AAPM Recommended Radiological Physics Curriculum for Diagnostic Radiology Residents

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Richard J. Massoth, Ph.D.

Overview

- AAPM Report 64 surveyed Diagnostic Radiology and Radiation Oncology Residency Programs
- There were several models for such programs, a range of hours devoted to didactic instruction, review (exam preparation) and (for some programs) practicum/laboratory.
- To accommodate the different instructional models, a weighted “unit of instruction” was chosen to express how much emphasis should be placed on particular topics without dictating the number of didactic hours.

Does The Curriculum "Have" To Be Followed?

- Not every program will necessarily have the same emphasis on each recommended section of the Core Curriculum.
- There are "additional areas" which will appear on the AAPM web page to address:
  - "New" and "emerging" areas in medical physics;
  - "Hot button" issues from regulatory agencies;
  - Areas where members of MPEP have identified a need to modify the core curriculum which are not fully and officially approved.
    - Example: "Radiological Disaster Response", "peephole fluoroscopy" or "fluoroscopy credentialing programs".

Core Curriculum

- Intended for Didactic Lectures or Independent Study Modules
- Learning Objectives are described for each Section in the Curriculum.
- Each program may develop tests to probe resident knowledge in each section.
- Laboratory exercises or use of clinical examples should be encouraged to tie materials to radiology practice.
- Study (by student) may be necessary to understand and retain purely didactic information.

Major Sections of the Curriculum

- General Radiology Physics (4 units)
- Diagnostic Radiology Physics (25.25 units)
- Nuclear Medicine Physics (6.5 units)
- Radiation Protection and Regulation (5.5 units)
- Radiation Biology (3 units)
- Additional or “special interest” sections or modules may be added as time and interest allow.

General Radiology Physics

- Sections
  - Structure of the Atom and Radiation Principles (1 unit)
  - Interaction of Radiation with Matter (2 units)
  - Radiation Units/Quantities (1 unit)

General Radiology Physics (2a)

- 1. Structure of the Atom and Radiation Principles (1 unit)
  - ***Learning Objectives for Resident:***
    - *learn the structure of the atom, including types of nucleons, relation between atomic number and atomic mass, as well as electron orbits and binding energy;*
    - *be able to relate energy to wavelength and rest mass, and understand and describe an energy spectrum;*
    - *learn about radioactivity, including decay processes, & half life.*

General Radiology Physics (2b)

- Topics to be Covered in Section 1:
  - Electromagnetic Radiation- x-rays and gamma-rays
  - Electronic Structure of the Atom
  - Characteristic X-rays
  - Atomic Nucleus
  - Radioactivity
  - Radioactive Decay- alpha, beta, gamma, x-ray, electron, and positron decay
  - Internal Conversion (and Auger) Electrons

General Radiology Physics (3a)

- #2. Interaction of Radiation with Matter (2 units)
  - Learning Objectives for the Resident
    - the physical description, random nature, and energy dependence of the four scatter and absorption interactions that x-ray photons undergo with individual atoms (coherent scatter, photoelectric effect, Compton effect, and pair production).
    - definitions of the key terms such as attenuation, scatter, beam geometry, linear and mass attenuation coefficients, energy transfer, energy absorption, half-value layer, and how these terms relate to radiation scatter and absorption through the exponential attenuation equation;
    - the physical description and energy dependence of the elastic and inelastic collision processes in matter for directly and indirectly ionizing particulate radiation
    - definitions of key terms such as linear energy transfer, specific ionization, mass stopping power, range, and how these terms relate to energy deposition by particulate radiation.

General Radiology Physics (3b)

- Topics to be Covered
  - Particle Interactions (emphasize electron interactions)
    - LET
    - Bremsstrahlung Interactions
    - Positron Annihilation
    - Neutron Interactions
  - X and Gamma Interactions
    - Rayleigh or Coherent Scattering
    - Compton Scattering
    - Photoelectric Effect
    - Pair Production
  - Attenuation of X and Gamma Ray
    - Linear Attenuation Coefficient
    - Mass Attenuation Coefficient
    - HVL

General Radiology Physics (4a)

- #3. Radiation Units (1 unit)
  - ***Learning Objectives for Resident:***
    - ***definitions and units for kerma, exposure, absorbed dose, dose equivalent, and RBE dose;***
    - ***the conditions under which each quantity applies; and,***
    - ***the physical basis for measuring or computing each quantity.***

General Radiology Physics (4b)

- Topics to be Covered in Section #3:
  - Absorbed Dose
  - Exposure
  - Equivalent Dose
  - Effective Dose
  - Quality factors
  - Tissue Weighting Factors

Diagnostic Radiology Physics

- Sections
  - X-ray Production (0.5 units)
  - X-ray Tubes (0.25 units)
  - X-ray Generators (0.25 units)
  - Film-Screen Radiography (0.5 units)
  - Film Processing (0.25 units)
  - Mammography (1.5 units)
  - Fluoroscopy (2 units)
  - Image Quality (5 units)
  - Digital Radiography (3 units)
  - Conventional Tomography (0.25 units)
  - Computed Tomography (CT) (3 units)
  - MR: Basic Principles (2 units)
  - MR: Imaging and Instrumentation (2 units)
  - Ultrasound (including Doppler) (3 units)
  - Computers in Radiology (2 units)

Diagnostic Radiology Physics (1a)

- #4. X-ray Production (0.5 unit)
  - ***Learning Objectives for Resident:***
    - the concepts of beam production, including acceleration of electrons in diagnostic X-Ray tubes;
    - Bremsstrahlung;
    - X-Ray tube design; and,
    - characteristic radiation.

Diagnostic Radiology Physics (1b)

- Topics to be Covered in Section #4:
  - Tube design elements
  - Bremsstrahlung Spectrum
  - Characteristic X-rays

Diagnostic Radiology Physics (2a)

- 5. X-ray Tubes (0.25 unit)
  - ***Learning Objectives for Resident:***
    - *the concepts X-Ray tube design;*
    - *characteristics of the cathode, and anode;*
    - *the concept of the heel effect;*
    - *filtration concepts (linear and K-edge);*
    - *collimation;*
    - *x-ray tube heat loads (instantaneous and integral); and,*
    - *technique charts.*

Diagnostic Radiology Physics (2b)

- Topics to be Covered in Section # 5:
  - Cathode
  - Anode
  - Focal Spot
  - Heel Effect
  - Off-focus Radiation
  - X-ray Tube Insert and Housing
  - Filtration
  - Collimators
  - Heat Loading
  - Rating Charts

Diagnostic Radiology Physics (3a)

- #6. X-ray Generators (0.25 unit)
  - ***Learning Objectives for Resident:***
    - *the individual components of an x-ray generator; and,*
    - *the properties of a timer and phototimer.*

Diagnostic Radiology Physics (3b)

- Topics to be Covered in Section #6:
  - Generator Components
  - Timer and Phototimer
  - Power Ratings
  - Generator Types
  - Ripple effects from various generator types

Diagnostic Radiology Physics (4a)

- #7. Film-Screen Radiography (0.5 unit)
  - ***Learning Objectives for Resident:***
    - *the basic theory of film/screen radiography including magnification radiography; and,*
    - *the properties of film/screen cassettes, screens, radiographic film, and grids.*

Diagnostic Radiology Physics (4b)

- Topics to be Covered in Section #7:
  - Basic projection geometry, Magnification
  - Film Screen Cassettes
    - Screen Characteristics
    - Conversion Efficiency
    - Absorption Efficiency
    - Noise
  - Film
    - Physical characteristics
    - Optical density
    - HD curve
    - Contrast/Latitude
  - Film screen systems
  - Dose
  - Anti-Scatter and Grids
    - Bucky Factor
    - Grid frequency
    - Grid Ratio
    - Thickness/Material
  - Artifacts

Diagnostic Radiology Physics (5a)

- #8. Film Processing (0.25 unit)
  - ***Learning Objectives for Resident:***
    - *the basic theory of film processing including formation of the latent image;*
    - *wet and dry processing systems;*
    - *film processing artifacts; and,*
    - *film processing quality assurance.*

Diagnostic Radiology Physics (5b)

- Topics to be Covered in Section #8:
  - Film emulsion
  - Latent Image
  - Development
  - Automatic Film Processor
  - Artifacts
  - Quality Assurance
  - Laser Cameras
  - Dry processing

Diagnostic Radiology Physics (6a)

- #9. Mammography Physics (1.5 units)
  - ***Learning Objectives for Resident:***
    - *the basic theory of mammography including film/screen mammography and digital mammography;*
    - *the importance of compression, grid, mammography film/screen system, proper film processing;*
    - *about mammography image characteristics including contrast and resolution; and,*
    - *MQSA regulations and quality control for mammography.*

Diagnostic Radiology Physics (6b)

- Topics to be Covered in Section #9:
  - X-ray tube
    - Anode
    - Tube tilt
    - Focal spot
    - Filtration
    - Collimation
    - Energy spectrum/ HVL
    - Output
  - X-ray Generator
    - Automatic Exposure Control
  - Bucky
    - Grid Ratio and construction
    - Movement
  - Compression
  - Magnification
  - Screen-film systems
    - Cassettes
    - Film
    - Film Sensitivity
    - Film Processing
    - Film Viewing conditions
  - Imaging Parameters
    - Contrast
    - Noise
    - Resolution
    - Dose-Average Glandular Dose
  - Quality Control

Diagnostic Radiology Physics (6c)

- More Topics for Section #9:
  - Stereotactic Breast Biopsy
  - Full Field Digital Mammography
  - CR Digital Mammography
  - Tomosynthesis
  - MQSA Regulations
    - Accreditation
    - Certification
    - Inspection
    - Mammography Phantom

Diagnostic Radiology Physics (7a)

- #10. Fluoroscopy (2 units)
  - ***Learning Objectives for Resident:***
    - *the basic principles of fluoroscopy, both analog and digital, continuous and pulsed;*
    - *the function of the imaging chain components including the image intensifier, TV system, digital recording equipment, automatic brightness control;*
    - *the magnitude of the dose to the patient and operator from fluoroscopy; and,*
    - *the regulations for fluoroscopy users.*

Diagnostic Radiology Physics (7b)

- Topics to be Covered in Section #10
  - Equipment description/ resolution
  - Image Intensifier
    - Input screen
    - Optics
    - Output phosphor
    - Conversion Gain
    - Brightness Gain
    - Field of View-- Magnification
  - Video System
    - Hardware
    - Video Resolution
  - Flat panel Digital Fluoroscopy
  - Modes of operation- continuous, high dose rate, pulsed etc
  - Automatic Brightness Control
  - Image Quality
    - Spatial Resolution
      - Include parts of imaging chain
    - Contrast Resolution and quantum noise
  - Radiation Dose
    - Patient dose rates- average, maximum, methods to reduce
    - Operator dose- effects of shielding

Diagnostic Radiology Physics (7c)

- Topics to be Covered in Section #10
  - Recording Methods
    - Digital Photo-spot camera
    - Spot-film device
    - Cine Camera
  - Regulations
  - Quality Assurance
    - Collimation
    - Patient entrance dose
    - High and low contrast resolution measurements

Diagnostic Radiology Physics (8a)

- #11. Image Quality (5 units)
  - ***Learning Objectives for Resident:***
    - *the basic theory of:*
      - *image formation;*
      - *image contrast*
      - *Resolution;*
      - *MTF;*
      - *Noise;*
      - *quantum detection; and,*
      - *sampling & aliasing.*
    - *the definition of ROC curves.*

Diagnostic Radiology Physics (8b)

- Topics to be Covered in Section #10:
  - Magnification
  - Contrast
    - Subject contrast
    - Detector Contrast
    - Film screen contrast
    - Digital image contrast
    - Displayed contrast
    - Radiographic Contrast
    - Displayed contrast (Digital Contrast)
  - Noise
    - Quantum Noise
    - Contrast Noise Ratio (Digital Images)
  - Quantum Detection efficiency
  - Spatial Resolution
    - Mechanisms of Blur or Unsharpness
    - Focal spot blur
    - Geometric blur
    - Motion blur
    - Detector blur
    - Composite blur
    - MTF (Point and line spread functions)
    - Practical QA measurements und Resolution Phantoms
  - Sampling and Aliasing
  - Contrast/Detail Curves
  - Receiver Operating Characteristics (ROC)

Diagnostic Radiology Physics (9a)

- #12. Digital Radiography (3 units)
  - ***Learning Objectives for Resident:***
    - *the basic theory of digital radiography;*
    - *the properties of different digital modalities:*
      - *DR,*
      - *CR,*
      - *"digital" cassettes, and*
      - *CCD detectors;*
    - *types of post-processing:*
      - *image processing;*
      - *image subtraction angiography.*

Diagnostic Radiology Physics (9b)

- Topics to be Covered in Section #12:
  - CR Technology
  - DR Technology
    - Indirect Flat Panel
    - Direct Flat Panel
  - CCD Detectors
  - Dose
  - Soft Copy Devices
  - Digital Image Processing
    - Corrections
    - Global Processing
    - Convolution
    - Filtering
  - Resolution
  - Digital Subtraction Angiography

Diagnostic Radiology Physics (10a)

- #13. Conventional (Classic) Tomography (0.25 units)
  - ***Learning Objectives for Resident:***
    - *the basic concept of conventional linear tomography (as differentiated from stereoradiography and tomosynthesis).*

Diagnostic Radiology Physics (10b)

- Topics to be Covered in Section #13:
  - Section thickness and tube arc
  - Section Location
  - Artifacts

Diagnostic Radiology Physics (11a)

- #14. Computed Tomography (CT) Physics (3 units)
  - ***Learning Objectives for Resident:***
    - *the basic theory of Computed Tomography Scanner;*
    - *about the properties of CT detectors, helical and multislice CT units;*
    - *the definition of the Hounsfield unit;*
    - *magnitude of dose from a CT scan;*
    - *the effect of kVp and mA on dose; and,*
    - *to recognize CT artifacts*

Diagnostic Radiology Physics (11b)

- Topics to be Covered in Section #14:
  - Basic Principles
  - History “4-7” Generations (depending upon count);
  - Detectors;
  - Slice thickness
    - Single and Multi-Detectors
  - Helical CT- Pitch and collimation
  - Reconstruction Kernels
    - Bone and soft tissue
  - CT Number- Hounsfield Units
  - Display
    - Multi-image and 3D

Diagnostic Radiology Physics (11c)

- Topics to be Covered:
  - Dose
    - Measurement
    - Patient
    - Pediatric
    - Modulated mA (CT-AEC).
  - Image Quality
  - Artifacts
    - Beam Hardening
    - Motion
    - Partial Volume
    - Hardware failure (Detector)

Diagnostic Radiology Physics (12a)

- #15. MR: Basic Principles (=2 units)
  - ***Learning Objectives for Resident:***
    - *the basic theory of magnetism and magnetic residence*
    - *the definition of:*
      - *The Larmor frequency;*
      - *Free induction decay; and*
      - *Tissue contrast parameters:*
        - *T1, T2, T2*, and proton density*
      - *To understand the principles of magnetic residence, and the magnetic properties of tissue.*

Diagnostic Radiology Physics (12b)

- Topics to be Covered in Section #15:
  - Magnetism
    - Magnetic Nuclei
    - Tissue Magnetization—including net magnetization vector
  - Larmor Frequency
  - Resonance
  - Longitudinal Magnetization
  - Transverse Magnetization
  - RF pulses (90 degree, 180 degree, and arbitrary or alpha)
    - Free induction decay (FID)
  - Proton density (PD)

Diagnostic Radiology Physics (12c)

- Relaxation effects:
  - T1 Relaxation
  - T2 Relaxation
  - T2* Relaxation including Non-uniformity and magnetic susceptibility effects
  - Free Induction Decay (FID)
- Basic Pulse Sequences
  - TR and TE
  - Weighted Images
- Signal from Flow
  - Flow enhancement
  - Flow voids
  - Flow compensation

Diagnostic Radiology Physics (13a)

- #16. MR: Imaging and Instrumentation (2 units)
  - ***Learning Objectives for Resident:***
    - *the basic theory of operation of an MRI unit;*
    - *the properties of magnetic coils such a the main magnetic, gradient coils, shim coils, and surface coils;*
    - *to understand slice encoding, frequency and phase encoding;*
    - *the different types of pulse sequences, signal to noise ratio of MR images;*
    - *what is K space;*
    - *to appreciate the need for safety around MR units;*
    - *to recognize MRI artifacts.*

Diagnostic Radiology Physics (13b)

- Topics to be Covered in Section #16:
  - Magnets
    - Magnetic Field Gradients Coils (X, Y, Z)
  - RF Coils
    - Body, head, surface, phased array
  - Shielding
    - Active
    - Passive
    - RF faraday cage
  - Slice Select Gradient (SEG)
  - Frequency Encoded Gradient (FEG)
  - Phase Encoded Gradient (PEG)
  - Gradient Sequencing and Pulse Sequence Diagrams
  - K- Space

Diagnostic Radiology Physics (13c)

- Imaging Sequences
  - Spin Echo
  - Fast Spin Echo—echo train length
  - Inversion Recovery—Stir Flair
  - Gradient recalled echoes
  - Echo Planar imaging
- T1, T2, PD weighting
- Multi-planar Acquisition
  - 2D vs. 3D imaging
  - Scan time for 2D vs. 3D
- Resolution
  - Pixel size
  - Slice thickness
- SNR
  - Voxel size
  - Static magnetic field strength
  - RF bandwidth
  - NSA,
  - RF Coil
- Angiography
  - Time of flight
  - Phase Contrast
- Artifacts
  - Chemical shift
  - Patient motion
  - Wraparound, truncation
  - Zipper
  - Ring

Diagnostic Radiology Physics (13d)

- Clinical Contrast Agents- Gd-DTPA
- Spectroscopy
- MR Safety
  - Screening patients
  - SAR Limits
- Quality Assurance
  - SNR
  - Resonant Frequency
  - ACR Accreditation phantom—weekly and annual tests

Diagnostic Radiology Physics (14a)

- #17. Ultrasound Iincluding Doppler) (3 units)
  - ***Learning Objectives for Resident:***
    - *the basic theory of how an ultrasound unit works;*
    - *about the properties of sound transmission, including reflection, refraction, scattering and attenuation;*
    - *about the properties of piezoelectric transducers, the ultrasound beam, its resolution;*
    - *about focusing and steering the ultrasound beam;*
    - *the different mode of ultrasound imaging including B mode scanning and real time imaging;*
    - *to understand Doppler ultrasound, its limitations, and understand the artifacts; and,*
    - *to recognize ultrasound artifacts.*

Diagnostic Radiology Physics (14b)

- Topics to be Covered in Section #17:
  - Characteristics of Sound
  - Pressure, Intensity and dB
  - Interactions of sound with matter
    - Acoustic Impedance
    - Reflection
    - Refraction
    - Scattering
    - Attenuation
  - Transducers
    - Piezoelectric Effect
    - Near field, Far field
    - Acoustic Profile
    - Focusing and lenses
  - Types of Transducers
    - Mechanical sector
    - Linear Array
    - Phased Array (Annular and Linear)
    - Curvilinear Array
  - Focusing and steering
    - Mechanical
    - Electronic Transmit
    - Electronic Receive
  - Spatial Resolution
    - Axial
    - Lateral
    - Slice Thickness (elevational)

Diagnostic Radiology Physics (14c)

- Real Time Imaging
  - Registration of echo in image
  - Lines of Sight
  - Frame Rate
  - Pulse Repetition Frequency
  - Time Gain Compensation
- Display Modes
  - A-mode
  - B-mode
  - M-mode
- Image Quality, Contrast and Noise
- 3D imaging
- Harmonic Imaging
- Image Processing
  - Time Gain Compensation
  - Logarithmic compression
  - Frame Averaging
  - Spatial Smoothing
- Artifacts
  - Shadowing
  - Enhancement
  - Miss registration
  - Reverberation
  - Comet Tail
  - Ring Down
  - Mirror Image
  - Side Lobe
- Elastography

Diagnostic Radiology Physics (15a)

- #18. Computers in Radiology (2 units)
  - ***Learning Objectives for Resident:***
    - *how computers are used in radiology;*
    - *about image display characteristics and monitor technology;*
    - *how PACS works and how networks operate;*
    - *to appreciate security problems associates with digital images; and,*
    - *what is needed for quality assurance in a PACS environment.*

Diagnostic Radiology Physics (15b)

- Topics to be Covered in Section #18:
  - Image display characteristics – resolution and image pixel depth
  - Image processing
  - Computer Aided Detection
  - Networks
  - Teleradiology
  - Security
  - PACs
  - Image storage and transmission
  - Display of Images
  - Hardcopy Recording Device
  - QA (SMPTE Test Pattern)

Nuclear Medicine Physics

- Radioactivity (0.5 units)
- Decay Schemes (0.5 units)
- Radioisotope Production (0.5 units)

Nuclear Medicine Physics (1)

- #19. Radioactivity (0.5 unit)
  - ***Learning Objectives for Resident:***
    - *learn about radioactivity and half life*
- Topics to be Covered in Section #19:
  - Decay
  - Half-life

Nuclear Medicine Physics (2)

- #20. Decay Schemes (0.5 unit)
  - ***Learning Objectives for Resident:***
    - *about decay processes including alpha decay, beta plus and minus decay, electron capture, isometric transition, nuclear fission and gamma decay.*
- Topics to be Covered in Section #20:
  - Alpha Decay
  - Beta Minus Decay
  - Beta Plus Decay
  - Electron Capture
  - Isomeric Transition
  - Nuclear Fission
  - Gamma Decay

Nuclear Medicine Physics (3a)

- #21. Radioisotope Production (0.5 unit)
  - ***Learning Objectives for Resident:***
    - *how radioisotopes are produced by a cyclotron and a nuclear reactor;*
    - *about the properties of radionuclides; and,*
    - *about regulatory issues (and recent [2005] changes in those issues) associated with radionuclides.*

Nuclear Medicine Physics (3b)

- Topics to be Covered in Section #21:
  - Cyclotron Produced Isotopes
  - Nuclear Reactor Produced Isotopes
    - Fission Products
    - Neutron Products
  - Radionuclide Generators
    - Transient Equilibrium
    - Secular Equilibrium
  - Radiopharmaceuticals
    - General Properties
    - Methods of Localization
  - QC
  - Regulatory
    - Investigational Regulations
    - Written Directives
    - Medical Events
    - NRC Requirements

Nuclear Medicine Physics (4a)

- #22. Counting Instrumentation (1 unit)
  - ***Learning Objectives for Resident:***
    - *about different technologies of counting equipment used in nuclear medicine;*
    - *how a NaI detector works.*

Nuclear Medicine Physics (4b)

- Topics to be Covered in Section #22:
  - Detector types
    - Gas Filled
    - Scintillation
    - Semiconductor
  - Data collection
  - Spectroscopy
    - Single Channel Analyzer
    - Multi Channel Analyzer
  - NaI Detector
    - Thyroid
    - Well
  - Dose Calibrator
  - Survey Meter
    - GM
    - Other types

Nuclear Medicine Physics (5a)

- #23. Counting Statistics (1 unit)
  - ***Learning Objectives for Resident:***
    - *to understand counting statistics and sources of error;*
    - *about different probability distributions including Binomial, Poisson and Gaussian distributions.*

Nuclear Medicine Physics (5b)

- Topics to be Covered in Section #23:
  - Sources of Error
  - Characterization of Data
    - Accuracy and Precision
    - Mean, Mode, and Median
    - Variance
    - Standard Deviation
  - Probability Distributions
    - Binomial
    - Poisson
    - Gaussian
    - Confidence Levels
    - Propagation of Error

Nuclear Medicine Physics (6a)

- #24. Scintillation Cameras (1 unit)
  - ***Learning Objectives for Resident:***
    - *how a gamma camera works;*
    - *about the performance of nuclear medicine gamma camera including the effect of collimators;*
    - *to understand artifacts produced by gamma cameras;*
    - *the use of computers in nuclear medicine.*

Nuclear Medicine Physics (6b)

- Topics to be Covered in Section #24:
  - Anger Camera
    - Crystals
    - PM tubes
  - Collimators
  - Image formation
  - Performance
  - Spatial Linearity and Uniformity
  - Artifacts
  - Whole body scanning
  - Computers in Nuclear Medicine
    - Image processing
    - Subtraction
    - Ejection Fraction-grated studies
    - Spatial Filtering
    - Other corrections

Nuclear Medicine Physics (7a)

- #25. Emission Tomography (PET & SPECT) (2 units)
  - ***Learning Objectives for Resident:***
    - *how a SPECT and PET camera works;*
    - *Understand attenuation correction methods and issues;*
      - CT (or Fusion Imaging) attenuation correction;
      - Emission attenuation correction; and,
      - Lack of attenuation correction, with its effects on images.
    - *to understand artifacts produced by SPECT and PET.*

Nuclear Medicine Physics (7b)

- Topics to be Covered in Section #25:
  - Sinograms and Image Reconstruction Algorithms
  - SPECT
    - Image reconstruction
    - Attenuation corrections
    - Multi headed Cameras
    - Center of Rotation (COR)
  - PET
    - Principles of Detection
    - Scanner Design
    - Data Acquisition
  - Image Fusion
  - PET/CT and SPECT/CT

Radiation Protection (& Regulation)

- Radiation Protection (2 units)
- Radionuclide Therapy (0.5 units)
- Regulatory Bodies and Regulations (2 units)
- Patient Dosimetry (1 unit)

Radiation Protection (1a)

- 26. Overview of Radiation Protection. (2 units)
  - ***Learning Objectives for Resident:***
    - *the magnitude and source of natural background radiation;*
    - *the units used in radiation protection and methods used to measure these units;*
    - *how to reduce dose to patient and operator: time, distance and shielding;*
    - *how to design radiation shielding.*

Radiation Protection (1b)

- Topics to be Covered in Section 26 (2 units total):
  - Sources of Ionizing radiation
    - Natural
    - Artificial
    - Medical
    - Background
  - Dosimetry
    - Dose Equivalent
    - GSD?
    - Personal Monitoring Equipment
      - Film Badges
      - TLD badges
    - Survey Instruments
      - GM Counter
      - Ionization Chamber

Radiation Protection (1c)

- Topics to be Covered in Section 26 (2 units total):
  - Radiation Protection Methods
    - Time
    - Distance
    - Shielding
    - Avoiding Internal Deposition (Nuclear Medicine)
  - Protective Barriers
    - CT Scanner
    - Radiographic
    - Fluoroscopic
    - Nuclear Medicine

Radiation Protection (2a)

- 27. Radionuclide Therapy. (0.5 unit)
  - ***Learning Objectives for Resident:***
    - What isotopes are used in radionuclide therapy and precautions needed in giving this treatment.

Radiation Protection (2b)

- Topics to be Covered in Section 27 (0.5 units):
  - Isotopes
  - Dose
  - Waste Disposal
  - Patient Isolation
  - Patient Release

Radiation Protection (3a)

- 28 Radiation Regulations. (2 units)
  - ***Learning Objectives for Resident:***
    - *the different regulatory agencies and their rules and influence;*
    - *what ALARA means;*
    - *the dose limits applied in their local area.*

Radiation Protection (3b)

- Topics to be Covered in Section 28 (2 units):
  - Agencies
    - State
    - FDA
    - NRC
    - International
    - MQSA
    - BEIR
    - NCRP
    - ACR
    - CRCPD
  - Units
  - Dose Limits
  - ALARA
  - NRC requirements

Radiation Protection (4a)

- 29. Patient Dosimetry. (1 unit)
  - ***Learning Objectives for Resident:***
    - *the patient and users dose from typical diagnostic and therapy procedures;*
    - *how to calculate the dose from these procedures.*

Radiation Protection (4b)

- Topics to be Covered in Section 29 (1 unit):
  - CT Dose
  - Radiographic
  - Fluoroscopy
  - MIRD
  - Occupational Exposures
  - Patient Exposures and Estimation
  - Application in Clinical Practice
    - Mammography Screening
    - Pediatric CT
    - Recommendations for Therapeutic Abortion
    - Management of Pregnant Worker
    - Management of Pregnant Patient

Radiation Biology

- ***Learning Objectives for the Resident (3 units)***
  - *the basic principles of radiation biology including how energy is transferred to the cells, cell survival properties;*
  - *the definition of genetic effects stochastic effects and Nonstochastic effects;*
  - *probability of cancer induction by radiation;*
  - *risk estimate as applied to radiation biology.*

Radiation Biology (2)

- Sections (3 units total)
  - Ionization and biomolecules
    - Microdosimetry
    - Direct and indirect effects
    - Oxygen effect – OER
    - Linear Energy Transfer (LET)
  - Cellular interactions (with radiation)
    - Cell survival studies
    - Radiosensitivity and the cell cycle
    - Effects of dose, dose-rate and fractionation
    - Target theory
    - Apoptosis
    - Radioprotectors and radiosensitizers

Radiation Biology (3)

- Sections (continued, 3 units total)
  - Genetic Effects
    - Genetically significant dose
    - Doubling dose
  - Stochastic effects
    - Threshold versus non-threshold
    - Dose-effect models
  - Nonstochastic (Deterministic) Effects
    - Acute Radiation Syndrome (ARS)
      - Hematopoetic Syndrome
      - GI Syndrome
      - Neurovascular Syndrome
    - Tissue and Organ Effects
    - Skin and Eye Injury

Radiation Biology (4)

- Sections (continued again total)
  - Population Dosimetry
  - Risk Estimation
    - Genetic Risks
    - In utero Risks – Time of fetal maturation
    - Cancer Risks – Leukemia, Thyroid, Breast

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  - F.-F. Yin, Ph.D.

Comments, Suggestions, Advice and Complaints

- Send email to these AAPM groups in order of importance:
  - The Syllabus SC Chair & Vice-Chair (vacant)
  - The Syllabus Subcommittee (in its entirety)
  - The MPEP Committee Chair & Vice-Chair
  - The MPEP Committee (in ins entirety)
  - The Chair & Vice-Chair of Education Council
  - … but not “to no-one at AAPM” or “to the world”