Clinical Rotation 2: PHYS 703
Spring (3rd Week of Feb. – 3rd Week of Aug.)
COURSE INFORMATION

Days: Monday-Friday
Times: Full Time
Location: One of the participating cancer clinics

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1. Course Overview

Description from the Official Course Catalog:
On-site, full-day clinical training covering physics concepts and implementation of standard radiation treatment (RT) techniques for common cancer treatment sites, routine quality assurance associated with patient specific RT and planning, special RT procedures, quality assurance of RT planning systems, monitor unit calculations, patient safety with respect to radiation therapy, and treatment planning

Description of the Purpose and Course Content:
This course is a clinical rotation that comprises an integral part of the residency training for radiation oncology physics. It is designed to be in accordance with American Association of Physicists in Medicine (AAPM) Task Group 249, 'Essential and Guidelines for Hospital based Medical Physics Residency Training Programs', and the Commission on Accreditation of Medical

Physics Educational Programs (CAMPEP). The course will also include didactic coverage of the topics during biweekly resident sessions at SDSU.

This clinical rotation course extends over the second-six months of the certificate program and consists of rotations through areas of clinical training covering physics concepts and implementation of standard radiation treatment (RT) techniques for common cancer treatment sites, routine quality assurance associated with patient specific RT and planning, special RT procedures, quality assurance of RT planning systems, monitor unit calculations, patient safety with respect to radiation therapy, and treatment planning under the supervision of Board Certified Medical Physicists at one of the participating cancer centers. The course also includes assigned reading on the various aspects of external beam radiation therapy and ethics and professionalism. Objectives are established at the commencement of the course. The Resident will be assigned to one of the participating centers for this 6-month course. The work at the clinic, including self-study of reading material and contact hours of the Resident with the clinic team (i.e., Medical Physicists, Dosimetrists, Radiation Oncologists, Radiation Therapists) and chart rounds/tumor board meetings will be full time.

Note: The proposed course requires access to external beam radiotherapy equipment, simulation equipment, imaging equipment, quality assurance, and treatment planning equipment that are only available at community/academic cancer centers. Arrangements will be made to have board certified Clinical Medical Physicists at the hospitals train the Resident in all aspects of the physics of external beam radiation therapy including equipment usage and quality assurance and control. Once trained, the Resident will be expected to perform routine quality control of the equipment available at the assigned cancer center under the supervision of a qualified Medical Physicist.

In addition to the clinical activities below, the resident may pursue optional research opportunities which do not compromise clinical training and is expected to attend:

- One medical physics conference per year
- Biweekly didactic resident sessions at SDSU covering the clinical topics below and resident progress/concerns (~2 hours/session)
- Medical physics seminars at SDSU (~ 4 per rotation)

Patient Treatment:

A. Treatment techniques – 4 weeks

1. Coplanar beam treatment techniques
2. Non-coplanar beams (3-D)
3. Image-guided radiation therapy
    a. Computed tomography (CT)
    b. Magnetic resonance imaging (MRI)
    c. Positron emission tomography (PET)
    d. Ultrasound
    e. Image registration and fusion
4. Site-specific techniques
    a. Breast
    b. Central nervous system (CNS)
    c. Genitourinary (GU)
    d. Gynecological (GYN)
    e. Gastrointestinal (GI)
    f. Head and Neck
    g. Lymphoma
    h. Melanoma
    i. Pediatrics
    j. Sarcoma
    k. Thoracic

B. Treatment planning – 3 weeks

1. Patient positioning, immobilization, and localization
2. Tumor localization/patient contours (radiographic/fluoroscopic, CT simulation)

3. Custom blocking and multileaf collimators (MLCs)
4. Computer-assisted isodose generation

C. Monitor unit (MU) calculations – 2 weeks

1. Source-skin distance (SSD) and percentage depth dose (PDD)
2. Source-axis distance (SAD)
    a. Tissue-air ratio (TAR)
    b. Tissue-maximum ratio (TMR)
    c. Tissue-phantom ratio (TPR)
3. Extended SSD
4. Off-axis points
5. Inhomogeneity (heterogeneity) corrections
6. Tissue compensation
7. Asymmetric collimation
8. S_c and S_p
9. Enhanced dynamic wedge
10. Virtual wedge

D. Quality assurance/Informatics – 4 weeks

1. Treatment plan verification
2. Treatment record verification
3. Monitor unit calculation rechecks
4. Patient positioning
    a. Ultrasound (US)
    b. Electronic portal imaging device (EPID)
5. Portal imaging (film, EPID, computed radiography [CR])
6. Tissue compensators and field-in-field techniques
7. MU calculators
8. Information systems data entry and integrity
9. Record and verify systems
10. Validation of data transfer
11. Record and verify systems
12. IHE – Radiation Oncology (IHE-RO)
13. Image registration, fusion, segmentation, processing
14. Fetal dose and pacemakers
15. Treatment delivery verification
16. In-vivo dosimetry

E. Special procedures (Note: These are covered didactically if they are not available in the clinic) – 4 weeks

1. Total body photon irradiation (TBI)
2. Total skin electron treatment (TSET)
3. Intraoperative (electrons)
4. Electron arc
5. Tissue compensation
6. Bolus and beam spoiler
7. Respiratory correlated planning and delivery

F. Treatment planning workstations – 3 weeks

1. Beam data acquisition/management
2. Beam modeling
3. Acceptance testing
4. Quality assurance
5. Treatment planning algorithms
6. Treatment techniques

7. Normalization
8. Inhomogeneity (heterogeneity) corrections
9. Beam modeling

G. Radiation Protection 4 weeks
1. Room design and shielding calculations
2. Licensing by Nuclear Regulatory Commission (NRC) and/or state
3. Construction supervision and site planning
4. Radiation survey; including low energy (4–6 MV) and high-energy (15–25 MV) units.

2. Student Learning Outcomes & Competency Evaluation Metrics

All of the outcomes listed in Appendix 1 of Clinical Rotation 2 below will be assessed by measurable competencies in clinical measurements and practice, oral evaluations, written reports and a final oral exam. Many of the objectives, learning outcomes, and competency evaluation metrics given in Appendix 1 of this syllabus have been adapted from AAPM Report Task Group 249.

A competency of "Meets Expectations" (i.e.,score ≥ 3) is required on all oral examinations and competency checklist to pass the rotation.

Real Life Relevance:
This clinical rotation course provides practical hands on clinical training in radiation oncology physics.

Relation to Other Courses:
This is the fourth clinical rotation course in the Advanced Certificate of Medical Physics Residency Program. The topics covered in this and the other clinical rotations are core requirements for the Commission on Accreditation of Medical Physics Education Programs (CAMPEP).

3. Enrollment Information

Prerequisites:
Clinical Rotation 1 (PHYS 701)

Adding/Dropping Procedures:
The course must be added before the end of the second week of the semester. Dropping procedures will follow the Physics Department guidelines. Note: Dropping a clinical rotation course is effectively equivalent to withdrawing from the residency program.

4. Course Materials

Required & Recommended Materials:
The following task group publications available at http://www.aapm.org/pubs/reports/ from the American Association of Physicists in Medicine (AAPM) and books and will be the references for the course:

1. Chapter 7 from: "Radiation Oncology Physics: a handbook for teachers and students", E.B. Podgorsak and G.H. Hartmann, IAEA Publication. PDF available for free download at: http://www-pub.iaea.org/MTCD/publications/PDF/Pub1196_web.pdf

2. F. Khan and B. J. Gerbi, "Treatment Planning in Radiation Oncology," 2011, 3rd Edition.

3. The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists, Volume 1, Editor: Jacob Van Dyk, Medical Physics Publishing Corporation, 1999.

4. The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists, Volume 2, Editor: Jacob Van Dyk, Medical Physics Publishing Corporation, 2005.

5. A.Barrett, J. Dobbs, S. Morris, T. Roques, “Practical Radiotherapy Planning.” 2009, 4th Edition.

6. AAPM TG-53. Quality Assurance for Clinical Radiotherapy Treatment Planning, Medical Physics, Vol. 25 (10), 1998.

7. IAEA TRS 430. Commissioning and Quality Assurance of Computerized Planning Systems for Radiation Treatment of Cancer. Technical Reports Series (TRS) No. 430. Vienna, Austria: International Atomic Energy Agency, 2004.

8. Stereotactic body radiation therapy: The report of AAPM Task Group 101, Medical Physics, Vol. 37 (8), 2010.

9. Report of the AAPM Task Group No.105: Issues associated with clinical implementation of Monte Carlo-based photon and electron external beam treatment planning, Medical Physics, Vol 34 (12), 2007.

10. Report of the AAPM Therapy Physics Committee Task Group No. 71: Monitor unit calculations for external photon and electron beams, Medical Physics, Vol. 41 (3), 2014.

11. ICRU Report 50: Prescribing, Recording, and Reporting Photon Beam Therapy.

12. ICRU Report 62: Prescribing, Recording and Reporting Photon Beam Therapy.

13. ICRU Report 83: Prescribing, Recording, and Reporting Intensity-Modulated Photon-Beam Therapy (IMRT).

14. ICRU Report 86: Quantification and Reporting of Low-Dose and Other Heterogeneous Exposures.

15. NCCN guidelines for treatment of cancer by site:
http://www.nccn.org/professionals/physician_gls/f_guidelines.asp#site

5. Course Structure and Conduct

Style of the Clinical Rotation:

- Residents will be trained by the Certified Clinical Medical Physicist to perform hands on clinical duties in the cancer center.
- Once trained the residents will gain practice by preforming routine clinical duties.
- Residents will be responsible for learning the recommended reference materials on their own.

6. Course Assessment and Grading

Grading Scale:

The Resident’s performance will be evaluated by direct observation, project/progress reports, and **three** oral evaluations (approximately bimonthly) administered by the supervising Medical Physicist. Note: The final oral examination is cumulative and will be administered by the Advisory Committee.

One of the writing components of this course will include a report by the resident that describes all of the clinical activities/projects in which they participated. The report will include the objectives and relevance, description, methods, and discussion/conclusions of each major clinical activity/project. Special assigned clinical project reports may also be included.

The final assessment breaks down as follows:

1. Observation of clinical measurements and practice by supervising Medical Physicist: 10%
2. Bimonthly oral evaluations based on the clinical rotation topics (Approximately ranging from 20 minutes to 1 hour long): 40%
3. Project/progress and reports: 20%

4. Final presentation and oral exam (1 hour): 30%

The following evaluation scheme from 1 to 5 will be used:

1. Unsatisfactory
   - Performance and/or consistency is below standard in most/all areas covered by evaluation
   - Immediate and consistent improvement to “Meets Expectations” rating is required in next evaluation and final oral exam
2. Needs Improvement
   - Performance and/or consistency is below standards in certain areas and improvement is needed
3. Meets Expectations
   - Competent level of performance that consistently meets high standards
4. Above Expectations
   - Examination results exceed expectations
   - Performance is consistently high quality
5. Outstanding
   - Knowledge of evaluation material is exceptional and consistently superior

The resident will be assigned a pass/fail for the course. An overall score of 3 or greater constitutes a pass. If the resident fails one section of the rotation, they will be given one chance to prepare and re-take the oral exam for that section two weeks later. A copy of all evaluations will be sent to the Program Director.

Excused Absence Make-up Policies:

Students should have an extraordinary reason (e.g., illness, death in the family, etc.), with proof, to miss the oral examination or final oral examination. A make-up for such a case will be arranged with the Advisory Committee

7. Other Course Policies

The residents are expected to:

- Engage with supervising Medical Physicist for training.
- Record daily activities and time spent in the clinic. This will be reviewed by regularly the supervising Medical Physicist and quarterly by the Advisory Committee.
- Report for duties at the clinic and meetings on time.
- Perform assigned readings, presentations, lectures, and clinical duties in a timely manner.
- Attend medical physics seminars (approximately 4 per semester) at SDSU.
- Attend all of the biweekly resident sessions at SDSU.
- Attend one Medical Physics Conference each year (e.g., the AAPM, ASTRO, or COMP Annual Meeting).
- Report any QC results that are out of tolerance to the supervising or other qualified Medical Physicist at the clinic as soon as possible.
- Hand in project and progress reports by assigned deadline.
- Dress appropriately in the clinic (e.g., dress shirt and dress pants).
- Interact respectfully with all staff members and patients in the clinic.
- Advise the supervising Medical Physicist and Program Director of planned absences (e.g., vacation time or sick leave). A record of vacation days absent shall be kept by the Associate/Program Director and should not exceed the allotted two weeks per six-month semester. In addition, the holidays allotted to Medical Physicists at the center are applicable to the resident. The resident may also take up to 1.5 days of personal leave per six-month rotation.

Note:

A senior resident will be chosen to be part of the Advisory Committee to provide input on resident issues and concerns.

If you are a student with a disability and believe you will need accommodations for this class, it is your responsibility to contact Student Disability Services at (619) 594-6473. To avoid any delay in the receipt of your accommodations, you should contact Student Disability Services as soon as possible. Please note that accommodations are not retroactive, and that I cannot provide accommodations based upon disability until I have received an accommodation letter from Student Disability Services. Your cooperation is appreciated.

Appendix 1 of Clinical Rotation 2

Note: For this rotation, a log of the 3D treatment planning and IMRT/VMAT rotations cases will have to be kept and signed by the mentor during the. The minimum number of cases to be done for each treatment site must be met to pass the rotation.

RADIATION ONCOLOGY RESIDENCY PROGRAM
Competency Evaluation of Resident

Resident's Name:	
Rotation:	PHYS 703: Clinical Rotation 2
Inclusive dates of rotation:	
Director or Associate Director:	

Competency Assessment Scheme:

1. Unsatisfactory
   - Performance/Knowledge is below standard
2. Needs Improvement
   - Performance/Knowledge is below standards in certain areas and improvement is needed
3. Meets Expectations
   - Performance/knowledge that consistently meets high standards of competency
4. Above Expectations
   - Performance/Knowledge exceeds expectations
   - Performance/Knowledge is consistently high quality
5. Outstanding
   - Performance/Knowledge is exceptional and consistently superior

Evaluation criteria	**Competency (from 1 – 5)**	**Explanatory Notes & Mentor Signature**
Treatment Techniques		
1. Demonstrates IMRT/VMATnderstanding of 2D coplanar beam treatment planning		
2. Demonstrates an understanding of the placement of non-coplanar beams (3D) in external beam treatment planning		
3. Demonstrates an understanding of the following image-guided radiation therapy techniques:		
a. Planar MV imaging		
b. Planar kV imaging		

c. Cone beam computed tomography (CBCT)		
d. Ultrasound (US)		
e. Non-radiographic localization, e.g., US, surface camera, radiofrequency (RF) beacon tracking.		
4. Demonstrates an understanding of image registration techniques, e.g., rigid and deformable registration		
5. Demonstrates an understanding of site-specific techniques (photons and electrons) and **performs two to five plans for each of the following sites**:		
a. Performs 3D or IMRT/VMAT treatment planning for breast and chest wall that includes axilla fields and the single isocenter technique		
b. Performs 3D or IMRT treatment planning for the brain, spine, and craniospinal irradiation		
c. Performs 3D or IMRT/VMAT treatment planning for the bladder, prostate, and testis		
d. Performs 3D or IMRT/VMAT treatment planning for gynecological tumors		
e. Performs 3D or IMRT/VMAT treatment planning for gastrointestinal tumors, e.g., colorectal tumors, tumors of the esophagus, stomach, and liver		
f. Performs 3D or IMRT/VMAT treatment planning for head and neck tumors		
g. Performs 3D treatment planning for common lymphomas that includes the mantle field technique;		
h. Performs 3D treatment planning for skin cancers		
i. Demonstrates an understanding of common 3D or IMRT/VMAT treatment planning techniques for pediatric cancers and performs 3D treatment planning for pediatric craniospinal irradiation		
j. Demonstrates an understanding of common 3D or IMRT/VMAT treatment planning techniques for sarcoma of the trunk and extremities		
k. Performs 3D or IMRT/VMAT treatment planning for the lungs, mediastinum, and thoracic region		
Treatment Planning		
1. Beam properties		

a. Demonstrates an understanding of photon and electron percent depth dose in tissue and other media		
b. Demonstrates an understanding of electron ranges (Rp, R80, R90, and dmax) for different energies		
c. Demonstrates an understanding of proton percent depth dose in tissue and other media and proton ranges for different energies, e.g., stopping and scattering power and range		
d. Demonstrates an understanding of the potential uncertainties in dose deposition in proton radiotherapy		
e. Demonstrates an understanding of the flatness and symmetry of photon and electron beams		
f. Demonstrates an understanding of the differences between source-to-axis distance (SAD) and source-to-skin distance (SSD) treatments;		
g. Demonstrates an understanding of the applicability of electron and photon therapy with regard to disease, depth, and critical normal structures		
h. Discusses the impact of dose and fractionation on normal and tumor tissues		
i. Demonstrates an understanding of the impact of beam quality (e.g., linear energy transfer [LET]) on the relative biological effectiveness (RBE) of different forms of ionizing radiation (e.g., electrons, photons, and protons)		
j. Discusses the uncertainties related to electron and photon therapy (e.g., in terms of physics, biology, machine and patient setup accuracy) and how they may be detected and mitigated during the planning and delivery process.		
2. Beam modifiers		
a. Demonstrates an understanding of the effect of beam modifiers (e.g., wedges, compensators) on the dosimetric characteristics of the incident beam		
b. Demonstrates an understanding of wedges (wedge angle, hinge angle) and the different types of wedges used clinically (physical, universal, dynamic)		
c. Demonstrates an understanding of the design of the different commercially available multileaf collimators (MLCs)		
d. Demonstrates an understanding of blocking and shielding for therapy beams		

e. Demonstrates an understanding of the use of custom bolus		
f. Demonstrates an understanding of the design and use of tissue compensators.		
3. Treatment simulation techniques		
a. Demonstrates an understanding of common patient-positioning and immobilization devices		
b. Demonstrates an understanding of when and how to use specific treatment devices for specific treatments		
c. Discusses how to account for beam attenuation from patient-positioning and immobilization devices in treatment planning.		
4. Tumor localization and normal tissue anatomical contouring		
a. Performs structure delineation on CT, MRI, PET, PET/CT, SPECT, or SPECT/ CT data sets		
b. Demonstrates an understanding of target volume determination, including the design of ICRU target structures (involving concepts such as gross tumor volume [GTV], clinical target volume [CTV], internal target volume [ITV], planning target volume [PTV], and planning organ at risk volume [PRV]);		
c. Demonstrates an understanding of how 4D data is used for target definition and relevant radiation treatment prescription parameters such as GTV, PTV, CTV, and ITV		
d. Demonstrates an understanding of the role of maximum intensity projection (MIP) images in the treatment planning process		
e. Demonstrates an understanding of the role of digitally reconstructed radiographs (DRRs) in the treatment planning process		
f. Demonstrates an understanding of and performs image registration and fusion of data sets for modalities such as CT/CT, CT/MRI, and CT/PET; deformable registration; and image/dose registration.		
5. Plan evaluation. Defines and discusses each of the following treating planning evaluation tools, including their limitations:		
a. Dose volume histograms (V(dose), D(volume), mean dose; cumulative and differential)		
b. Conformity index		
c. Homogeneity index		

d. Biological evaluators (e.g., generalized equivalent uniform dose [gEUD], equivalent uniform dose [EUD], normal tissue complication probability [NTCP], and tumor control probability [TCP]).		
e. Discusses dose tolerances for various normal tissue structures along with relevant volume effects.		
Intensity-modulated Radiation Therapy (IMRT/VMAT)		
1. Inverse planning		
a. Demonstrates an understanding of the use of objective functions for IMRT/VMAT optimization		
b. Demonstrates an understanding of the optimization processes involved in inverse planning		
c. Performs inverse planning optimization for a variety of treatment sites in sufficient number to become proficient in the optimization process (see Section 4.5.2.1)		
d. Demonstrates an understanding of commonly used planning procedures and guidelines as well as optimization and dose calculation algorithms.		
2. IMRT/Volumetric modulated arc therapy (VMAT) delivery		
a. Demonstrates an understanding of various IMRT/VMAT delivery techniques (e.g., compensators, static field IMRT, rotational delivery techniques) and their relative advantages and disadvantages		
b. Explains the differences between dynamic multileaf collimator (DMLC) and segmental multileaf collimator (SMLC) leaf sequencing algorithms in terms of delivery parameters and dose distributions		
c. Participates in IMRT/VMAT delivery for patients with a variety of treatment sites and demonstrates an understanding of the techniques and requirements for patient setup, immobilization, and localization.		
Monitor Unit (MU) Calculations		
1. Demonstrates an understanding and performs derivation of the following factors:		
a. Percent depth dose (PDD)		
b. Tissue-air ratio (TAR)		

c. Tissue-maximum ratio (TMR)		
d. Tissue-phantom ratio (TPR)		
e. Scatter factors (i.e., Sc, Sp, Scp)		
f. Off-axis factors		
g. Inverse square factors		
h. Calibration factor (monitor unit [MU] reference conditions)		
i. Standard wedge factors		
j. Virtual and dynamic wedge factors		
k. Compensator factors		
l. Tray and other insert factors		
2. Performs manual MU calculations for photon or electron beams of the following configurations:		
a. SSD setup		
b. SAD setup		
c. Extended distance setup		
d. Off-axis calculation points		
e. Rotational beams		
3. Demonstrates an understanding of and performs MU calculations using heterogeneity corrections		
Quality Assurance (QA)		
1. Performs treatment plan verification involving:		
a. Review of patient history (such as prior radiotherapy and potential overlap with current treatment), disease, course of treatment, and dose prescription		
b. Review of appropriateness of the treatment plan and dose distribution to achieve the goals of the treatment course		

c. Review of simulation (e.g., patient positioning and immobilization), planning, imaging, and treatment field parameters		
d. Review of monitor unit or time calculations		
e. Review of images to be used for patient positioning or monitoring		
f. Review of transfer of plan parameters and images to record and verify system and any other patient monitoring systems		
2. Performs ongoing review of treatment records (e.g., chart checks, review of treatment or setup images), including verification of delivered treatments		
3. Demonstrates an understanding of the following components of an *in vivo* dosimetry program:		
a. Acceptance, commissioning, calibration, and ongoing quality assurance procedures for *in vivo* dosimetry systems		
b. Use of *in vivo* dosimetry systems for patient-specific measurement		
c. Limitations of specific *in vivo* dosimetry systems		
4. Demonstrates familiarity with the dose limits relevant to sensitive structures outside of the treatment field (e.g., gonads, fetus, and electronic implanted device such as cardiac pacemaker and/or defibrillator) and the ability to determine the dose to these structures		
Special Procedures		
1. Total body (photon) irradiation (TBI)		
a. Describes the rationale for TBI treatments for the treatment of malignant and benign conditions		
b. Demonstrates an understanding of TBI prescription and delivery techniques and of issues related to the clinical commissioning and maintenance of a TBI program		
c. Describes and demonstrates an understanding of the significance of beam modifiers commonly used during TBI treatments (e.g., lung/kidney blocks, beam spoilers)		
d. Participates in all aspects of TBI treatment (i.e., simulation, planning, plan verification, treatment, treatment verification, and in vivo measurements). NOTE: This competency		

is optional.		
2. Total skin electron treatment (TSET)		
a. Describes the rationale of TSET treatments for the treatment of malignant and benign conditions		
b. Demonstrates an understanding of TSET delivery techniques and of issues related to the clinical commissioning and maintenance of a TSET program		
c. Explains the significance of the B-factor		
d. Describes and demonstrates an understanding of the significance of beam modifiers commonly used during TSET treatments (e.g., shields, beam scatter); and		
e. Participates in all aspects of TSET treatment (i.e., simulation, planning, plan verification, treatment, treatment verification, and *in vivo* measurements). NOTE: This competency is optional.		
3. Respiratory-correlated planning and delivery		
a. Describes the rationale for using respiratory management systems in radiation therapy		
b. Describes the common issues introduced by respiratory motion in imaging, planning, and treatment delivery		
c. Describes common treatment sites affected by respiratory motion and the typical range of tumor excursion		
d. Describes methods for evaluating and managing respiratory motion		
e. Describes QA tests for common respiratory management systems and their recommended frequency		
Treatment Planning Workstations		
1. Data acquisition		
a. Explains the connection between linac commissioning and the data required for operation of a treatment planning system		
b. For a particular treatment planning system, describes the linac data needed for:		
c. Photon beams		
d. Electron beams		

e. IMRT and VMAT		
2. Acceptance testing		
Describes what tests of the treatment planning system need to be performed before patient-specific planning can commence for:		
i. Photon beams		
ii. Electron beams, and		
iii. Brachytherapy sources		
3. Quality assurance		
a. Describes the tests that need to be performed and their accuracy		
b. Describes accuracy checks for the following input devices and types of images:		
c. Digitizers		
d. Film scanners		
e. Imported images from instruments such as CT scanners, MRI scanners, and picture archiving and communication (PAC) systems		
f. Describes accuracy checks for the following output devices:		
i. Printers		
ii. Record and verify systems		
iii. DICOM output		
4. Computer algorithms (models)		
Describes how the computer algorithm calculates dose for at least one major treatment planning system with regard to:		
i. Photon beams		
ii. Electron beams		
iii. Brachytherapy calculations		
iv. Proton beams (Optional)		

a. Describes the advantages and disadvantages of the various treatment planning calculation algorithms		
b. Describes how the computer algorithm determines the number of monitor units per beam or segment (for step-and-shoot IMRT)		
5. Plan normalization		
a. Describes the numerous normalization capabilities available on a treatment planning system		
b. Describes how different normalization schemes affect final isodose curve representation		
c. Describes how the computer plan normalization relates to the calculation of monitor units for patient treatments		
6. Inhomogeneity (heterogeneity) corrections		
a. Describes the type of data that need to be taken on a CT scanner in preparation for treatment planning using inhomogeneous material		
b. Describes how these CT data are converted into inhomogeneity data usable in a treatment planning system		
c. Describes how computerized treatment planning systems take inhomogeneities into account		
d. Identifies where the computer algorithm calculates dose with acceptable accuracy and in which regions calculational accuracy is suspect		
e. Describes how the accuracy of the inhomogeneity corrections performed by a treatment planning system would be checked		
7. Beam modeling		
a. Completely models at least one photon beam energy for a treatment planning system		
b. Completely models at least one electron beam energy for a treatment planning system		
c. Completely models at least one proton beam energy for a treatment planning system (optional)		
d. Tests the accuracy of his or her modeling for the beams and is able to describe the criteria for acceptability of the modeling		
8. Imaging tests		
a. Describes the tests that would be performed to ensure that the imported		

image data are correct		
b. Demonstrates that images can be imported from CT, MR, and PET or PET/CT scanners		
c. Demonstrates that the above imaging sets can be accurately fused with the primary treatment planning image set		
d. Describes the different image fusion algorithms available on a treatment-planning system (e.g., CT-CT, CT-MR, CT-PET)		
9. Secondary monitor unit check computer programs		
a. Describes what input data need to be acquired		
b. Describes the checks of that input data that need to be performed to ensure that the monitor unit check program is working correctly		
c. Describes how imported data from treatment-planning systems are handled in a monitor unit check program		
d. Describes how the monitor unit check program calculates the number of monitor units for off central-axis normalization points		
e. Describes how the monitor unit check program calculates monitor units for treatments involving inhomogeneous material		
Protection		
a. Understands the federal (e.g., Nuclear Regulatory Commission [NRC], Canadian Nuclear Safety Commission [CNSC]) and state licensing requirements for by-product materials and x-ray-producing devices		
b. Explains the principles behind a radiation protection program, including the rationale for the dose limits for radiation workers and members of the public		
c. Understands federal, state/provincial, local, and institutional regulatory requirements		
d. Explains the concept of ALARA		
e. Understands site planning and how to supervise construction (i.e., key elements to monitor)		
f. Understands structural shielding designs relevant to a radiotherapy department (e.g., NCRP 151) and discusses the key parameters necessary to perform a shielding calculation		

g. Performs shielding calculations for an accelerator vault, including primary and secondary barrier transmission calculations		
h. Discusses the shielding requirements for the maze and door of a high-energy room		
i. Performs a radiation survey of a facility that includes low-energy and high- energy (greater than 10 MV) units		
j. Explains the advantages and disadvantages of various materials that may be used for shielding		
k. Explains how special procedures such as TBI and SBRT may impact shielding parameters		