



AAPM Recommended  
Radiological Physics  
Curriculum for Radiation  
Oncology Residents

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# What is MPEP?

- ◆ The AAPM Committee charged with considering issues pertaining to the medical physics education of Diagnostic Radiology Residents is the Medical Physics Education of Physicians (MPEP) Committee under the Education Council.
- ◆ MPEP programs
  - AAPM/RSNA Physics Tutorial
  - Visual Aids for Education
  - Periodic Reports and Recommendations on Training Programs
  - Recommended Syllabi for Medical Physics Instruction of Diagnostic Radiologists



# AAPM Report 64

- ◆ AAPM Report 64 surveyed Diagnostic Radiology and Radiation Oncology Residency Programs in conjunction with ARRO and A3CR2 (American Association of Academic Chief Radiology Residents).
- ◆ The results of the survey were published in 1999.
- ◆ The report is freely and publicly available on the AAPM website.
- ◆ The report also contains recommendations on educational overhead and available resources to support medical physics instruction.



# AAPM Report 64 (2)

- ◆ Not all Radiation Oncology Residency Programs responded to the survey.
- ◆ Several models for Medical Physics training in Radiology Residency programs were found with a wide range of hours devoted to didactic instruction, laboratory courses and physics rotations.
- ◆ Including orientation and physics rotation brings the total teaching effort up to 170 hours of physics instruction per year. NRC now requires 200 to be a full user of 35.300 material and 700 hours for RSO.
- ◆ The “average” program provided 61.4 didactic hours and 27 laboratory hours.



# MPEP Syllabus Subcommittee

- ◆ Was formed in 2001-2002 to continuously review and revise the syllabus recommended in AAPM Report 64.
- ◆ 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 and laboratory hours.
- ◆ A “unit of instruction” should be no less than 1 didactic hour, and may be 2 or more. A weight of no less than 1 is recommended.



# AAPM MPEP Syllabus SC

- ◆ The members of the AAPM MPEP Syllabus Subcommittee:
  - Philip Heintz, Ph.D. – Chair (Univ. New Mexico)
  - C. A. Kelsey, Ph.D. (Univ. New Mexico)
  - M. S. Al-Ghazhi, Ph.D. (UC Irvine)
  - H. Elson, Ph.D. (Univ. of Cincinnati)
  - E. P. Lief, Ph.D. (Maimonides Comprehensive C.C.)
  - R. J. Massoth, Ph.D. (Medical X-Ray Center, P.C.)
  - R. A. Price, Jr., Ph.D. (Fox Chase C.C.)
  - C. B. Saw, Ph.D. (Univ. of Pittsburgh)
  - C. L. Thomason, Ph.D. (St. Luke's Med. Center, Milwaukee, WI)
  - M. K. West, Ph.D. (International Med Physics Svcs)
  - F.-F. Yin, Ph.D. (Duke Univ. Med Center)



# Recommended Syllabus

## Overview

- ◆ ASTRO Ad-Hoc Committee on Teaching Physics to Residents published a proposed curriculum in the Red Journal (IJROBP 2004). This curriculum was approved by the ASTRO Board.
- ◆ AAPM Report 64 used data published by Klein, et al. in 1995. This Report (published by AAPM in 1999) included the abbreviated Radiation Oncology Physics curriculum from Klein's 1995 paper.


# Recommended Syllabus

## Overview (2)

- ◆ AAPM Physics Tutorial Subcommittee reviewed the draft curriculum and has approved it, with some modifications and extensions.
- ◆ The largest modification is to use weighted “units of instruction” instead of “hours”.
- ◆ The use of “hours” as a measure of instruction is often controversial, because different programs will provide more or fewer didactic hours. Variance from the “norm” is perceived as an avoidable issue.
- ◆ The “units” or “hours” listed should be considered the minimum level of effort.







# ASTRO Ad-Hoc Committee on Teaching Physics to Residents

- ◆ Eric E. Klein, M.S.
  - (Washington Univ.; St. Louis, MO)
- ◆ James M. Balter, Ph.D.
  - (Univ. of Michigan; Ann Arbor, MI)
- ◆ Edward L. Chaney, Ph.D.
  - (Univ. of North Carolina; Chapel Hill, NC)
- ◆ Bruce J. Gerbi, Ph.D.
  - (Univ. of Minnesota; Minneapolis, MN)
- ◆ Lesley Hughes, M.D.
  - (Drexel University; Philadelphia, PA)



# Must The Curriculum Be Explicitly 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 Syllabus 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.
    - Examples: “Radiological Disaster Response”, IGRT or IMRT.



# Core Curriculum

- ◆ Intended for Didactic Lectures and lab/practicum during a Physics Rotation.
  - See table 1 in IJROBP 2004 paper by Klein, et al.
- ◆ Learning Objectives are described for each Section in the Curriculum.
- ◆ Study (by student) may be necessary to understand and retain purely didactic information.



# Didactic Sections of the Curriculum

- ◆ §1. Atomic & Nuclear Structure (3 units)
- ◆ §2. Production of X-Rays, Photons & Electrons (2 units)
- ◆ §3. Radiation Interactions (3 units)
- ◆ §4. Treatment Machines, Generators & Simulators (CT and Fluoro) (3 units)
- ◆ §5. Radiation Beam Quality and Dose (2 units)
- ◆ §10. Radiation Protection and Shielding (2 hours)
- ◆ §11. Imaging for Radiation Oncology (4 units)
- ◆ §17. Hyperthermia (1 unit)
- ◆ §18 (ASTRO 17'). Particle Therapy (1 unit)



# Physics Rotation/Lab Curriculum

- ◆ §6. Radiation Measurements and Calibration (4 units tied to lab)
- ◆ §7. Photon and X-rays (7 units tied to lab)
- ◆ §8. Electrons (3 units tied to lab)
- ◆ §9. External Beam Quality Assurance (2 units tied to lab)
- ◆ §12. 3D-CRT (3 units tied to lab)
- ◆ §13. Assessment of Patient Setup & Tx (2 units tied to lab)
- ◆ §14. IMRT (3 units tied to lab)
- ◆ §15. Special Procedures (3 units tied to lab)
- ◆ §16. Brachytherapy (7 units tied to lab)



# AAPM Proposed Extensions to Curriculum

- ◆ Proton therapy curriculum.
  - As CAQ or as subspecialty.
  - 1 hour to cover both proton and neutron therapy is not sufficient at a proton facility
- ◆ Tomotherapy CAQ?
- ◆ Superficial, orthovoltage and Grenz-ray physics should be covered in didactic part.
- ◆ More unsealed radiopharmaceutical therapy training (including waste handling and regulations) are needed for full 10CFR35.300 uses by Radiation Oncologists (200 hours class&lab with 700 hours total training & experience).



# AAPM Curriculum Subcommittee Projects

- ◆ A question set for use in resident review was partially developed.
  - Each question was to have been tied to the didactic or lab rotation section of the curriculum.
  - Answers were provided
  - Resident expected to discuss “missed” questions with on-site therapy or imaging physicist (depending on section).
  - Question set tabled (at present time) because a low number of questions were submitted.
  - Would such a set still be useful, or is it redundant?



# Atomic & Nuclear Structure

- ◆ §1. *Learning Objectives for Resident (3 units):*
  - *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, probability, half life, parent-daughter relationships, equilibrium, and nuclear activation.*





# Atomic & Nuclear Structure (2)

- ◆ §1. 3 lectures (1 unit each) to cover:
- ◆ The Atom
  - Protons, neutrons, electrons (charge, rest mass)
  - Atomic number and atomic mass
  - Orbital electron shells (binding energy, transitions)
- ◆ Wave and quantum models of radiation
  - Energy and wavelength, energy spectrum
- ◆ Radioactivity and decay
  - Decay processes
  - Probability and decay constant
  - Activity, half life, mean life
  - Radioactive series
  - Parent-daughter relationships and equilibrium
  - Nuclear reactions, bombardment, and reactors



# Photon & Electron Production

- §2 *Learning Objectives for the Resident*
  - *the concepts of beam production, including acceleration of electrons in diagnostic X-ray tubes, Bremsstrahlung, X-ray tube design, and characteristic radiation.*
  - *about the general design of a linear accelerator, including major components and their functions, steering, flattening filtration, and beam hardening.*



# Photon & Electron Production (2)

## ◆ §2: 2 lectures to cover:

- Physics concepts of beam production
  - Concept of Bremsstrahlung
  - X-ray tube design
  - Energy spectrum (of x-ray tube)
  - Characteristic radiation
- Generation of beams
  - Filters
  - Gamma-radiation teletherapy sources (Co-60, Cs-137)
  - Linear accelerator production



# Radiation Interactions

## ◆ §3. Radiation Interactions (3 lecture units)

### – *Learning Objectives for Resident:*

- *1. The physical description, random nature, and energy dependence of the five scatter and absorption interactions that X-ray photons undergo with individual atoms (coherent scatter, photoelectric effect, Compton effect, pair production, and photonuclear disintegration).*
- *2. 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.*
- *3. The physical description and energy dependence of the elastic and inelastic collision processes in matter for directly and indirectly ionizing particulate radiation.*
- *4. 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.*



# Radiation Interactions (2)

## ◆ Topics to be Covered (3 lecture units)

- Photon Interactions with matter
  - Scatter versus Absorption
  - Rayleigh or Coherent Scattering
  - Compton Scattering
  - Photoelectric Effect
  - Pair Production
  - Photonuclear disintegration
- Attenuation of photon beams
  - Attenuation, energy transfer and energy absorption
  - Exponential attenuation equation
  - Attenuation Coefficients
  - Attenuation Coefficients
  - Half-value Layer (HVL)
  - Beam geometry



# Radiation Interactions (3)

- Interactions of particulate radiation
  - Directly and indirectly ionizing particles
  - Elastic and inelastic collisions with orbital electrons and the nucleus
  - Linear energy transfer, specific ionization, mass stopping power, range
  - Interactions of electrons
  - Interactions of heavy charged particles
  - Interactions of neutrons



# Das Ende?

- ◆ There are 47 slides to go...
- ◆ Any specific topic the audience would care to see?
- ◆ If not – Thank You for Your Attention
- ◆ Time for Discussion.



# Treatment Machines and Generators; Simulators

- §4 *Learning Objectives for the Resident (3 units)*
  - 1. *the mechanics and delivery of radiation with respect to wave guides, magnetron vs. klystron for production.*
  - 2. *the production and delivery of electrons by the electron gun, buncher, and scattering foil vs. scanning.*
  - 3. *the production and delivery of photons including the target and flattening filter.*
  - 4. *benefits and limitations of multileaf collimator (MLC) collimators and cerrobend and hand-block.*
  - 5. *the production and collimation of superficial photons.*
  - 6. *the production of low-energy X-rays for imaging.*
  - 7. *the differences in film and other imaging modalities for simulation.*
  - 8. *digitally reconstructed radiograph (DRR) production and use.*





# Tx Machines & Generators; Simulators (2)

## ◆ *Topics to be covered (3 units):*

### – A. Linear accelerators

- Operational theory of wave guides
- Bending magnet systems
- Photon beam delivery
- Electron beam delivery
- Beam energy
- Monitor chamber

### – B. Linac collimation systems and other teletherapy

- Primary and secondary collimators
- Multileaf collimators
- Other collimation systems
- Radiation and light fields (including field size definition)
- Cobalt units
- Therapeutic X-ray (300 kVp)



# Tx Machines & Generators; Simulators (3)

## – C. Simulators


- Mechanical and radiographic operation
- Fluoroscopy and intensifiers
- Computed tomography (CT) simulation machinery
- CT simulation operation



# Radiation Beam Quality and Dose

– §5 *Learning Objectives for the Resident (2 units):*

- *the physical characteristics of monoenergetic and heteroenergetic photon and particle beams, the terms such as energy spectrum, effective energy, filtration, geometry, and homogeneity that are used to describe such beams.*
- *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.*



# Radiation Beam Quality & Dose

## (2)

- ◆ Topics to be covered (2 units):

- A. Monoenergetic and heteroenergetic Bremsstrahlung beams

- Energy spectra for Bremsstrahlung beams
- Effects of electron energy, filtration, beam geometry
- Homogeneity coefficient
- Effective energy
- Clinical indices for megavoltage beams (e.g.,
- percent depth dose (PDD) at reference depth)

# Radiation Beam Quality & Dose

(3)


- B. Dose quantities and units
  - Kerma
  - Exposure
  - Absorbed dose
  - Dose equivalent
  - RBE dose
  - Calculation of absorbed dose from exposure
  - Bragg-Gray cavity theory






# Radiation Measurement & Calibration

- §6 *Learning Objectives for the Resident (4 lab units):*
  - 1. *the units and definitions associated with radiation absorbed dose.*
  - 2. *the relationship between kerma, exposure, and absorbed dose.*
  - 3. *how absorbed dose can be determined from exposure, and the historical development of this approach.*
  - 4. *Bragg-Gray cavity theory and its importance in radiation dosimetry.*
  - 5. *stopping power ratios, and the effective point of measurement for radiation dosimetry.*
  - 6. *how photon and electron beams are calibrated, the dose calibration parameters, and the calibration protocols for performing linac calibrations.*
  - 7. *how to determine exposure and dose from radioactive sources.*



# Radiation Measurement & Calibration (2)

- 8. *the various methods by which to measure absorbed dose; these should include calorimetry, chemical dosimetry, solid-state detectors, and film dosimetry.*
- Topics to be covered (4 lab units)
  - A. Dose and relationships
    - Radiation absorbed dose—definition and units
    - Relationship between kerma, exposure, and absorbed dose
    - Bragg-Gray cavity theory—stopping powers
  - B. Ionization chambers
    - Cylindrical
    - Parallel-plate
    - Effective points of measurement
  - C. Calibration of megavoltage beams
    - Photon beams
    - Electron beams
    - Dose calibration parameters
    - Task Group-21 and Task Group-51



# Radiation Measurement & Calibration (3)

- D. Other methods of measuring absorbed dose
  - 1. Calorimetry
  - 2. Chemical dosimetry
  - 3. Solid state detectors
    - Thermoluminescent Dosimeter (TLD)
    - Diode detectors
    - Scintillation detectors
    - Diamond detectors
  - 4. Film dosimetry
    - Xonat Verification (XV)-2 film
    - Extended Dose Range (EDR)-2 film
    - Radiochromic film





# Photon & X-rays

- §7 *Learning Objectives for the Resident (7 lab units):*
  - 1. *basic dosimetric concepts of photon beams.*
  - 2. *how these concepts relate to calculation concepts.*
  - 3. *basic calculation parameters.*
  - 4. *how these parameters relate to one another and how to cross convert.*
  - 5. *parameters used for calculations and their dependencies for source-to-skin distance (SDD) and source-to-axis distance (SAD) setups.*
  - 6. *how beam modifiers affect beams and calculations.*
  - 7. *basic treatment planning arrangements and strategies.*
  - 8. *how beam shaping affects isodose maps.*
  - 9. *surface and exit dose characteristics.*
  - 10. *the effect and use of beam modifiers including bolus.*
  - 11. *heterogeneity corrections and effects on isodoses.*
  - 12. *beam matching techniques and understanding of peripheral dose.*
  - 13. *special considerations for pacemaker, pregnant patients.*



# Photon & X-rays (2)

- ◆ Topics to be covered (7 lab units):
  - A. External beam dosimetry concepts (part I)
    - 1. Dosimetric variables
      - Inverse square law
      - Backscatter factor
      - Electron buildup
      - Percent depth dose
      - Mayneord F-factor
      - Tissue Air Ratio correction to F-factor
      - Equivalent squares
  - B. External beam dosimetry concepts (part II)
    - Tissue-air ratio
    - Scatter-air ratio
    - Tissue-phantom ratio
    - Tissue-maximum ratio



# Photon & X-rays (3)

- C. System of dose calculations
  - 1. Monitor unit calculations
    - (a) Output factor
    - (b) Field size correction factors
    - (c) Collimator scatter factor and phantom scatter factor
    - (d) Beam modifier factors
    - (e) Patient attenuation factors
  - 2. Calculations in practice
    - (a) SSD technique
      - 1. SSD treatment same as SSD of calibration
      - 2. SSD treatment different from SSD of calibration
  - 3. SSD treatment and SAD calibration
    - (b) SAD technique
      - 1. SAD treatment and SAD calibration
  - 2. SAD treatment and SSD calibration
  - 3. SAD rotational treatment



# Photon & X-ray (4)

- D. Translation of planning to calculations
  - 1. Beam parameters
  - 2. Beam weighting
  - 3. Arc rotation therapy
  - 4. Irregular fields
- E. Computerized treatment planning
  - 1. Isodose curves (beam characteristics)
  - 2. Surface dose
  - 3. Parallel opposed beam combination
  - 4. Wedge isodose curves
    - (a) Wedge angle and hinge angle
    - (b) Wedge factor
  - 5. Wedge techniques
    - (a) Wedge pair
    - (b) Open and wedged field combination
    - (c) Skin compensation
  - 6. Beam combination (3-, 4-, 6- field techniques)



# Photon & X-ray (5)

- F. Surface corrections and heterogeneities
  - 1. Corrections for surface obliquities
  - 2. Corrections for inhomogeneities
    - (a) Linear (1-D) attenuation method
      - 1. Two-dimensional methods
      - 2. Volumetric methods
      - 3. Dose perturbations at interfaces
- G. Adjoining fields and special dosimetry problems
  - 1. Two-field problem
  - 2. Three-field problem
  - 3. Craniospinal gapping
  - 4. Pacemaker
  - 5. Gonadal dose
  - 6. Pregnant patient



# Electron Beam

- §8 *Learning Objectives for the Resident (3 lab units):*
- 1. *the basic characteristics of electron beams for therapy, including components of a depth-dose curve as a function of energy, electron interactions, isodoses, oblique incidence, and electron dose measurement techniques.*
- 2. *the nature of treatment planning with electrons, including simple rules for selecting energy based on treatment depth and range, effect of field size, dose to skin and bolus, and effects of field shaping, especially for small fields.*
- 3. *about field matching with photons and other electron fields, internal shielding, backscatter, and the effects of inhomogeneities on electron isodoses.*



# Electron Beam (2)

- Topics to be covered (3 lab units):
  - A. Basic characteristics
    - Depth-dose/isodose characteristics
    - Electron interactions
    - Coulomb scattering and range
    - Dose vs. depth
    - Isodoses
    - Oblique incidence
    - AAPM TG-25
  - B. Treatment planning with electrons
    - 1. Rules of thumb
    - 2. Selection of energy, field size
    - 3. Electron skin dose
    - 4. Electron bolus
    - 5. Electron field shaping



# Electron Beam (3)

- C. Field matching and other considerations
  - 1. Electron-electron gapping
  - 2. Electron-photon gapping
  - 3. Electron backscatter
  - 4. Inhomogeneities
  - 5. Internal shielding





# External Beam QA

- §9 *Learning Objectives for the Resident (2 lab units):*
  - 1. *the goals of a departmental quality assurance (QA) program, the staffing required to perform these QA activities, and the duties and responsibilities of the individuals associated with the QA program.*
  - 2. *what is entailed in making equipment selections in radiation therapy and the content of equipment specification.*
  - 3. *what is involved in acceptance testing of a linear accelerator and in commissioning both a linear accelerator and a treatment planning system.*
  - 4. *what linear accelerator quality assurance is required on a daily, monthly, and yearly basis and the acceptance tolerances associated with these tests.*



# External Beam QA (2)

- ◆ Topics to be covered (2 lab units)
  - A. Overview of quality assurance in radiation therapy
    - Goals
    - JCAHO
    - ACR
    - AAPM TG-40
    - Staffing
    - Roles, training, duties and responsibilities of individuals
    - Equipment selection and specifications
  - B. Linac quality assurance
    - 1. Acceptance testing—Linac
    - 2. Commissioning—Linac
      - Data required
      - Computer commissioning
    - 3. Routine QA and tolerances
      - Daily QA
      - Monthly QA
      - Yearly QA



# Radiation Protection & Shielding

- §10 *Learning Objectives for the Resident (2 units):*
  - 1. *the general concept of shielding, including “As Low As Reasonably Achievable” (ALARA) and Federal regulations.*
  - 2. *the units of personnel exposure, sources of radiation (manmade and natural), and means of calculating and measuring exposure for compliance with regulations.*
  - 3. *components of a safety program, including Nuclear Regulatory Commission (NRC) definitions and the role of a radiation safety committee.*



# Radiation Protection & Shielding

## (2)

### ◆ Topics to be covered (2 units)

#### – A. Radiation safety

- 1. Concepts and units
  - Radiation protection standards
  - Quality factors
  - Definitions for radiation protection
  - Dose equivalent
  - Effective dose equivalent
- 2. Types of radiation exposure
  - Natural background radiation
  - Manmade radiation
  - National Council on Radiation Protection (NCRP) #91 recommendations on exposure limits



# Rad. Protection & Shielding (3)

- 3. Protection regulations
  - (a) NRC definitions
    - (1) Medical event
    - (2) Authorized user
  - (b) NRC administrative requirements
    - (1) Radiation safety program
    - (2) Radiation safety officer
    - (3) Radiation safety committee
  - (c) NRC regulatory requirements
  - (d) Personnel monitoring
- B. Radiation shielding
  - 1. Treatment room design
    - (a) Controlled/uncontrolled areas
    - (b) Types of barriers



# Rad. Protection & Shielding (4)

- (c) Factors in shielding calculations
  - (1) Workload (W)
  - (2) Use factor (U)
  - (3) Occupancy factor (T)
  - (4) Distance
- 2. Shielding calculations
  - (a) Primary radiation barrier
  - (b) Scatter radiation barrier
  - (c) Leakage radiation barrier
  - (d) Neutron shielding for high-energy photon and electron beams
- 3. Sealed source storage
- 4. Protection equipment and surveys
  - (a) Operating principles of gas-filled detectors
  - (b) Operating characteristics
  - (c) Radiation monitoring equipment
    - (1) Ionization chamber (Cutie Pie)
    - (2) Geiger-Mueller counters
    - (3) Neutron detectors



# Imaging for Oncology

- §11 *Learning Objectives for the Resident (4 units):*
  - 1. *the physical principles associated with good diagnostic imaging techniques.*
  - 2. *the rationale behind taking port films, how port films are used in the clinic, and the response characteristics of common films used in the radiation therapy department.*
  - 3. *the types of portal imaging devices that are available in radiation therapy, the operating characteristics of these various devices, and the clinical application of this technology in daily practice.*
  - 4. *the physical principles of ultrasound, its utility and limitations as an imaging device, and its application to diagnosis and patient positioning.*
  - 5. *the physical principles behind CT, magnetic resonance imaging (MRI), and positron emission tomography (PET) scanning, how these modalities are applied to treatment planning, and their limitations.*



# Imaging for Oncology (2)

- 6. *the advantages of one imaging modality over another for various disease and body sites.*
  - 7. *image fusion, its advantage in treatment planning, the difficulties and limitations associated with image fusion, and how image fusion can be accomplished.*
- Topics to be covered (4 units):
- A. Routine imaging
    - Diagnostic imaging physical principles
    - Port films
    - XV-2 film, EDR-2 film characteristics
    - Processors
  - B. Other imaging
    - 1. Electronic portal imaging
      - Overview of electronic portal imaging devices (EPID)
      - Types of portal imaging devices
      - Clinical applications of EPID technology in daily practice





# Imaging for Oncology (3)

- 2. Ultrasonography
  - Physical principles
  - Utility in diagnosis and patient positioning
- C. Image-based treatment planning
  - 1. CT scans
    - Physical principles
    - Hounsfield units, CT numbers, inhomogeneity corrections based on CT scan images
  - 2. MRI scanning
    - Physical principles
    - T1, T2, TE, TR imaging characteristics
    - Advantages and limitations of MRI images for diagnosis and computerized treatment planning



# Imaging for Oncology (4)

- D. PET imaging
  - 1. Physical principles
  - 2. Utility for radiation therapy
  - 3. Image fusion
    - (a) Advantages
    - (b) Challenges
    - (c) Techniques
    - (d) Limitations



# 3D-Conformal Radiation Therapy

- §12 *Learning Objectives for the Resident (3 lab units):*
  - *1. the concepts, goals, and technologies needed for planning and delivering 3D-CRT compared with conventional RT.*
  - *2. concepts and definitions associated with 3D-CRT planning including optimization strategies, uniform vs. nonuniform tumor dose distributions, nonbiologic and biologic models for computing dose-volume metrics, beam shaping techniques, and magnitudes, sources, and implications of day-to-day treatment variabilities.*
  - *3. ICRU definitions and reporting recommendations for tumor-related volumes such as gross tumor volume (GTV), clinical target volume (CTV), and planning target volume (PTV).*



# 3D-Conformal Rad. Therapy (2)

- Topics to be covered (3 lab units)
  - A. 3D-CRT concepts and goals vs. traditional RT, comparison with protons
    - Technology and methods for planning
    - Multiple volume images (CT, MR, PET, MRSI, etc.)
    - Image processing (registration, segmentation)
    - Virtual simulation
    - DRRs
    - Multiple beams (4)
    - Noncoplanar beams
  - B. Optimization methods
    - Biologic implications of uniform vs. nonuniform dose delivery
    - Nonbiologic and biologic dose-volume metrics
    - (Dose Volume histograms [DVHs], tumor control probability [TCPs], Normal Tissue Complication Probability [NTCP])
    - Margins



# 3D-Conformal Rad. Therapy (3)

- C. Implications of treatment variabilities (systematic and random setup variabilities, patient breathing)
  - ICRU 50 prescribing, recording, and reporting
  - ICRU report 62 (supplement to ICRU report 50)



# Assessment of Patient Setup & Treatment

- §13 *Learning Objectives for the Resident (2 lab units):*
  - 1. *patient immobilization and positioning.*
  - 2. *imaging methods for monitoring patient geometry in the treatment position and how such images can be used for correcting patient alignment and modifying the initial treatment plan via an adaptive planning strategy.*



# Assessment of Patient Setup & Treatment

- Topics to be covered (2 lab units)
  - A. Immobilization devices and methods
    - Table positions, lasers, distance indicators
    - Immobilization methods
    - Positioning methods (calibrated frames, optical and video guidance, etc.)
  - B. In-the-room intratreatment imaging (cont'd)
    - Cone-beam
    - Ultrasound
    - Internal markers (e.g., implanted seeds)
    - On-line correction of setup errors
    - Adaptive planning concepts



# IMRT

- §14 *Learning Objectives for the Resident (2 lab units):*
  - 1. *details on the different delivery system including advantages, differences, and limitations.*
  - 2. *the differences for simulation and positioning compared with conventional therapy.*
  - 3. *principles of inverse planning and optimization algorithms.*
  - 4. *systematic and patient specific quality assurance.*





# IMRT (2)

- Topics to be covered (2 lab units):
  - A. IMRT delivery systems
    - 1. Segmental MLC (SMLC) and dynamic MLC (DMLC)
    - 2. Serial tomotherapy (MIMiC)
    - 3. Helical tomotherapy
    - 4. Robotic Linac
    - 5. Simulation and immobilization/repositioning
  - B. Dose prescription and inverse planning
    - 1. Treatment calculations
    - 2. IMRT quality assurance



# Special Procedures

- §15 *Learning Objectives for the Resident (3 lab units):*
  - 1. *the basis of stereotaxic frame systems.*
  - 2. *the frame placement, imaging, and treatment logistics.*
  - 3. *differences in the stereotactic radiosurgery (SRS) systems and accuracy requirements.*
  - 4. *dosimetry of small-field irradiation.*
  - 5. *Total Body Irradiation (TBI) techniques and large-field dosimetry.*
  - 6. *Logistics and dosimetric considerations for Total Skin Electron Radiotherapy (TSET) and e-arc*



# Special Procedures (2)

- Topics to be covered (3 lab units):
  - A. Stereotactic radiosurgery
    - 1. SRS delivery systems
    - 2. Linac based
    - 3. Gamma knife
    - 4. Robotic Linac
    - 5. Simulation and immobilization/repositioning
  - B. SRS Dose prescription and treatment planning
    - 1. Treatment calculations
    - 2. SRS quality assurance
  - C. Other special procedures
    - 1. Photon total body irradiation
      - Patient setup
      - Dosimetry
      - Selection of energy, field size, distance
      - Monitor unit calculations
    - 2. TSET
    - 3. Electron arc



# Brachytherapy

- §16 *Learning Objectives for the Resident (7 lab unit):*
  - 1. *characteristics of the individual sources: Half-life, photon energy, half-value layer shielding, exposure rate constant, and typical clinical use.*
  - 2. *source strength units: Activity, apparent activity, air kerma strength, exposure rate, equivalent of mg h of radium, and National Institute of Science and Technology (NIST) standards for calibration.*
  - 3. *High-dose rate vs. low-dose rate in terms of alpha/beta ratios, fractionation, dose equivalence.*
  - 4. *Specification of linear and point sources.*
  - 5. *Implant dosimetry for planar implants vs. volume implant, including Patterson-Parker, Quimby, Memorial, Paris, and computational optimizations and calculations.*
  - 6. *Implantation techniques for surface and interstitial implants, the sources used, and how they are optimized.*



# Brachytherapy (2)

- 7. *Uterine cervix applicators: Fletcher-Suit applicators (tandem and ovoids), high-dose rate applicators (tandem and ovoids/ring), and vaginal cylinders, and the treatment planning systems for each applicator.*
- 8. *Cervix dosimetry conventions: Milligram-h, Manchester system, bladder and rectum dose, and the ICRU system (point A and point B).*
- 9. *Radiation detectors used for calibration and patient safety.*
- 10. *Remote afterloading units, including dose rates and devices for delivery, safety concerns and emergency procedures, and shielding for patient and personnel.*
- 11. *Discuss NRC and state regulations regarding use, storage, and shipping of sources.*

A vintage key with a circular head and a notched bit, resting on a textured, light-colored surface. The key is positioned vertically on the left side of the slide.

# Brachytherapy (3)

## ◆ Topics to be covered:

- A. Radioactive sources (general information)
  - Radium
  - Cesium-137
  - Cobalt-60
  - Iridium-192
  - Gold-198
  - Iodine-125
  - Palladium-103
- B. Calibration of brachytherapy sources
  - Specification of source strength
  - Radium substitutes and radioactive isotopes currently used in brachytherapy
  - Linear sources
  - Seeds
  - Exposure rate calibration



# Brachytherapy (4)

- C. Calculations of dose distributions
  - Biologic considerations of dose, dose rate, and fractionation
  - Calculation of dose from a point source
  - Calculation of dose from a line source
- D. Systems of implant dosimetry
  - Paterson-Parker
  - Quimby
  - Memorial
  - Paris
  - Computer



# Brachytherapy (5)

- E. Implantation techniques
  - Surface molds/plaques
  - Interstitial therapy
  - Intracavitary therapy
  - Uterine cervix
  - Milligram-h
  - Manchester system
  - Bladder and rectum dose
  - ICRU system
  - Absorbed dose at reference points
- F. Gynecological implants
  - General information (advantages/disadvantages)
  - Remote afterloading units
  - High-dose rate (HDR) vs. Low-dose-rate (LDR)





# Brachytherapy (6)

- G. Radiation protection for brachytherapy
  - Detectors
  - Regulatory requirements
  - Surveys
  - Inventory and wipe tests
  - Shipping and receiving



# Hyperthermia

- §17 *Learning Objectives for the Resident (1 unit)*:
  - 1. *basic physics of hyperthermia and how this applies clinically.*
  - 2. *hyperthermia systems.*
  - 3. *Thermometry.*
- *Topics to be covered (1 unit)*:
  - A. *Physics aspects of hyperthermia*
    - The bio-heat equation and simplified solutions
    - Specific absorption rate (SAR).
    - Thermal aspects of blood flow/perfusion
    - Basic physics of ultrasound
    - Important technical considerations with microwaves and ultrasound devices



# Hyperthermia (2)

- B. Elements of clinical hyperthermia physics
  - External superficial electromagnetic hyperthermia applicators.
  - Interstitial electromagnetic hyperthermia applicators.
  - Electromagnetic applicators for regional hyperthermia.
  - Thermometry performance criteria, tests, and artifacts.
- C. Ultrasound hyperthermia systems



# Particle Therapy

- §18 *Learning Objectives for the Resident (1 unit)*:
  - 1. *basic physics of neutron and proton beams.*
  - 2. *configurations of proton and neutron delivery systems.*
  - 3. *treatment planning considerations for particle therapy.*



# Particle Therapy (2)

- Topics to be covered (*1 unit*):
  - A. Protons
    - Proton beam energy deposition
    - Equipment for proton beam therapy
    - Clinical beam dosimetry
    - Clinical proton beam therapy
    - Treatment planning
    - Treatment delivery
    - Clinical applications



# Particle Therapy (3)

- B. Neutrons
  - Fast neutron production
  - Basic interactions
  - Accelerator requirements
  - Clinical beam dosimetry
  - Treatment planning
  - Treatment delivery
  - Clinical applications
  - Boron neutron capture



# Comments, Suggestions, Advice and Complaints

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