NMTCB RADIATION SAFETY CERTIFICATION EXAMINATION CONTENT OUTLINE

I. Content Pertaining to a RAM License: (Expertise Area)

A. Radiation physics and instrumentation

1. Basic radiation physics
   - Atomic structure
   - Definitions – radiation, radioactivity, half-life
   - Modes of radioactive decay
   - Units and quantities of radioactivity
   - Decay calculations
   - Interactions of radiation with matter
2. Radiation detection and measurement
   - Detector types and uses (survey meters, dose calibrator, well counters, probes, gamma camera, PET Scanner)
   - Detector / Instrument Selection
     - Detection efficiency
     - Energy Response
   - Statistics of counting
   - Detector use, calibration, quality control requirements and regulations
3. Production of Radionuclides
   - Reactors (basic principles and radionuclides)
   - Accelerators (basic principles and radionuclides)
   - Generators (column breakthrough limits, shielding, proper disposal)
     - $^{99}Mo/^{99m}Tc$ generator (LEU & HEU)
     - $^{82}Sr/^{82}Rb$ generator
     - $^{68}Ge/^{68}Ga$ generator
     - Others
4. Production of x-rays

B. Radiation dosimetry

1. Units of radiation exposure and dose – US and SI (definitions and conversions)
2. Personal monitoring devices
3. Bioassays
4. Area monitoring – room surveys
5. Effluent Monitoring

   - Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage
6. Sealed source monitoring

7. Basic concept of Medical Internal Radiation Dose (MIRD)

C. Radiation protection and ALARA
   1. Time, distance and shielding
   2. Regulations – personnel and the general public
   3. Dose and exposure Limits
      - Radiation workers
      - Pregnant radiation workers
      - The public
   4. Personnel monitoring and records
      - Periodic review and annual reports
      - Employer responsibilities
      - Action limits and notifications level
      - Lead apron inspection and inventory
      - Dosimeter badge types (assigned badge position, electronic dosimeters, EDE1, EDE2, Webster, etc)
      - SDE, DDE, LDE, TEDE, Extremities
   5. Restricted and unrestricted areas (definitions and sign posting)
   6. Work place rules – best practices
   7. ALARA philosophy
   8. Patient radiation safety & instructions
      - Factors affecting patient dose
      - Pregnancy and breastfeeding
      - Patient release rule and underlying theory

D. Mathematics pertaining to the use and measurement of radioactivity
   1. Decay equation & tables
   2. Counter efficiency / cpm to dpm
   3. Exposure calculations based on time, distance and shielding
      - Time
      - Distance – inverse square law
      - HVL definition, concept and calculation
   4. Effective Half-Life
   5. Dose calibrator tests
      - Accuracy Test (percentage error calculations)
      - Geometry
      - Constancy
      - Linearity
      - Measurement of betas
      - Energy resolution calculation and window setting

E. Radiation biology

F. Security and control of radioactive materials
   1. Room security and access
   2. Signs & Sign Posting
   3. Proper storage and shielding
   4. Inventory and recordkeeping
   5. Security of a “spill area”

G. Shipping & receiving of radioactive materials *(air and ground)*
   1. Related radiation surveys and records
   2. Regulations
   3. Package labeling
   4. Internal Transport of Radiation within the facility

H. Disposal of byproduct material (and all required records)
   1. General trash
   2. Sewer
   3. Biohazard trash
   4. Decay in storage
   5. Return to the manufacturer
   6. Shipment for offsite disposal

I. Administrative controls to avoid a medical event

J. Emergency procedures
   1. Major and minor spill – definitions and procedures
   2. Lost or stolen radioactive source
   3. Medical event – definitions and procedures
   4. Therapy patient requiring emergency care
   5. Death of therapy patient (soon after therapy)
   6. Community radiation emergency response.

K. Regulations & resources
   1. License requirements, applications and amendments
      - Facility design shielding requirements
      - Broad scope / limited scope
   2. Agreement and non-agreement states
   3. Authorized user, training / experience requirements
   4. NRC Regulations:
      -NRC Title **10CFR19** Notices, Instructions and Reports to Workers)
      -NRC Title **10CFR20** (Standards for Protection Against Radiation)
      -NRC Title **10CFR35** (Medical Use of Byproduct Material)
      -NRC Title **10CFR71** (Transportation of Radioactive Materials)
   5. Department of Transportation Regulations
      -Title 49CFR170 (Hazardous Materials)
      -Training requirements for medical licenses
      -White I, Yellow II, Yellow III, UN2910, UN2908, TI
      -Exempt quantities and limited quantities
   6. Other agencies
      -Environmental Protection Agency (EPA)
      -FDA CDRH

L. Radionuclide therapy best practices
   1. Radio-iodine therapy
      - Handling of doses
      - Patients receiving less than 33 mCi
        - Inpatients – instructions for patients and nursing staff

        - Outpatients – instructions for patients and family members
    - Patients receiving more than 33 mCi
        - Regulatory requirements for hospitalization and release from the hospital
        - Room preparation and cleanup for hospitalized patients
        - Inpatients – instructions for patients and nursing staff
        - Outpatients – instructions for patients and family members
    - Storage and disposal of radio-iodine waste
2. Radionuclide therapy
    - Lu-177 dotatate (Lutathera®)
    - Lu-177 Vipivotide tetraxetan (Pluvicto®)
    - Ra-223 Radium dichloride (Xofigo®)
    - Sr-89 chloride (Metastron®)
    - Y-90 microspheres (SIR-Spheres®, TheraSphere®)
        - Isolation room requirements
        - Surveys
        - Inpatient vs outpatient
        - Storage and waste disposal
        - Documentation and record keeping
        - Post-therapy scanning
        - Dosimetry
        - Pediatrics
3. Brachytherapy

M. Reference Documents: NUREG 1556 – Volume 9 and 10 CFR Part 37

II. Content Pertaining to CT: (Expertise Area)

A. CT Basics and Physics
1. Production of x-rays
2. X-ray detection
3. Shielding of poly-energetic beams
4. Scan Mode
    4. Helical
    5. Axial
5. MDCT/Single slice/CBCT
6. AEC Tube current modulation
7. CT scatter iso-dose map application
8. Reconstruction methods- filter back projection, iterative

B. CT Dose Metrics
1. CTDI
2. DLP
3. Effective Dose
4. SSDE Size Specific Dose Estimate
5. Multiple Scan Average Dose (MSAD)

C. CTDI Diagnostic Reference Levels

1. ACR values
    - Adult
    - Pediatric
2. NCRP Report 172
3. CRCPD NEXT Data
4. CTDI Phantom size

D. Dose optimization
    - Protocol review
    - With or without contrast use
    - Reformations
    - Radiation penumbra

E. Radiation Dose Management
1. Equipment Factors
    - kVp
    - mA
        - Fixed mAs
        - Tube current modulated mAs
    - Rotation time
    - Slice thickness
    - Pitch
    - Beam collimation
    - Resolution settings
    - Scan lengths
    - Bolus tracking
    - Delayed scans
    - Repeat scans
2. Patient Factors
    - Body Habitus
    - Centering
    - Motion
    - General patient positioning
    - Increased attenuation
    - Pediatric
    - Pregnancy
3. Other Factors
    - Patient Shielding
    - Holding patients
    - Facility Shielding
    - PPE for staff
    - CT Fluoro

F. Deterministic vs. Stochastic Effects

G. High Radiation Dose CT Settings
    6. CT Brain Perfusion, CT Fluoro, Bolus tracking

III. Content Pertaining to X-ray & Fluoroscopy (Competence but not expertise)

A. X-ray and Fluoroscopy Physics
   1. Production of X-rays
   2. Detection of X-rays
   3. Fluoroscopy Units
      - Fixed
      - C-Arm, Cone beam CT with fluoro, Mini
      - Bi-Plane

B. Fluoroscopy Dose Metric
   1. Fluoroscopy time
   2. Air kerma at the reference point (Ka,r)
   3. Dose Area Product (P_{KA})
   4. Peak skin dose (Dskin,max)

C. Patient risk factors for hypersensitivity to radiation exposure

D. High dose fluoroscopically guided intervention
   7. Interventional Radiology
   8. Cardiac Catheterization Lab
   9. Operating Room

E. Radiation Dose Management
   1. ALARA
      10. Time
      11. Distance
      12. Shielding
          - Types
            - Patient
            - Staff
          - Equipment
          - Thickness
          - Storage
          - Inspections
      13. ALARA action levels
      14. Room Shielding
      15. Reporting requirements
   2. Equipment Factors
      16. kVp
      17. mA
      18. Time
      19. Field size
      20. Quality control frequency
      21. Equipment Geometry

- X-ray tube position
- Image receptor
- Table height

22. Grids
23. Magnification
24. Collimation
25. Filtration
    - Inherent vs. added
26. last Image Hold
27. Pulse fluoroscopy
28. Cine Mode
    - Fluoroscopy frames rates
29. Low verses normal detail mode
30. Beam angle

3. Patient Factors
   - Body habitus
   - Pediatric
   - Pregnancy
   - Scatter
   - Entrance versus exit exposure ratios
   - Dose notifications levels
     - Fluoroscopy time
     - Air kerma at the reference point (Ka,r)
     - DAP (P_{KA})
4. Staff Factors

   -Position, training, apparel, PPE

F. Deterministic Exposure Levels
   - Substantial Radiation Dose Level (SRDL) and time to onset
     - Erythema
       - Early transient
       - Main erythema
       - Late erythema
     - Epilation
     - Dermal Atrophy
     - Dermal Necrosis
     - Secondary Ulceration
   - Patient follow up after a SRDL

IV. Content Pertaining to MRI Safety: (Competence but not expertise)

A. Magnetic field units of measure
   - Gauss
   - Tesla

B. Magnet types in MRI
   - Superconducting, Permanent, Resistive
   - Magnetic Susceptibility (Diamagnetic, Paramagnetic, Superparamagnetic, Ferromagnetic)

C. Magnetic Fields
   - Static magnetic fields
   - Static magnetic field issues: Site Access Restriction Zoning
   - Gradient magnetic fields
   - Slew Rate
   - Spatial Gradient
   - Active vs. Passive Shielding
   - Fringe Field (Importance of 5 Gauss line)

D. MRI Safety
   - Ferromagnetic objects/detectors
   - Codes in a MRI environment
   - Emergency responders (fire, police)
   - Define Zones I, II, III, & IV.
   - Personnel training levels
   - Screening (Patient, Staff, Equipment)
   - Appropriate MRI labeling (MR safe vs. MR conditional vs. MR unsafe)
   - MRI Quenching
   - Hazards associated with liquid Helium
     - Thermal Hazards
     - Fire Hazards
     - Asphyxiation Hazards
   - Hazards associated with strong radio frequency fields
     - Specific Absorption Rate (SAR)
     - Burns caused by Loops
     - Operating modes for MR systems
   - Sequences looping
   - Padding
   - Coils
   - Acoustic noise
   - Explosive decompression

E. Contrast Agent Safety

V. Optimizing Radiation Exposure / Other Topics

A. Appropriateness Criteria
B. Image Wisely
C. Image Gently
D. Protocols
E. Considerations for pregnant and/or pediatric patient
   - Alternative exams
   - Benefit vs. risk

F. Regulations around Brachytherapy
    - High-dose-rate (HDR), low-dose-rate (LDR), permanent
G. Mammography
H. DEXA / Bone density
I. Research with Radioactive Materials
J. Radioactive Seed Localization
K. Linac – linear accelerator
L. Blood irradiator

Related Guidelines & References:

- AAHP/HPS Qualifications for Health Care Facility Radiation Safety Officer (2024)
- National Council on Radiation Protection and Measurements (NCRP) - Publications
- ACR – Disaster Preparedness for Radiology Professionals
- NRC: 10 CFR Part 35, "Medical Use Licenses"
- AAPM Report No. 124 - A Guide for Establishing a Credentialing and Privileging Program for Users of Fluoroscopic Equipment in Healthcare Organizations (2012)
- AAPM Report No. 160 - Radiation Safety Officer Qualifications for Medical Facilities: Report of Task Group 160;
- AAPM Report No. 204- Size-Specific Dose Estimates (SSDE) in Pediatric and Adult Body CT Examinations
- ACR-SPR Practice Parameter For Imaging Pregnant or Potentially Pregnant Adolescent and Women with Ionizing Radiation
- ACR Guidance Document on MR Safety Practices: 2013. Journal of Magnetic Resonance Imaging 37:501–530 (2013) Authors: E. Kanal, AJ Barkovich, C Bell et al.
- Image Gently® - The Alliance for Radiation Safety in Pediatric Imaging
- Image Wisely® - Radiation Safety in Adult Medical Imaging