Initial Certification

Medical Physics Study Guide

PLEASE NOTE: List of Constants and Physical Values

The ABR is now providing candidates with a list of constants, physical values, and related information, which can be found on the bottom of this page. While the list includes many constants and physical values, the ABR does not warrant the list as a compilation of all constants and physical values needed on the examinations. Candidates should review the list carefully before their examinations to familiarize themselves with the contents and list organization.

Exam Study Guide

- Computer-Based Exams
- Medical Physics Oral Exam

Computer-Based Examinations

An important disclaimer is that the exam samples all the practice areas, so there is some variation from administration to administration in the fine details of the exam content. New content that is viewed as being widely relevant is added, and material that is no longer relevant is removed.

PART 1: General

The nature and sources of radiation
Radioactivity
Ultrasound
Nuclear magnetic resonance
Interactions of radiation with matter
Spatial distribution and transmission of radiation
Concepts of dosimetry
Instrumentation and measurement techniques
Principles of safety
Methods of quality control and quality assurance
Radiobiology
Radiation protection
Basic atomic and nuclear physics
Mathematics relevant to medical physics
Statistics

- See sample questions. (includes advanced item types)

PART 1: Clinical

- Anatomy
  - Breast
  - Cardiovascular
  - Gastrointestinal
  - Musculoskeletal
  - Neurological system
  - Reproductive / Endocrine
  - Thoracic cavity
  - Urinary system

- Radiation Biology
  - Physics and chemistry of radiation interactions with matter
  - Molecular and cellular radiobiology
  - Tumor radiotherapy
  - Normal tissue response to radiotherapy
  - Time dose fractionation
  - Radiobiological basis of radiation protection

- Human Physiology
  - Nervous system
  - Musculoskeletal system
  - Cardiovascular system
  - Respiratory system
  - Gastrointestinal system
  - Integumentary system
  - Urinary system
  - Reproductive system
  - Immune system
  - Endocrine system

- General Medical / Radiology / Radiation Therapy Terminology
  - Medical Root Words
  - Diagnostic Radiology terminology
  - Radiation Therapy terminology

- Radiation Protection
  - Radiation accidents and environmental radiation exposure
Diagnosis and medical management of radiation syndromes
- Deterministic effects
- Stochastic Effects
- Radiation carcinogenesis
- Heritable radiation effects
- Effects on the developing embryo
- The system for radiation protection
- ALARA Program
- Radiation areas
- Management of Radioactive sources
- Regulatory Exposure Limits
- Radiopharmaceutical administration
- Radiopharmacy ("hot lab")
- Administrative/practice controls and responsibilities
- NRC Authority/Agreement States

**Clinical Procedure Applications**
- Diagnostic Radiology
- Radiation Therapy

**Pathology**
- Neoplastic Diseases
- Infectious Diseases
- Cardiovascular Diseases
- Neurological
- Respiratory
- Renal
- Epidermis (Skin)
- Breast

*See sample questions.*

**PART 2: Diagnostic Medical Physics**

**Radiography, Mammography, Fluoroscopy, and Interventional Imaging**
- X-ray production, beam characteristics and interactions;
- X-ray tube and filtration, x-ray generator components and function;
- Detectors: photostimulable phosphors, flat panel arrays, image intensifiers;
- Scattered radiation and scatter control; automatic exposure control, automatic exposure rate control, density settings;
- Dedicated mammography equipment (e.g., DBT, SBB, FFDM, CEDM);
- Fluoroscopy and interventional radiology: image acquisition, equipment, and procedures;
• Dual energy x-ray imaging and absorptiometry, dental imaging;
• Body tomosynthesis principles and applications;
• Factors that affect image quality (spatial, contrast, and temporal resolution, noise);
• Clinical techniques, protocols, and procedures;
• Radiation dose, dose metrics and indices, patient safety, and personnel safety;
• Acceptance testing, annual testing, and periodic quality control;
• FDA and MQSA regulations and accreditation standards;
• Artifacts: recognition, causes, solutions

• Computed Tomography

  o CT components and function: x-ray tubes, beam collimation, bowtie filter, detector arrays, gantry geometry;
  o Data acquisition modes: localizer, axial, helical;
  o Data acquisition parameters (e.g., kV, mA, rotation time, detector coverage, pitch, tube current modulation);
  o Image reconstruction techniques and parameters;
  o CT number and representative tissue values;
  o Clinical protocols, procedures, management, and optimization;
  o Specialized procedures and techniques (e.g., cardiac, perfusion, angiography, fluoroscopy, dental);
  o Image quality (e.g., spatial resolution, contrast resolution, uniformity evaluation, noise);
  o CT radiation dose: metrics and indices, dose optimization, and patient safety;
  o CT accreditation programs: phantoms, equipment and performance requirements;
  o CT acceptance testing, annual testing, and periodic quality control;
  o CT artifacts: recognition, causes, solutions

• MRI and Ultrasound

  o Magnetism and magnetization properties of elements and nuclei;
  o Precession, resonance, excitation, free induction decay;
  o Tissue magnetization properties: T1, T2, spin density;
  o MR equipment and fundamentals of operation;
  o Acquisition parameters and pulse sequences;
  o Encoding gradients, localization, properties of k-space;
  o MR image reconstruction and formation;
  o MR clinical protocols and special procedures (e.g., parallel imaging, functional MR, perfusion, diffusion, angiography, elastography, biopsy, and spectroscopy);
  o MR image quality;
  o MR siting requirements, safety program, conditional devices, bioeffects;
  o Ultrasound (US) basic physics, production, interactions, and beam properties;
  o US transducer operation, equipment, data acquisition modes;
  o US image characteristics: temporal, spatial, contrast resolution;
- US harmonic imaging, compound imaging;
- Doppler US, power Doppler, color flow;
- US clinical protocols and special procedures (e.g., elastography, 3D and 4D imaging, biopsy);
- US patient safety considerations and indicators;
- Contrast agents for MR and US;
- MR and US accreditation programs: phantoms, equipment and performance requirements;
- MR and US acceptance testing, annual testing, and periodic quality control;
- Artifacts: recognition, causes, solutions

- Informatics, Image Display, and Image Fundamentals
  - Information systems infrastructure: PACS, RIS, EMR;
  - Informatics standards (DICOM, HL7) and interoperability profiles (IHE);
  - Network configuration and modality connectivity;
  - Privacy and security (e.g., HIPAA);
  - Image display monitor and workstation hardware, software, peripherals;
  - Image interpretation environment and ergonomics (e.g., ambient lighting, human perception);
  - Modality-specific image characteristics: matrix/pixel size, bit depth, file format;
  - Image analysis metrics: LSF, PSF, MTF, NPS, DQE;
  - Sampling theorem, Nyquist frequency, aliasing;
  - Image processing, image compression, spatial filtering, noise reduction, edge enhancement, Fourier transforms, convolutions;
  - Observer performance; receiver operator characteristic curves, contrast-detail curves;
  - Descriptive statistics;
  - Quality control and assessment of display performance;
  - Display artifacts: recognition, causes, solutions;
  - Professional ethics (note: applies to all categories)

- Radiation Biology, Dosimetry, Protection, and Safety
  - Deterministic (tissue reaction) effects and thresholds;
  - Stochastic effects and risk estimates for cancer induction and death;
  - Acute radiation syndromes and teratogenesis;
  - Dose reference levels and typical effective doses;
  - Dosimetry fundamentals, dose units, patient and fetal dose;
  - Instrumentation: principles of operation (e.g., dosimeters, survey meters, ion chambers, electrometers, solid state detectors);
  - Personnel monitoring, occupational dose limits and ALARA;
  - Sources of exposure to the public and personnel;
- Radiation protection: time, distance, shielding, specification and evaluation of personal protective equipment;
- Advisory and regulatory agencies;
- Radiation safety regulations and recommendations;
- Radiation safety officer duties and responsibilities;
- Room shielding design concepts, definitions, modality considerations;
- Postinstallation shielding survey, shielding integrity evaluation

- See sample questions.

PART 2: Nuclear Medical Physics

- Radiation Protection
  - Internal dosimetry
  - Dose terminology and Definitions
  - Dose Regulations
  - Expected doses
  - Fetal Dosimetry
  - CT dosimetry
  - Occupational safety
  - Safety for the patient, family and public
  - Time, distance shielding
  - Shielding calculations

- PET & Hybrids
  - Basic PET scanner Instrumentation
  - Radionuclide production and characteristics
  - PET Detectors
  - Acquisition
  - Reconstruction
  - Corrections (Attenuation, random, scatter)
  - Quantitative PET
  - PET/CT
  - QC procedures
  - Acceptance/Annual testing

- Single photon imaging systems including scintillation cameras, solid state cameras and hybrids
  - Basic system instrumentation
  - Radionuclide production and characteristics
  - Intrinsic Specifications
  - Extrinsic Specifications
  - Collimation
  - Digital Systems
  - Dynamic imaging
  - SPECT
- SPECT/CT
- QC procedures
- Acceptance/Annual testing
- Radiation measurements including dose calibrators, well counters, survey meters, thyroid probes
  - Scintillation detector system
  - Solid State Detectors
  - Well Counters and Probes
  - Survey Meters
  - Dose Calibrator
  - Dead-time
  - Efficiency
  - Operation of SCA, MCA
  - Statistical distributions
  - Statistical Tests
  - Propagation of Errors
  - Digital Image Statistics
  - Chi-Square Tests
  - Minimum detectable activity
  - Quantitative measurements including calibration
  - Quality Control
- Clinical Procedures
  - Cardiac
  - Pulmonary
  - Tumor Imaging
  - Bone Imaging
  - Brain
  - Endocrine (Thyroid)
  - Lymphatic
  - Radionuclide therapy
  - Brachytherapy
  - Other

- See sample questions.

PART 2: Therapeutic Medical Physics

- Radiation sources and units
- Measurements of radiation quantity and quality
- Physical principles of radiation therapy, treatment planning and setup
- Clinical radiation therapy
- Treatment planning for external beam therapy, brachytherapy, and stereotactic radiosurgery
- Treatment simulation
Applications of imaging to radiation therapy
Radiobiological principles of therapy
Dose calculations
Quality assurance
Calibration
Informatics
Digital techniques and image processing
Picture archiving and communication systems (PACS)
Radiation protection (including survey techniques and installation design)
Radiation safety

- See sample questions.

Medical Physics Oral Exam

The oral examination is designed to test your knowledge and fitness to practice applied medical physics in the specified specialty(ies). You will be examined by five physics examiners, each of whom will ask one question from each of the five physics categories of the examination.

Medical Physics Oral Exam Categories

The categories below will be used for the Part 3 exam (oral) in medical physics, beginning in 2015. The category descriptions are general descriptions of the content of a category. In any particular examination, the material from the categories is sampled. Additional material related to the categories may be included as the field evolves. Beginning in 2015, these categories will be used in all oral exams, for both first-time candidates and candidates who have previously taken the oral exam.

Conditioned Exams

Candidates who conditioned the oral exam in 2014 or earlier will continue to be examined in the category(ies) in which they were conditioned. (View the list of pre-2014 categories.) Candidates who are conditioned in 2015 and subsequent years will be examined in the new categories.
<table>
<thead>
<tr>
<th>DMP</th>
<th>Category Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiography, mammography, fluoroscopy,</td>
<td>X-ray production, beam characteristics, interactions, and image-formation principles;</td>
</tr>
<tr>
<td>and interventional imaging</td>
<td>clinical protocols for common imaging exams; fluoroscopy and interventional procedures,</td>
</tr>
<tr>
<td></td>
<td>including acquisition parameters and dose-reduction strategies; image noise assessment and</td>
</tr>
<tr>
<td></td>
<td>dose metrics for all projection imaging modalities; common artifacts, quality assurance,</td>
</tr>
<tr>
<td></td>
<td>quality control, mammography accreditation, and MQSA standards</td>
</tr>
<tr>
<td>Computed tomography</td>
<td>CT system design and principles of operation; image-acquisition protocols, including</td>
</tr>
<tr>
<td></td>
<td>helical acquisition and tube current modulation techniques; cone beam geometry; post-</td>
</tr>
<tr>
<td></td>
<td>processing protocols, multiplanar and volumetric reconstruction; quantitative CT; image</td>
</tr>
<tr>
<td></td>
<td>noise assessment, statistics, dose metrics (CTDI, DLP, SSDE), and effective dose</td>
</tr>
<tr>
<td></td>
<td>estimation; common CT artifacts, quality assurance, and CT accreditation program</td>
</tr>
<tr>
<td>MRI and ultrasound</td>
<td>MR equipment, principles of magnetization, resonance, and excitation; MR pulse sequences,</td>
</tr>
<tr>
<td></td>
<td>localization, acquisition, and processing; ultrasound (US) principles, beam properties,</td>
</tr>
<tr>
<td></td>
<td>acquisition methods, signal processing, and image display; Doppler US and color flow</td>
</tr>
<tr>
<td></td>
<td>imaging principles and operation; common artifacts for MRI and US, siting requirements</td>
</tr>
<tr>
<td></td>
<td>for MRI, quality assurance, and accreditation for MRI and US</td>
</tr>
<tr>
<td>Informatics, image display, and image</td>
<td>Informatics infrastructure, standards, and patient security; PACS-modality connectivity,</td>
</tr>
<tr>
<td>fundamentals</td>
<td>workflow, display, and archive functions; image display requirements, characteristics,</td>
</tr>
<tr>
<td></td>
<td>and calibration procedures; image processing techniques and qualitative data extraction;</td>
</tr>
<tr>
<td></td>
<td>image fundamentals, sampling theory, and ROC analysis</td>
</tr>
<tr>
<td>Radiation, dosimetry, protection, and</td>
<td>Radiation biology, radiation effects, and age/gender-specific risks; radiation</td>
</tr>
<tr>
<td>safety</td>
<td>protection principles, guidelines, and regulations; radiation dosimetry, detectors,</td>
</tr>
<tr>
<td></td>
<td>standards, and units; radiation shielding design factors, barrier requirements, surveys,</td>
</tr>
<tr>
<td></td>
<td>and reports; patient safety and error-prevention issues, including dose reduction,</td>
</tr>
<tr>
<td></td>
<td>sentinel events, and MR- and US-specific safety issues</td>
</tr>
<tr>
<td>NMP</td>
<td></td>
</tr>
<tr>
<td>Radiation protection</td>
<td>Internal dosimetry, including MIRD; fetal dose; units; personnel safety, including</td>
</tr>
<tr>
<td></td>
<td>facility surveys and occupational dose limits; radiation protection principles; patient</td>
</tr>
<tr>
<td></td>
<td>safety, including breastfeeding and pregnancy; shielding, including facility and personnel</td>
</tr>
<tr>
<td></td>
<td>protection; regulations and regulatory bodies, including</td>
</tr>
</tbody>
</table>
shipping and waste disposal; ALARA; time, distance, and shielding; and radiation surveys

Radionuclide production, assay, and characteristics; QC procedures, including ACR and acceptance testing; artifacts; system principles; image fusion; quantitative PET; image reconstruction, including attenuation correction, random coincidences, scattered radiation, deadtime, and 2D versus 3D

SPECT radionuclide production, assay, and characteristics; QC procedures, including ACR and acceptance testing; artifacts; system principles, including gamma cameras and collimators; deadtime; image fusion; dynamic imaging; renograms; cardiac function, ejection fraction, and tracer kinetics; image reconstruction, including scanograms, attenuation correction, and filters; edge enhancement; smoothing; unsharp masking; and segmentation

Radioactivity measurement, including dose calibrators and well counters; statistics, including minimum detectable activity; radiation detectors, including survey meters, personnel monitoring, and deadtime; quantitative measurements, including calibration; and QC procedures

Radionuclide therapy, including facilities, dosimetry, radiation protection, and release criteria; PET and hybrids; SPECT and hybrids, including gamma cameras; radiation dose, including risk; radiopharmaceutical usage; thyroid imaging/uptake; informatics and display performance; miscellaneous

<table>
<thead>
<tr>
<th>Category Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation protection and patient safety</td>
</tr>
<tr>
<td>Assuring patient safety: error prevention, identification, and reporting; chart rounds, chart checks, safety environment, procedural pauses, integrated staff training, and introduction of new technologies. Clinical radiation biology: compromise among tumor/normal tissue dose, out-of-field dose, fetal dose, and pacemaker doses; risk of second malignancies; chart checks, peer review (chart rounds, tumor boards), and error reporting.</td>
</tr>
<tr>
<td>Patient-related measurements</td>
</tr>
<tr>
<td>External beam planning and simulation: representative clinical treatment plans, plan quality and improvement, use of wedges and other modifiers, identification of target volumes and organs at risk,</td>
</tr>
</tbody>
</table>
commissioning of CT for RT planning, use of DVHs and other metrics, and tolerance doses. Photon beam algorithms and dose calculations: photon beam characteristics and modeling, calculation algorithms, heterogeneity corrections (historical and contemporary), methods for separating primary and scatter, and MU calculations. Electron beam treatments: electron beam characteristics and modeling, calculation algorithms, heterogeneity corrections (historical and contemporary), gap and VSD calculations, and MU calculations. Brachytherapy treatments: representative clinical plans, source characteristics, treatment applicators, calculation methods (historical and contemporary), and tolerance doses, special procedures.

Reference images (DRR, etc.): identification of modalities, understanding of influence of imaging parameters, and understanding of DRRs, EPIDs, etc. Image fusion: image registration and fusion, use, pitfalls, and errors. Organ/target segmentation: definitions of GTV, CTV, PTV, OAR, etc.; identification of structures and methods of segmenting. Verification and localization images: characterization of images, influence of imaging parameters, equipment for imaging, and purposes of different image types. Basic imaging and physics: function of imaging systems, use of nuclides, and physics of imaging for different systems.

Absolute calibration protocols: external beam and details of TG-51 calibration protocols. Quality assurance: QA procedures for mechanical and radiological alignment, beam QA, equipment for QA, recommendations, and requirements. Acceptance testing and commissioning: performance specifications, commissioning equipment, commissioning of accelerator, IMRT, VMAT, wedges, etc. Brachytherapy calibration and QA: LDR and HDR commissioning, calibration, QA procedures, and equipment needed. Photon beam characteristics: isodose distributions, surface dose, beam parameters, kerma versus dose, electronic equilibrium and dose buildup, definition of flatness and symmetry, relationships among depth dose, field size, SSD, etc.

Linac treatment head components and function: monitor chamber, bending magnet, wedges, collimators, wedges and independent jaws, target, flattening filter, and leakage characteristics. Ion chamber design, characteristics, and function: temperature and pressure effects, stem effect, effect of volume, recombination, polarity effect, and comparison with other instruments. Other detectors: TLD, OSLD, diodes, radiographic, and radiochromic film. Linac acceleration system – waveguide and power components: design and operation of klystron, magnetron electron gun, energy switch, accelerator guide, and electron acceleration. Miscellaneous equipment: electrometers,
water/tissue substitute materials and appropriate use, phantoms, beam-scanning systems, CT and MR simulators, test/QA equipment for imaging systems, equipment for SRS QA, and equipment for 4D CT.

The table above contains general descriptions of category contents. In any particular examination, the material from the categories is sampled. Additional material related to the categories may be included as the field evolves.

**Conditioned Exams**

Candidates who conditioned the oral exam in 2014 or earlier will continue to be examined in the category(ies) in which they were conditioned. Candidates who condition the oral exam in 2015 and subsequent years will be examined in the new categories.