FLORIDA HOSPITAL DIAGNOSTIC RADIOLOGY RESIDENCY PROGRAM

PHYSICS GOALS AND OBJECTIVES

Goals and objectives are based on recommendations and requirements from the AAPM, RSNA, NRC, FL DOH, and ACGME

Module 1: Basic Physics and Interactions

YEAR 1:
1. List the components of the atom
2. Describe how energy levels define radiation-associated properties (including binding energy and ionization)
3. Describe the structure of the nucleus
4. Describe how nuclear structure influences whether an atom decays and what radiation it emits
5. Perform calculations regarding decay and half-life
6. Describe relationships between energy, wavelength, frequency, and velocity
7. Describe how charged and uncharged particles interact with matter and how properties such as density and atomic number alter the probability of a specific interaction
8. Describe and perform calculations with attenuation and half-value layer
9. Describe why a contrast agent is radio-opaque
10. Perform calculations using scientific notation, log, exponential, square root and the metric system
11. Describe the SI and Classical units for measuring the radiology related quantities (e.g., KERMA, dose, activity, energy, etc.)
12. Identify the different categories and properties of particulate radiation
13. Describe types of photon interactions and their energy deposition

YEAR 2:
1. Describe appropriate x-ray beam energies to be used when iodine and barium contrast agents are used
2. Identify which photon interactions are dominant for each modality and therapy in radiology
3. Describe how image quality and patient dose are affected by interactions of radiation with matter
4. Describe the purpose of adding Cu filters in vascular imaging
5. Convert between various units of measurement for activity, dose, and other radiologic quantities
6. Explain radiation exposure and dose quantities in lay language to a patient

YEAR 3:
1. Describe how particulate radiation properties alter our approaches to safety
2. Discuss the appropriate use or applicability of radiation quantities in the health care applications of imaging, therapy, and safety
YEAR 4:
1. Be able to explain all topics of basic physics and interactions of ionizing radiation with matter to a layperson

Module 2: Basic Image Science and Informatics

YEAR 1:
1. Define the methods used to describe the uncertainty in a measurement
2. Calculate image quality using various metrics (e.g., COV)
3. Calculate how uncertainties propagate (e.g., $x \pm \sigma_x + y \pm \sigma_y = ?$)
4. Calculate the statistical significance of a measurement or a combination of measurements
5. Illustrate how the properties of the imaging system can be used to select the best system for a specific task
6. Describe various image quality metrics (e.g., DQE, NEQ, Resolution, etc.)
7. Calculate storage requirements for various images
8. Explain binary and how it relates to digital images
9. Describe basic informatics infrastructure (PACS, LAN, WAN, etc.)

YEAR 2:
1. Describe the different methods for representing image data, and identify the attributes used to assess the quality of the data acquired or an imaging system
2. Review the methods and technology used to display image data accurately and consistently (e.g., LCD, Luminance, Illuminance, etc.)
3. Describe the purpose of IHE, DICOM and HL7
4. Give examples of what is required to optimize a display system and its associated environment in viewing images for different applications
5. Trace the information associated with a patient exam through the HIS and RIS to the PACS
6. Explain ROC Analysis

YEAR 3:
1. Describe the different processes used to convert the acquired raw data into a final image used for interpretation
2. Associate the characteristics of the human visual system with the task of viewing image data and the metrics used to assess an observer’s response to the data
3. Determine how changes in image processing impact the final image produced
4. Evaluate how these changes affect the image of different objects or body parts and their associated views
5. You have been asked to design a new radiology reading room. What are the important aspects in this design?
6. Choose the appropriate image processing to be used for a specific exam
7. Describe FROC analysis
8. A series of portable chest x-ray images show blurring in the lung parenchyma. Explain possible causes for this occurrence
YEAR 4:
1. Use an observer performance result to determine whether there is a difference in a procedure or study compared to the standard procedure or study
2. Be able to explain all topics of basic image science to a layperson

Module 3: X-ray Production and Projection Imaging Concepts

YEAR 1:
1. Describe the two mechanisms by which energetic electrons produce x-rays and the energy distribution for each mechanism of x-ray production
2. Describe the function of the cathode and anode of an x-ray tube and how variations in their design influence x-ray production
3. Define the attributes of an x-ray beam including the function of filtration, spectrum of energies produced, and beam restriction
4. Describe the detector types used to acquire an x-ray imaging
5. Describe common artifacts
6. Describe how distance to the patient and detector affect patient dose

YEAR 2:
1. Describe the heel effect and how it can be used to improve clinical radiographs
2. Analyze how changes in the x-ray system components change the image quality and dose for different procedures
3. Discuss image quality differences between CR and DR systems. How does this difference affect patient dose?
4. What are the properties of a detector system that determines its suitability for pediatric procedures?

YEAR 3:
1. Describe how the controls of an x-ray system affect the technique factors used in diagnostic imaging
2. Describe how the x-ray tube design, target material, beam filtration, and focal spot size are optimized for a specific imaging task (e.g., mammography, interventional imaging, CT)
3. Give examples of how each detector type performs in imaging a specific body part or view, and describe how the attributes of each detector type influence the resulting image.

YEAR 4:
1. Be able to explain all topics of x-ray production and projection imaging to a layperson

Module 4: General Radiography

YEAR 1:
1. Describe the components of a radiographic imaging system
2. List and describe the factors affecting radiographic image quality
3. Explain how the geometric features of a general radiographic system affect the resulting image
4. Define entrance skin exposure and how it relates to patient dose
5. Describe scatter and scatter factor
YEAR 2:
1. Describe the different types of acquisition systems used in general radiography.
2. Give examples of appropriate technique factors used in common radiographic procedures.
3. Differentiate among the imaging acquisition parameters used in various clinical applications.
4. Why is image quality frequently compromised in mobile radiography?
5. Which factors determine the appropriate grid to use for different radiographic exams?
6. Describe QA.

YEAR 3:
1. Distinguish among the basic imaging requirements for specific body part or views acquired in general radiography.
2. List the system components that affect patient radiation dose, and describe how to reduce patient dose.
3. Analyze the radiation dose from a medical procedure, and communicate the benefits and risks to the referring physician.

YEAR 4:
1. Be able to explain all topics of general radiography to a layperson.

Module 5: Mammography

YEAR 1:
1. Describe unique features of mammography tubes and how they affect the x-ray spectrum.
2. Describe automatic exposure control (AEC) performance.
3. Explain compression benefits.
4. Explain magnification techniques.
5. Discuss possible image artifacts in mammography and corrective methods that could be used to reduce them.

YEAR 2:
1. Associate image quality changes with radiation dose changes.
2. Describe AGD and breast radiation dosimetry.
3. Discuss MQSA (Mammography Quality Standards Act) and its effect on mammography image quality and dose.
4. Describe appropriate uses of the different targets and filters available in mammography systems.
5. Describe QA.
6. Identify factors influencing image contrast and detail as they relate to the visualization of lesions in mammography.

YEAR 3:
1. Describe the BIRADS system.
2. Describe breast tomosynthesis systems and how they differ from conventional mammography.
3. What are the MQSA training and CME requirements for radiologists, technologists and physicists?
4. Be able to explain dose from screening mammography to a layperson.
YEAR 4:
1. Be able to explain all topics of mammography to a layperson

Module 6: Fluoroscopy and Interventional Radiography (IR)

YEAR 1:
1. Describe and identify the basic components of a fluoroscopic system
2. Explain how the geometric features of a fluoroscopic system contribute to the resulting image
3. Explain the features and functions of image intensifier (II) systems used for fluoroscopy
4. Explain the features and functions of flat panel detector systems used for fluoroscopy
5. Describe the different operating modes used in fluoroscopy imaging
6. Identify the components that determine image quality in a fluoroscopy system and the causes of image degradation
7. Name the factors that affect patient dose during a fluoroscopic or interventional procedure
8. Describe concepts of exposure and how patient radiation dose is estimated in fluoroscopy and interventional procedures
9. Describe the artifacts that can occur with image intensified and flat-panel fluoroscopy systems
10. Describe where the operator should stand to minimize personnel dose when performing an interventional fluoroscopy procedure
11. Describe the geometric factors that affect operator dose during an interventional fluoroscopy procedure

YEAR 2:
1. Discuss basic image processing methods used in fluoroscopy and describe how they are used clinically
2. Review the various application requirements for fluoroscopy and interventional radiology systems
3. Differentiate among the various image acquisition parameters used in specific clinical applications of fluoroscopy and interventional radiology
4. Describe the geometric and clinical equipment settings which can be implemented to minimize patient peak skin dose in fluoroscopy and interventional radiology

YEAR 3:
1. Identify the technique factors and appropriate system features to use to optimize image quality while minimizing patient dose in fluoroscopy and interventional radiology
2. What steps can be taken to minimize the dose to the fetus of a pregnant patient who needs a fluoroscopic or interventional procedure?
3. Describe how 2D projections allow for depth calculation in breast biopsy (stereoscopic imaging)

YEAR 4:
1. Be able to explain all topics of fluoroscopy and interventional radiography to a layperson
Module 7: Computed Tomography (CT)

YEAR 1:
1. Identify the major components of a CT system
2. Explain how dose modulation affects patient dose
3. Define the Hounsfield unit, and describe how a CT image is formed
4. Compare image characteristics of CT to other modalities such as digital radiography
5. Describe the concepts of CT Dose Index (CTDI), Dose-Length Product (DLP), Effective Dose and Organ Dose
6. Understand how the reconstruction kernel (i.e., software filter) selected affects image quality
7. Describe common artifacts and their causes
8. Describe the relationship between contrast resolution and radiation dose and the effect of imaging parameters on both
9. Explain over-beaming and over-ranging and how each affects patient dose
10. List typical CT numbers for tissues such as air, water, fat, blood, brain, and bone

YEAR 2:
1. Describe QA
2. Describe the differences between conventional and helical scanning
3. Explain the difference between reconstructing and reformatting an image
4. List the image acquisition parameters, and explain how each affects the CT image quality
5. Describe the concepts of CT Dose Index (CTDI), Dose-Length Product (DLP), Effective Dose and Organ Dose
6. Identify the sources of CT image artifacts, and describe how those artifacts may be eliminated or reduced
7. Explain why pre-set window width and levels are selected for viewing images
8. Discuss the use of breast shields and lead shielding in CT
9. Discuss appropriate protocols for pediatric CT

YEAR 3:
1. Describe the modes of CT operation and their clinical applications
2. Differentiate among the different rendering techniques used in 3D imaging
3. Discuss the radiation exposure to patients and personnel during CT fluoroscopy
4. Specify the image acquisition parameters that affect patient radiation dose, and describe how dose can be minimized
5. Review the considerations necessary when a CT scan needs to be performed on a pregnant patient

YEAR 4:
1. Be able to explain all topics of CT to a layperson
Module 8: Nuclear Medicine (NM, PET, & SPECT)

YEAR 1:
1. Describe the modes of radioactive decay, particle and photon emissions, and interactions of radiation with matter
2. Describe the instrumentation, major components, and principles of operation for instruments commonly used for detecting, measuring, and imaging radioactivity
3. Describe the factors that affect image quality
4. Describe the methods of determining organ dose and whole body dose to patients and caregivers
5. Describe probability distributions, nuclear counting statistics and statistics applicable to nuclear imaging
6. Explain how to determine the radiopharmaceutical activity administered to adults and pediatric patients for various imaging procedures
7. Describe common artifacts
8. Discuss the impact that contrast agents used in non-nuclear imaging procedures have on the nuclear medicine image

YEAR 2:
1. Describe the instrumentation and software required for image generation and display
2. Describe instrumentation and software QC tests
3. Describe radionuclide production and the principles of radiochemistry
4. Identify established radiopharmaceuticals, the indications for use and appropriate adult and pediatric dosages
5. Describe radiopharmaceutical QC tests
6. Explain how various disease processes (e.g., malignant, metabolic, infectious, etc.) can be evaluated by each imaging agent

YEAR 3:
1. Identify established radiopharmaceuticals, the indications for use and appropriate adult and pediatric dosages
2. Demonstrate a working knowledge of computational image-processing, quality control of image acquisition and processing
3. Explain and discuss for each organ system the advantages, disadvantages, indications and contraindications for each radiopharmaceutical used in imaging and therapeutic procedures
4. Explain how radioisotope imaging supports staging disease, determining residual or recurrent disease, assessing response to and monitoring of therapy, and providing prognostic information
5. Determine the period of time a lactating patient should be instructed to cease breastfeeding following a radioisotope imaging or therapeutic procedure
6. Evaluate the risk of performing a nuclear imaging procedure on a pregnant patient. Which isotopes cross the placenta and which isotopes do not?
7. Analyze the radiation dose from a nuclear medicine procedure and correlate the radiation risks to the potential benefit
Year 4:
1. Be able to explain all topics of NM, PET, & SPECT to a layperson

Module 9: Magnetic Resonance Imaging (MRI)

Year 1:
1. Describe the properties of magnetism and how materials react to and interact with magnetic fields
2. Describe how the magnetic resonance signal is created
3. Define the magnetic properties of a material that determine the MR signal
4. Compare the basic pulse sequences used to produce contrast between tissues in MRI
5. List the components of an MR system and how they are used
6. Describe how spatial localization is achieved in MRI
7. Describe how to fill k-space to optimize signal strength (signal-to-noise ratio) or acquisition time
8. Describe how T1, T2, proton density and T2* contrast can be achieved in MRI
9. Describe the types of contrast agents used in MR and how they affect the signal relative to the pulse sequence used
10. Describe the concept of partial saturation and how it affects the signal acquired
11. Identify the source and appearance of MRI artifacts
12. Review the safety and bioeffects of concern in MR systems
13. Describe common clinical artifacts

Year 2:
1. Review the principles of k-space generation and describe how to "fill k-space" to optimize signal strength (signal-to-noise ratio) or acquisition time
2. Explain how secondary tissue properties like diffusion, perfusion and flow can be distinguished in MRI
3. Describe parallel imaging and its impact on SNR and acquisition time
4. Distinguish between phase contrast, 2D and 3D time of flight MRA
5. Review the important concepts of functional MRI
6. Review the important concepts of MR spectroscopy
7. Describe contrast-induced nephropathy and methods to reduce risk of such an outcome
8. Describe the risks and benefits when MR imaging is used on a pregnant patient
9. Estimate how the installation of different hardware (e.g., different field strength system) might change the acquisition parameters and image quality in MRI
10. Analyze how a change in the acquisition parameters affects the resulting MR image
11. Describe QA

Year 3:
1. Identify the most appropriate pulse sequences for a specific diagnostic task
2. Discuss clinical situations in which MRI should be requested over alternative diagnostic procedures
2. Discuss clinical situations in which MRI procedures are contra-indicated.
YEAR 4:
1. Be able to explain all topics of MRI to a layperson

Module 10: Ultrasound (US)

YEAR 1:
1. Identify common terms of sound wave propagation and ultrasound interactions with matter
2. Describe the basic design of ultrasound transducers, and explain the principles of beam formation
3. Describe the different types of array transducers
4. Understand the definitions of axial, lateral and elevational resolution.
5. Describe the factors affecting spatial and temporal resolution, including multiple focal zones
6. Identify common artifacts seen in ultrasound.
7. Describe the Doppler principal and its applications in various Doppler imaging modes
8. Explain aliasing and other Doppler-related artifacts
9. Delineate the mechanisms for producing ultrasound bioeffects and describe the significance of the parameters MI and TI.

YEAR 2:
1. Understand the principles of advanced ultrasound technologies, such as harmonic imaging, extended field of view, compound imaging, 3D/4D ultrasound and ultrasound contrast agents
2. Describe how scanner settings affect the clinical image and how to adjust the scan parameters to optimize image quality for different clinical applications
3. Explain how to improve image quality during ultrasound imaging
4. Explain the causes of ultrasound imaging artifacts and Doppler aliasing. Discuss how to reduce such artifacts, and explain how to use imaging effects and artifacts for diagnosis

YEAR 3:
1. Describe appropriate indications when advanced ultrasound technologies, such as harmonic imaging, extended field of view, compound imaging, 3D and 4D ultrasound, and ultrasound contrast agents, should be used in clinical imaging.
2. Discuss the accuracies of distance measurements with respect to scanning orientation
3. Describe the ultrasound parameters related to ultrasound bioeffects and safety
4. Discuss risks versus benefits of using ultrasound in various clinical areas, especially in obstetrics

YEAR 4:
1. Be able to explain all topics of Ultrasound to a layperson

Module 11: Radiation Biology

YEAR 1:
1. Describe R's of radiobiology
2. Discuss the probability of cell survival for low-LET radiations
3. Compare the radiosensitivities of different organs in the body
4. Describe stages of ARS from whole body irradiation
5. Understand the thresholds for deterministic effects, including cutaneous radiation injury, cataracts and sterility
6. Explain the risk of carcinogenesis due to radiation
7. Understand the latencies for different cancers
8. Describe the effect of radiation on mutagenesis and teratogenesis
9. List the most probable in utero radiation effects at different stages of gestation
10. Define the principles of how radiation deposits energy that can cause biological effects
11. Explain the difference between direct and indirect effects, how radiation affects DNA and how radiation damage can be repaired

YEAR 2:
1. Recognize the risk vs. benefit in radiation uses, and recognize the information sources that can be used to assist in assessing these risks
2. Describe the different dose response models for radiation effects
3. Understand the risks to patients from high-dose fluoroscopy regarding deterministic effects, such as cutaneous radiation injury and cataractogenesis, and the importance of applying radiation protection principles in clinical protocols to avoid damage
4. Understand the risks to the female breast, especially in girls, from repeated imaging for scoliosis, from mobile chest radiography and CT scans; and the importance of applying radiation protection principles in clinical protocols to minimize future harm
5. Explain radiation risks to pregnant technologists assisting in fluoroscopic procedures
6. Explain radiation risks to pregnant nurses who are incidentally exposed in mobile radiography (“portables”)
7. Understand the best use of gonad shielding and breast shields

YEAR 3:
1. Plan an interventional procedure to minimize the risk of deterministic effects
2. Select the most appropriate radiological exam for a pregnant patient
3. Determine the risk vs. benefit for a new procedure shown at a conference
4. Read BEIR and UNSCEAR reports

YEAR 4:
1. Be able to explain all topics of radiation biology to a layperson

Module 12: Radiation Protection

YEAR 1:
1. Identify the sources of background radiation, and describe the magnitude of each source
2. State the radiation limits to the public and radiation workers (Maximum Permissible Dose Equivalent limits)
3. Define the principles of time, distance and shielding in radiation protection
4. Define ALARA and its application in radiation protection
5. Identify the methods used to monitor occupational exposure
6. Describe the fundamental methods used to determine patient and fetal doses.
7. List the steps in managing radiological emergencies
8. Discuss the contributions of medical sources to the collective effective dose
9. Describe the use of personnel radiation protection equipment
10. Discriminate between workers in an area who are occupationally exposed and those who are treated as members of the general public
11. Discuss the factors that determine dose to a pregnant person seated next to a patient injected with a radionuclide for a diagnostic or therapeutic procedure

YEAR 2:
1. Understand the differences among advisory bodies, accrediting organizations and regulatory organizations for radioactive materials and radiation-generating equipment, and recognize their respective roles
2. Discuss appropriate equipment used to monitor radiation areas or areas of possible exposure or contamination
3. Define the responsibilities and qualifications of an authorized user (all categories) and the radiation safety officer
4. Describe the training and experience requirements for using sealed and unsealed sources of radioactive material
5. Describe the appropriate equipment for wipe tests and contamination surveys
6. Provide information to the public concerning radon
7. Describe what must be done before administering a radioactive material in a patient
8. Describe what is required to have a person listed on a facility’s Nuclear Materials license as an Authorized User

YEAR 3:
1. Explain the basic principles for designing radiation shielding
2. Understand the safety considerations for patients and staff, including pregnant staff, in mobile radiography (“portables”)
3. Use your knowledge of radiation effects in planning for and reacting to an emergency that includes the exposure of personnel to radiation
4. Provide clinical examples that demonstrate ALARA principles
5. Describe the steps used in applying appropriateness criteria

YEAR 4:
1. Be able to explain all topics of radiation protection to a layperson

Module 11: Patient Case and Technical Skills (ACGME PCTS1) – Use of Physics

YEAR 1:
1. Understand the place of the ACR appropriateness Criteria

YEAR 2:
N/A
YEAR 3:
1. Integrate current research and literature with guidelines, taking into consideration cost effectiveness and risk-benefit analysis, to recommend imaging

YEAR 4:
1. Participate in research, development, and implementation of imaging guidelines

Module 11: Protocol Selection and Optimization of Images (ACGME MK1) – Use of Physics
YEAR 1:
1. Recognize sub-optimal imaging

YEAR 2:
1. Demonstrates knowledge of physical principles to optimize image quality

YEAR 3:
1. Applies physical principles to optimize image quality

YEAR 4:
1. Teach and/or write imaging protocols

Module 12: Patient Safety: Contrast Agents; Radiation Safety; MR safety; Sedation (ACGME PBLI1) – Use of Physics
YEAR 1:
1. Radiation safety: Describes the mechanisms of radiation injury and the ALARA concept
2. MR Safety: Describes risks of MRI

YEAR 2:
1. Radiation safety: Accesses resources to determine exam-specific average radiation dose information
2. Describes risks of MRI: Accesses resources to determine the safety of implanted devices and retained metal

YEAR 3:
1. Communicates the relative risk of exam-specific radiation exposure to patients and practitioners
2. Describes risks of MRI: Communicates MR safety of common implants and retained foreign bodies to patients and practitioners

YEAR 4:
1. Apply principles of Image Gently and Image Wisely
2. Applies principles of MR safety including safety zones and pre-MR screening

YEAR 1:
Complete 2 modules

YEAR 2:
Complete 2 modules

YEAR 3:
Complete all modules

YEAR 4:
N/A

Module 13: Work Experience

YEAR 1:
1. I-131: Participate in room prep/breakdown and nurse education review
2. Technologist Shadowing: Begin shadowing
3. Nuclear Medicine AU Training: Visit nuclear pharmacy and elute generator

YEAR 2
1. I-131: Begin taking part in administration of I-131
2. Technologist Shadowing: Continue shadowing
3. Nuclear Medicine AU Training: Continue tracking experience for AU

YEAR 3:
1. I-131: Completed 3 high dose and 3 low dose cases
2. Technologist Shadowing: Continue shadowing technologists as necessary

YEAR 4:
1. Technologist Shadowing: Complete all shadowing requirements
By signing this document you are confirming that you have received and reviewed, with your preceptor, the physics curriculum for this academic year.

This receipt will be kept in your personal file.

Resident Name (please print)

Resident Signature

by signing this – you confirm that you have reviewed the curriculum with your preceptor

Date

Preceptor Signature

by signing this – you confirm that you have reviewed the curriculum with the resident

Date