions?

A. Increasing the kilovolt peak
B. Decreasing the beam filtration
C. Increasing milliampere-seconds
D. Decreasing the exposure time

2. To minimize geometric unsharpness, this radiograph should be acquired with which of the following geometric configurations?

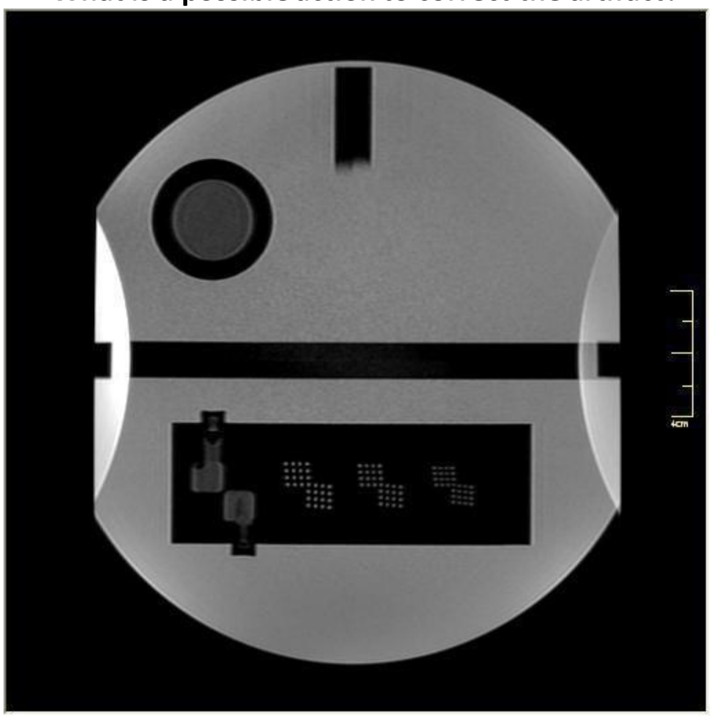
A. Hand directly on image receptor
B. Hand on table Bucky surface
C. Hand midway between image receptor and x-ray tube
D. Hand near exit of collimator assembly

Application of Medical Physics to the Effective Use of the Modality

Each imaging modality has certain characteristics that the radiologist must understand in order to create effective protocols, help technologists adjust imaging technique and compensate for pediatric or obese patients. For example increasing the amount of a PET radiopharmaceutical to an obese patient often degrades the image. The questions in this section focus on how the characteristics of the medical physics features of modality and the requirements of category relate to give optimal images.

EXAMPLES of Effective Use of the Modality Items

1. This image of the ACR MR accreditation phantom illustrates a wrap-around artifact. What is a possible action to correct the artifact?



A. Inverting the frequency and phase directions
B. Keeping all image parameters the same and using a larger coil
C. Increasing the image repetition time
D. Increasing the field of view

2. In a multislice fast-spin-echo (FSE) pulse sequence (TE/TR = 100/4000 ms, ETL = 12, field of view [FOV] = 30 cm, 256x256), which of the following modifications would further reduce the imaging time?

A. Reducing the TE to 50 ms
B. Reducing the FOV to 25 cm
C. Reducing the ETL to 10
D. Reducing the TR to 3000 ms

Safety as it Relates to Specify Modalities and Categories

While there is a general quality and safety category on the CORE exam there are also safety questions as they relate specifically to medical physics in each category and modality. These questions address issues like avoiding epilation in diffusion CT, specific concerns about appropriate power levels for OB ultrasound and avoiding burns in MRI. These safety questions are tied specifically to the technology used. Questions about safety principles and medical safety are in other sections of the exam.

EXAMPLES of Safety as it Relates to Specify Modalities Items

1. A measure of radiation damage to an organ in humans is described by which of the following?

A. Activity
B. Exposure
C. Kerma
D. Equivalent dose

2. Patient burns in MRI are usually associated with which of the following?

A. Long TR pulse sequences
B. Loops in EKG leads
C. Patient touching wall of scanner
D. Patients weighing less than 20 kg

3. Interventional procedures may on occasion cause skin injuries. Those that typically result in non-healing skin ulcers requiring surgical repair usually occur when the skin dose for a single port exceeds:

A. 1 Gy
B. 5 Gy
C. 10 Gy
D. 15 Gy

Artifacts

All imaging techniques have artifacts that are associated with the technique. Radiologists need to be able to recognize these artifacts, separate them from abnormalities and be able to recommend to technologists how to modify the imaging procedure to minimize them. The artifact-related questions will ask the candidate to identify the artifact, to distinguish the artifact from normal or abnormal findings on the image and to recommend strategies to reduce or eliminate the artifact.

EXAMPLES of Artifact-Related Items

1. In the computed radiography (CR) image, what is the most likely cause of the artifact indicated by the arrow?

Image from: Cesar LJ et al, 2001, Artifacts found in computed radiography, BJR 74: 195-202.

A. Debris on the CR reader light guide
B. Debris on the CR imaging plate
C. A line of dead pixels
D. Grid lines

2. In the CT image of the head, what is the most likely cause of the "streak" artifact?

A. Partial volume effect
B. Wrong reconstruction filter
C. Low kilovolt peak selection
D. Partial data loss

Summary

The medical physics content on the CORE exam is intended to reflect the medical physics that is commonly encountered by radiologists in image interpretation, executing procedures, and consulting with colleagues, staff and patients. The exam avoids classical physics topics. It addresses basic material only to the extent that fundamental knowledge is necessary to practice effectively. It avoids questions about basic physics facts. Like all parts of the exam, the physics questions are image rich and ask the candidate to make judgments.