RADIATION ONCOLOGY PHYSICS COURSE (3 Credits)
Course Code: BME 5072
SPRING 2018

Scheduled Days: Mondays and Wednesdays
Time: 3:30 – 5:00 pm
Place: Rm B12 (Physics Computer Lab) Lower Level (LL) of the Center for Advanced Medicine Building (CAM)
Office hours: By appointment only
NOTE: Make-up Sessions, if necessary per instructor, on Fridays 7:30 – 9 am

<table>
<thead>
<tr>
<th>Lecture #</th>
<th>Date</th>
<th>Topic</th>
<th>Lecturer</th>
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<tr>
<td>01/17/18</td>
<td></td>
<td>Introduction. Overview of Course</td>
<td>J. Zoberi</td>
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<td>A. Syllabus/Expectations</td>
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<td>B. Instructors – Contact Information</td>
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<td>C. Department Profile/Tour</td>
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<td>1 01/22/18</td>
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<td>Imaging in RO (KV, CBCT, EPID, US, MRI, PET/CT) – 1</td>
<td>M. Altman</td>
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<td>Ref: Bushberg p. 327-576</td>
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<td>A. Instrument Description, Basic Principles of Image Production, Operation and Use of:</td>
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<td>1. Physical (Film) Radiographic Imagers (Port Films)</td>
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<td>2. Onboard MV Imagers (EPID)</td>
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<td>3. Onboard KV Imagers</td>
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<td>4. CBCT Principles</td>
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<td>2 1/24/18</td>
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<td>Imaging in RO (KV, CBCT, EPID, US, MRI, PET/CT) – 2</td>
<td>M. Altman</td>
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<td>Ref: Bushberg p. 327-576 and Ch 25, Khan</td>
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<td>A. Basic principles, Artifacts and Clinical Use of:</td>
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<td>1. Ultrasound</td>
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<td>2. MRI</td>
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<td>3. PET/CT</td>
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**Homework #1 to be distributed (M. Altman)**
3 01/29/18  Production of X-rays  J. Zoberi
Ref: Ch 3, Khan

A. X-ray Tubes
   1. Anode and Cathode
   2. Focal Spot Size
   3. Reflection and Transmission Targets
   4. Heel Effect
   5. X-ray Emission Spectrum
   6. X-ray Circuits

B. Physics of X-ray Production
   1. Bremsstrahlung
   2. Characteristic X-rays
   3. X-ray Energy Spectra
   4. Operating Characteristics

C. Beam Quality Parameters and Measurements of Beam Quality
   1. HVL
   2. Effective Energy
   3. Narrow Beam Geometry
   4. Broad Beam Geometry
   5. Effects of Measurement Geometry on HVL

**Homework #1 to be collected**

4 01/31/18  Clinical Radiation Generators  J. Zoberi
Ref: Ch 4, Khan

A. Kilo voltage Units
B. Linear Accelerators
   1. Major Subsections
   2. Accelerator Section
   3. Microwave Power(Magnetrons, Klystrons)
   4. Bending Magnet Types
   5. Monitor Chamber
   6. Photon Beam Production
      a. Target
      b. Flattening Filter
      c. Flattening Filter Free
      d. Collimation (including Multileaf Collimators)
      e. Beam Profiles (“Horns”)n
   7. Computer Control System
   8. Electron Beam Production
      a. Scattering Foil Systems
      b. Scanning Electromagnet Systems
      c. Collimation
Dose Distribution and Scatter Analysis

A. Phantoms
B. Depth Dose Distribution
C. Percentage Depth Dose (PDD)
   1. Dependence on Beam Quality, Depth
   2. Dependence on Field Size, Shape (Equivalent Squares)
   3. Dependence on Source to Source Distance
D. Tissue-Air Ratio (TAR)
   1. Effect of Distance
   2. Variation with Energy, Depth and Field Size
   3. Backscatter Factor (BSF)
   4. Relationship between TAR and PDD
E. Scatter-Air Ratio (SAR)

A System of Dosimetric Calculations

A. Dose Calculation Parameters
   1. Collimator Scatter Factor
   2. Phantom Scatter Factor
   3. Tissue-Phantom Ratio (TPR)
B. Monitor Unit (MU) Calculations in Practice
   1. SSD Technique
      a. SSD Treatment same as SSD of Calibration
      b. SSD Treatment different from SSD of Calibration
   2. SAD Technique
      a. SAD Treatment and SSD Calibration
      b. SAD Rotational Treatment
   3. Irregular, Asymmetric Fields
C. Other Methods for Dose Calculation
   1. Irregular Fields
   2. Points Off-axis, Outside the Field, and Under Block

**Homework #2 to be distributed (J. Zoberi)**
A. Isodose curves (beam characteristics)
   1. Measurement
   2. Parameters

B. Wedge Isodose Curves
   1. Wedge Angle and Hinge Angle
   2. Wedge Factor
   3. Wedge Systems: Individualized Wedge vs. Universal Wedge

C. Combination of Radiation Fields
   1. Parallel-opposed Fields
   2. Multiple Fields

D. Isocentric Techniques
   1. Stationary vs. Rotation Therapy

E. Wedge Field Techniques

F. Dose-Volume Specification ICRU 50
   1. GTV, CTV, PTV
   2. Organs at Risk
   3. Dose Specification

G. Dose-Volume Specification ICRU 62
   1. ITV
   2. Planning Risk Volume
   3. Specification of Target Dose

**Homework #2 to be collected**

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A. Acquisition of Patient Data
   1. Body Contours
   2. Internal Structures

B. Treatment Simulation
   1. Conventional Simulators
   2. CT Simulators

C. Patient Positioning
   1. SAD vs. SSD setups
   2. Positioning Principles and Devices
   3. Immobilization Methods (thermoplastic masks, bite blocks, etc.)
   4. Skin marks

D. Treatment Verification
   1. Port films, EPIDs, CBCT (kV, MV)

E. Correction for Contour Irregularities

F. Correction for Tissue Inhomogeneities

G. Tissue Compensation
09 02/19/18 **Treatment Planning III: Field Shaping, Skin Dose, and Field Separation** M. Altman  
Ref: Ch 13, Khan

A. Field Blocks  
B. Field Shaping  
C. Field Separation  
   1. Gapping Fields (Craniospinal)  
D. Field Matching  
   1. Two-Field Problem (Mantle + Inverted Y)  
   2. Three-Field Problem (Tangents + SCV)  
   3. Photon-Electron (Head and Neck)

10 02/21/18 **Electron Beam Therapy** M. Altman  
Ref: Ch 14, Khan

A. Depth-dose/Isodose Characteristics  
   1. AAPM TG-25, TG-70  
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  
   6. MU Calcs  
C. Field Matching  
   1. Electron-electron Gapping  
   2. Electron-photon Gapping  
D. Electron Backscatter  
   1. Internal/External Shielding  
E. Inhomogeneities

**Homework #3 to be distributed (M. Altman)**

11 02/26/18 **Conformal Radiation Therapy** M. Altman  
Ref: Ch 19, Khan

A. Treatment Planning Process  
   1. Imaging Data  
   2. Image Registration  
   3. Image Segmentation  
   4. Beam Aperture Design  
   5. Multiple Fields and Collimation  
   6. Plan Optimization and Evaluation  
B. Dose Calculation Algorithms  
   1. Correction-based Algorithms  
   2. Model-based Algorithms  
   3. Convolution-superposition Method  
   4. Monte Carlo  
C. Electron Algorithms  
   1. Pencil Beam
2. Monte Carlo

**Homework #3 to be collected**

12 02/28/18 **Quality Assurance**
Ref: Chapter 17, Khan

A. Goals of QA Program
B. Physics Staffing
C. Equipment
D. Dosimetric Accuracy
E. Equipment Specifications
F. Acceptance Testing
G. Commissioning
H. Periodic QA

03/05/18 Reading week
03/07/18 Midterm exam

03/11/18 thru 03/17/18 SPRING BREAK

13 03/19/18 **Brachytherapy I: Source Production, Characteristics, and Strength Specification**
Ref: Chapter 15, Khan and Williamson Chapter from Perez and Brady

A. Physical Properties of Sources
   1. Decay
   2. Source Construction
   3. Source Specification
   4. Exposure Rate Constant
B. Examples of Brachytherapy Sources
C. Calibration of Brachytherapy Sources
   1. Activity
   2. Exposure Rate
   3. Equivalent Mass of Radium
   4. Apparent activity, Air kerma, conversions between Exposure Rate Calibration
D. Open Air Measurements vs Well-type IC

14 03/21/18 **Brachytherapy II: Calculation of Dose Distributions**
Ref: Chapter 15, Khan and Williamson Chapter from Perez and Brady

A. Calculation of Dose Distributions
   1. Sievert Integral
   2. TG-43
B. Systems of Implant Dosimetry
1. PP, Quimby, Memorial, Paris
2. Computer Dosimetry
3. Total Dose from Sources

15  03/26/18  **Brachytherapy III: Implantation Techniques**  J. Zoberi
Ref: Chapters 15 and 23, Khan
A. Implantation Techniques
B. Surface molds (eye)
C. Interstitial (LDR prostate)
D. Intracavitary (Uterine Cervix and Uterine Corpus)
E. Milligam-hour, Manchester, ICRU 38

16  03/28/18  **Remote-Afterloading and High Dose Rate Brachytherapy**  J. Zoberi
Ref: Chapter 22, Khan
A. RAUs
B. HDR Applicators
C. Facility Design
D. Licensing Requirements
E. Policies and Procedures
F. Source Calibration
G. Treatment Planning
H. QA
I. Clinical Applications

**Homework #4 to be distributed (J. Zoberi)**

04/02/18  Reading week

17  04/04/18  **Special Procedures**  V. Rodriguez
Ref: Chapter 18, Khan
A. TBI
B. TSET
C. Scalp Irradiation
D. Electron Arc
E. Dot Decimal
F. ART – Adaptive Radiotherapy

**Homework #4 to be collected**

18  04/09/18  **IMRT Techniques (SMLC, DMLC, TOMO, VMAT)**  V. Rodriguez
Ref: Chapter 20, Khan
A. Solid Compensators
B. SMLC
C. DMLC
D. Helical Tomo
E. VMAT
F. Intercomparison in between Delivery Techniques
G. Effects of Target/Organ Motion

19 04/11/18  IMRT Optimization & Planning & Treatment  V. Rodriguez
Plan Evaluations
Ref: Chapter 20, Khan
A. Forward Plan IMRT
B. Inverse Planning Optimization Algorithms
C. Optimization Parameters
D. Rapid Planning
E. Image Artifacts and Organ Motion Management
F. Contouring Caveats
G. Anatomical Changes Caveats
H. Comparison of “Optimization Algorithms
I. DVH and Differential DVH
J. Conformity Index, R50
K. Heterogeneity Index
L. Good vs Poor IMRT Plan

**Homework #5 to be distributed (V. Rodriguez)

20 04/16/18  Special Topics: MR-Guided External Beam Therapy  V. Rodriguez

**Homework #5 to be collected

21 04/18/18  Stereotactic Procedures I: SRS  N. Knutson
Ref: Chapter 21
A. Stereotactic Radiosurgery Techniques
   1. Linac-based
   2. Gamma Knife
   3. Robotic Linac
B. Simulation and Immobilization/Repositioning
C. Dose Prescription & Treatment Planning
D. Treatment Calculations
E. SRS Quality Assurance

22 04/23/18  Stereotactic Procedures II: SRT/SBRT  N. Knutson
Ch. 14, Khan’s Treatment Planning in RO, 4th Edition
A. Delivery Systems
B. Patient Setup, Immobilization and Motion Management
C. Dose Rx and Treatment Planning
D. Quality Assurance

23 04/25/18  Special Topics: Protons and Charged Particles  N. Knutson
Ref: Chapter 26, Khan
04/30/18 - Reading Week

05/02/18  FINAL EXAM

Evaluation:

Students will be evaluated on the basis of active class participation (10%); homework assignments (20%); midterm (35%); and final examination (35%).

References:  More to be added per instructor (see Syllabus)


2. F.M.Khan “The Physics of Radiation Therapy”, 4th Ed. 2010 Lippincott Williams & Wilkins


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