



University Hospitals – Case Western Reserve University

Residency Program in Medical Physics

(2-year Full-time Clinical Training Program)

University Hospitals Cleveland Medical Center Cleveland, Ohio

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Introduction

Program Evolution and History

In its inception, Radiation Oncology at University Hospitals Case Medical Center was first a Division of the Department of Radiology. This held true for decades until Radiation Oncology became an autonomous department in 1999. The Medical Residency program in Radiation Oncology was first accredited on October 1, 1977 and had one graduate per year (on average). It is currently operating under a 5-year accreditation by the American Council of Graduate Medical Education. On March 31, 2005, the Department of Radiation Oncology initiated its most recent educational/ training program: the Clinical Medical Physics Residency Program in Radiation Oncology.

Since 1998 the University Hospitals Cleveland Medical Center is a part of by the NCI-designated Comprehensive Cancer Center and nationally ranked 18th best Cancer Center in 2012 by US News & World Report. It is a natural evolution that in the Department of Radiation Oncology we have a high quality training program for medical physicists. The Department of Radiation Oncology has 20 full-time medical physicists on staff and 20 full-time Radiation Oncology clinical faculty. The department currently has 8 physician residents in the Radiation Oncology Residency Program and 4 medical physics (therapeutic) residents.

Our approach to the training of Medical Physicist has been similar to the evolution that has been going on nationally. To fill our demands of clinical practice of medical physics support for IMRT QA, image fusion, dose composite, and routine quality assurance of linear accelerators and special projects (Proton Therapy and Brachytherapy), entry-level positions were available in the department to work and be trained by senior Board-certified medical physicists. This served as an excellent mechanism to bring on talented post-doctoral candidates for the special projects and masters or doctoral level candidates for the on-going supervised QA work. During initial clinical training period (2002-2007), five individuals were trained as a Univ. of Wisconsin style "Rad Lab" based program while performing their clinical duties. No special time allotment from clinical duty was given to them to complete the course of study, but their medical physics training was provided on an individualized basis and opportunity was given to each to acquire the necessary prerequisite/ remedial course work. In the period from 2007 to 2012, we have taken another five residents from CAMPEP approved graduate program for residency training. These ten individuals were trained as part-time basis and their residencies lasted for three or more years for them to complete their training and prerequisites.

Our medical physics residency (MPR) program was accredited by the CAMPEP in 2013 and the full-time residency training program started with a duration of 2 years. For this CAMPEP accredited full-time residency program we primarily accept candidates graduating from CAMPEP approved graduate programs. Currently, we have four full-time residents whose main goal is to participate in the clinical training program.

1. Program Goals and Objectives

The goal of the Clinical Medical Physics Residency Program at the University Hospitals Case Western Reserve University (UH-CWRU) is to prepare individuals to practice independently as a certified medical physicist in Radiation Oncology. Clearly, few individuals can be experts in all areas of Medical Physics, but the graduate should have the experience and knowledge base necessary to implement and maintain routine clinical procedures, and establish novel techniques.

Major objectives of the program include:

- Prepare the graduate for certification in the specialty of Medical Physics (Therapeutic, i.e. Radiation Oncology) by an appropriate certification Board.
- Provide a broad based in-depth training that will permit the graduate to immediately contribute to the quality
 of medical care received by the radiation oncology patient.

The training program is designed to provide the resident with an understanding of the role of patient safety in the clinical practice of medical physics; the technical knowledge, skills and competency required for the safe application of the technologies used in the practice of medical physics; an appreciation of the clinical purpose and applications of sophisticated technologies; an understanding of the protocols and practices essential to the employment of technologies to detect, diagnose and treat various cancer related illnesses; the ability to use analytical and research methods to solve problems arising in the clinical environment; the ability to deploy new strategies within the clinical environment; the ability to critically evaluate research and scholarly articles in medical physics; the communication and interpersonal skills that are necessary to function in a collaborative, multidisciplinary environment; the professional attributes and the ethical conduct and actions that are required of medical physicists; and a valuing of career-long continuing education to keep professional knowledge and skills current.

Training will take place under the close supervision of experienced radiation oncology physicists. The program emphasizes all areas of training and experience that will be needed by a radiation oncology medical physicist in a "state-of-the-art" treatment facility, as well as exposes them to management of a single accelerator community-based free-standing facility.

2. Program Structure and Governance

Structure within Hospital or Medical Center

The expected process for an internal review of the program would be the same as for all programs at the University Hospitals Cleveland Medical Center (UHCMC). An Organizational Chart of the Radiation Oncology within UHCMC has been provided in Table 1. Two main divisions of the Department of Radiation Oncology are: (i) Radiation Oncology, and (ii) Medical Physics. Both the divisions are mainly administered by the hospital. Most of the faculty members of both the divisions have joint appointments or affiliations with both the institutes (UHCMC and Case Western Reserve University (CWRU)).

Program Structure in Radiation Oncology Department

The Department of Radiation Oncology is an autonomous department within University Hospitals Cleveland Medical Center. All the medical physics faculty have appointments at Case Western Reserve University School of Medicine or University Hospital Cleveland Medical Center and medical physics residents are employees of the University Hospitals Cleveland Medical Center. There are currently 20 full-time medical physicists. Faculty members are board certified by the ABR in Therapeutic Radiology. The medical/physician residency program in Radiation Oncology currently has 8 residents. There are 20 full-time physicians Radiation Oncology faculty. The department also includes the Radiation Biology Program including wide ranging areas of research including Hypoxic Cancer Biology, Radiation Biology, and Radiation Oncology. Apart from the radiation biology course, the medical physics residents have convenient access to the radiation biology labs. Extramural funded physics research efforts include several sponsored projects from federal agencies (NIH/NCI, DoD, DoE, etc.) as well as from various foundations, industries, and pharmaceuticals.

The Medical Physics Residency Program (MPRP) is governed by the *Steering Committee*. The MPRP Steering Committee consists of Drs. Price, Geis, Kashani, Colussi, Pereira, Mr. Lyons and Woods, Department Chair, Chief of Medical Physics, Chief Medical Physics Resident and a Dosimetrist. This committee meets at least twice per year. The program Director is appointed by the Department Chair and the Division Chief/Director and is confirmed by the Steering Committee. If deemed necessary, the director of the program may select an Associate director in consultation with the Steering Committee. The program is governed by the director of the program with the help from Associate director, as applicable. The role of the Associate Director is to help the Director in managing and smooth running of the residency program, especially in the absence or non-availability of the program director. He/she she helps in coordinating the bi-weekly meetings, journal clubs, residents presentations, etc. Mr. Lyons has been acting as the Associate Director. The Director reports relevant matters to the Division Director/Chief and the Chair of the department. The program director meets the residents twice per month. The chief resident or representative of the residents is a member of the steering committee and he/she can conveniently communicate with all members of the committee. Additionally, all the physics residents may also attend the steering committee meetings, if deemed necessary.

The departmental facilities are substantial, featuring a wide array of treatment modalities and an adequate number and variety of equipment (details can be found in Section 7). Eight faculty members of the Medical Physics Division are located in the Radiation Oncology department on main campus. Ten additional physicists are full time at 8 off-site facilities (Satellite Centers) which are located in the range of 9 - 78 miles from the main campus in Cleveland (more information are in Table 2). All the full-time physicists at main campus are part of the team who teach the physics residents and MD residents. A majority of the teaching team are faculty of the Case Western Reserve University. All physicists are well qualified to assist in the physics residency training program either through didactic lectures or mentoring for clinical rotations/competencies as described in Section C. The residents are trained at the main campus facility at Seidman Cancer Center, Cleveland, Ohio. Residents may also be engaged in assisting Linac commissioning, annual QA and patient-specific IMRT QA at Satellite Centers, if found useful and necessary (e.g. for Linac commissioning, Linac Annual QA)

We have 4 Medical Physics Residency positions. Incoming residents are provided with written copies of department policy regarding expected performance and training schedule (Section 8 and Appendix C) as well as expected behavior in the clinical and department. Residents are required to complete at least 11 core/mandatory rotation modules during 2 years of clinical training (details are in Section 8). Upon successful completion of the training, a

certificate of completion of residency training is issued with the medical physics Director, division Chief/Director and department Chair as signatories.

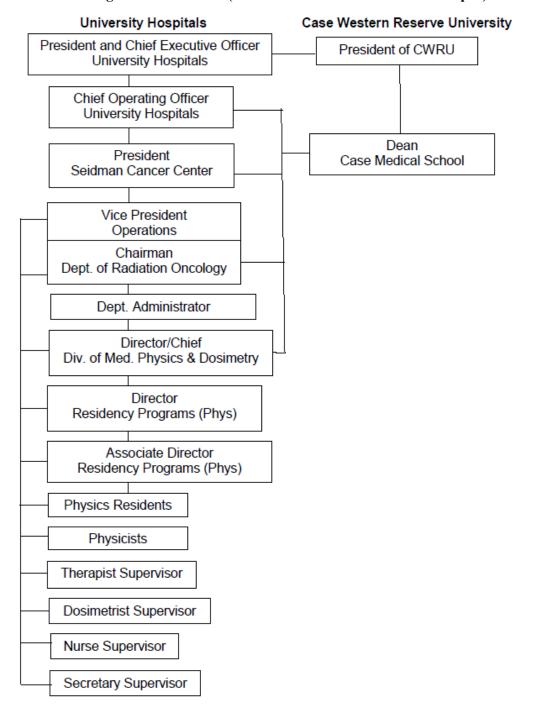


Table 1: Organizational Chart (UHCMC/CWRU/UHSCC main campus)

Table 2: A brief statistics of the department.

Clinical Centers	Distance from Main Campus	No. of Physicians	No. of Physicists	Major Tx Equipment	No. of pt. treatment per day (average)
UH Main Campus (CMC & SCC)	0 miles	11	11	Linac (3), Ethos (1) GammaKnife (1), HDR (1), Proton (1), Research Machine	95
UH-SCC at Chagrin	9 miles	1	1	Linac (1)	20
UH-SCC at Parma	16 miles	1	1	Linac (1)	18
Southwest Gen. Hospital	19 miles	1	1	Linac (1)	20
UH-SCC at Mentor	25 miles	2	2	Linac (2), HDR (1)	35
UH Avon Medical Center	32 miles	2	1	Linac (1)	40
UH Portage Medical Center	37 miles	1	1	Linac (1)	15
Firelands Med. Center	65 miles	1	1	Linac (1)	12
Salem Reg. Med. Center	78 miles	1	1	Linac (1)	10
8 MD residents and 4 Physics residents	TOTAL =	21	22	Linac (12), Ethos (1), GammaKnife (1), HDR (2), Proton (1)	265 (approx.)

<u>Note:</u> No resident is required to go to Southwest Gen., Firelands, or Salem Regional Medical Center due to affiliation status. Residents are mainly trained at UHCMC (main campus).

Evaluation of Resident's Progress

After each rotation, the resident may be required to submit a written report or clinical module rotation evaluation form (see Appendix C). The written report (if any) of the completed module *should not be more than ten pages long* containing six sections as Introduction, Materials & Methods, Results & Discussion, Conclusion, and References. *A presentation (~30min) and an oral examination (~60min) are administered by the mentor and mentoring team at the end of each rotation* (evaluation form is in Appendix J). This is evaluated and graded by the mentor and/or program director(s) along with an evaluation of the resident's ability to articulate their knowledge developed during the rotation and ability to respond to oral examination. The mentor discusses the conclusions with the resident, and provides the resident and the program director a copy of the mentor's evaluation for the rotation. The evaluation form includes written report grade, oral exam grade, comments, recommendations, overall recommended grade of pass, fail or conditional pass and remediation if conditional pass. The pass/ fail in the written report and/or the oral examination is at the discretion of the mentor and/or program director(s). Any disagreement are discussed and resolved rationally. The program director(s) review the performance evaluations with the resident during the resident's quarterly review. Any critical issues such as fail or conditionally pass are immediately discussed with the program director.

Residents meet with the program director and associate director bi-weekly to discuss their progress. These meetings are useful for providing guidance and praise/criticism. With the resident, the program director reviews the rotations since the last progress meeting, conference participation, recommended readings, remediation, if necessary, and outstanding assignments. Minutes are taken at these meetings. We recognize the amount of time spent by the resident in writing their reports and preparing for their oral exam is substantial. We view this process as an important tool in the resident's successful learning progress, and must be balanced with the clinical responsibilities managed by the resident. Residents discuss the evaluation of their mentors during their quarterly review with the program

director. This information is received and consolidated by the program director, and discussed by the director with each mentor annually or as needed. Examples of evaluation forms are included in Appendix J.

It is to be noted that a resident can continue the clinical rotation even if he/she fails in maximum one rotation. He/she will be given two additional opportunities to clear the failed or conditionally passed rotation. The failed rotation must be cleared before starting a new rotation. However, the resident can start a new rotation if he/she is conditionally passing a rotation. The resident cannot have more than two conditionally pass rotations at any point of time. To make up the lost time, the resident's schedule has 6.4 weeks allocated for Catch-Up time in Appendix C. The program director and associate director will discuss with the resident and try to understand the resident's cause of failure in the rotation. The resident will be given opportunity to spend more time in the clinic with the mentor and other physicists as well as will be provided with supplemental reading materials and necessary guidelines to succeed.

Guidelines for Resident Dismissal

Residents and fellows may be discharged by the Program Director for failing a clinical rotation, failing a required course, unprofessional or unethical conduct, illegal actions, or gross unsatisfactory performance. A decision not to renew a contract made within 4 months of expiration or a decision to cancel a renewed contract before the beginning of the contract period shall be considered a discharge. After explaining the grounds for discharge to the resident, the Program Director shall give written notice of the discharge to resident, including a statement of the grounds for the action.

Individual disciplinary actions (except suspension or discharge) and other departmental actions affecting the individual resident may be reviewed by a committee if an affected resident requests such a review within ten days of his or her becoming aware of the action. The committee will be selected by the Program Director and composed of at least two active clinical staff members and one resident. The only exception in to this review is when the resident has already been afforded an opportunity to present information to such a committee which advised the Program Director before the action and the resident has been informed of the Program Director's action in writing. After its review, the committee will submit its recommendations to the Program Director. If the committee recommends a change in the action, the Program Director will then reconsider the action, giving due consideration to the review committee's recommendation. The resulting decision of the Program Director shall be provided to the resident and the Chair of the Department of Radiation Oncology in writing and shall be final, unless the resident believes that the action could significantly threaten his or her intended career development. Actions will not be postponed while they are being reviewed, unless the Program Director in his or her discretion decides to do so.

If the resident submits a written request to the Chair of the Department of Radiation Oncology within 10 days of receipt of the Program Director's written decision (described in the previous paragraph) and the request includes the reasons for the belief that the action could significantly threaten the house staff member's intended career development, the Chair will review the decision, if he or she finds the alleged threat to be significant. The Chair may seek the advice of an ad hoc committee as part of the review. If the action is non-renewal of a contract prior to completion of the training program, the decision of the Chair shall be given to the resident and Program Director in writing and is final. For all other actions, if the Chair recommends that the Program Director modify the decision, the Program Director will then reconsider the action, in consultation with the Chair. The resulting decision of the Program Director shall be provided to the resident and the Chair in writing.

3. Admissions

Educational Requirements:

A Masters or Doctoral degree from a CAMPEP accredited (or equivalent) program is required for 2- year full-time residency program.

Application Requirements

Applicants will submit the following items (or as outlined by the AAPM MP-RAP) for initial evaluation:

- 1. Official college and graduate transcripts
- 2. A personal essay describing career goals and interest in medical physics
- 3. Three letters of recommendation from the applicant's college/graduate instructors, and/or employers.
- 4. A curriculum vitae, if the applicant has relevant work experience.

After the deadline, all complete applications are divided equally among the faculty physicists to review. The program director (with the help of faculty members) reviews and ranks all applicants. They rate each applicant as one of the following and include rationale:

- Do invite to interview
- Don't invite to interview
- Undecided

Upon receiving the review comments and suggestions from the faculty/staff physicists the program director makes a final list of candidates who will be interviewed. Approximately 10-15 candidates are invited to interview for each medical physics resident opening. They are invited via email, with the invitation letter and agenda as an attachment. Ranked candidates are listed with the MP-RAP or NMS.

If an applicant is not chosen to invite for an interview, he/she is informed by an email about our decision. Up to 30 candidates may be brought over a 2-3 weeks period for on-site interview or may be interviewed virtually. They rotate through interviews with the Selection/Interview Committee as follows:

- Radiation Oncology Chair or Vice Chair or Radiation Oncology Medical Residency Program Director(s)
- At least 3 faculty physicists
- Physics Residency program Director
- Dosimetrist, Radiobiologist or lead Therapist
- Chief Physics Resident

Each Selection/Interview Committee member submits an evaluation form for each interviewee to the program coordinator. The coordinator enters all evaluations into a table that is distributed to the Selection/Interview Committee prior to the selection meeting. The evaluation scores are also entered into a spreadsheet so each candidate is ranked by average score across interviewers. In the selection meeting the strengths and weaknesses of each candidate are discussed and each member of the Selection/Interview Committee ranks the candidates. The composite ranking is provided to the program director for the selection of candidates.

B. Recruitment Efforts

We recruit via AAPM MP-RAP and national matching. The application due date is mentioned in the advertisement and emails. The admission process takes about 6-8 weeks.

C. Enrollment

Our program capacity is 4 full-time residents (2-year program). These positions are funded by the hospital.

4. Program Director

The Residency Program Director is appointed by the Division Chief/Director and the Department Chair. The current Director, Dr. Price, is ABR certified medical physicist (therapeutic) having more than 10 years of clinical

experience. He is an assistant professor in Radiation Oncology at Case Western Reserve University. He is actively involved in teaching, research and clinical activities at UHCMC. He directly reports to the physics division director. He coordinates and conducts residency interview process, convening meeting, keeping track of resident's rotation, documents, progress and resolving issues and concerns as required. The program director is responsible and accountable for ensuring that the residency program satisfies the CAMPEP standards. He is responsible for ensuring that all resident statistics, annual reports, and other information that is required by CAMPEP are reported accurately and in a timely fashion. The program director convenes a bi-weekly meeting with the residents and also reviews their progress and status quarterly. All these meeting minutes and review reports are officially documented and saved; a copy of these documents is provided to the residents. Moreover, the residents are allowed to meet or communicate the program director anytime, if necessary.

5. Program Staffs

Currently, there are 21 full-time and 2 part-time medical physicists (see the list in Appendix-G) in the UH system. These physics faculty and staff members are involved in teaching and mentoring the physics residents. The mentors of the residency rotation modules are selected based on their clinical experiences and currently involved clinical practices. Any mentor is expected to be an ABR or equivalent board certified clinical physicist with adequate knowledge and experience in the subject matter. Each rotation module should have one primary mentor and multiple secondary mentors. The secondary mentors will help the primary mentor, if required or in case of non-availability of the primary mentor. The selection of the mentors is discussed and approved in the Steering Committee meeting. The residency supporting staff is assigned by the department administration consulting with the division director/chief and the program director. Biographical sketches and clinical interests of the physics faculty and staff members are provided in Appendix G.

6. Institutional Support

The physics residents have access to all personnel, equipment and institutional resources, the same as any member of the physics staff. Each resident is provided with a workspace shared with physician residents in close proximity to physics faculty offices or clinic within the department. Every resident is provided with a dedicated/separate office space, a desktop computer with necessary software and access to hospital network as well as a telephone and a pager. All the residents have access to clinical machines/equipment, computers and two conference rooms in the department.

Current Typical Financial Support for Medical Physics Residents: Currently (in 2022), the annual salary varies between \$55,000 and \$65,000. Residents are covered by the Institution's Professional Liability Insurance for malpractices. Residents joining the CAMPEP Program at UHCMC will have a salary of \$60,000 (the minimum; may go up depending on education and experience) plus the UHCMC standard benefit package. Institutional support letters are provided in Appendix A.

Travel and Academic support: Residents are encouraged to present and publish clinical research studies in the form of abstracts and/or manuscripts. Residents having abstracts in the national scientific meetings such as AAPM or ASTRO annual meeting are provided with financial supports to attend the meetings.

Typical living expenses in University Circle, Cleveland, OH

Housing: \$1600/month average for 1 bedroom

Health Care: varies (UH provides employee healthcare benefits)

Orientation of New Resident: A new resident starts with a two week long formal rotation in the department and facilities to become familiar with the department and staff as well as to become comfortable in the work

environment. A senior medical physicist (normally the Director or Associate Director of the program) is in-charge of this orientation. Example of a new resident orientation schedule is provided below.

Date	Time	Торіс	Place/Zoom	Presenter
Day	8:00 AM – 12:00 PM	UH Orientation		UH
1	12:00 PM – 4:00 PM	Move into office / Department Tour	Resident Office	2nd Year Residents
	9:00AM- 10:00AM	Introduction to UH Rad Onc		Physics Residency Leadership
Day	11:00AM- 12:00PM	Basics of CT Simulation	CT Sim	CT Simulation Staff
2	1:00PM- 2:00PM	Introduction to Physics Residency		2nd Year Residents
	2:00PM- 4:00PM	QA Introduction		2nd Year Residents
	9:00AM- 10:00AM	Introduction to the RT Workflow		Physics Residency Leadership
Day	10:00AM- 12:00PM	Introduction to Clinical Software	Resident Office	2nd Year Residents
3	1:00PM- 2:00PM	Research and Clinical Project Overview		Physics Residency Leadership
	2:00PM- 4:00PM	Introduction to Treatment Planning	Residents Room	Chiefs and Dosimetry Staff
	8:30AM	Introduction to Radiation Therapy (RTT) Staff		Medical Resident Chiefs
Day	9:00AM- 12:00PM	Introduction to the Linacs, Patient Immobilization, Daily Set up, & Onboard Imaging Review	Edge, Ethos, and TrueBeam	RTT Leads
4	12:00PM- 1:30PM	Residents Lunch	TBD	Medical & Physics Residents
	1:30PM- 4:00PM	Make-Up or Meetings with Specific Faculty	-	TBD
	TBD	Radiation Safety Training	TBD	TBD
	7/4/25	Independence Day Holiday	Clinic Closed - l	Holiday
	8:00AM-			
	9:00AM	Chart Rounds	Zoom	RO Physicians
Day 5	9:00AM- 12:00PM	Res 1: Brachy; Res 2: Proton	Brachy Suite; Protons	Service Leads
	1:00PM- 4:00PM	Res 1: Simulation; Res 2: Physicist of the Day	SimCT; TBD	Sim Therapy; TBD
Day 6	8:00AM- 9:00AM	Chart Rounds	Zoom	RO Physicians

	9:00AM- 12:00PM	Res 1: Proton; Res 2: Simulation;	Protons; SimCT	Service Lead; Sim Therapy	
	1:00PM- 4:00PM	Res 1: Dosimetry; Res 2: Plan Check	Dosimetry Room; TBD	TBD	
	8:00AM- 9:00AM	Chart Rounds	Zoom	RO Physicians	
Day 7	9:00AM- 12:00PM	Res 1: Adaptive; Res 2: Brachy	Ethos; Brachy Suite	Service Leads	
	1:00PM- 4:00PM	Res 1: Plan Check; Res 2: Dosimetry	TBD; Dosimetry Room	TBD	
	8:00AM- 9:00AM	Chart Rounds	Zoom	RO Physicians	
Day 8	9:00AM- 12:00PM	Res1: Edge; Res 2: Adaptive	Edge; Ethos	Therapy; Service Lead	
	1:00PM- 4:00PM	Res 1: Physicist of the Day; Res 2: Edge	TBD; Edge	TBD; Therapy	
	8:30AM- 9:45AM	Physics Course	Zoom	Physics Instructor	
Day 9	10:00AM- 10:30AM	Introduction with Satellite Physicists	Zoom	Sat Physicists	
	11:00AM- 4:00PM	Make-Up or Meetings with Specific Faculty	-	TBD	

Hazard and Safety Issues

The following safety training and hazard issues are covered during the resident's orientation, which is conducted by the Program Director or Supervisor of Dosimetry or appropriate designated personnel:

- PPE Training
- Mandatory Reporting
- Bloodborne Pathogens
- Safety and Infection Control Test
- HIPAA Training
- Culture Diversity Training
- Patient and Staff Rights and Responsibilities
- Gowns
- Patient Safety
- CPR Certification
- Health Protection Office staff training and test (includes Radiation Safety)
- Hazard Communication Safety Training
- Hazmat Training and Test
- Fire and Tornado Plans and Procedures
- Code Blue Procedures
- Universal Precautions
- Sharps Disposal

• TLD Handling

All residents perform on-line radiation safety training and complete an exam administrated by the UH corporate office or the Radiation Safety Office during their initial two-week orientation, as outlined above. Additionally, the orientation in-charge discuss about the potential hazards that the residents may encounter during their clinical training. Moreover, the rotation titled "Radiation Protection and Safety" does include radiation safety training, with the intention of the mentor to assure the residents have successfully comprehended the components of safety instructions and training on each clinical system used (e.g., brachytherapy, linac, and other high-voltage device safety) in each of the rotations throughout their training.

Professional, ethical and regulatory issues:

The residents are required to follow the American Board of Radiology Foundation (ABRF) online modules on ethics and professionalism issues. The modules are accessed through the AAPM website at http://www.aapm.org/education/onlinemodules.asp, which covers the following topics.

- a) Historical Evolution and Principles of Medical Professionalism
- b) Physician/Patient/Colleague Relationships
- c) Personal Behavior, Peer Review, and Contract Negotiations with Employers
- d) Conflict of Interest
- e) Ethics of Research
- f) Human Subjects Research
- g) Vertebrate Animal Research
- h) Relationships with Vendors
- i) Publication Ethics
- j) Ethics in Graduate and Resident Education
- k) Professionalism in Everyday Practice; The Physician Charter

Residents are also required to read TG 109: Ethics for AAPM. A mandatory rotation on professionalism and ethics provides the residents with the opportunity to learn about legal, professional, and ethical commitments as a medical physicist. In this rotation module, the NRC and the state regulations governing the practice of radiation therapy are reviewed. The resident will also learn about the ethical and professional aspects of medical physics such as patient and colleague relationships, ethical encounters or dilemmas, employer/employee relationships, conflicts of interest, human/ animal research principles, scientific misconduct and publication ethics as well as the role of leadership in the profession. For more details see Appendix C (rotation #10 entitled Professionalism and Ethics).

7. Educational Environment

Radiation Oncology (overall)

The Radiation Oncology Department at UH Cleveland Medical Center (UHCMC) expanded into the new state of the art Seidman Cancer Center (SCC), which is located at an adjacent building, in the May of 2011. The SCC houses 3 state-of-the-art Varian linear accelerators (1 Varian Edge, 1 Varian TrueBeam, and 1 Ethos) and 1 Elekta Versa with on-board cone beam kVCT, respiratory gating capabilities (Identify, ABC, and RPM) for VMAT and SBRT along with 6DoF couches. A Siemens Go.OpenPro 4D-CT and a Phillips Bigbore 4D-CT are installed and clinically used in the new Radiation Oncology department. The clinic has access to several Siemens MR scanners at the Department of Radiology (in both UHCMC and SCC) ranging from 1.5T to 3T as well as a Phillips PET/CT scanner. A dedicated special procedures room houses the brachytherapy procedures. A variety of treatment options are available through the Department of Radiation Oncology at Seidman Cancer Center, including: Three-Dimensional Conformal Radiation Therapy (3DCRT), Intensity Modulated Radiation Therapy (IMRT), Volumetric Modulated Arc Therapy (VMAT), stereotactic body radiotherapy (SBRT), stereotactic radiosurgery (SRS), Image Guided Radiation Therapy (IGRT), Brachytherapy (HDR), and Adaptive Radiotherapy. The MOSAIQ record and verification system is integrated with the clinical equipment and planning system to make the department truly

paperless and filmless.

A radiosurgery suite is located in an adjacent separate building on campus where a Gamma Knife, and a single room Proton Therapy facility. Intracranial radiosurgery is performed with the Gamma Knife the Perfexion. A single room proton therapy (Mevion), first in Ohio, is treating patients since July 2016.

The physics residents have access to all personnel, equipment and institutional resources, the same as any member of the physics staff. The physics and physician residents have dedicated office, telephone, pager and computer facilities. Each resident is provided with a workspace in close proximity to physics faculty offices within the department. The residents having computer with intranet and internet access to electronic journals through the UH Systems. The Department has a library with numerous journals and a number of medical physics text that was acquired by MPRP. Residents are also encouraged to travel with a faculty physicist to any of the 6 satellites within 37 miles radius (note that two of the satellites are at about 70 miles away and residents are not required to go there). These tools provide the resident learning opportunities in conventional radiation therapy and beyond. Specifically, with regards to the satellite location, they participate in weekly review of patient treatment records, equipment performance records, daily QA records, and perform monthly QA and annual QA on treatment delivery and simulation systems. Some of the physics staffs from satellite facilities are also involved in teaching physics resident through special lectures, guiding/supervising when the residents are in their facilities for performing assigned tasks. The physics residents are encouraged to participate in research and clinical studies with physics faculties, radiation oncologists and medical residents. Major facilities and patient treatment statistics are summarized in Tables 3a and 3b.

All the radiation therapy facilities under University Hospitals have adequate dosimetry equipment. Some of the major dosimetry equipment at main campus are listed below (numbers of equipment are in the parenthesis).

- Blue (water) Tank/Phantom (2)
- Sun Nuclear 3D water Tank (1)
- Electrometer (23)
- Densitometer (2)
- Film Dosimeter Cassette Holder (2)
- MAPCHECK (2)
- ArcCheck (6)
- PROFILER (5)
- Portal Dosimetry
- Ionization (well-type) Chamber (4)
- Ion Chamber (38)
- Survey Meter (12)
- Thermometer (5)
- Barometer (3)
- In-vivo dosimetry systems (2)
- Sr-90 source for ionization chamber calibration (1)

Patient Care Treatment Options

A variety of treatment options and equipment are available through the Department of Radiation Oncology at main campus of University Hospitals, which has two centers: (i) Seidman Cancer Center (SCC, newer one), and (ii) Bolwell Center (old one).

At Seidman Cancer Center (SCC):

- Three-Dimensional Conformal Radiation Therapy (3DCRT)
- Intensity Modulated Radiation Therapy (IMRT)

- Volumetric Modulated Arc Therapy (VMAT)
- Stereotactic body radiation therapy (SBRT)
- Stereotactic Radiosurgery (SRS)
- Online Adaptive Radiotherapy (ART)
- 4D-CT simulator, and 4D-CBCT
- 3-D and deformable image fusion and dose composite (MIM)
- Total Body Irradiation (TBI)
- Total Skin Electron Irradiation (TSEI)
- Radiolabeled Monoclonal Antibody Therapy
- Brachytherapy (HDR)
- MOSAIQ record and verification system
- Raystation Treatment Planning System
- Respiratory gating system
- Surface Monitoring with Identify
- Active Breathing Control (ABC)
- Image-Guided Radiation Therapy (IGRT)

At Bolwell Center (old section of UHCMC):

Proton Radiation Therapy

Table 3a: Departmental statistics (also see Table 2 for additional information).

Major equipment (main and satellites)	LINAC (12), ART (1), HDR (2), CT/CT-Sim (6), 4D-CT (4), CBCT (12), Proton Therapy (1)	
Patients treated per day	about 100 at Main Campus with combined average of 270 at the 10 campuses	
Treatment types	3DCRT, IMRT, VMAT, IORT, TSEI, TBI, HDR, SRS, SBRT, ART	
	Brachytherapy (HDR)	
Staffing	Physicians: 10 in main campus, 10 at satellites	
	Physicists: 20 full-time and 1 part-time (10 full-time at main campus)	
	Dosimetrists: 17	
	Therapists: 40	
	Nurses: 10	
	Billing & Scheduling Clerks: 15	
Research and Clinical Trials	Funding: NIH/NCI, DoD, Industries/Pharmaceuticals	
	Co-operative groups: RTOG/NRG, ACOSOG, COG, GOG, ZCOG, NSABP, NCCTG, ACRIN	
	Patient Accruals per year: NRG (40), other (55)	

Table 3b: Brachytherapy, Special Procedures, SRS and SBRT performed at Main Center per year (approx.)

HDR (cases)	ART (cases)	TBI/TSEI (cases)	SRS (pt. Gamma Knife, (cases)	SBRT (cases)
375	500 (fx)	35	205	1500 (fx)

Residents are required to complete all the 10 mandatory rotations. The elective rotations are allowed, if the mandatory rotations are successfully completed. An oral presentation or exam is required to complete a rotation.

Conference, seminar, and journal club activities:

We document the residents' attendance in conference, seminar, chart rounds, grand rounds, etc. in excel spreadsheet. Please see the attached sample documents. The residents also present their rotation modules using PPT slides in front of physics and department staffs. Additionally, we are also having one journal club per month (on 4th Tuesday of the month) for the physics residents.

Clinical, educational and scholarly activities record:

We record and update all the clinical, educational and scholarly activities and progress of the residents in biweekly meeting using MS-word and excel sheet. Please see the attached sample documents.

Records Available for Review

The following records are kept for access and review as needed.

- 1. Residency program committee minutes including:
 - Steering Committee minutes
- 2. Resident applications:
 - Application forms
 - Transcripts
 - Candidate interview evaluations

3. Residents:

- Training schedules
- Rotation objectives and expectations
- Rotation evaluations
- Examination (oral/ presentation) results
- Bi-weekly meeting minutes
- Log of recommended readings, clinical, education and scholarly activities
- Quarterly progress reports

Research and Development

The UH Cleveland Medical Center (UHCMC), (note that Seidman Cancer Center is a part of UHCMC) Clinical

Trials Unit (CTU) provides a centralized infrastructure to support cancer related research. The CTU's mission is to provide the highest quality nursing, data management, regulatory, financial and quality assurance services for the conduct of clinical trials for the benefit of our patients and investigators. Many of our UHSCC clinical trials are offered at regional sites and affiliates. Faculty members of the Radiation Oncology Department participate in clinical trials of various cooperative groups such as NRG, ACOSOG, COG, GOG, ZCOG, NSABP, NCCTG, and ACRIN. There are several funded projects (funded by federal, agencies state, industries) in the department in which some of the physics faculties and physics residents along with the faculties from Radiation Oncology and Radiology are involved as principal investigators (PIs), Co-PIs, and Co-Investigators (Co-Is). The Medical Physics division is actively involved in translational research. There are collaboration opportunities for the residents with basic scientists in Radiation Biology as well as scientists in Bioengineering, Electrical and Computer Engineering, and Radiology. Participation in these research and development activities provides the residents a very good opportunity to extend their knowledge and clinical experience in the field. Moreover, these activities enable the residents to attend scientific conferences and meetings as well as publish in peer-reviewed journals.

8. Residency Curriculum

A. Requirements for Successful Program Completion

The Clinical Medical Physics Residency Program is 2 years in length to include a minimum of 10 rotations, attendance at case conferences, recommended readings, a maximum of 2 didactic courses (if required), written report assignments, and oral examinations. In addition to the experiences from didactic training and clinical rotations, the Medical Physics Residents receive clinical training through their participation in monthly and annual quality assurance on the linear accelerators, perform patient-specific IMRT/VMAT quality assurance measurements with a gantry-mounted diode array and/or with film and ionization chambers as well as perform electron cutout measurements. The residents will become familiar with all aspects of treatment planning (from manual calculation to computer-assisted planning) for both electron and photon clinical cases. As the residents progresses through the clinical rotations, they begin to participate in post-planning and weekly chart review, HDR brachytherapy quality assurance, and assist the "physicist of the day" providing first response physics support to all activities within the clinic. Attendance in required courses (if any) and required number conferences (75% attendance) are mandatory. The residents are expected to participate in research studies and submit to scientific conferences/meetings such as AAPM and ASTRO as well as in journals. The residents must follow the department policy and behave as per clinical, departmental and institutional norms. The progression of the resident through these clinical responsibilities is evaluated and discussed with the resident during regular bi-weekly meetings with the program directors. The purpose of these meetings is to discuss with the residents regarding their progression through the program; i.e., successful completion of each rotation, participation in conferences and courses, their evolution in QA participation, and general performance within the department. These meetings also provide the residents an opportunity to voice any concerns they may have about the learning environment. Minutes of the meetings are taken and stored on the S-drive of a server computer which is accessible to department staffs and residents.

B. Design and Content

Medical physics residents are trained by rotating through a minimum 11 (core) out of 12 possible comprehensive clinical and didactic rotations (details are below in this section and also in Appendix C). Each rotation has an evaluation for the resident's performance at the end of the rotation (Appendix J1). Written acceptance of the Clinic Module and/or graded oral exam are administered and reviewed following each clinical rotation. All core rotations (total 11) must be completed for the resident to be eligible for completion of the program requirements. However, the resident is encouraged to complete all 12 rotations.

The evaluation is specified either as a written "Clinical Competency" and/or graded "Oral presentation and exam" review of the rotation subspecialty. The highlights of the knowledge base acquired and the learning opportunities they experience in each rotation are summarized below in the order experienced by the resident.

- 1. Dosimetric Systems rotation (core): During this rotation, the medical physics resident develops a basic understanding of the design, characteristics, and clinical limitations of several radiation measurement systems: ionization chambers, radiographic and radiochromic film, diodes, thermoluminescent dosimeters, diode arrays and ion chamber arrays. All radiation measurement systems to be used by the resident throughout the program are to be operated by the resident during this rotation under the supervision of a qualified Medical Physicist. During this process, the resident develops an understanding of the specifications and capabilities of these systems. The resident also develops an understanding of the design and utility of multiple phantom systems, with the most complex system (3D water tank) being operated by the resident during linear accelerator (LINAC) annual QA and calibrations. The resident compiles the signed clinical module and associated documentation regarding the learning opportunities that were experienced during the rotation. The rotation concludes with an oral exam or a presentation organized by the mentor, who is a qualified staff physicist. For more details see Appendix C.
- **2.** Treatment Planning rotation (core): This rotation has two parts (A) Treatment Planning I and (B) Treatment Planning II.
- 2A. Treatment Planning I (3DCRT): This part of the rotation is the resident's introduction into treatment planning, which includes observing the Medical Dosimetrists during the treatment planning process of multiple anatomical sites (Brain, Head and Neck, Lung & Esophagus, Breast, Abdomen & Rectum, Pelvis & Bladder, Skin, Sarcoma, whole CNS, and Prostate) and develops treatment plan for each site observed. Additionally, the resident will develop an understanding of the different 3D photon beam dose algorithms, electron beam dose algorithms, non-dosimetric calculations performed by the planning system (e.g., DRRs, contouring tools, etc.), and dose evaluation tools. The resident performs treatment plans cases for wide range of anatomical sites, transfers all data to required information systems, and performs all required quality assurance for those plans. The resident compiles a clinical module detailing the learning opportunities that were experienced during the rotation. The rotation concludes with an oral exam or a presentation organized by the mentor. For more details see Appendix C.
- 2B. Treatment Planning II (IMRT/VMAT): This part of the rotation is focused on Intensity Modulated Radiation Therapy (IMRT) and Volumetric Modulated Arc Therapy (VMAT). The medical physics resident will be introduced to optimization, critical organ doses, parallel vs. serial organs, typical dose-volume constraints, and dose calculation algorithms specific to IMRT/ VMAT, film as a dose measuring device, small field dosimetry, and the basics of imaging for IMRT/ VMAT. During the rotation, residents will follow a patient from the CT scan process all the way through the initial treatment delivery. This will require shadowing the CT therapists, the dosimetrist, the medical physicist, and the linac therapists. With the first patient, it will be observation. With the second patient, it will be supervised performance of the tasks. With a phantom, it will be an independent performance of the tasks. There are a fair number of IMRT/ VMAT patients (H&N, Lung, GI and GU) in our department, and there will be no lack of opportunities. The resident will work through the Competency Module detailing the learning opportunities that were experienced during each part of the process. The resident compiles a clinical module detailing the learning opportunities that were experienced during the rotation. The rotation concludes with an oral exam or a presentation organized by the mentor. For more details see Appendix C.
- 3. Linear Accelerator (Linac) and TPS Modeling rotation (core): This rotation is consisted of two parts (A) Linac Acceptance, Commissioning and Annual QA, and (B) TPS Modeling, Acceptance and Commissioning.

 3A. Linac Acceptance, Commissioning and Annual QA: During this part of the rotation, the medical physics resident performs the tasks necessary to accept and commission a Linac, including the annual QA of the system. The resident will develop an understanding of linear accelerator fundamentals relevant to commissioning, beam optics, flattening, and control parameters, collimation, beam specs and non-beam specs, and more. Residents will also determine the data necessary to commission 1 photon and 1 electron beam in the Raystation treatment planning system, collect that data, and format it for commissioning, as well as determine the data necessary to perform MU calculations for 1 photon and 1 electron beam. Finally, an Annual Quality Assurance procedure (including TG-51 calibration) will be performed for one of the systems during this rotation. The resident compiles the signed clinical module and associated documentation regarding the learning opportunities that were experienced during the rotation. The rotation concludes with an oral exam given by the mentor. For more details see Appendix C.
- 3B. TPS Modeling, Acceptance and Commissioning: The TPS modeling part of the rotation provides the medical physics resident the opportunity to accept and commission a three-dimensional treatment planning system. During

the rotation resident will determine all input data needed to characterize the CT scanner, linear accelerator, photon beam energy, and electron beam energy. The resident will utilize data acquired during the previous rotations to commission the system for photon and electron beam energy and compare the results with measurements. The resident is expected to learn each component of the beam modeling within the planning system, as well as treatment planning dose engines for both photons and electrons. The resident will learn to evaluate their results in the context of published literature including task group reports. The resident compiles clinical module detailing the learning opportunities that were experienced during the rotation. The rotation concludes with an oral exam or a presentation organized by the mentor. For more details see Appendix C.

- 4. Image Guidance for Radiation Therapy (IGRT) (core): During this rotation, the medical physics resident will gain an understanding of the Radiotherapy Simulation process, ranging from CT-based virtual simulation to 4DCT and the utility of multimodality imaging. Also, the resident will follow a patient through the CT (PET/CT) simulation process, with an emphasis being on geometric aspects of the process (setup geometry specification, immobilization, marking, tattoos, CT including x-ray technique, and transfer to planning system). Finally, the resident will observe the use of combined imaging modalities in the simulation process (such as MRI and CT for SRS) and follow a patient through the image-guided setup simulation process. The resident will develop knowledge in basic medical imaging physics and the terms that impact image quality, the design and application of different electronic portal imaging systems, and the necessary processes for commissioning and continuing quality assurance of portal imaging systems. During the rotation, the resident will perform monthly and annual quality assurance on 4DCT and different portal imaging systems. The resident compiles a written report detailing the learning opportunities that were experienced during the rotation. The rotation concludes with an oral exam given by the mentor. The treatment verification part of the rotation is structured to provide the medical physics resident with knowledge of portal imaging systems used either during the simulation/planning process or during treatment verification. In the IGRT part of the rotation, the resident will participate in the clinical implementation of prospective and retrospective CT image acquisition, gated treatment delivery, treatment planning process for IGRT (including multi-modality image registration and fusion), and data export/import into each system. The resident will observe and participate in the IGRT treatment planning and delivery process and understand the functionality of the systems utilized. Quality assurance of every aspect of each IGRT system will be studied, from image acquisition through verification and treatment delivery. The resident compiles the signed clinical module and associated documentation regarding the learning opportunities that were experienced during the rotation. The rotation concludes with an oral exam or a presentation organized by the mentor. For more details see Appendix C.
- 5. Stereotactic Radiosurgery (SRS) and Stereotactic Body Radiation Therapy (SBRT) rotation (Core): The SRS-SBRT rotation is designed to give the medical physics resident experience with a intracranial and extracranial hypofractionated radiation therapy with Gamma Knife and/or Linac. The resident first reviews the key principles of SRS and SBRT, then actively participates in both the treatment process and the quality assurance process. The treatment process for a patient involves image acquisition, treatment planning, and treatment delivery. The resident will participate alongside a staff physicist in clinical SRS and SBRT treatments during this rotation. The resident compiles the signed clinical module and associated documentation regarding the learning opportunities that were experienced during the rotation. The resident is given an oral exam or asked for a presentation at the end of the rotation. For more details see Appendix C.
- **6. Brachytherapy rotation (core):** The rotation is structured to provide the medical physics resident with knowledge of brachytherapy basics and brachytherapy applications. The resident should develop a knowledge base including radioactive decay, characteristics of radioactive sources, source calibration, calculation of dose distributions, different systems of implant dosimetry and implantation techniques. Basic definitions in dose specification will be covered, along with an overview of remote afterloading systems and various applicators. During the rotation, the resident will observe the medical physicist during brachytherapy procedures, perform source calibration checks, and perform computerized and hand calculated dosimetry to include fundamental calculation techniques. The resident should develop the imaging and treatment planning of brachytherapy, along with patient-specific and system quality assurance. The resident will learn the principles of both interstitial brachytherapy (e.g. prostate seed implantation for LDR) and intracavitary brachytherapy (e.g., cervix, uterus/vagina treatment for HDR). During the rotation, the resident will assist the medical physicist during brachytherapy

procedures and reproduce treatment plans and quality assurance tests for multiple procedures. The resident compiles the signed clinical module and associated documentation regarding the learning opportunities that were experienced during the rotation. The rotation concludes with an oral exam or a presentation organized by the mentor. For more details see Appendix C.

- 7. Radiation Safety and Protection rotation (core): The radiation safety and protection rotation is structured to give the medical physics resident experience in designing facilities appropriate for radiation oncology equipment. The resident is asked to design the shielding for different types of rooms typically found in a radiation oncology department, including a high energy linear accelerator vault and an HDR vault. The resident consults with the physics mentor during the rotation to discuss the specifics of the design process. The mentor will propose alternate scenarios that force the resident to re-work the design using different clinical or occupancy criteria. The resident is also expected to perform portions of a radiation survey around existing vaults to gain practical experience in obtaining and analyzing low level radiation data. The resident compiles a written report detailing the learning opportunities that were experienced during the rotation. The rotation concludes with an oral exam or a presentation organized by the mentor. For more details see Appendix C.
- **8.** Physicist of the Day (POD) rotation (core): This rotation will provide the resident with the fundamental knowledge and practical training for proficiency with day-to-day clinical operations as the floor physicist. Resident performs all clinical tasks under the supervision of a senior staff physicist, i.e. the mentor. The resident is expected to learn and become experience with all the details about the clinical tasks that need to be performed in the clinical workflow and the responsibilities of the physicist on clinical duty. The rotation concludes with an oral exam or a presentation organized by the mentor. For more details see Appendix C.
- **9. Proton Therapy rotation (Core):** In this rotation, the resident will be given an overview of the proton therapy physics and treatment techniques. The resident will learn through observation and direct participation in the clinical physics activities. The resident will participate in technical aspects of patient care under the supervision of staff proton physicists. These activities include quality assurance (daily, monthly, annual, and patient-specific), patient treatment simulation, treatment planning, review of patient positioning and immobilization. The resident is expected to gain experience in both technical and clinical aspects of proton therapy. At the end of the rotation the resident's performance will be evaluated by the mentor by taking an oral examination or a presentation on proton therapy. For more details see Appendix C.
- 10. Professionalism and Ethics rotation (core): In this rotation, the resident will learn about his/her legal, professional, and ethical commitments as a medical physicist. The NRC and the state regulations governing the practice of radiation therapy will be reviewed. The resident will participate in hospital inspections conducted by state or other agencies providing oversight of the radiation therapy program. The resident will gain an understanding of the cooperative trials process and entities involved: NRG Oncology, Imaging and Radiation Oncology Core (IROC), and the hospital's Institutional Review Board (IRB). The resident will also learn about the ethical and professional aspects of medical physics such as patient and colleague relationships, ethical encounters or dilemmas, employer/employee relationships, conflicts of interest, human/ animal research principles, scientific misconduct and publication ethics as well as the role of leadership in the profession. The resident is expected to be very familiar with the legal, professional, and ethical issues related to medical physics practice. The rotation concludes with an oral exam or a presentation organized by the mentor. For more details see Appendix C.
- 11. Adaptive Radiotherapy rotation (core): The Adaptive Radiotherapy rotation is structured to provide the medical physics resident with a comprehensive understanding of adaptive radiotherapy (ART) techniques and their clinical applications. The rotation emphasizes the iterative nature of ART, which involves modifying treatment plans based on changes in patient anatomy, tumor response, or other factors observed during the course of treatment. The resident will actively participate in each stage of the ART workflow. This includes the acquisition and evaluation of daily imaging data, image registration, and the creation of adaptive treatment plans. The resident will work closely with radiation oncologists, dosimetrists, and therapists to understand the clinical decision-making process behind when and how to adapt a plan. The resident will also perform quality assurance on adaptive treatment plans and the associated imaging systems to ensure accurate and safe delivery of therapy. For more details, see Appendix C.

12a. Special Procedures rotation (elective I): Total Body Irradiation (TBI), Total Skin Electron Irradiation (TSEI), and Intraoperative Irradiation (IORT). This rotation prepares the medical physics resident to develop and commission a total body irradiation program. The resident will develop knowledge of the clinical basis for TBI, equipment, dosimetry issues in TBI, field uniformity, beam energy/penetration, blocking, beam data for TBI, and hand calculations. During the rotation, the resident will observe/attend a TBI simulation, fabricate the blocks under supervision, verify the block attenuation on the machine, attend/observe in-vivo dose measurements for TBI, perform hand calcs and compare to diode results. Additionally, the resident gains an understanding of total skin electron and intraoperative irradiation. The resident will reinforce their basic knowledge of electron beam dosimetry and develop knowledge in the clinical basis and beam data required for TSEI and IORT, equipment, dosimetry issues in TSEI and IORT, field uniformity, beam energy/ penetration, field shaping, collimation and patient alignment, collimation and energy adjustment. During the rotation, the resident will develop an understanding of intraoperative cone effects on electron beam, as well as the effect of different electron applicators (including IORT cones and TSEI beam definer on effective source position). Electron shielding using lead sheets vs. cerrobend blocks will also be measured. The resident compiles a written report detailing the learning opportunities that were experienced during the rotation. The rotation concludes with an oral exam or a presentation organized by the mentor. For more details see Appendix C.

12b. Dedicated Research rotation (elective II): Resident may opt for dedicated research time, provided he/she is in a good position to complete the 11 core rotations successfully and on-time. Research topic(s) can be elected based on the resident's interest and availability of a suitable guide/ supervisor. Details of this rotation are provided in Appendix C.

C. Evaluation of the Curriculum

The mentor responsible for a given rotation may propose the creation or modification of the rotation's design and content in consultation with the program director. Any major change needs to be approved by the Steering Committee. At the end of each rotation, the resident is also given the evaluation form for evaluating the content of the clinical rotation as well as to evaluate the faculty mentor (see Appendix J2). The resident submits the evaluated form and suggestions to the program director. Additionally, at the end of the residency program (at the end of final rotation), the resident is asked to evaluate the whole program and make suggestions for improvement (see Appendix J3). The proposal by the mentor and the comments by the residents are then reviewed by the program director and the Steering Committee for approval and implementation. Suggestions about content, effectiveness, and areas of improvement of the program from each of the mentors of the rotations and the residents are reviewed and compiled by the program director. The compiled review report is then presented to the Steering Committee for further discussion and implementation. The clinical rotation contents and the residency program curriculum are revised as per any modifications approved by the program director and/or the Steering Committee. Then the modifications are informed to the residents in writing. Any substantial modifications are implemented in such a way so that they do not affect the current residents adversely.

Ethics and Professionalism Curriculum

These standards shall be fully addressed before completion of the resident educational programs.

Professionalism and Ethics	How covered	
Professionalism	ABR/ACR/RSNA/AAPM/ASTRO/ARR/ARS	
o Definition of a profession and	Online Modules on Ethics and Professionalism Historical Evolution and Principles of Medical	
professionalism	Professionalism.	
 Elements of a profession 	110105510114115111.	

0	Definition of a professional	
0	Elements of professionalism	
0	How is professionalism judged?	
0	Do's and don'ts of professionalism	
0	Physician's charter and applicability	
	to physicists	
Lea	adership	Attended departmental QI/leadership meeting.
0	Vision and charisma	
0	Qualities of leaders	
0	Rules of leadership	
0	Causes of leadership failure	
Etł	nics	The residents are required to follow the American
0	Ethics of a profession	Board of Radiology Foundation (ABRF) online modules on ethics and professionalism issues
0	Ethics of an individual	http://www.aapm.org/education/onlinemodules.asp,
		nttp://www.aapm.org/education/onlinemodules.asp,
0	Interactions with colleagues and co-	Physician-Physician and Physician-Patient
	workers	Interactions.
o Interactions with patients and the		
	public	
0	Confidentiality	Review of department and hospital policies;
0	Peer review	Personal Behavior, Peer Review, and Contract
0	Negotiation skills	Negotiations with the Employers.
0	Relationships with employers	regotiations with the Employers.
0	Conflicts of interest	Conflict of Interest
0	Ethics in research	Publication Ethics
	77 0 1 1 1	T defication Edition
0	Use of animals in research	Vertebrate Animal Research
0	Use of humans in research	Ethics of Research
	Palationships with wandows	
O	Relationships with vendors	Relationships with Vendors
0	Publication ethics	Publication Ethics
0	Ethics in graduate and resident education	Ethics in Graduate and Resident Education
0	Selected case studies	Professionalism in Everyday Practice; The Physician Charter

The residents are required to follow the American Board of Radiology Foundation (ABRF) online modules on ethics and professionalism issues. The modules are accessed through the AAPM website at http://www.aapm.org/education/onlinemodules.asp, which covers the following topics.

- a) Historical Evolution and Principles of Medical Professionalism
- b) Physician/Patient/Colleague Relationships
- c) Personal Behavior, Peer Review, and Contract Negotiations with Employers
- d) Conflict of Interest
- e) Ethics of Research
- f) Human Subjects Research
- g) Vertebrate Animal Research
- h) Relationships with Vendors
- i) Publication Ethics
- j) Ethics in Graduate and Resident Education
- k) Professionalism in Everyday Practice; The Physician Charter

Sample Training Plan

Didactic Training

Clinical conferences, seminars, small discussion groups, journal clubs and one-on-one instruction are integral part of the program. The resident will participate in the following:

- Medical Physics Resident Meeting (bi-weekly)
- Radiation Oncology Chart Rounds conferences (5 per week)
- Radiation Oncology Grand Rounds conferences (bi-weekly)
- Physics Division Meetings (monthly)
- Medical Physics Seminars (bi-weekly/ monthly)
- Site-specific Tumor Board conferences (vary)
- Assigned readings with course work or clinical rotation (as required)

Timeline for meetings and courses:

Daily: 8:00 – 9:00 am	Radiation Oncology Chart Rounds conferences
Every 2 nd & 4 th Thursdays: 3:00 – 4:00 pm	Physics Residents meeting
Every 1st Thursday: 3:00 – 4:00 pm	UHCMC physics research meeting
Every 3 rd Thursday: 3:00 – 4:00 pm	Journal Club
Every 4 th Friday: 2:00 – 3:00 pm	Physics Division meetings
Summer, Fall, & Spring Semester: 1.5 hours per week	Medical Physics of Radiation Oncology (optional)
Summer & Fall Semester: 3 hours per week	Radiation Biology (optional or if required)

The following two courses offered by the Radiation Oncology department are now combined for the Medical Physics residents and the Radiation Oncology residents. These courses are optional for the Medical Physics residents, i.e. any Medical resident can attend any lecture if he/she and/or the mentor/director feel that the resident will benefit attending any particular lectures.

Medical Physics of Radiation Oncology (optional): This course is designed to help the medical physician residents better understand the principles and application of physics in radiation therapy. At the conclusion of the course, the student should understand the following areas: Atomic and Nuclear Structure, The Production of Photons and Electrons, Radiation Interactions, Treatment Machines and Simulators, Photons and X-Rays, Electron Beams, External Beam Quality Assurance, Radiation Protection and Shielding, Imaging for Radiation Oncology, Three-dimensional Conformal Radiation Therapy (3DCRT) including International Commission on Radiation Units (ICRU) Concepts, Intensity Modulated Radiation Therapy (IMRT), and Beam-Related Biology, Assessment of Patient Setup and Verification, Importance of Image-guidance in Radiation Therapy, Importance of Tumor Motion Management, Special Procedures, Brachytherapy, Hyperthermia, and Particle Therapy.

Text Book: McDermott, Patrick N., and Colin G. Orton. 2010. *The Physics & Technology of Radiation Therapy*. Madison, WI: Medical Physics Publishing Corporation.

Reference Book: Physics of Radiology (4th ed), HE Johns and JR Cunningham, Charles C Thomas Pub, 1983. Radiation Therapy Physics, (3rd ed), WR Hendee, GS Ibbott, and EG Hendee, John Wiley & Sons, 2005. The Physics of Radiation Therapy (4th ed), Faiz M. Khan, Lippincott Williams & Wilkins, 2010.

Radiation Biology (optional): This course provides a comprehensive introduction to all modern principles necessary for developing a strong working knowledge of Radiation Biology. Areas of focus include radiation chemistry, the physics of interaction of ionizing radiation with biological material, radiation protection, radiation mutagenesis and carcinogenesis, radiation therapy and the effects of radiation on signal transduction and gene expression. The emphasis is placed on mammalian radiobiology; however, principles derived from lower organisms are also discussed. Students will attend 1 didactic lecture/wk (1.5 hrs) given by experts on each respective topic, as well as making oral and written presentations on student selected cutting edge topics relevant to Radiation Biology in the 21st century. Radiation biology topics to be covered include: Radiation Protection, Human Radiobiology, Metabolic Oxidative Stress and Radiation Effects, Radiation Therapy, Radiation Mutagenesis, Radiation Carcinogenesis, Radiation Teratology, Radiation-induced DNA Damage and Repair, Radiation Effects on the Cell Cycle, Radiation Effects on Signal Transduction and Gene Expression, Bystander Effects, Genomic Instability, Radiation-induced Adaptive Responses, and Modes of Cell Death.

Text: Radiobiology for the Radiologist (7th ed), EJ Hall and AJ Giaccia, Lippincott Williams & Wilkins, 2012.

Reference Book: Molecular Biology of Cancer – Mechanisms, Targets and Therapeutics (3rd ed), L Pecorino, Oxford University Press, 2012.

Clinical Rotations

During each rotation, the residents are expected to acquire all necessary data and information pertinent for the rotation to establish the relevant procedures for their *own* Radiation Oncology department. They may spend significant time reviewing the literature for the rotation (AAPM Task Group reports, journal publications, textbook, and other reference materials) in their preparation for the written report and oral exam for the rotation. In addition to the rotation, residents are participating clinically in several ways, depending on their demonstrated competency and evolution within the program; routine quality assurance of all machines and equipment, IMRT measurements, electron cut out measurements, clinical projects treatment planning checks, weekly chart reviews, brachytherapy planning and procedures, and responding to all clinical physics requests following the "Physicist of the Day." Details of the elements of clinical training of each rotation are provided in Appendix F.

Example Daily Schedule:

Below is a summary of a sample day on any given rotation. This does not reflect individual rotation requirements.

8:00 – 9:00 a.m. Conference/ Grand Rounds/ Seminar/ Chart Rounds

8:30 – 9:45 a.m. Medical Physics of Radiation Oncology (Friday) - optional

Throughout the day: (a) review literature, (b) collect and analyze data, (c) perform clinical projects (e) meet with mentor, (f) called to machines to observe/perform procedures, (g) work on rotation report and/or work on assignment/task given by the rotation mentor.

5:00/5:30 – 7:00 p.m. IMRT QA, monthly QA, electron cut-out, QA documentation analysis, reporting, and clinical projects.

<u>Teaching opportunities for residents</u>: Medical Physics residents have the opportunity to teach Medical Radiation Oncology residents in the basics of Therapeutic Radiological Physics. Teaching any of these lectures will depend upon the medical resident's suitability and interest. The presentation of a CAMPEP approved seminar has served in the past as an excellent vehicle to demonstrate abilities in a special topic or research area.

Summary

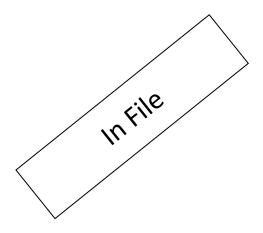
Program strengths, weakness and Goals for the future

The University Hospitals Cleveland Medical Center, i.e. Seidman Cancer Center (SCC) and Bolwell Center is a tertiary care patient care center in Cleveland, a city which is undergoing rapid renovation and upgrading of a 20 mile "high-tech corridor." Our program is fully integrated within the University Hospitals health systems and affiliated to Case Western Reserve University, providing us collaboration and teaching/learning opportunities with university physicists, imaging scientists in Bioengineering, Electrical and Computer Engineering, and Radiology. We currently participate in teaching in several programs: Clinical Medical Physics Residency Program in Radiation Oncology, Radiation Oncology Medical Residents and graduate level Medical Physics courses in the Radiation Biology Program. Finally, we have several active research projects with faculty members of the three groups mentioned above.

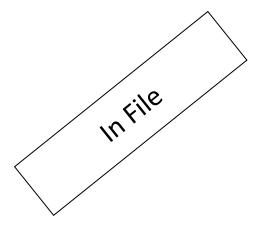
The Department of Radiation Oncology is a part of the NCI-designated "Case Comprehensive Cancer Center". The Department of Radiation Oncology is designated a "Center of Excellence" at the UHCMC, having recently moved into an expanded, 250,000 sq. ft. state-of-the-art Seidman Cancer Center that includes 4DCT, CT/PET, and a 3-Tesla MRI in Radiation Oncology used for functional imaging and treatment simulation. The department is truly paperless and filmless.

Because we are part of an academic institution, we have a number of different ways to teach our residents. We are continually assessing our curriculum and delivery based on the needs of the individual residents. We anticipate including a greater emphasis on diagnostic imaging physics as applied to radiation oncology, as image guidance in radiation therapy is increasing in importance.

Appendix A - Letters of Invitation and Institutional Commitment



Appendix B - Documentation of *Institutional* Accreditation



Appendix C – Clinical Rotation Summaries

Radiation Oncology Clinical Medical Physics Resident Rotation - Year 1

Sequence	Duration (week)	Rotation (rotation #)	Mentor
0	2	Orientation	ATP (KL, RK)
1	16	Treatment Planning (#1)	GP (ATP, Dosi)
2	6	Imaging for Simulation, Planning and Treatment Verification (IGRT) (#2)	TA/KC (ATP/KL)
3	8	Brachytherapy (#3)	RW (VC)
4	4	Professionalism and Ethics (#4)	TA (PG, GP)
5	8	Proton Therapy (#5)	RJ (TA, KL)
	5.6	Vacation / Sick Leave / Family Leave / Conferences	ATP (KL, RK)

Radiation Oncology Clinical Medical Physics Resident Rotation - Year 2

Sequence	Duration (week)	Rotation (rotation #)	Mentor
6	12	Physicist of the Day (POD) (#6)	KL (TA, ATP)
7	4	Dosimetric Systems (#7)	VC/KG (KL, GP)
8	8	Adaptive Radiation Therapy (ART) (#8)	ATP (GP, RK)
9	8	SRS and SBRT (GK and Linac-based) (#9)	BG/ATP (RK)
10 (flexible)	8	Linear Accelerator Acceptance, Commissioning, Annual QA, and TPS Modeling (#10)	TA/KL (VC, PG)
11	4	Room Design, Radiation Protection and Safety (#11)	PG (VC, TA)
12	4	Catch-up (#1-11) or Special Procedures (#11) or Dedicated Research (#12) Proces Improvement or Clinical-focus	VC/ATP (RK)
	5.6	Vacation / Sick Leave / Family Leave / Conferences	ATP (KL, RK)

Attendance at the following conferences is required (at least 75%):

Grand Rounds: Tuesdays, 8:00 – 9:00am

Journal Club: 4th Tuesday, 3:00-4:00pm

A total of 11 core rotations out of the 12 rotations must be completed for the resident candidate to be eligible for completion of the program requirements. The mentor of the clinical rotation evaluates the resident's performance at the end of each rotation (see Appendix J). Quarterly review of the resident's progress is performed by the Directors (see Appendix J).

New Resident Orientation

Clinical Medical Residency Program Department of Radiation Oncology University Hospitals Cleveland Medical Center

Name of the Resident:				
Start date:	Completion date:			
Name of the Mentor:				

New Resident Orientation schedule and attendance

Date	Time	Торіс	Place/Zoom	Presenter
Day 1	8:00 AM – 12:00 PM	UH Orientation		UH
	12:00 PM – 4:00 PM	Move into office / Department Tour	Resident Office	2nd Year Residents
Day 2	9:00AM- 10:00AM	Introduction to UH Rad Onc		Physics Residency Leadership
	11:00AM- 12:00PM	Basics of CT Simulation	CT Sim	CT Simulation Staff
	1:00PM- 2:00PM	Introduction to Physics Residency		2nd Year Residents
	2:00PM- 4:00PM	QA Introduction		2nd Year Residents
Day 3	9:00AM- 10:00AM	Introduction to the RT Workflow		Physics Residency Leadership
	10:00AM- 12:00PM	Introduction to Clinical Software	Resident Office	2nd Year Residents
	1:00PM- 2:00PM	Research and Clinical Project Overview		Physics Residency Leadership
	2:00PM- 4:00PM	Introduction to Treatment Planning	Residents Room	Chiefs and Dosimetry Staff
Day 4	8:30AM	Introduction to Radiation Therapy (RTT) Staff		Medical Resident Chiefs
	9:00AM- 12:00PM	Introduction to the Linacs, Patient Immobilization, Daily Set up, & Onboard Imaging Review	Edge, Ethos, and TrueBeam	RTT Leads

	12:00PM- 1:30PM	Residents Lunch	TBD	Medical & Physics Residents
	1:30PM- 4:00PM	Make-Up or Meetings with Specific Faculty	-	TBD
	TBD	Radiation Safety Training	TBD	TBD
	7/4/25	Independence Day Holiday Clir	nic Closed - Holi	day
Day 5	8:00AM- 9:00AM	Chart Rounds	Zoom	RO Physicians
	9:00AM- 12:00PM	Res 1: Brachy; Res 2: Proton	Brachy Suite; Protons	Service Leads
	1:00PM- 4:00PM	Res 1: Simulation; Res 2: Physicist of the Day	SimCT; TBD	Sim Therapy; TBD
Day 6	8:00AM- 9:00AM	Chart Rounds	Zoom	RO Physicians
	9:00AM- 12:00PM	Res 1: Proton; Res 2: Simulation;	Protons; SimCT	Service Lead; Sim Therapy
	1:00PM- 4:00PM	Res 1: Dosimetry; Res 2: Plan Check	Dosimetry Room; TBD	TBD
Day 7	8:00AM- 9:00AM	Chart Rounds	Zoom	RO Physicians
	9:00AM- 12:00PM	Res 1: Adaptive; Res 2: Brachy	Ethos; Brachy Suite	Service Leads
	1:00PM- 4:00PM	Res 1: Plan Check; Res 2: Dosimetry	TBD; Dosimetry Room	TBD
	8:00AM- 9:00AM	Chart Rounds	Zoom	RO Physicians
Day 8	9:00AM- 12:00PM	Res1: Edge; Res 2: Adaptive	Edge; Ethos	Therapy ; Service Lead
	1:00PM- 4:00PM	Res 1: Physicist of the Day; Res 2: Edge	TBD; Edge	TBD; Therapy
	8:30AM- 9:45AM	Physics Course	Zoom	Physics Instructor
Day 9	10:00AM- 10:30AM	Introduction with Satellite Physicists	Zoom	Sat Physicists
	11:00AM- 4:00PM	Make-Up or Meetings with Specific Faculty	-	TBD

Safety Training

The following safety training and safety issues are covered in resident safety orientation, which is conducted by the Hospital/ Program Director/ Physics Div. Director/ any qualified personnel:

- Personal Protective Equipment (PPE) Training
- Mandatory Reporting
- Bloodborne Pathogens
- Safety and Infection Control Test
- HIPAA Training
- Culture Diversity Training
- Patient and Staff Rights and Responsibilities
- Gowns, protective equipment
- Patient and Resident Safety
- Health Protection Office staff training and test (includes Radiation Safety)
- Hazard Communication Safety Training
- Hazmat Training and Test
- Fire and Tornado Plans and Procedures
- Code Blue Procedures
- Universal Precautions
- Sharps Disposal
- Handling TLDs, potential risks and safety issues during residency training

Comments:		_
Signature of the Resident, Date	Signature of the Mentor/Supervisor, Date	

1. Dosimetric Systems rotation (core, rotation module #1)

Name of th	e Resident:
Start date:	Completion date:
Name of th	e Mentor:
A. Skills	
a. I	Linac Operation
	i. Use Treat and Record System with Linac
b. U	Jse of an Ionization Chamber and Electrometer to read Dose (Monthly QA)
	i. Steps to perform a point-dose measurement
	ii. Review TG-51 calculation, how to derive cGy/MU
	iii. Process of cross-calibrating a chamber
с. Т	TBI/TSE Commissioning
	i. Review the process and necessary measurements for TBI/TSE commissioning
	dge Base – Instrumentation
a. I	Design and Basic Operation of Dose Measurement Devices
	i. Review PTW Manual on different chambers
1 7	ii. Review https://oncologymedicalphysics.com/common-dosimeters/
b. I	onization Chambers
	i. Review design of chambers (thimble, parallel-plate, and farmer)
	ii. Leakage and stem effectiii. Signal-to-noise ratio of different chamber volumes
	iv. Temperature and pressure effects (sealed versus non-sealed chambers)
	v. Humidity effects on chamber reading
	vi. Gas Amplification curve (effect of bias level)
c. I	Electrometer
	i. Review functionality of an electrometer
	ii. P _{elec} for TG-51
d. I	Film
	i. How to create an H&D curve in RIT
	ii. Running a film processor
	iii. How to convert optical density to dose
	iv. Composition of Radiochromic and Radiographic film
e. N	MOSFET
	i. Construction and design
	ii. Dose measurement using a MOSFET
fГ	iii. Modes of operation Diodes
1. L	i. Construction and design
	ii. Dose measurement using a diode
	iii. Review PN Junction and how radiation measurement is done
g. 7	FLDs/OSL
5.	i Difference between the two, and advantages and disadvantages

ii. Dose measurement using a TLD and OSLD iii. Review the process of annealing (TG-191)

C. Clinical Processes

- a. Commissioning of Dose Measurement Systems
 - i. Review different dosimeters used during commissioning of a new linac
 - ii. What is appropriate for small fields, scanning, etc.?
- b. Perform dose measurements with different detectors and compare the results
 - i. Use film, TLDS, ion chambers, etc. to measure and calculate dose
- c. Review and perform electron cutout measurements
 - i. Review cutout factors
 - ii. Review inverse square factors
 - iii. Review cone factors
 - iv. Considerations on chamber choice and placement
 - v. Perform a cutout factor measurement for an electron patient going through the entire process

Learning opportunities

Observe physicist measurements performed with ion chamber and phantom: monthly calibration, electron cutout measurements, IMRT/VMAT QA. Observe dose verification on patient using TLDs.

Reading List

- 1. The Physics of Radiation Therapy, 3rd ed., Khan, Ch.6 and 8.
- 2. Comprehensive QA for Radiation Oncology (Reprinted from Medical Physics, Vol. 21, Issue 4) (1994) Radiation Therapy Committee Task Group #40; 37 pp, focus on Table IV.
- 3. Diode in Vivo Dosimetry for Patients Receiving External Beam Radiation Therapy (2005) Radiation Therapy Committee Task Group #62.
- 4. TG 235: RadioGraphic and RadioChromic Film Dosimetry (Updated to TG 55)
- 5. Oncology Medical Physics review of dosimeters. https://oncologymedicalphysics.com/
- 6. AAPM TG 191: Clinical Use of Luminescent Dosimeters: TLDs and OSLDs (2019).
- 7. TG 219: Tolerance Limits for IMRT-based QA (Optional)

3. Measurements and Data Collection

Module: Dosimetry Systems		
Competency: Dosimetry Systems		
Objectives: This module intends to provide fundamental knowledge and sufficient practical training		
experience for active competency in IVD, Film, TLD Dosimetry and Cutout measurements.		
1. Physics Class:		
☐ Mentor sign and Date:		
2. Reading Guidelines:		
☐ Complete assigned reports and literature		
☐ Mentor sign and Date:		

☐ Participate in actual patient IVD diode measurement	ts
☐ Calibrate/Modify Calibration of IVD style Device	
☐ Create an H and D Curve using EDR Film/Linac and	d RIT Software
☐ Use RIT or similar software to do film analysis usin	g H and D curve created above
☐ Perform e- cutout measurements to determine cutou	t output factor
☐ Perform TLD Patient Measurements	
☐ Use ArcCHECK, MapCHECK or Matrixx array styl	le device to perform dose measurements and
analysis	
☐ Perform Special Physics consults for IVD measuren	nents of pace makers in patients.
☐ Learn to pour a simple block or device.	
☐ Mentor sign and Date:	
4. Documentation and Reporting	
☐ Documentation of Testing and data	
☐ Writing Special Physics Consults as appropriate	
☐ Mentor sign and Date:	
Assessment (rotation #1): The resident will take an oral exam and/or give a presprocesses as well as comprehension of other relevant info	sentation. An understanding of the principles behind the formation from the reading lists must be demonstrated.
Summary of Resident's activities:	
Competency attainedyes	no
Mentor's Signature	Date

2. Treatment Planning rotation (core, rotation #2)

Name of the Resident:	
Start date:	Completion date:
Name of the Mentor:	

2A. Treatment Panning I:

A. Prepare Knowledge Base

- a. Determination of Data Required for TPS Modeling
- b. General Operation of Planning System
- c. 3D Photon Beam Dose Algorithms
 - i. Convolution Method
 - ii. Polyenergetic Spectra
 - iii. Inhomogeneity Corrections
 - iv. Collapsed Cone Convolution
 - v. Output Factors
 - vi. Monitor Units
- d. Electron Beam Dose Algorithms
 - i. Pencil Beam model
 - ii. Verification Data
- e. Non-dosimetric Parameters within Treatment Planning Systems
 - i. CT dataset resolution
 - ii. CT number to electron density
 - iii. Contouring thresholds / expansion / contraction
 - iv. Transformations / Projections in Beams-eye-view
 - v. Digitally Reconstructed Radiographs
- f. Dose Evaluation Tools
 - i. Dose grid resolution
 - ii. Isodose lines
 - iii. Tolerance of Normal Tissues
 - iv. Dose-Volume Histograms
 - v. TCP/NTCP
- g. Treatment Planning Protocols
- h. Data transfer, DICOM formats / RT Objects
- i. Treatment Planning Quality Assurance
- j. Record and Verify system data import/verification/approval

B. Clinical Processes – Use Clinical Module Work Sheet

- a. Observe 3-D Treatment Planning
 - i. Brain, Lung & Esophagus, Breast, CNS, Abdomen & Rectum, Pelvis & Bladder, Prostate, Skin, and GYN.
- b. Determine the treatment planning protocol for each anatomical site observed.
 - i. Prescription summary (total, fractionation, max/min)
 - ii. Typical imaging techniques
 - iii. fields, beam energy, beam shaping/blocking
 - iv. Regions of interest and their associated doses
- c. Create Treatment Plans
 - i. Brain, Breast, Lung, Rectum, Prostate, GYN, GI, CNS, Sarcoma, Skin.

d. Perform Quality Assurance on all plans

Learning opportunities (TP-I)

Observe dosimetrists in performing the treatment planning process, and understand the functionality of the planning system. After adequate hands-on time with the planning system and observing 10 different types of cases from 10 different sites (Brain, Breast, Prostate, H&N, whole CNS, GI, GYN, Skin, Sarcoma) perform treatment planning for 13 cases including (i) two cases from each site of Breast, Prostate, and Lung, and (ii) one case from each site of Brain, H&N, whole CNS, GI, GYN, Skin, Sarcoma. Most cases, if not all, should be real patient/clinical cases; as if the resident is working as a dosimetrist. Quality assurance of every aspect of the plan, from plan evaluation through verification within the record and verify system.

Treatment Planning - Operation and Clinical Module

A. Skills

- a. TPS system operation
 - i. Login
 - ii. Access to Patient Database
 - iii. Access to Syntegra/Planning
- b. Mosaig Record and Verify system

B. Knowledge Base

- a. Determination of Data Required for TPS Modeling
- b. 3D Photon/Electron Beam Dose Algorithms
- c. Operation of Planning System
- d. Treatment Planning Methods/Techniques
- e. Dose Evaluation Tools
- f. Data transfer
- g. DICOM formats / RT Objects
- h. Treatment Planning Quality Assurance
- i. Record and Verify system data import/approval

Module: Treatment Planning I

I. Objective: Provide the resident with an introduction to dosimetry and treatment planning

II. Didactic Activities:

A. Photon Dosimetry

	Task	Mentor Sign/Date
1.	Attend 6 hours of lab in dosimetry provided in physics residents' syllabus (if applicable/ available).	
2.	Review Chapters 9 & 10 in Khan (3 rd ed.) for basic dosimetry calculations.	
	Submit following problems from Hendee Chapter 7: 1, 3, 5, 7, 9, & 11.	
3.	Review Chapters 11 – 13 in Khan (3 rd ed.) for treatment planning. Submit following problems from Hendee Chapter 8: 2, 4, 6, & 8.	

B. Electron Dosimetry

Tools	Mentor
Task	Sign/Date

1. Review Chapter 14 and example problems in Khan (3rd ed.) for treatment planning. Submit problem 7 from Chapter 8 of Hendee.

III. Clinical Activities:

The resident will work with the therapist/dosimetrist/physicist to observe and perform the steps listed in A and B below for the designated number of patients.

A. Pre-planning process:

- Patient set-up and immobilization
- CT simulation (including isocenter placement)
- Secondary image acquisition and image fusion (if requested by MD)
- Importing images into Raystation Treatment Planning System

B. Planning process:

- Plan/patient set-up (couch removal, localization)
- Contour (both normal tissues and target)
- Point placement (isocenter and calc. points, if necessary)
- Beam placement and calculation
- Plan evaluation
- Plan review with physician
- Plan export to Mosaiq and RadCalc
- Plan review with floor physicist

When observing or creating a particular treatment plan, particular attention should be paid to the following items in the planning process:

- Prescription dose summary (total dose, fractionation, min. and max.)
- Imaging techniques utilized
- Fields used, beam energy, blocks
- Potential organs at risk (OAR) and their associated dose limits.

2A.1. Observed Patient Plan Cases (10):

Type:	Lung	Prostate	Breast	Brain	GI
Patient Initials:					
Mentor sign:				 -	
Date:					

Type:	GYN	H&N	whole CNS	Skin	Sarcoma
Patient Initials:					
Mentor sign:					
Date:					

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.)

Type:	Lung (2)	Prostate (2)	Breast (2)	Brain	GI
Patient Initials:					
Mentor sign:					
Date:					
Tuna	GYN	H&N	whole CNS	Skin	Sarcom
Type:	GIN	nan	whole CNS	SKIII	Sarcom
Patient Initials:					
Mentor sign: Date:					
2A.3. Image Fusion				Case #4	Case #5
	Cases (5) (Brain,	Lung, GI/GYN, p	Case #3	Case #4	Case #5
Case Type:				Case #4	Case #5
Case Type: Patient Initials:				Case #4	Case #5
Case Type: Patient Initials: Mentor sign:				Case #4	Case #5
Patient Initials:	Case #1	Case #2	Case #3		
Case Type: Patient Initials: Mentor sign: Date: Vote: Collect docum	Case #1	Case #2	Case #3 various steps (i.e.	., printouts, etc.)
Case Type: Patient Initials: Mentor sign: Date: Vote: Collect docum	Case #1	Case #2	Case #3 various steps (i.e.	., printouts, etc.)
Case Type: Patient Initials: Mentor sign: Date: Vote: Collect docum	Case #1 mentation (electronic	Case #2 ———————————————————————————————————	various steps (i.e.	., printouts, etc.) dition and/or E
Case Type: Patient Initials: Mentor sign: Date: Vote: Collect docum 2A.4. Dose Compose	Case #1 mentation (electronic	Case #2 ———————————————————————————————————	various steps (i.e.	., printouts, etc.) dition and/or E

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.)

Reading List (TP-I)

Date:

- 1. Khan's Physics in Radiation Therapy Chapters 9-14.
- 2. TG-85: Inhomogeneity Correction Methods
- 3. TG-25: Clinical Electron Dosimetry
- 4. TG-71: Monitor Unit Calculations and Sc, Sp, and Scp Scatter Corrections
- 5. VanHerk Paper on Errors and Margins in Radiotherapy
- 6. Medical Resident Physics Slides on Treatment planning, electron beam therapy, and dose calculation algorithms
- 7. Bentel Treatment Planning Book
- 8. TG-81: Update to TG-63 covering Hip Replacement
- 9. TG-176: Dosimetric Effects of couches and immobilization devices (optional)
- 10. NRG Contouring Atlases (optional)
- 11. QUANTEC Guidelines for dose constraints (optional)
- 12. Timerman Dose Constraints Tables (optional)

2B. Treatment Planning II

I. Skills

- A. Treatment planning
 - 1. Must complete the Treatment Planning I rotation
 - 2. Read a Dose Volume Histogram
 - 3. Transfer a plan to a phantom
 - 4. Obtain the dose matrices of the plan
 - 5. Specify Dose-Volume constraints
- B. Film Densitometry
 - 1. H&D curve creation
 - 2. Running a film processor
 - 3. Scanning Film
 - 4. Converting pixel values to dose
- C. Use of an Ionization Chamber and Electrometer to read Dose
- D. Operate the Record & Verify system
- E. Operate the Linac
- F. CT scanning a phantom and importing it into the planning system
- G. Positioning a phantom determining shifts from fiducials to isocenter

II. Knowledge Base

- A. Optimization an introduction
- B. Critical organ doses, parallel vs serial organs, typical dose-volume constraints
- C. Dose calculation algorithms specific to IMRT
- D. Film as a dose measuring device
- E. Small field dosimetry measurement and modeling in the planning system
- F. Imaging for IMRT CT basics

III. Clinical Processes

- A. IMRT planning
- B. VMAT planning

- C. IMRT& VMAT chart check (in MOSAIQ)
- D. IMRT & VMAT OA
 - 1. Patient specific
 - 2. Delivery system specific
- E. IMRT boosts
- F. IMRT & VMAT delivery
- G. Film densitometry QA

Learning opportunities (TP-II)

Take a patient from the CT scan all the way through the initial treatment delivery. This will require shadowing the CT therapists, the dosimetrist, the medical physicist, and the linac therapists. With the first patient, it will be observation. With the second patient, it will be supervised performance of the tasks. With a phantom, it will be an independent performance of the tasks. There are a fair number of IMRT/VMAT patients in our department, and there will be no lack of opportunities. Most cases, if not all, should be real patient/clinical cases; as if the resident is working as a dosimetrist.

Module: Treatment Planning II

<u>I. Objective</u>: This module intends to demonstrate fundamental knowledge and sufficient practical experience for active competency in LINAC-based intensity modulated radiation therapy (IMRT), volumetric modulated arc therapy (VMAT) and quality assurance (QA).

II. Didactic Activities:

	Task	Mentor Sign/Date
1.	Read Chapter 21 in Khan (3 rd ed.).	
2.	Read AAPM Reports: IMRT Guidance Document [Med. Phys 30(8), 2003), TG 119.	

III. Clinical Activities:

The resident will work with the therapist/physicist to observe and perform the steps listed in A - C below for the designated number of patients.

- A. Simulation/Treatment Planning activities:
 - Observe patient set-up and immobilization in CT-Sim
 - Transfer images from CT to Raystation
 - Set-up patient-planning objectives, avoidance, and DVH
 - Utilize DMPO for plan optimization
- B. Patient-specific quality assurance:
 - Review patient QA protocol
 - QA phantom selection/planning
 - Run the QA treatment and analyze using RIT and/or Mapcheck
 - Perform relative calibration for energy being used
 - Create H and D Film and curve
 - Use Film and/or array analysis software (i.e. Mapcheck, Matrixx or RIT)

C. Treatment day activities:

- Ensure treatment chart and plan are ready for treatment (review 1st day sheet)
- Ensure applicable IGRT is ready for treatment utilization (i.e., calibration, etc.)
- Treatment console operation/machine operation

2B.1. Practice Planned P	Patient Cases	(3) (IMRT -	- Step & Shoot):
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	Case #1	Case #2	Case #3	
Case Type:				
Patient Initials:				
Mentor sign:				
Date:				

	Case #1	Case #2	Case #3
Case Type:			
Patient Initials:			
Mentor sign:			
Date:			

2B.3. Planned Patient Cases (10) (VMAT):

	Case #1	Case #2	Case #3	Case #4	Case #5
Case Type:					
Patient Initials:					
Mentor sign:					
Date:					

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc).

2B.3 (cont). Planned Patient Cases (VMAT):

	Case #6	Case #7	Case #8	Case #9**	Case #10**
Case Type:					
Patient Initials:					
Mentor sign:					
Date:					

^{**}Cases 9 and 10 are Adaptive Re-Plans

Reading List (TP-II)

- 1. Radiation Therapy Physics, Hendee, Ibbott and Hendee, Ch. 11, focus on pp 270 to 277, Ch. 15, focus on pp. 394-397.
- 2. The Physics of Radiation Therapy, 3rd ed., Khan, Chs.19 and 20, Ch 8 (focus on pp 151-153) and ch 14 (pp 304-305).
- 3. Treatment Planning in Radiation Oncology, Khan and Potish, editors, Chs. 8 (focus on pp172-176), 9, 12.
- 4. Radiation Therapy Planning, Bentel, see the summaries ("Morbidity") at the end of the various anatomical sections in chapters 9 through 13 to get a good idea of dose tolerances for various organs.
- 5. http://www.sprawls.org/resources/CTIMG/module.htm-This is a nice intro to CT image acquisition. Needed to understand the data acquisition requirements for IMRT.
- 6. Guidance document on delivery, treatment planning, and clinical implementation of IMRT: Report of the IMRT subcommittee of the AAPM radiation therapy committee. Med. Phys. 30(8), 2003.
- 7. IMRT commissioning: Multiple institution planning and dosimetry comparisons, a report from AAPM Task Group 119. Med. Phys. 36(11), 2009.
- 8. Dosimetry tools and techniques for IMRT. Med. Phys. 38(3), 2011.
- 9. Treatment planning for volumetric modulated arc therapy (VMAT). Med Phys. 36(11): 2009.
- 10. Evaluation of MatriXX for IMRT and VMAT dose verifications in peripheral dose regions. Med Phys. 37(7), 2010.
- 11. TG-166: Biological Functions for Treatment Planning

Assessment (rotation #2):

The resident will present a report giving an overview of all the processes, describing the individual steps conceptually, and results from their assessment of treatment planning methods for 3DCRT, IMRT and VMAT. Finally, the resident will take an oral exam and/or a presentation. An understanding of the principles behind the processes as well as comprehension of other relevant information from the reading lists must be demonstrated

Summary of Resident's activities:					
Competency attainedyes	no				
Mentor's Signature	Date				

3. Linear Accelerator (Linac) and TPS Modeling rotation (core, rotation #3)

Name of the Resident:		
Start date:	Completion date:	
Name of the Mentor:		

General Concepts - Linac Quality Assurance (3A)

General Knowledge Factors – Things to be discussed during rotation

Linac Design

- 1. Describe the major beamline components and how they differ between Elekta and Varian from power on to patient?
 - a. What makes up the pulse modulator?
 - b. Differences between a klystron and magnetron?
 - c. How are modern electron guns designed?
 - d. How do standing versus traveling waveguides differ?
 - e. How are bending magnets different between vendors? What are pros and cons?
 - f. How do the overall treatment heads differ? What is the order of components? How are MLC and jaw tracking done between the two?
 - g. When I load a "6MV" beam, what does that mean and how is that handled on the machine side? What does "beam loading" mean for Elekta machines? How does Varian handle energy selection?
 - h. Why is it easier for a linac to run in electron mode versus photon? Why is 6MV the hardest on the machine to run?
 - i. What are the differences in MLC design between Elekta and Varian? Are there pros and cons to each? What are typical transmission values you'd expect on each machine?

2. Linac IGRT

- a. Briefly discuss how modern linac imaging panels are designed.
- b. How does CBCT work and what are some limitations?
- c. How does 4D CBCT work on Elekta machines? Fluro mode?
- d. What are some of the ways we perform periodic QA on imaging devices? What test do we need to do?

3. Concept of isocenter

- a. How many isocenters are there on a linac?
- b. How do we distinguish the radiation isocenter?
- c. How would you go about diagnosis an iso mismatch/laser misalignment?
- 4. Linac Nomenclature

a. Cover some of the common names/differences between Varian & Elekta Linacs (things like XVI, iView, Precise table versus HexaPod versus PerfectPitch, DLG and what that means on each machine)

5. Linac Acceptance Testing

- a. What is the goal of Acceptance Testing and how does this differ from Comissioning?
- b. What are some of the things you are testing for? Do you do this with the vendor? If something is not in spec, what do you do?
- c. Walk through acceptance documents of TrueBeam & Versa

6. Linac Commissioning

- a. Fundamentally, what are the main goals of what we are after with commissioning?
- b. What is some equipment you need to commission a linac? What are some pros and cons of different detectors you might need?
- c. What are the three classes of ionization chambers?
- d. What are the differences between scanning data versus point dose data?
- e. For your water tank, what are the recommendations as far as sizes go? What are some of the main considerations you need to think about when setting up the tank? What are the effects on beam profiles due to things not being leveled (draw these out)
- f. What is the purpose of the reference detector? How does this change your signal response?
- g. Describe the process of setting your chamber at water surface
- h. What do you think is a reasonable timeline for commissioning? What are some other things you need to test and verify for commissioning outside of measurements?

7. Linac Quality Assurance

- a. What was the document prior to TG 142? What are some of the changes between the two?
- b. Know what is tested daily, monthly, and annually, and how tolerances change between IMRT versus SBRT machines
- c. What is a tolerance limit versus an action limit?

8. TG-51

- a. What are some of the changes between TG-21 versus TG-51? Why did we make the change?
- b. Describe the process of NIST calibration. What is the "gold" standard? How does our chamber get NIST calibrated?
- $_{c.}$ Walk through the TG-51 equation and how we get to dose-to-water (D^{Q}_{W})
 - i. What is the purpose of kQ? What does it depend on and how do you find it?
 - ii. What are the differences in PDD nomenclature? Which one do you want? Do you have to use lead? Why do we even care?
 - iii. What does effective point of measurement mean and why do we apply it for kQ? What is the value for photons? Electrons?
 - iv. Why for photons do we measure PDD, but for electrons we have to convert?

- v. Where do we place our chamber when measuring M (fully corrected reading)
- vi. Explain Ptp (What are we correcting? How do you calculate? What if your chamber is sealed?)
- vii. Explain Pion (What are we correcting for? How do you calculate? How does the curve change between pulsed beams versus continuous? Can this value be <1?)
- viii. Explain Ppol (What are we correcting for? How do you calculate?)
- ix. Explain Pelec (What are we correcting for? Does it matter if you calibrate your chamber & electrometer together?)
- x. How does the formulism change for electrons?
- xi. What does kQ become for electrons?
- xii. Where is the depth of calibration for electrons? How do you determine this spot?
- xiii. Does it matter what cone size you do your calibration with? When does it become a requirement to change cone sizes?

9. TG-51 A

- a. What are some of the major updates proposed in the addendum?
- b. How should we now approach FFF beams? Do we do this in our clinic? What does Prp correct for and what is a value for a farmer chamber?
- c. Explain the uncertainty budget. What are some expected uncertainties in the overall process and what has the highest uncertainty?
- d. What does it mean to use a "reference class" ion chamber? What are the four important characteristics for using another chamber (from most important to least)?
 - i. Describe chamber stabilization and leakage current. What are the recommendations for these?
 - ii. How much can Ppol differ by? Is it per energy or across all energies?
 - iii. How much can Pion drift by? How does the addendum want you to measure this? Do we do this clinically?

Clinical Expectations

- 1. Residents are expected to learn monthly machine QA with staff physicist and perform routine quality assurance on the machine
- 2. Every 6 months, residents will rotate machines at CMC (between Edge, TrueBeam, Ethos, and Versa)
- 3. Residents are also encouraged to go to satellites to learn/perform monthly QA's on TrueBeam and/or Versa
- 4. It is expected for residents to A) observe at least one annual QA within the first year of residency. This can be at CMC or at a satellite with a staff physicist and B) perform an annual QA at CMC with oversight from a staff physicist.
- 5. Residents will work with mentor to establish a clinical improvement project and present this work to the rest of the staff physicists.

Monthly QA Activities

Please log below when steps of monthly QA are performed with a staff physicist

Task	Treatment Machine	Date	Physicist Reviewing	Feedback
Mechanical Testing				
Profile & Radiation Light Field testing				
MLC Testing				
Imaging Testing				
Output & Energy				

Annual QA Activities

Observation:

Task	Treatment Machine	Date	Physicist Reviewing	Feedback
Water Scanning				
Water Tank Measurements				
TG-51				
Mechanical Testing				
MLC Testing				
Imaging Testing				

Performing:

Task	Treatment Machine	Date	Physicist Reviewing	Feedback
Water Scanning				
Water Tank Measurements				
TG-51				
Mechanical Testing				
MLC Testing				
Imaging Testing				

Reading List (Bold are required)

TG-142: Quality Assurance for Linear Accelerators

TG-198: Practical Implementation of TG-142

MPPG 8A: Linear Accelerator Performance Testing

TG 51/TG-51A: Absolute Dosimetry for Linear Accelerators

TG 106: Linear Accelerator Commissioning

Kazmark paper on Linac Functionality and X-ray production

Training Materials from Elekta & Varian (Presentation Slides)

TG-40: Comprehensive Quality Assurance

Khan Chapter's 3-4, 17

The Multileaf Collimator Complete Guide

TG-21: Determination of Absorbed Dose for high energy photon and electron beams

<u>General Concepts – TPS Modeling, Algorithms, and Validation (3B)</u>

General Knowledge Factors – Things to be discussed during rotation

1. Data Acquistion

- a. When it comes to designing a beam model, what are some of the data you need to input into the TPS?
- b. What does collecting the PDD for different field sizes do for you? What about profiles at difference depths?
- c. What are some important jaw and MLC characteristics we need to measure for our TPS?
- d. What about things like wedges, trays, and blocks?
- e. How many fields sizes and depths do we need?

2. CT Data Acquistion and Modeling (RayStation)

- a. What information do we need from our CT scanner to create a density curve? How do we create a CT-density curve?
- b. What are the units on the curve for RayStation?
- c. How does the planning system handle HU values that are higher than our calibration curve?
- d. How does the dose grid affect the HU density value the planning system reports? In what areas of the patient geometry may we expect some uncertainties in the HU density value?
- e. Explain the overall process of how RayStation takes a CT, and determines effective density to calculate TERMA
- f. What are some considerations we need to think about when generating CBCT density tables?

3. Dose Calculation

- a. What are some of the basic inputs that are required in the planning system to calculate dose?
- b. What does a dose kernel refer to? What does TERMA represent?
- c. How do we convert TERMA to dose?
- d. For RayStation, what are the 3 primary components of the TERMA calculation
- e. For dose algorithms, create a short presentation talking about how the following algorithms work, and what their strengths/weaknesses are and what planning systems you can find them in:
 - i. Pencil Beam
 - ii. Collapsed Cone Convolution/Superposition (CCC)
 - iii. Anisotropic Analytical Algorithm (AAA)
 - iv. Boltzmann Transport Dose Computation
 - v. Monte Carlo

4. RayStation TPS Modeling

- a. Basic overview of how the RayStation model works. What does the multi-source model consist of?
- b. How does RayStation handle collimator transmission? How about MLC transmission/MLC modeling?
- c. How does RayStation utilize field size output factors and what are the 3 influences?
- d. How does RayStation handle wedge transmission? How is the universal wedge modeled? What about EDW?

- e. Walk through with mentor on the machine characterizations. Explain where jaw/MLC limitations come from.
- f. Under the MLC tab what does the table refer to? What are the 3 sources of MLC leaf tip position for rounded MLC leaves and which one'd do we for modeling? Draw the graph of MLC displacement for leaf tips
- g. How just RayStation calculate MU's?

TPS Optimization Algorithms (more unique machines) - to be reviewed with Mentor Clinical Expectations

- 1. Residents are expected (with the assistance of the mentor) to create a beam model for either Versa or TrueBeam.
- 2. Walk through the different tabs in RayStation and how you can adjust the model, and what affects occur on PDD, profiles, etc
- 3. Discuss what makes a "good model" and what type of agreement are you looking for.
- 4. Discuss TPS model validation. What test would you perform and why and what are expected tolerances.

Reading List (Bold are required)

AAPM TG 53: Quality Assurance for TPS

AAPM TG 106: Accelerator Beam Data Commissioning Equipment and Procedures

MPPG 5A: Commissioning and QA of treatment planning dose calculations

RayStation Physics Training Presentations

AAPM TG 329: Reference dose specification for dose calculations: Dose-to-water versus dose-to-muscle

Agility & Varian Technical Data

TG 157: Beam Modeling and Beam Modeling Commissioning for MC

Raystation RayPhysics Manuals

4. Image Guidance for Radiation Therapy (IGRT) rotation (core, rotation #4)

Name of the Resident:	
Start date:	Completion date:
Name of the Mentor:	

4A.1. Imaging for Simulation

A. Prerequisite Skills

a. Radiation Safety – X-ray machine operation

- b. Human Anatomy common bony landmarks
- c. Fundamental Physics of Radiographic Imaging
 - i. Radiation Interactions with Matter
 - 1. Photoelectric Effect, Compton, Pair Production
 - 2. Attenuation and Scatter
 - ii. Basic Imaging Parameters
 - 1. Contrast and Spatial Resolution
 - 2. Detective Quantum Efficiency
 - 3. Signal to Noise Ratio
 - 4. MTF
- d. Introductory Imaging Technologies
 - i. Imaging Detector Concepts
 - 1. Films
 - 2. Computed Radiography
 - 3. Diode Arrays (aSi)
 - 4. Other planar X-ray imagers
 - ii. X-ray CT
 - iii. PET
 - iv. MRI
 - v. Ultrasound

B. Knowledge Base

- a. Principle understanding of simulation process.
- b. Fundamental Principles of Simulation Equipment
 - i. CT/4D-CT
 - i. Immobilization and Localization aids.
 - ii. Other simulation technologies: PET/CT, MR, US, Photogrammetric.
 - iii. Image co-registration ("fusion") and the role of multimodality imagery in simulation.
 - iv. PET/CT
- c. Medical Physicist Role in Simulation and Equipment Management
 - i. CT Simulation
 - 1. CT numbers, electron density, and relationship to Radiation Oncology treatment planning.
 - 2. Diagnostic CT v. Planning CT (or Simulator)
 - 3. CTSim QA
 - a. Mechanicals, lasers, fiducials
 - b. Imaging
 - c. Heterogeneity correction tables
 - ii. PET/CT Simulator (if applicable)
 - 1. Radiation isotope safety
 - 2. OA
 - 3. Issues in utilizing PET images in simulation.
 - iii. MRI (if applicable)
 - 1. Application as image set for fusion
 - 2. Potential as primary simulation modality
 - 3. QA for RTMRI
 - iv. Use of "other" modes in RT Simulation (such as photogrammetry, Ultrasound, setup "aids").

C. Clinical Processes

- a. CT Simulation
- b. Virtual simulation as an alternative to CT-Sim.

Learning Opportunities:

- Attend a conventional simulation for EBRT. Observe patient setup, use of fluoroscopy and image capture, and annotation of films.
- Follow a patient through the CT (PET/CT) simulation process. Emphasis should be on geometric aspects of the process (setup geometry specification, immobilization, marking, tattoos, CT including x-ray technique, and transfer to planning system).
- Note: Much of this is done for phantom as part of monthly CT simulator QA.
- Follow a patient and then take a phantom through the VSIM process.
- Observe the use of combined imaging modalities in the simulation process (such as MRI and CT for SRS).
- Follow a patient through the Optical Image guided setup simulation process, attend CT, bite block registration, and initial treatment.
- Perform CT (PET/CT) QA include using CatPhan and/or ACR phantom.

Reading List:

- 1. "Quality assurance for computed-tomography simulators and the computed-tomography simulation process: Report of the AAPM Radiation Therapy Committee Task Group No. 66," Med Phys 30 (10), 2003.
- 2. Christensen's Physics of Diagnostic Radiology (In order) Chapters 14, 15, 19, 12, 24.
- 3. Perry Sprawl' On-line lectures:
- a. http://www.sprawls.org/ppmi2/IMGCHAR/
- b. http://www.sprawls.org/resources/CTIMG/module.htm
- 4. Johns & Cunningham, "The Physics of Radiology," Chapter 16.
- 5. "The phantom portion of the American College of Radiology (ACR) Computed Tomography (CT) accreditation program: Practical tips, artifact examples, and pitfalls to avoid", Med Phys 31(9), 2004.
- 6. AAPM Report #14, "Performance specifications and acceptance testing for x-ray generators and automatic exposure devices", 1985.

4A.1. **Observed Patient CT-Sim Setup Cases** (1 H&N, 1 Lung, 1 SBRT):

	Case #1	Case #2	Case #3	
Case Type:				
Patient Initials:				
Mentor sign:			- <u></u> -	
Date:				

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.)

4A.2. **Perform (with RTTs) Patient CT-Sim Setup Cases** (1 H&N, 1 Lung, 1 Breast, 1 SBRT, 1 GYN/ Prostate):

	Case #1	Case #2	Case #3	Case #4	Case #5
Case Type:					
Patient Initials:					
Mentor/RTT Sign:					
Date:					

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.)

4A.3. Imaging for Planning and Treatment Verification

A. Skills

- 1. Fundamental Understanding of Basic Radiotherapy Process
 - a. Simulation imaging
 - b. Treatment planning
 - c. Treatment delivery/verification
- 2. Basic Understanding of Radiological Imaging Modalities
 - a. X-ray film/fluoroscopy
 - b. X-ray CT
 - c. MRI
 - d. PET (PET/CT)
- 3. Basic Imaging Science
 - a. Contrast Resolution
 - b. Signal to Noise
 - c. Image Quality
 - i. Point/Line spread function
 - ii. Modulation transfer function
 - d. Digital imaging
 - i. Quantum mottle
 - ii. Noise frequency/spectrum
 - iii. Detective Quantum Efficiency
- 4. Image registration in MIM
 - a. Rigid and deformable image registration and fusion

- b. Biologically effective dose
- c. Dose composition

B. Knowledge Base

- 1. Radiotherapy Simulation
 - a. CT simulation/virtual simulation
 - b. DRR generation
 - i. Set-up verification
 - ii. Portal image verification
- 2. Verification Imaging in Radiotherapy
 - a. Kilovoltage x-ray images
 - iii. Beams eye view DRR from CT
 - iv. Set-up verification
 - b. Megavoltage x-ray images
 - i. X-ray film/cassette
 - ii. Comparison to hardcopy DRR
 - iii. Electronic portal images
 - c. Conebeam CT
 - i. 3-D localization
 - ii. Adaptive targeting
- 3. Electronic Portal Imaging Devices
 - a. Fluoroscopic screen/camera based systems
 - i. Principles of operation
 - ii. Disadvantages/Limitations
 - iii. Clinical prevalence
 - b. Active Matrix Flat Panel (aSi) based systems
 - i. Principles of operation
 - ii. Advantages/Limitations
 - iii. Clinical prevalence

C. Clinical Processes

- a. CT simulation
 - i. Patient set-up
 - ii. Iscocenter localization
- b. Digital Reconstructed Radiograph
 - i. Generation
 - ii. Clinical use
- c. Electronic Portal Imaging Devices
 - i. Principles of operation
 - ii. Daily/monthly quality assurance testing
 - iii. Set-up/portal image verification
 - iv. Conebeam computed tomography

Learning Opportunities:

- 1. Clinical Use of Medical Images
- 2. Portal Imaging Detector Systems
- 3. Image Quality
- 4. Commissioning and QA

Reading List:

- 1. Radiation Therapy Physics 3rd Ed, Hendee, Ibbott and Hendee, Chapter 9.
- 2. TG132 "Use of image registration and fusion algorithms and techniques in radiotherapy", Med. Phys., 44 (2017).
- 3. The Physics of Radiation Therapy, 3rd Ed, Khan, Chapter 12 (focus on pp 228 244), Section 12.7 (Patient Positioning) pp 264 268.
- 4. The Physics of Radiation Therapy, 3rd Ed, Khan, Chapter 19 pp 467 474.
- 5. TG-66: CT Simulator Quality Assurance
- 6. TG-76: Respiratory Motion Management
- 7. TG-104: In-Room KV Systems for Localization
- 8. TG-179: CT-Based Quality Assurance
- 9. TG-132: Image Fusion and Registration
- 10. TG-284: MRI Simulation for Radiotherapy (Optional)
- 11. TG-58: Clinical Use of Electric Portal Imaging Devices (EPID) (Optional)
- 12. TG-147: QA for Non-Radiographic Radiotherapy Localization (Optional)

4A.4. Observed Dry-run (Tx-Sim) Patient Cases (Brain, Lung, GI/GYN, Pelvic, Spine):

	Case #1	Case #2	Case #3	Case #4	Case #5
Case Type:					
Patient Initials:					
Mentor sign:					
Date:					

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc).

4B. Image Guided Radiation Therapy (IGRT)

A. Skills

- a. TPS system operation
- b. Linear Accelerator operation
- c. KV Cone Beam CT (and 4D CBCT, if applicable)
- d. Megavoltage cone-beam operation (if available)
- e. MR and PET/CT operation

B. Knowledge Base

- a. Prospective and Retrospective CT principles
- b. Gated treatment delivery principles
- c. Treatment planning process for IGRT
- d. Data export/import into each system

C. Clinical Processes

- a. Perform Quality Assurance on each of the IGRT components
 - i. 4D image acquisition
 - ii. gated delivery using ABC
 - iii. megavoltage conebeam (if applicable)
- b. Export IGRT Treatment Plans for
 - i. Brain, Head and Neck, Lung, GI/GYN, and Prostate.

Learning opportunities

Observe and participate in the IGRT treatment planning and delivery process and understand the functionality of the systems utilized. Quality assurance of every aspect of each IGRT system studied, from image acquisition through verification and treatment delivery.

4B. Observed Patient Cases (Brian, Lung, GI/GYN, prostate, H&N):

	Case #1	Case #2	Case #3	Case #4	Case #5
Case Type:					
Patient Initials:					
Mentor sign:					
Date:					

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.)

Module: IGRT

I. Objective: This module intends to demonstrate fundamental knowledge and sufficient practical experience for active competency in IGRT.

II. Didactic Activities:

	Task	Mentor Sign/Date
1.	Read AAPM TG-104 report and TG-179	
2.	Read AAPM TG-76 report	
3.	Read Chapter 21 in Khan (3 rd ed.) and AAPM TG-101 report	
4.	Read AAPM Reports: IMRT Guidance Document [Med. Phys 30(8), 2003]	

III. Clinical Activities:

The resident will work with the therapist/physicist to observe and perform the steps listed in A - C below for the designated number of patients.

- A. Simulation/Treatment Planning activities:
 - Observe patient set-up and immobilization in CT-Sim
 - Observe and/or assist with the 4D-CT image acquisition and motion management
 - Transfer images from CT to Raystation (or relevant Tx planning system)
 - Set-up patient-planning objectives, avoidance,
 - Calculate and optimize treatment plan (through Full dose and Final dose steps)
- B. Patient-specific quality assurance:
 - Review patient QA protocol
 - IMRT/VMAT/SBRT phantom selection/planning
 - Run the IMRT/VMAT/SBRT treatment and analyze
- C. Treatment day activities:
 - Ensure QA and First Day Checklist are filled-in, reviewed and is approved for treatment
 - Ensure treatment chart, Mosaiq, and treatment plan are ready for treatment
 - Treatment console operation/machine operatio

IV. CT simulator related Quality Assurance/Calibration/Safety

The resident will work with the therapist/physicist to perform the daily QA. The resident will work with the physicist to actively participate in all other tasks listed below.

Tasks:	Case #1	Case #2	Case #3	Case #4
Daily QA				
Monthly QA			N/A	N/A
Follow FSE for PMI		N/A	N/A	N/A
Annual QA Review:	 	N/A	N/A	N/A
Complete linac CBCT relate	d requirement in other	rotation.		

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.)

Assessment (rotation #4):

The resident may require to present a report that describes the simulation process and equipment in Radiation Therapy as well as prepare a summary of his/her experiences for IGRT. This information is to be submitted to the physics faculty during an oral exam and/or a presentation. The resident will develop knowledge of portal imaging systems used during the simulation/planning process and during treatment verification. The application of different patient immobilization techniques, and different electronic portal imaging systems will be studied by comparison of systems from Varian and Siemens. The resident will perform the necessary processes for commissioning the EPID systems, as well as identify and perform continuing quality assurance. During the rotation, the resident will perform monthly and annual quality assurance of CT-simulator, CBCT and different portal imaging systems.

Summary of Resident's activities	:		
Competency attained	yes	no	
Mentor's Signature		Date	

5. SRS and SBRT rotation (core, rotation #5)

Name of the Resident:		
Start date:	Completion date:	
Name of the Mentor:		

Prerequisite Skills

- 1. Successfully completed the treatment planning, physicist of the day rotation, and completion of at least one annual QA procedure.
 - a. This includes the basics of treatment planning (including 3D conformal and VMAT) and machine coverage experience both during simulation and treatment.
 - b. Additionally, the resident should be familiar with basic dosimetric measurement devices.

General SBRT/SRS

Generic Knowledge Factors – These will be discussed during the rotation.

Quality Assurance

- 1. Describe the importance of isocenter in SBRT.^{1,2}
- 2. What tests are used to determine isocenter uncertainty?³
- 3. Describe appropriate measurement devices for small output factors.⁴
- 4. What correction factors are used to determine the small output factors?⁴
- 5. Describe the appropriate measurement devices for small field beam scanning.^{4,5}
- 6. Why are MLC and jaw positioning so important at small fields? ⁴
- 7. What is the difference between physical field size and radiation field size at small fields?⁴
- 8. How would you test latency?
- 9. What are the differences between tolerances for SBRT vs. IMRT.⁶
- 10. How do you perform an off-axis Winston-Lutz test?⁷
- 11. Discuss how to measure SRS QA on an SRS-Mapcheck.⁸
- 12. Discuss what a TPR is.⁹
- 13. Describe the Gamma-Knife system. 10
- 14. Describe the CyberKnife system.¹¹
- 1. Describe the importance of isocenter in SBRT.^{1,2}
- 2. What tests are used to determine isocenter uncertainty?³
- 3. Describe appropriate measurement devices for small output factors.⁴
- 4. What correction factors are used to determine the small output factors?⁴
- 5. Describe the appropriate measurement devices for small field beam scanning.^{4,5}
- 6. Why are MLC and jaw positioning so important at small fields? ⁴
- 7. What is the difference between physical field size and radiation field size at small fields?⁴
- 8. How would you test latency?
- 9. What are the differences between tolerances for SBRT vs. IMRT.⁶
- 10. How do you perform an off-axis Winston-Lutz test?⁷
- 11. Discuss how to measure SRS QA on an SRS-Mapcheck.^{8,9}
- 12. Discuss what a TPR is.¹⁰
- 13. Describe the Gamma-Knife system.¹¹
- 14. Describe the CyberKnife system. 12
- 15. Describe a linac-based SBRT system.

Treatment

- 1. Please describe the coverage recommendations for SBRT coverage. 1,13
- 1. Please describe the coverage recommendations for SBRT coverage. 1,12
- 2. What is the billing related restrictions for SBRT/SRS?
- 3. Why is high dose important in SBRT/SRS?²?²
- 4. What is the importance of localization?¹⁴
- 5. What is the relationship between margin and localization?¹⁵
- 2. What is the importance of localization?¹³
- What is the relationship between margin and localization?¹⁴
- 6. What is the rationale for needing high dose rate for SBRT/SRS?
- 7. What is the difference between prescription dose and prescription isodose line?
- 8. What is the role of couch kicks in SBRT/SRS?^{15,16}?^{16,17}
- 4. Describe how CyberKnife performs lung treatment. 11
- 5. Describe how CyberKnife performs brain treatment. 11
- 6. Describe how the Gamma Knife performs brain treatment.¹⁰
- 7. Know how to communicate a clearance check for SBRT couch kicks.

Brain¹⁷

Knowledge Factors

Pretreatment

- 1. What type of CT acquisition is needed for SRS?
- 2. What secondary imaging is used in SRS?
- 3. What spatial considerations are needed for MRI in SRS?¹⁸
- 4. What type of MRIs are used for SRS?
- 5. What are the clinical indications for SRS?¹⁹
- 6. Describe the immobilization for Gamma Knife.²⁰
- 7. Describe the immobilization for linac-based SRS.²¹
- 8. What are dosimetric objectives seen in SRS?²²
- 9. What is gradient margin?
- 10. What is the difference between standard conformality index and a Paddock conformality index?
- 11. What dose and fractionation is typically used?

Treatment 23

- 1. How do we monitor motion during Gamma Knife?
- How does we monitor motion during linac-based SRS?²¹
- 3. What is the role of surface monitoring in SRS?²³
- 4. What is the expected level of uncertainty for target localization?
- 5. Does the expected level of uncertainty change in multi-met SRS?²⁴

Competency

- 1. Create a gamma-knife treatment plan for a single lesion in a single business day with QMP supervision/review and physician review.
- 2. Create a gamma-knife treatment plan for multiple lesions in a single business day with QMP supervision/review and physician review.
- 3. Create a linac-based SRS treatment plan for a single lesion in a single business day with QMP supervision/review and physician review.
- 4. Create a linac-based SRS treatment plan for multiple lesions in two business days with QMP supervision/review and physician review.
- 5. Setup an off-axis Winston-Lutz test.

Lung²⁹

Pretreatment

- 1. What clinical disease sites are treated with lung SBRT?
- 1. What does and fractionation schemes are used? Are fractionation schemes related to target position?
- 2. Describe the difference between free-breathing and 4DCT scans for simulation setup. ²⁶ ³⁰
- ^{2.} Describe the derived images from a 4DCT scan. Which one would be used for treatment planning?^{26,27}
- 3. What is the difference between an iGTV and an ITV?²⁸
- 4. Describe the rationale for when to use motion management for lung SBRT.²⁶
- How do you consider the interplay effect during treatment planning?²⁹
- 6. What are the clinical goal constraints used during treatment planning?
- Please describe the dose distribution in lung SBRT, including dose hot-spot and dose fall-off.³⁰
- 3. Describe the derived images from a 4DCT scan. Which one would be used for treatment planning?^{30,31}
- 4. What is the difference between an iGTV and an ITV?³²
- 5. Describe the rationale for when to use motion management for lung SBRT.³⁰
- 6. How do you consider the interplay effect during treatment planning?³³
- 7. What are the clinical goal constraints used during treatment planning?
- 8. Please describe the dose distribution in lung SBRT, including dose hot-spot and dose fall-off.³⁴
 - a. What is R50?
- 9. What secondary images are used in lung SBRT?
- 10. What and why is there a length recommendation for lung SBRT?

Treatment

- 1. Physiologically, what is the difference between inhale and exhale breath-hold for lung SBRT?
- 1. How does ABC work for gating?³¹
- 2. How does surface monitoring work for gating?²³
- 3. How does RPM block for gating?
- 4. When would you use breath-hold vs. passive gating?³²
- 5. Which phase would use choose for passive gating?
- 6. What is the difference between amplitude and phase gating?³²
- 7. How is fluoro used in lung SBRT?³³
- 2. How does ABC work for gating?³⁵
- 3. How does surface monitoring work for gating?²⁷
- 4. How does RPM block for gating?
- 5. When would you use breath-hold vs. passive gating?³⁶
- 6. Which phase would use choose for passive gating?
- 7. What is the difference between amplitude and phase gating?³⁶
- 8. How is fluoro used in lung SBRT?³⁷

Competency

- 1. Create a lung SBRT plan in a single business day with QMP supervision/review and physician review.
- 2. Describe the process for motion management in lung SBRT.
- 3. What is the process for a troubleshooting a challenging gating case at the machine.
- 4. Cover a gated lung SBRT with QMP supervision/review.

Upper Abdomen

Knowledge Factors

Pretreatment

- 1. What clinical sites are treated for upper abdomen SBRT?³⁴
- 1. What clinical sites are treated for upper abdomen SBRT?³⁸
- 2. What secondary imaging is needed for liver SBRT?
- 3. What secondary imaging is needed for pancreas SBRT?

- 4. What is the role of fiducials in upper abdomen?
- 5. What scans are acquired for upper abdomen SBRT?
- 6. What is the role of compression in upper abdomen SBRT?³⁵?³⁹
- 2. How do we account for inter- and intrafraction motion in upper abdomen SBRT?³⁶
- 3. Describe the role of target coverage sacrifice in upper abdomen SBRT?³⁷
- 7. How do we account for inter- and intrafraction motion in upper abdomen SBRT?⁴⁰
- 8. Describe the role of target coverage sacrifice in upper abdomen SBRT?⁴¹
- 9. What are the clinical goal constraints used during treatment planning?
- 10. What does the dose distribution typically look like?
- 11. What are the differences in dose conformality in liver vs. pancreas SBRT?
- 12. What dose and fractionation would you expect?

Treatment

- What is the expected amount of intra-fraction motion for abdominal organs?³⁸
- 1. What is the expected amount of intra-fraction motion for abdominal organs?⁴²
- 2. How do we evaluate treatment setup for upper abdomen SBRT?
- 3. What are the physiological considerations of breath-hold in upper abdomen SBRT?
- 4. When would you use diaphragm as a gating surrogate?
- 5. What gating surrogates are appropriate for pancreas SBRT and what are not?³⁹?⁴³
- What are the expected discrepancies in spinal column and target in upper abdomen SBRT?⁴⁰
- 6. What are the expected discrepancies in spinal column and target in upper abdomen SBRT?⁴⁴

Competency

- 1. Create an upper abdomen SBRT treatment plan within a given day with QMP supervision/review and physician review.
- 2. Cover an upper abdomen SBRT with QMP supervision/review.

Prostate⁴⁵

Knowledge Factors

Pretreatment

- 1. What secondary image is used for prostate SBRT? Why is this imaging needed?
- 1. What type of CT imaging is need for treatment setup?
- 2. What is the role of spaceOAR?⁴²?⁴⁶
- 3. Describe the dose and fractionation seen in prostate SBRT.
- Describe the requirements needed for margin reduction in prostate SBRT?⁴³
- 4. Describe the requirements needed for margin reduction in prostate SBRT?⁴⁷
- 5. What are the considerations needed for multiple target prostate SBRT?
- 6. How does conformality index, gradient margin, R50 change in the setting of prostate SBRT?

Treatment

- What is the role for fiducials in prostate SBRT?⁴⁴
- 1. What is the role for fiducials in prostate SBRT?⁴⁸
- 2. What type of anatomical issues result in patients not being able to receive treatment for prostate SBRT?
- 3. Why is stability of bladder filling important?
- 4. What type of rotation is most often needed in prostate SBRT? Why does this occur?

Competency

- 1. Create a prostate+node+bony met within 2 business days QMP supervision/review and physician review.
- 2. Cover a prostate SBRT case where re-setup is required.

Oligometastases

Knowledge Factors

Pretreatment

- 1. What is SABR-Comet?⁴⁵
- 2. What is the role of SBRT in oligometastatic disease?
- 3. Where can oligometastatic occur?
- 4. What is the role of re-treatment dosimetry in oligometastatic disease?^{46,47}
- 5. What considerations are needed treat single iso multi-met treatments?
- 1. What is SABR-Comet?⁴⁹
- 2. What is the role of SBRT in oligometastatic disease?
- 3. Where can oligometastatic occur?
- 4. What is the role of re-treatment dosimetry in oligometastatic disease?^{50,51}
- 5. What considerations are needed treat single iso multi-met treatments?

Competency

- 1. Provide re-treatment physics guidance on a clinical case with QMP supervision/review.
- 2. Create a spine SBRT treatment case within a single business day with QMP supervision/review and physician review.⁴⁸

Clinical Expectations

Gamma-Knife (3 weeks)

- 1. Observe 3 daily QAs on Gamma-Knife.
- 2. Observe 1 Gamma-Knife monthly and perform 1 Gamma-Knife monthly.
- 3. The expectation is that you are present in the Gamma-Knife suite for 80% of Gamma-Knife cases during these 3 weeks, observing at least 5 Gamma-Knife cases.
- 4. Independently plan 5 Gamma-Knife cases with QMP supervision/review.
- 5. Perform 5 secondary checks for Gamma-Knife cases with QMP supervision/review.
- 1. The resident will acquire TPR/OPF/Calibration data for 2 small collimator fields on the Gamma Knife platform
- 2. The resident will perform QA on the mechanical system, from localization to delivery giving quantitative analysis of the geometrical errors at each step of the process.

Linac-Based SRS/SBRT (5 weeks)

- 1. Observe 80% of all SBRT/SRS deliveries at the machine when scheduled during these 5 weeks, observing at least 10 lung cases (5 gated and 5 non-gated), 10 prostate, 5 brain, and 10 other various cases.
- 2. In the final 2 weeks of the linac-based SRS/SBRT rotation, the resident is expected to lead SBRT coverage with QMP supervision/review.
- 3. Plan at least 1 clinical SBRT case a week during these 5 weeks. All 5 cases must be a different treatment site. These will be with QMP and CMD supervision/review.

Please keep a detailed log of the coverage and planning on this rotation. This will be attached to this document.

	Date	Physicist Checking	Feedback
Linac-Based Presence			

Linac-Based Coverage		
Linac-Based Planning		

Practical Assignments -

Practical assignments are meant to help the clinic improve processes or implement new procedures. Practical assignments solidify clinical competency and teach residents how to approach clinical projects during their careers. You must complete at least 1 practical assignment during the course of your rotation. Please fill out Appendix X which describes your practical assignment.

- 1. Benedict SH, Yenice KM, Followill D, et al. Stereotactic body radiation therapy: the report of AAPM Task Group 101: Stereotactic body radiation therapy: The report of TG101. *Med Phys.* 2010;37(8):4078-4101.
- 2. Solberg TD, Balter JM, Benedict SH, et al. Quality and safety considerations in stereotactic radiosurgery and stereotactic body radiation therapy: Executive summary. *Pract Radiat Oncol.* 2012;2(1):2-9.
- 3. Lutz W, Winston KR, Maleki N. A system for stereotactic radiosurgery with a linear accelerator. *Int J Radiat Oncol Biol Phys.* 1988;14(2):373-381.
- 4. Das IJ, Francescon P, Moran JM, et al. Report of AAPM Task Group 155: Megavoltage photon beam dosimetry in small fields and non-equilibrium conditions. *Med Phys.* 2021;48(10):e886-e921.
- 5. Das IJ, Cheng CW, Watts RJ, et al. Accelerator beam data commissioning equipment and procedures: report of the TG-106 of the Therapy Physics Committee of the AAPM: TG-106: Accelerator beam data commissioning. *Med Phys.* 2008;35(9):4186-4215.
- 6. Klein EE, Hanley J, Bayouth J, et al. Task Group 142 report: quality assurance of medical accelerators. *Med Phys.* 2009;36(9):4197-4212.
- 7. Eagle A, Tallhamer M, Keener J, Geneser S. A simplified and effective off-axis Winston-Lutz for single-isocenter multi-target SRS. *J Appl Clin Med Phys.* 2023;24(2):e13816.
- 8. Rose MS, Tirpak L, Van Casteren K, et al. Multi-institution validation of a new high spatial resolution diode array for SRS and SBRT plan pretreatment quality assurance. *Med Phys.* 2020;47(7):3153-3164.
- 9. Khan FM, Gibbons JP. *Khan's the Physics of Radiation Therapy*. 5th ed. Lippincott Williams and Wilkins; 2014.
- 10. Petti PL, Rivard MJ, Alvarez PE, et al. Recommendations on the practice of calibration, dosimetry, and quality assurance for gamma stereotactic radiosurgery: Report of AAPM Task Group 178. *Med Phys.* 2021;48(7):e733-e770.

- 11. Dieterich S, Cavedon C, Chuang CF, et al. Report of AAPM TG 135: quality assurance for robotic radiosurgery: Report of AAPM TG 135. *Med Phys.* 2011;38(6):2914-2936.
- 12. Das IJ, Dawes SL, Dominello MM, et al. Quality and Safety Considerations in Stereotactic Radiosurgery and Stereotactic Body Radiation Therapy: An ASTRO Safety White Paper Update. *Pract Radiat Oncol.* 2022;12(4):e253-e268.
- 13. Luximon DC, Neylon J, Ritter T, et al. Results of an artificial intelligence-based image review system to detect patient misalignment errors in a multi-institutional database of cone beam computed tomographyguided radiation therapy. *Int J Radiat Oncol Biol Phys.* 2024;120(1):243-252.
- 14. Sharma M, Nano TF, Akkati M, Milano MT, Morin O, Feng M. A systematic review and meta-analysis of liver tumor position variability during SBRT using various motion management and IGRT strategies. *Radiother Oncol.* 2022;166:195-202.
- 15. Yu AS, Maxim PG, Loo BW Jr, Gensheimer MF. Chest wall dose reduction using noncoplanar volumetric modulated arc radiation therapy for lung stereotactic ablative radiation therapy. *Pract Radiat Oncol*. 2018;8(4):e199-e207.
- 16. Vergalasova I, Liu H, Alonso-Basanta M, et al. Multi-institutional dosimetric evaluation of modern day stereotactic radiosurgery (SRS) treatment options for multiple brain metastases. *Front Oncol.* 2019;9:483.
- 17. Suh JH. Stereotactic radiosurgery for the management of brain metastases. *N Engl J Med*. 2010;362(12):1119-1127.
- 18. Masitho S, Putz F, Mengling V, et al. Accuracy of MRI-CT registration in brain stereotactic radiotherapy: Impact of MRI acquisition setup and registration method. *Z Med Phys.* 2022;32(4):477-487.
- 19. Schiff D, Messersmith H, Brastianos PK, et al. Radiation Therapy for Brain Metastases: ASCO guideline endorsement of ASTRO guideline. *J Clin Oncol*. 2022;40(20):2271-2276.
- 20. Pappas EP, Seimenis I, Kouris P, et al. Target localization accuracy in frame-based stereotactic radiosurgery: Comparison between MR-only and MR/CT co-registration approaches. *J Appl Clin Med Phys.* 2022;23(5):e13580.
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- 22. Liu H, Thomas EM, Li J, et al. Interinstitutional plan quality assessment of 2 linac-based, single-isocenter, multiple metastasis radiosurgery techniques. *Adv Radiat Oncol*. 2020;5(5):1051-1060.
- 23, (Brain) Sebastian NT, Glenn C, Hughes R, et al. Linear accelerator-based radiosurgery is associated with lower incidence of radionecrosis compared with gamma knife for treatment of multiple brain metastases. *Radiother Oncol.* 2020;147:136-143.
- 23. Al-Hallaq HA, Cerviño L, Gutierrez AN, et al. AAPM task group report 302: Surface-guided radiotherapy. *Med Phys.* 2022;49(4):e82-e112.

- 24. Cullom ET, Xia Y, Chuang KC, et al. Single isocenter SRS using CAVMAT offers improved robustness to commissioning and treatment delivery uncertainty compared to VMAT. *J Appl Clin Med Phys*. 2021;22(7):36-43.
- 25. Ball D, Mai GT, Vinod S, et al. Stereotactic ablative radiotherapy versus standard radiotherapy in stage 1 non-small-cell lung cancer (TROG 09.02 CHISEL): a phase 3, open-label, randomised controlled trial. *Lancet Oncol.* 2019;20(4):494-503.
- 26. Brandner ED, Chetty IJ, Giaddui TG, Xiao Y, Huq MS. Motion management strategies and technical issues associated with stereotactic body radiotherapy of thoracic and upper abdominal tumors: A review from NRG oncology. *Med Phys.* 2017;44(6):2595-2612.
- 27. Tian Y, Wang Z, Ge H, et al. Dosimetric comparison of treatment plans based on free breathing, maximum, and average intensity projection CTs for lung cancer SBRT: Dosimetric comparison between FB, MIP, and AIP datasets. *Med Phys.* 2012;39(5):2754-2760.
- 28. Robinson CG, Xing L, Tanaka H, et al. Phase 3 study of durvalumab with SBRT for unresected stage I/II, lymph-node negative NSCLC (PACIFIC-4/RTOG3515). *J Clin Oncol*. 2023;41(16_suppl):TPS8607-TPS8607.
- 29. Edvardsson A, Nordström F, Ceberg C, Ceberg S. Motion induced interplay effects for VMAT radiotherapy. *Phys Med Biol.* 2018;63(8):085012.
- 30. Desai DD, Cordrey IL, Johnson EL. A physically meaningful relationship between R50% and PTV surface area in lung SBRT. *J Appl Clin Med Phys*. 2020;21(9):47-56.
- 31. Dawson LA, Eccles C, Bissonnette JP, Brock KK. Accuracy of daily image guidance for hypofractionated liver radiotherapy with active breathing control. *Int J Radiat Oncol Biol Phys.* 2005;62(4):1247-1252.
- 32. Mageras GS, Yorke E. Deep inspiration breath hold and respiratory gating strategies for reducing organ motion in radiation treatment. *Semin Radiat Oncol.* 2004;14(1):65-75.
- 33. Mageras GS, Yorke E, Rosenzweig K, et al. Fluoroscopic evaluation of diaphragmatic motion reduction with a respiratory gated radiotherapy system. *J Appl Clin Med Phys.* 2001;2(4):191-200.
- 34. Parikh PJ, Lee P, Low DA, et al. A Multi-Institutional Phase 2 Trial of Ablative 5-Fraction Stereotactic Magnetic Resonance-Guided On-Table Adaptive Radiation Therapy for Borderline Resectable and Locally Advanced Pancreatic Cancer. *Int J Radiat Oncol Biol Phys.* 2023;117(4):799-808.
- 35. Ferris WS, George B, Plichta KA, et al. Clinical experience with adaptive MRI-guided pancreatic SBRT and the use of abdominal compression to reduce treatment volume. *Front Oncol.* 2024;14:1441227.
- 36. Simoni N, Micera R, Paiella S, et al. Hypofractionated Stereotactic Body Radiation Therapy With Simultaneous Integrated Boost and Simultaneous Integrated Protection in Pancreatic Ductal Adenocarcinoma. *Clin Oncol* . 2021;33(1):e31-e38.
- 37. Eufemon Cereno R, Mou B, Baker S, et al. Should organs at risk (OARs) be prioritized over target volume coverage in stereotactic ablative radiotherapy (SABR) for oligometastases? a secondary analysis of the population-based phase II SABR-5 trial. *Radiother Oncol*. 2023;182(109576):109576.

- 38. Zhang Y, Balter J, Dow J, Cao Y, Lawrence TS, Kashani R. Development of an abdominal dose accumulation tool and assessments of accumulated dose in gastrointestinal organs. *Phys Med Biol*. 2023;68(7):075004.
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- 40. van der Horst A, Wognum S, Dávila Fajardo R, et al. Interfractional position variation of pancreatic tumors quantified using intratumoral fiducial markers and daily cone beam computed tomography. *Int J Radiat Oncol Biol Phys.* 2013;87(1):202-208.
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- 44. O'Neill AGM, Jain S, Hounsell AR, O'Sullivan JM. Fiducial marker guided prostate radiotherapy: a review. *Br J Radiol*. 2016;89(1068):20160296.
- 45. Palma DA, Olson R, Harrow S, et al. Stereotactic ablative radiotherapy for the comprehensive treatment of oligometastatic cancers: Long-term results of the SABR-COMET phase II randomized trial. *J Clin Oncol*. 2020;38(25):2830-2838.
- 46. Schröder C, Tang H, Lenffer B, et al. Re-irradiation to the prostate using stereotactic body radiotherapy (SBRT) after initial definitive radiotherapy A systematic review and meta-analysis of recent trials. *Clin Transl Radiat Oncol*. 2024;48(100806):100806.
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- 48. Younge KC, Marsh RB, Owen D, et al. Improving quality and consistency in NRG Oncology Radiation Therapy Oncology Group 0631 for spine radiosurgery via knowledge-based planning. *Int J Radiat Oncol Biol Phys.* 2018;100(4):1067-1074.

Summary of Resident's activities:				
Competency attained	yes	_no	-	

Mentor's Signature	Date
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6. Brachytherapy rotation (core, rotation #6)

Name of the Resident:		
Start date:	Completion date:	
Name of the Mentor:		

6A. Brachytherapy – (Basics and LDR)

A. Skills

- 1. Radiation Safety
 - a. Safe source handling
 - b. Time/distance/shielding
- 2. Radiation Dosimetry
 - a. Electrometer
 - b. Re-entrant well chamber
- 3. Treatment Planning
 - a. Dose prescription Written directive
 - b. Dose objectives DVH parameters

B. Knowledge Base

- 1. Radioactive Decay
 - a. Alpha
 - b. Beta
 - i. Electron capture
 - ii. Internal conversion
 - c. Gamma
- 2. Radioactive Sources Commonly Used in Radiotherapy
 - a. Radium
 - i. Decay
 - ii. Source construction
 - iii. Source specification
 - iv. Exposure rate constant
 - v. Applications
 - vi. Physical characteristics
 - b. Cesium-137
 - c. Cobalt-60
 - d. Iridium-192
 - e. Gold-198
 - f. Iodine-125
 - g. Palladium-103
 - h. Cesium-131
- 3. Calibration of Brachytherapy Sources
 - a. Specification of source strength
 - i. Activity
 - ii. Exposure rate at distance
 - iii. Equivalent mass of radium
 - iv. Apparent activity
 - v. Air Kerma strength

- b. Exposure rate calibration
 - i. Open-air measurements
 - ii. Well-type ion chambers
- 4. Calculation of dose distributions
 - a. Exposure rate
 - Sievert Integral
 - ii. Effects of inverse square law
 - b. Absorbed dose in tissue
 - c. Modular dose calculation model: TG-43
 - d. Isodose curves
- 5. Systems of Implant Dosimetry
 - a. Paterson-Parker
 - i. Planar implants
 - ii. Volume implants
 - iii. Paterson-Parker tables
 - iv. Determination of implant area or volume
 - b. Quimby
 - c. Memorial
 - d. Paris
 - e. Computer
- 6. Computer Dosimetry
 - a. Localization of sources
 - i. Orthogonal imaging method
 - ii. Stereo-shift method
 - b. Dose computation
- 7. Implantation Techniques
 - a. Surface molds
 - b. Interstitial therapy
 - c. Intracavitary therapy
 - i. Uterine cervix
 - ii. Uterine corpus
- 8. Dose Specification: Cancer of the Cervix
 - a. Milligram-hours
 - b. The Manchester System
 - i. Bladder dose
 - ii. Rectum dose
 - The International Commission on Radiation Units and Measurements System
 - i. Absorbed dose at reference points
- 9. Remote Afterloading Units
 - a. Advantages
 - b. Disadvantages
 - c. High-dose rate versus low-dose rate

C. Clinical Processes

- 1. Source Calibration check
 - a. HDR
 - b. LDR seed
- 2. Low Dose Rate Cesium-137 Implant (if available)
 - a. Dosimetry planning
 - b. Hand calculation (time)
- 3. Implant Dosimetry Hand Calculation

- a. Paterson-Parker tables
- b. Quimby System
- c. Memorial System
- d. Paris System
- 4. Eye Plaques (if available)
 - a. COMS (Collaborative Ocular Melanoma Study) protocol
 - b. Treatment planning/prescription
 - c. Seed ordering
 - i. Single Source Strength Assay
 - ii. Plaque construction
 - d. Plaque placement/recovery source disposal
- 5. Prostate Seed Implants
 - a. Volume Study
 - i. Ultrasound/ CT/MR imaging
 - ii. Volume estimate
 - iii. Contouring volume for planning
 - b. Treatment planning
 - i. Dose-volume constrained
 - ii. Nomogram based (if any)
 - c. Seed ordering
 - d. Source strength assay
 - e. Implant QA checklist
 - f. Implant Procedure
 - i. Seed sterilization
 - ii. Needle placement
 - iii. Seed placement
 - iv. Cystoscopy (seed recovery from bladder)
 - v. Recovery/disposal of waste seeds
 - g. Post Implant Dosimetry
 - v. CT-based planning/assessment
 - vi. Dose-volume parameters

Learning Opportunities:

The resident is expected to perform extensive reading of background materials.

- 1. Observe HDR source exchange. Participate in HDR source calibration check.
- 2. Observe and participate in LDR source calibration check measurements.
- 3. Write up solutions to the following exercises:
 - a. Hendee (reference 1) pg. 294: 12-4, 12-5 and 12-6.
 - b. Hendee pp 329-330: 13-1, 13-4, 13-5, 13-6, 13-8, 13-9, 13-12, 13-13, 13-14, 13-15. The resident is encouraged to write solutions to as many more of these problems in Chapter 13 as they desire.
 - c. Johns and Cunningham (reference 3) pg. 497: 8, 9, 10, 11, 14, 15, 16, 17.

Reading List:

- 1. Radiation Therapy Physics 3rd Ed, Hendee, Ibbott and Hendee, Chapter 1 (focus pp 8-19), Chapters 12 & 13, Chapter 15 (pp 399-408).
- 2. The Physics of Radiation Therapy, 3rd Ed, Khan, Chapters 1 & 2 (focus pp 20-23), Chapter 15, Chapter 17 (pp 444-447).
- 3. The Physics of Radiology (4th Ed.), Johns and Cunningham, Chapter 13.

- 4. Brachytherapy Physics, 2nd Ed (2005 AAPM Summer School Proceedings), Thomadsen, Rivard, Butler (Eds), Chapters 1, 2, 3, 4, 5 (Overview & Fundamentals), Chapters 12, 13 (Localization), Chapters 14, 15, 16 (Dosimetry).
- 5. Code of Practice for Brachytherapy Physics (Reprinted from Medical Physics, Vol. 24, Issue 10) (1997) Radiation Therapy Committee Task Group #56.
- 6. ICRU. Dose and volume specification for reporting intracavitary therapy in gynecology. ICRU Report No. 38 and No. 89.

Module: LDR Brachytherapy – Prostate Seed Implant (PSI)

<u>I. Objective</u>: This module intends to provide fundamental knowledge and sufficient practical experience for active competency in prostate seed implant

II. Didactic Activities:

	Task	Mentor Sign/Date
1.	Attend 5 hours of class for Brachytherapy provided in the physics residents' syllabus (if necessary).	
2.	Read Chapter 23 in Khan (3 rd ed.) for PSI overview. Submit following problems from Hence Chapter 13: 14, 15.	
3.	Read following AAPM Reports: TG-43, TG-64, TG-128, TG-137, TG-138	
4.	Review prostate seed device/applicator with physicist/therapists.	

III. Clinical Activities:

The resident will work with the therapist/physicist to observe and perform the steps listed in A and B below for the designated number of patients.

- A. Pre-treatment process:
 - Volume study via ultrasound
 - Target and normal tissue delineation
 - Pre-treatment plan for seed determination
 - Seed ordering with therapists
 - Seed assay and enter data into spreadsheet
- B. Treatment day planning process in operating room (OR):
 - Input seed data/patient information into treatment planning system
 - Plan/assist radiation oncologist with treatment plan
 - Ensure/verify seed inventory
 - Perform patient and room survey after procedure is complete
- C. Post-treatment activities:
 - Perform CT-based assessment
 - Perform final dose assessment

6A.1. Observed PSI Patient Cases (3):

	Case #1	Case #2	Case #3	
Patient Initials:				
Mentor sign:				
Date:				

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.)

6A.2. PSI Planned & OR Patient Cases (5):

	Case #1	Case #2	Case #3	Case #4	Case #5
Patient Initials:					
Mentor sign:					
Date:					

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.)

Reading List:

- 1. Collaborative Ocular Melanoma Study Group, "Collaborative Ocular Melanoma Study (COMS) randomized trial of I-125 Brach therapy for choroid melanoma", multiple COMS Reports. See Ed Pennington for copies.
- 2. Radiation Therapy Physics 3rd Ed, Hence, Abbott and Hence, Chapter 13 (focus pp 322-329).
- 3. The Physics of Radiation Therapy, 3rd Ed, Khan, Chapter 22 (HDR), Chapter 23 (Prostate Implants) and Chapter 24 (Intravascular Brachytherapy).
- 4. Brachytherapy Physics, 2nd Ed (2005 AAPM Summer School Proceedings), Thomason, River, Butler (Eds.), Chapter 6 (HDR), Chapter 7 (HDR QA), Chapters 28-33 (Prostate Brachytherapy) Chapter 34 (Eye plaques).
- 5. Code of Practice for Brachytherapy Physics (Reprinted from Medical Physics, Vol. 24, Issue 10) (1997) Radiation Therapy Committee Task Group #56.
- 6. Dosimeter of Interstitial Brachytherapy Sources (Reprinted from Medical Physics, Vol. 22, Issue 2) (1995) Radiation Therapy Committee Task Group #43.
- 7. Update of AAPM Task Group No. 43 Report: A revised AAPM protocol for Brach therapy dose calculations. Medical Physics, Vol. 31, Issue 3 (2004).
- 8. High Dose-Rate Brachytherapy Treatment Delivery (Reprinted from Medical Physics, Vol. 25, Issue 4) (1998) Radiation Therapy Committee Task Group #59.
- 9. Permanent Prostate Seed Implant Brachytherapy (Reprinted from Medical Physics, Vol. 26, Issue 10) (1999) Radiation Therapy Committee Task Group #64.
- 10. Dose Prescription and Reporting Methods for Permanent Interstitial Brachytherapy for Prostate Cancer (AAPM TG #137).
- 11. Report of the Task Group 186 on model-based dose calculation methods in brachytherapy beyond the TG-43 formalism: Current status and recommendations for clinical implementation (TG-186).

Assessment (rotation #6A):

The resident may require to prepare a written report summarizing their experiences and present this information to the physics faculty during an oral exam and/or give a presentation. This report will include any treatment planning results performed by the resident and overall understanding of the clinical procedure.

Summary of Resident's activities:			
Competency attained	yes	no	
Mentor's Signature		Date	

6B. Brachytherapy (HDR)

A. Skills

- 1. Brachytherapy Safety
 - a. Safe source handling
 - b. Time/distance/shielding
- 2. Brachytherapy Dosimetry
 - a. Exposure Rate Constant Formalism
 - b. Air Kerma Strength Formalism
- 3. Brachytherapy Treatment Planning
 - a. Dose prescription Written directive
 - b. Dose objectives DVH parameters

B. Knowledge Base

- 1. Source Exchange/Calibration & QA
- 2. Daily (day of treatment) QA
- 3. Applicator/catheter placement
- 4. Imaging for treatment planning
 - a. Orthogonal images
 - b. Reconstruction geometry
 - c. CT-based planning
- 5. Dose prescription/fractionation/rational
- 6. Treatment planning
 - a. Written Directive
 - b. Dose planning objectives
 - c. Critical structure doses
 - d. Treatment planning procedures
 - e. Treatment plan QA
- 7. Treatment delivery
 - a. Pre-treatment survey
 - b. Attach catheters/applicator
 - c. Authorized User/Medical Physicist requirements
 - d. Treatment progress assessment
 - e. Post-treatment survey
 - f. Recovery/remove catheters/applicator
- 8. Emergency procedures
 - a. Annual HDR safety training
 - b. Manual source retract
 - c. Stuck source
 - d. Patient safety

C. Clinical Processes

- 1. High Dose Rate Procedures
 - a. Vaginal (single and multichannel) Cylinder
 - b. Ring and Tandem; Venezia Applicator
 - i. Split-Ring & Tandem, Venezia Applicator
 - ii. MR-guided CT based volumetric planning
 - iii. Dose-volume constraint evaluation
 - iv. Bladder rectal dose points
 - v. Prescription dose (Point A)
 - vi. Dose optimization points

- vii. Treatment plan assessment
- viii. Treatment plan QA and physics 2nd check
- ix. Treatment Delivery and documentation
- x. Patient recovery
- c. Interstitial Implant
 - i. CT-based planning
 - ii. Dose-Volume assessment
 - iii. Manual plan/dose manipulation
- d. Endobronchial
 - i. Pre-planned treatment template
 - ii. Endoscopic-guided catheter placement
 - iii. Pre-treatment verification imaging
- e. MammoSite (partial breast irradiation, if available)
 - i. Prescription dose/fractionation/rational
 - ii. CT-based planning/assessment
 - iii. Point dose prescription/dwell time calculation
 - iv. Pre-treatment verification imaging

Learning Opportunities:

This rotation requires reading an extensive amount of background material.

Accompany the medical physicist during brachytherapy procedures at least one time for each of the following: prostate implant planning volume study, prostate implant treatment planning session, prostate implant procedure, prostate implant post implant dosimetry assessment, HDR vaginal cylinder (VC) placement procedure, HDR tandem and ovoid/ring (T&O/R) placement procedure, HDR VC/Venezia simulation and planning session, HDR T&O/R simulation and planning session, HDR VC treatment delivery, HDR T&O/R treatment delivery. Observe as many less frequently performed clinical cases as possible (endobronchial, MammoSite, interstitial implants).

Participate in the brachytherapy treatment planning with the qualified medical physicist for each of the following clinical cases: prostate implant, high dose rate tandem and ovoid/ring/Venezia, and high dose rate vaginal cylinder.

Perform the quarterly HDR QA and single source activity assays for prostate and eye plaque implants. Perform one set of hand calculation (following TG-43) for clinical sources and attend in HDR source exchange activities.

Module: Brachytherapy – High Dose Rate (HDR)

<u>I. Objective</u>: This module intends to provide fundamental knowledge and sufficient practical experience for active competency in high dose rate brachytherapy,

II. Didactic Activities:

	Task	Mentor Sign/Date
1.	Attend 6 hours of class for brachytherapy provided in the physics residents' syllabus (if necessary).	
	Read/review Chapter 15 in Khan (3 rd ed.) for brachytherapy overview, Section 18-5 in Modern Tech. of Radiation Oncology (Van Dyke, 1999).	
	Read following AAPM Reports: TG-41, TG-56 and TG-59.	
4.	Read ICRU 089	
5.	Submit following problems from Hendee – Chapter 12: 4, 5, and 6.	
6.	Review types of high dose rate applicators with physicist/therapists.	

III. Clinical Activities:

The resident will work with the therapist/physicist to observe and perform the steps listed in A and/or B below for the designated number of patients.

A. Intracavitary HDR (Vaginal Cylinder, Split-ring & Tandem, Venezia, Ring& Tandem, Simon-Hyman Capsules, Mammosite, etc.):

Pre-treatment activities

- Observe CT scan
- Import CT scan into Oncentra treatment planning system
- Perform/assist in critical structure contouring
- Generate optimized plan

Treatment day(s) activities

- Verify optimized plans
- Verify treatment parameters including time and activity (after 1st fraction)
- B. Interstitial HDR (Syed, Venezia, etc):

Pre-treatment activities

- Observe CT scan
- Import CT scan into Oncentra treatment planning system
- Perform/assist in critical structure contouring
- Generate treatment plan
- Check the plan using TG-43 formulation

Treatment day(s) activities

- Verify treatment parameters including time and activity (after 1st fraction)
- C. Other types of HDR brachytherapy cases, which occur less frequently, can be observed as well. These cases can be substituted for one of the observed cases.

6B.1. Observed HDR Patient Cases (5):

	Case #1	Case #2	Case #3	Case #4	Case #5
Case Type:					
Patient Initials:					
Mentor sign:					
Date:					

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.)

6B.2. **Planned HDR Patient Cases (10)** (expected to have at least one multichannel cylinder, one Ring & tandem (SplitRing), one Syed or Simon-Heyman capsule, and two Venezia case):

	Case #1	Case #2	Case #3	Case #4	Case #5
Case Type:					
Patient Initials:					
Mentor sign:					
Date:					

	Case #6	Case #7	Case #8	Case #9	Case #10
Case Type:					
Patient Initials:					
Mentor sign:					
Date:					

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.)

IV. Quality Assurance/Calibration/Safety for HDR

The resident will work with the special procedures therapist/physicist to perform the daily QA. The resident will work with the physicist to actively participate in tasks associated with the monthly QA, the source exchanges, and other related activities. The resident will also attend at least one of the scheduled HDR safety training sessions proctored by the Nucletron/Elekta field service engineer.

Tasks:	Case #1	Case #2	Case #3	Case #4
Daily QA				
Monthly/Quarterly QA			N/A	N/A
Source Exchange:			N/A	N/A
Console Update:			N/A	N/A
Oncentra Update:			N/A	N/A
RadCalc Update:			N/A	N/A
Emergency/ Safety Training:			N/A	N/A

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.)

Assessment (rotation #6B):

The resident may require to prepare a written report summarizing their experiences and present this information to the physics faculty during an oral exam and/or give a presentation. This report will include any treatment planning results performed by the resident and overall understanding of the clinical procedure.

Summary of Resident's activities:						
Competency attained	yes	_no				
Mentor's Signature		Date				

7. Radiation Safety and Protection (core, rotation #7)

Name of the Resident:	
Start date:	Completion date:
Name of the Mentor:	
Prerequisite Skills	

None

General Radiation Safety

General Knowledge Factors – these will be discussed during the rotation

Application of Basic Principles

- 1. Discuss specific examples of how the three basic principles of radiation safety time, distance, shielding are applied in the Radiation Oncology environment.
- 2. What policies and procedures prevent accidental patient, staff or visitor exposure at the linac vault? The HDR Suite?
- 3. Identify sources of radiation exposure in a hospital relevant to Radiation Oncology staff. Include OR and interventional or diagnostic procedures we may be involved in. What are the relative exposure risks?

Regulatory

1.

Hospital Radiation Safety Office

A. **Skills**

- a. Interpretation of architectural drawings
- b. Survey meter operation (x-ray and neutrons)
- c. Use of spreadsheet for data analysis

Knowledge Base В.

- a. Understand radiation safety principles
- b. Understand dose limits/regulatory requirements
- c. Understand barrier material composition and preferences
- d. Understand process of neutron production
- e. Barrier HVL/TVL values
- f. Methodology of barrier thickness computation
- g. Understand differences between head leakage, scatter and primary radiation

Clinical Process C.

- a. Apply radiation safety principles to situations found in a radiation oncology clinic
 - i. Time-Distance-Shielding
 - ii. Brachytherapy safety and source accountability
 - iii. Operational safety practices for linac, CT, PET, and HDR
 - iv. Patient safety
- b. Identify allowable radiation limits for occupational workers and members of the public

- c. Identify/define controlled areas vs. non controlled areas
- d. Identify sources of radiation exposure found in typical radiation therapy facility
- e. Compute workloads
 - i. Accelerator
 - ii. HDR
 - iii. CT simulator
- f. Understand radiation protection design factors (occupancy, use, workload, etc.)
- g. Calculate barrier thickness
- h. Measure actual exposure outside treatment vault
- i. Review the shielding considerations for HDR treatment room, Gamma Knife Treatment room, CyberKnife treatment room and Proton Beam treatment room

D. Learning opportunities

- a. The resident will demonstrate to the mentor that he/she has developed a solid grasp of radiation safety practices that need to be implemented in a typical radiation oncology facility.
- b. Compute barrier thicknesses for a typical linear accelerator room layout.
- c. Initial and final linac vault survey
- d. Optional: Patient specific shielding design (i.e., fetal dose reduction)

Reading list

- 1. NCRP Report 151
- 2. The Physics of Radiation Therapy, 3rd ed., Khan, Ch. 16
- 3. Ohio Dept of Health Regulations (http://www.odh.ohio.gov/rules/final/finalRules.aspx)
- 4. Shielding Techniques, 2nd ed McGinley
- 5. AAPM task group 32 Fetal Dose
- 6. M.T. Masden, et al. AAPM Task Group 108: PET and PET/CT Shielding Requirements. Medical Physics, 33(1): 2006.)
- 7. Radiobiology for the Radiologist (Hall Textbook Chapter 8, 10, 17).
- 8. TG 108: PET and PET/CT Shielding Design

Assessment (rotation #7):

The resident will compile a report describing the individual steps that were taken to perform the shielding design and analysis for the linear accelerator vault. This report should be written as if the intended recipient was the architect in charge of designing the facility and/or a state inspector. While the bulk of this rotation involves a shielding design project, the resident's overall understanding of radiation safety will be evaluated during this rotation. Radiation safety training is a continuous process throughout the 2-year rotation, and residents should attend these trainings when available (HDR, Gamma Knife, etc). The resident will take an oral exam and/or give a presentation at the conclusion of the rotation.

General Activities (rotation #7):

- 1. Perform radiation room shielding design for a newly installed linac (including calculations)
- 2. Perform initial and final room shielding survey (x-ray/neutron)

- 3. Observe Radiation Safety (receiving radioactive materials, radiation monitoring, etc)
- 4. Attend at least 2 QA/QI Meetings (department meetings)
- 5. Attend at least 2 Radiation Safety Quarterly meetings (Radiation Safety/QA/X-ray safety)6. Review ODH regulations covering Room Shielding Design (3701:1-67)

Summary of Resident's activition	es:			
Competency attained	yes	no		
Mentor's Signature]	Date		

8. Physicist of the Day (POD) rotation (core, rotation #8)

Name of the Resident:		
Start date:	Completion date:	
Name of the Mentor:		

<u>I. Objective</u>: Provide the resident with the fundamental knowledge and practical training for proficiency with day-to-day clinical operations as the floor physicist. Resident will perform all tasks under the supervision of a senior physicist.

II. Clinical Activities:

The resident will work with the designated floor physicist of the day on the activities listed below:

- A. Under the supervision of the senior physicist, assist with clinical issues that arise during the treatment day (linac issues, plan/dosimetry issues, CT-Sim issues, SBRT delivery issues, etc.), prepare and review PHY SMPC as needed. It also includes the activities performed by the current service line physicist(s).
- B. Daily Quality Assurance: Review morning machine quality assurance data for all treatment units and identify any parameters outside of specification.
- C. Complete at least 30 initial treatment plan/chart checks. All initial and plan checks are to be logged and recorded by residents, and will be a final signoff by mentor to show competency/independence to perform initial & plan checks
 - a. Review & perform plan check procedures for RayStation
 - b. Review & perform dose composite reports, EQD2 calculations, and SMPC constraints
 - c. Review and perform initial chart check procedure including secondary MU calcs, SMPCs, and IMRT OA documentation.
 - d. Shadow and perform these with a variety of QMPs
 - D. Complete at least 50 weekly treatment plan/chart checks
 - a. Overall check of chart for completeness & signatures
 - b. Check fractions treated & dose site summary
 - c. Check the tolerance table values in Mosaiq compared those found in the treatment chart.
 - d. Check and review CBCT imaging
 - E. Complete at least 10 final physics checks
 - a. Work through Final Physics Checks spreadsheet with senior physicist
 - F. Review the billing procedure for the variety of checks, including how to link charges to Epic (billing to be done by senior physicist)

<u>Note</u>: It is the responsibility of the resident to track (by spreadsheet) work associated with the items above. For a given chart check, annotate the type of chart check, date, patient initials, MRN, and senior physicist reviewing the work

I. Special Project

- Working with mentor to find a clinical improvement project to either enhance a clinical workflow or to further improve patient care.
- Cover reading list & lectures with mentor
- Perform a "final" signoff/credentialling of plan checks, initial checks, and weekly checks to show
 competency with performing these independent. This will be organized and arranged by the mentor and
 competency forms will be signed at the end of the rotation by mentor and clinical chief of physics.
- Submit log of all plan checks, initials, weeklies, and final physics checks to mentor & residency directory.

J. Reading List:

- 1. Physicist of the Day Document
- 2. AAPM TG 218/219: Secondary MU Calculations & IMRT QA
- 3. AAPM TG 275: Plan and Chart Check Review
- 4. AAPM MPPG 11A: Plan and Chart Check Review
- 5. AAPM TG-100: FMEA Analysis in Radiotherapy
- 6. AAPM TG 203: CIED (updated to TG-34)
- 7. Review functionality of Mosaiq, DailyQA3, and RadCalc

Final Assessment (Plan Check) - One-on-One Review with Mentor & Performed by Resident

RayStation Plan Check Workflow	What to review with Mentor	Competency?
Patient Data Management	Review importance of: Patient demographic info, CT info/considerations (CT slices, scan type, density curves)	
Patient Modeling	Review importance of contour checks (OARs/Targets), bolus/FLASH, localization points	
Plan Design	Review importance of: dose grids, prescription checks, beam/machine technical information, control points, setup fields, CIAO	
Plan Evaluation	Review importance of: clinical goals, SBRT plan evaluation (each of the main disease sites), what to look out for as far as plan issues go, Prior RT considerations/constraints	
Other	Review what to cross check between Mosaiq & RayStation, review planning limitations with Versa/TrueBeam/Edge, when is collision is a concern, and other technical aspects	

Final Assessment (Initial/Weekly Checks) - One-on-One Review with Mentor & Performed by Resident

Mosiaq Chart Check Workflow	What to review with Mentor	Competency?
D&I	Review importance of: Prescription versus TPN, Individual Field data and differences between Versa & TrueBeam, Site setup and considerations	
RO Treat	Review how to do patient scheduling, how to schedule muti-iso, how to handle partial treatments, and different color indicators	
Assessments	Review importance of SSD measurements and why we do it weekly, where to check for machine QA and how to address failures/conditional pass	
Images	Review importance of: correct CT information, how DRR association is done, and other considerations with site setup	
Documents	Review important documents for us as physicist (TPN, ICD, SMPCs, etc), and what to check during plan/initial chart check	

Assessment (rotation #8):

The resident's performance will be evaluated based on his/her understanding and confidence of handling clinical situations, behavior and relationship with other clinical staff and patients. The resident will take an oral exam and/or give a presentation at the conclusion of the rotation.

Summary of Resident's activities:				
Competency attained	yes	no		
Mentor's Signature		Date	 	

9. Proton Therapy (core, rotation #9)

Name of the Resident:		
Start date:	Completion date:	
Name of the Mentor:		

I. Objective: This module intends to provide fundamental knowledge and sufficient practical experience for active competency in Proton Therapy Procedures.

A. Prerequisite Skills

- a. Experienced in QAs with linear accelerator
- b. EBRT with photons and electron beams
- c. MU calculation (TPR, PSF, CF, ISF) for EBRT treatments
- d. Use of ion chamber/electrometer/diodes/MOSFETs/Planar array detector/scanning water phantom
- e. Film dosimetry
- f. Knowledge of TG142
- g. Treatment planning for photon and electron beams

B. Knowledge Base

- a. Physics in proton therapy
- b. Dosimetry protocol for proton therapy (TRS-398), (TG-224)
- c. Uncertainties in proton therapy with emphasis on passive scattering technique
- d. Stoichiometric Calibration Curve.
- e. Passive PT and Scanning PT dosimetry.
- f. Detectors for Proton dosimetry and Shielding
- g. Compensator design and manipulation of compensator in plan optimization
- h. Patient immobilization
- i. Treatment Planning
 - i. Image fusion
 - ii. Delineation of anatomical structures
 - iii. Beam setup and compensator design
 - iv. Dose computation
 - v. Dose verification and analysis
- j. Delivery techniques

C. Clinical Process

- a. Beam data acquisition
 - i. Raystation data acquisition requirements for the Mevion S250 system
- b. Planning system commissioning
 - i. Enter beam data into planning system *
 - ii. Beam modeling
 - iii. Verify planning system beam data
- c. Treatment planning
 - i. Perform image fusion
 - ii. Create single isocenter plan
 - 1. Identify gantry angle/couch limitations
 - iii. Create multiple isocenter plan (composite or CSI)
 - 1. Explain isodose line normalization

- 2. Explain isodose line prescription
- d. Plan Export to R&V
 - i. Transfer RT ion plan, RT structures, Dose prescription, DICOM CT and orthogonal DRRs to Mosaiq
 - ii. Ordering hardware (apertures and compensators)
 - iii. Perform patient specific QA
 - (a) QA of apertures and compensators
 - a. Output factor measurements and MU second check
 - b. Verification of planar dose
- e. Geometrical Alignment
 - i. Patient Position
 - ii. Patient Immobilization
- f. iii. Verify alignment using laser, orthogonal x rays with VerityDelivery (observe or assist RTT)
 - i. Identify patient safety precautions
 - ii. Observe patient setup and treatment procedures
 - iii. Review or verify treatment completion & documentation

II. Didactic Activities:

	Task	Mentor Sign/Date
1.	Attend 3.0 hours of class for Proton Therapy provided in the physics residents' syllabus.	
2.	Read Chapter 26 in Khan (4 th ed.).	
3.	Read AAPM Reports: TG 224	
4.	Read book "Proton and Charged Particle Radiotherapy", by DeLaney and Kooy	
5.	Read book "Proton and Charged Particle Radiotherapy", by Harald Paganetti	
6.	Read "Symposium on the promise and perils of proton radiotherapy" (L:\physics\RedidentTeaching\Proton\Symposium2008)	

III. Clinical Activities:

The resident will work with a proton physicist to perform the steps listed in A-B below for the designated number of patients.

- A. Treatment planning activities:
 - Contouring (all to be reviewed by senior physicist/attending physician)
 - Setup beams
 - Compute dose as per prescription
 - Handling of uncertainties
 - Perform patient-specific plan QA
 - Perform initial plan check (to be reviewed and approved by senior staff physicist)
- B. Treatment day activities:
 - Assist with treatment patient set-up in room for the VSIM
 - Assist therapists with collision checks (if necessary)
 - Prepare SMPC for physicist review and signature (if applicable)
 - Observe the treatment (1st fraction)

Perform final physics check on chart

For each set of cases (Observed and Planned), at least three different anatomical sites must be included in the five documented cases.

Observed Patient Cases:

	Case #1	Case #2	Case #3	Case #4	Case #5
Case Type:					
Patient Initials:					
Mentor sign:					
Date:					

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.)

Planned and Delivered Patient Cases:

	Case #1	Case #2	Case #3	Case #4	Case #5
Case Type:					
Patient Initials:					
Mentor sign:					
Date:					

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc).

IV. Quality Assurance/Calibration/Safety

The resident will work with the therapist/physicist to perform the daily QA. The resident will work with the physicist to actively participate in tasks associated with the monthly QA and annual QA.

Tasks:	Case #1	Case #2	Case #3	Case #4
Daily QA				
Monthly QA			N/A	N/A
Review output factor measurements:		N/A	N/A	N/A
Review annual calibration/ QA:		N/A	N/A	N/A
Receive safety training:		N/A	N/A	N/A

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.).

Assessment (module #9):

Summary of Resident's activities:				
Competency attained	yes	no		

Mentors Signature _____ Date ____

The resident will provide a written report of learning experience about Proton Therapy. The report should also contain data acquired through measurements or experiment as well as analysis thereof. Finally, the resident will take an oral exam and/or give a presentation at the end of the rotation. An understanding of the principles behind the processes as well as comprehension of other relevant information from the reading lists must be demonstrated.

10. Professionalism and Ethics (core, rotation #10)

Name of the Resident:		
Start date:	Completion date:	
Name of the Mentor:		

A. Skills

- a. Ability to interact with medical colleagues and patients in a professional manner
- b. Technical, personal, and professional skills required to represent a radiation oncology program during an inspection/audit by IROC, The Joint Commission, or a state or federal regulatory agency.

B. Knowledge Base

- a. NRC, state regulations and rules governing radiation oncology
- b. Institutional technical requirements for participation in multi-institutional clinical trials governed by NRG Oncology, IROC, and other cooperative trials organizations
- c. Compliance requirements common to U.S. healthcare providers, The Joint Commission, and other accrediting organizations
- d. Knowledge of HIPAA requirements relevant to the medical physicist
- e. Understand the ethical issues of human and animal research
- f. Understand professional issues related to vendors, coworkers, and medical peers
- g. Understand legal and ethical issues involved in medical error evaluation and reporting

C. Learning opportunities

- a. The resident will demonstrate to the mentor that he/she has developed a solid understanding of the professional, legal, and ethical issues related to radiation therapy.
- b. The resident will review medical error case studies, and gain an understanding of the failure modes common to many previous technical medical accidents in the field of radiation therapy.

Clinical Activity

The resident will participate in an Ohio Department of Health Bureau of Radiation Protection inspection. Participation includes being present for and possibly assisting the staff physicists during the inspection process. The inspection may be at any campus, covering either radioactive materials or radiation generating equipment. This requirement may be satisfied any time during the residency, but is a requirement for rotation completion unless waived by the rotation mentor or program director.

1.) OSLD IROC dosimetry check

Highly recommended when available:

1. IROC phantom study

Online Training

Residents are required to complete the following online training modules. Certification of completion should be submitted to the rotation mentor.

- 1. Collaborative Institutional Training Initiative (CITI) modules, accessed through UH's Clinical Trial Unit.
- 2. American Board of Radiology Foundation (ABRF) online modules on ethics and professionalism issues. The modules are accessed through the AAPM website at http://www.aapm.org/education/onlinemodules.asp:
 - a. Historical Evolution and Principles of Medical Professionalism
 - b. Physician/Patient/Colleague Relationships
 - c. Personal Behavior, Peer Review, and Contract Negotiations with Employers
 - d. Conflict of Interest
 - e. Ethics of Research
 - f. Human Subjects Research
 - g. Relationships with Vendors
 - h. Publication Ethics
 - i. Ethics in Graduate and Resident Education
 - j. Professionalism in Everyday Practice; The Physician Charter

Reading list

- 1. NRG Oncology and NCI
 - a. https://www.nrgoncology.org
 - i. Includes links explaining the mission of NRG Oncology, and links to oncology protocols.
 - b. http://www.cancer.gov/research/areas/clinical-trials/nctn
 - i. An overview of the National Clinical Trial Network with links to additional information.
- 2. The Joint Commission
 - https://www.jointcommission.org/assets/1/6/Accreditation Guide Hospitals 2011.pdf
- 3. The Joint Commission Accreditation Guide for Hospitals, pages 1-14
- 4. HIPAA: The Health Insurance Portability and Accountability Act https://www.healthit.gov/sites/default/files/pdf/privacy/privacy-and-security-guide.pdf
- 5. Guide to Privacy and Security of Electronic Health Information, Chapters 1-4
- 6. Code of Ethics for the American Association of Physicists in Medicine (revised): report of Task Group
- 7. NRG Protocol (to be determined at the time of rotation).

Assessment (rotation #10):

The resident will take an oral exam and/or give a presentation at the conclusion of the rotation. The resident should be able to demonstrate knowledge of these processes and other relevant information obtained from the reading lists.

The resident will also submit paperwork certifying satisfactory completion of:

- 1. The Collaborative Institutional Training Initiative (CITI) modules, or equivalent, and
- 2. The AAPM (ABRF) Online Modules on Ethics and Professionalism.

Summary of Resident's activities:				
		_		
Competency attained	yes	no		
Mentor's Signature	Date_		 	

11. Advanced Imaging Guided Machines and Adaptive Radiotherapy (AIM-ART) Rotation

Resident:	 Session:	
Mentor:		

Knowledge Factors – These will be discussed during the comprehension.

Advanced Imaging Guided Machines

Linac Design[1,2]

- 1. Describe the differences between Ethos and Halcyon.
- 2. What is the difference between the Halcyon/Ethos and a TrueBeam or Edge?
- 3. Please describe the beamlines for ViewRay, Unity, and Ethos.
- 4. What is unique about the beamlines for MR-linacs.
- 5. What is unique about the ViewRay and Ethos MLC design? How does that compare to the Unity MLC design?
- 6. How is dose deposited with MR-linacs. How does this change with magnetic field strength?
- 7. Please describe MRI safety as it relates to vault construction and treatment console area.

Linac IGRT[3-5]

- 1. What is the difference between the HyperSight imaging panel and the standard Varian TrueBeam panel?
- 2. Please describe the imaging geometry for Ethos/Halcyon.
- 3. Please describe the differences in the MRI imaging in the Unity and ViewRay.
- 4. What special setup considerations are needed for MRI imaging on an MR-linac?
- 5. What are the geometric implications when using an MR-linac?
- 6. How does MLC/Gantry movement effect imaging on an MR-linac?
- 7. How is MRI cine motion management conducted on an MR-linac?
- 8. Please describe the algorithm and latency tests needed for this evaluation.
- 9. What are some of the ways we perform periodic QA on imaging devices? What test do we need to do?

Linac Acceptance Testing

- 1. What additional testing will be needed during acceptance for these machines?
- 2. Walk through acceptance documents of Ethos & ViewRay.

Linac Commissioning

- 1. What is some equipment you need to commission these linacs? What are some pros and cons of different detectors you might need?
- 2. Specifically, what considerations are needed when measuring dose in a magnetic field?
- 3. Please describe methods for setting up ion chambers in bore-style systems.

Linac Quality Assurance

- 1. Please describe how QA is different for these machines compared to standard C-arm machines.
- 2. Please describe the imaging QA for MR-linacs.
- 3. Please describe the imaging QA for HyperSight direct CBCT calculations.
- 4. Please describe how TG-51 is different.
- 5. Please describe motion management QA for MR-linacs.

General Adaptive Knowledge Factors[6–8]

- 1. What is offline adaptive radiotherapy?
- 2. What is online adaptive radiotherapy?
- 3. What is real-time adaptive radiotherapy?
- 4. What is the difference between fixed interval, triggered, serial, and cascade ART?[9]
- 5. Understand the clinical rationale for adaptive radiotherapy?
 - a. Target response
 - **b.** Margin reduction
 - c. Dose escalation
 - d. Temporal feathering
 - e. Interfraction motion
 - **f.** Intrafraction motion
 - g. Clinical efficiency
- 6. What is isotoxic sparing?[10]
- 7. Be able to describe the online-adaptive radiotherapy process.
 - a. ViewRay
 - **b.** Ethos
 - c. Unity
- 8. What is direct-to-unit adaptive radiotherapy?[11]
- 9. Discuss the failure modes of online adaptive radiotherapy?[12]
- 10. Understand the pros and cons of each modality used for adaptive radiotherapy.[13,14]
 - a. Imaging
 - b. Contour delineation
 - c. Treatment planning
 - d. Motion management
 - e. Adaptive QA
 - f. Treatment
 - g. Dose tracking
- 11. Describe the method of contouring in ART.[15,16]
- 12. Please describe methods to handle dose accumulation in adaptive radiotherapy.
- 13. Describe advanced methods to handle prior treatment in ART.
- 14. How do you commission an adaptive radiotherapy program?[17,18]
- 15. Describe QA for ART.[19–24]

AIM-ART Clinical Knowledge Factors

Pancreas[25,26]

- 1. What is the clinical rationale for pancreas ART?
- 2. What are the OARs, expected movement, and dose limits for pancreas ART?
- 3. What are the common areas contour errors in pancreas ART?
- 4. Describe plan construction for pancreas ART.
- 5. Describe motion management techniques for pancreas ART.
- 6. Describe the differences soft-tissue visualization for pancreas?
- 7. Does MRgRT mean you do not need ART for pancreas?

Prostate[27–29]

- 1. What is the clinical rationale for prostate ART?
- 2. What are the OARs, expected movement, and dose limits for prostate ART?
- 3. What are common areas for contour errors in prostate ART?
- 4. What are the motion management challenges in prostate ART?
- 5. Describe margin reduction attempts in prostate using MRgRT.
- 6. How do patient instructions change in prostate ART?
- 7. Where is prostate ART most likely not advantageous?

Bladder[30,31]

- 1. What is the clinical rationale for bladder ART?
- 2. What are the OARs, expected movement, and dose limits for bladder ART?
- 3. What are common areas for contour errors in bladder ART?
- 4. What are the motion management challenges in ART? Specifically intrafractional motion.
- 5. Describe margin reduction attempts in bladder using MRgRT.compared to CBCTgRT. Does MRgRT give you an advantage?

Breast[32,33]

- 1. Describe margin reduction using AIM-ART for breast.
- 2. What is the clinical rationale for breast ART?
- 3. What are the OARs, expected movement, and dose limits for breast ART?
- 4. What are common areas for contour errors in breast ART?
- 5. What are the motion management challenges in breast ART?
- 6. Describe margin reduction attempts in breast using MRgRT.compared to CBCTgRT. Does MRgRT give you an advantage?

Lung[34,35]

- 1. What are the dose calculation considerations for lung treatment using an MRgRT and CBCTgRT?
- 2. What is the clinical rationale for lung ART?
- 3. What are the OARs, expected movement, and dose limits for lung ART?
- 4. What are common areas for contour errors in lung ART?
- 5. What are the motion management challenges in lung ART? MRgRT cine vs Ethos methods.

Head and Neck[36]

- 1. What are the dose calculation considerations for HnN treatment using an MRgRT and CBCTgRT?
- 2. What is the clinical rationale for HnN ART?
- 3. What are the OARs, expected movement, and dose limits for HnN ART?
- 4. What are common areas for contour errors in HnN ART?
- 5. Discuss the margin reduction techniques in HnN ART.

<u>Direct-to-Unit[11,37–39]</u>

- 1. What are the dose calculation considerations for DTU treatment using an MRgRT and CBCTgRT?
- 2. What is the clinical rationale for DTU ART?
- 3. What are challenges associated with DTU ART?
- 4. What are common areas for errors in DTU ART?
 - a. Contour
 - b. Imaging
 - c. Communication
- 5. Discuss the setup techniques in DTU ART and the potential for reproducibility challenges.

Clinical Requirements – These need to be completed during your rotation. Please work with various members of the physics/dosimetrists team to accomplish.

- 1. You must be able to complete three patient's plan from dosimetry contour to precheck with minimal assistance on an adaptive clinical or emulator patient on the Ethos system for both prostate and abdomen.
- 2. You must be able to solo cover 3 clinical or emulator adaptive radiotherapy sessions with minimal physics input on the Ethos System for both prostate and pancreas.
- 3. Fill out the credentialling sheet used for clinical coverage.

Coverage Timeline:

- Week 1: Observe adaptive contouring and practice contouring. In charge of Mobius upload.
- Week 2: In charge of kidney, canal, femurs, and bladder, and timeout. Review practice contours with physicist and physician.
- Week 3: In charge of target alignment. In charge of adaptive coverage note.
- Week 4: In charge of large bowel and colon sigmoid.
- Week 5: In charge of post ART imaging review.
- Week 6: Equally collaborate with faculty physicist during adaptive process.
- Week 7: In charge of running adaptives with supervision.
- Week 8: In charge of instructing faculty physicist during adaptives.

Planning Timeline:

- Week 1: Observe planning, plan checks, and initial checks.
- Week 2: Observe planning, plan checks, and initial checks.
- Week 3: Observe planning, plan checks, and initial checks.
- Week 4: Supervised planning, plan checks, and initial checks.
- Week 5: Supervised planning, plan checks, and initial checks.
- Week 6: Supervised planning, plan checks, and initial checks.
- Week 7: Lead plan checks, and initial checks.
- Week 8: Lead plan checks, and initial checks.

Practical Assignments (These will change based on resident and clinical needs) –

Task 1. Please perform literature review of 5 adaptive papers published in 2024-2025 and write a report.

Task 1. Please develop a troubleshooting method for pancreas adaptive planning that includes multiple OAR intersection planning.

Task 2. Please organize all current procedures for Ethos, identify, and create needed procedures.

Task 3. Develop a powerpoint presentation discussing the process and failure modes of adaptive radiotherapy. This will be a 20 minute presentation with 10 minutes for questions.

Literature Review – All bolded texts are required readings.

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12. Special Procedures rotation (elective, rotation #12)

Name of the Resident:		
Start date:	Completion date:	
Name of the Mentor:		

A. Prerequisite Skills

- a. Radiation Safety X-ray machine operation
- b. Human Anatomy common bony landmarks
- c. Introductory MV Imaging
- d. Introduction to custom shielding used in Radiation Therapy.

B. Knowledge Base

- a. Clinical Basis for TBI
- b. Equipment
- c. Dosimetry issues in TBI
 - i. Field uniformity
 - ii. Beam energy/penetration
 - iii. Blocking
- d. Beam Data for TBI -hand calculations

C. Clinical Processes

- a. Simulation and Custom Block management
- b. MU calculations
- c. In-vivo dose measurement
- d. Custom compensation

D. Commissioning of a TBI Program

Learning Opportunities

- 1. Observe/attend a TBI simulation, Fabricate the blocks under supervision; verify the block attenuation on the machine.
- 2. Collect sufficient TBI beam data to perform hand calculations.
- 3. Perform measurements to determine efficacy of the current TBI flattening filter.
- 4. Attend/observe in-vivo dose measurement for TBI. Perform hand calcs and compare to MOSFET results.

Assessment

The resident will provide a written report of principles and process of Total Body Irradiation with an overview and detailed descriptions of the relevant underlying principles for each major step. Some emphasis should also be placed on practical issues in establishing a TBI program. The report should also contain data acquired through measurements or experiment as well as analysis thereof. Finally, an understanding of the principles behind the processes as well as comprehension of other relevant information from the reading lists must be demonstrated in an oral exam and/or a presentation.

Clinical Competency: Total Body Irradiation (TBI)

<u>I. Objective</u>: Provide the resident with the fundamental knowledge and practical training for proficiency in the Total Body Irradiation (TBI).

II. Didactic Activities:

	Task	Mentor Sign/Date
1.	Review/read Chapter 18 in Kahn (3 rd ed.), AAPM Report 17 (TG-29), Chapter 17A in Modern Technology of Radiation Oncology (Van Dyke, 1999).	
2.	Attend 1.5 hours of class provided in physics residents' syllabus.	

III. Clinical Activities:

The resident will work with one of the physicists and/or dosimetrists to observe the steps below for one TBI case and perform the same steps listed below for three additional cases.

A. Pre-treatment

- Review physician prescription
- Obtain measurements for patient
- Observe CT scan for applicable treatments
- Perform dosimetry calculations
- Fabricate special custom lung block using cerrobend
- Create custom compensators
- Perform chart check (Mosaiq, treatment chart)

B. Treatment

- Assist with in-vivo dosimetry set-up
- Provide treatment day physics assistance
- Perform final physics chart check

Reading List:

- 1. Van Dyk et al, AAPM Report 17 /TG-29 "Physical Aspects of Total and Half Body Irradiation"
- 2. Johns & Cunningham, "The Physics of Radiology," Chapter 11.
- 3. Perez CA, "Principles and Practice of Radiation Oncology" Chapter 11.
- 4. Zierhut, Dietmar et al, "Cataract incidence after total-body irradiation", IJBORP 45(1) p. 131, 2000.
- 5. Thomas, Oliver et al, "Long-term complications of total body irradiation in adults", IJBORP 49 (1) p.125, 2001.
- 6. Faraci, Maura, et al, "Very late nonfatal consequences of fractionated TBI in children undergoing bone marrow transplant", IJORBP 63(5) p. 1568, 2005.
- 7. A literature review is strongly suggested for this topic.

Patient Cases

	Observed Case	Case #1	Case #2	Case #3
Patient Initials:				
Mentor sign:				
Date:				

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.)

Summary of Resident's activiti	es:			
			· · · · · · · · · · · · · · · · · · ·	
Competency attained	yes	no		
Mentor's Signature	I	Date		

Total Skin Electron Irradiation (TSEI) and Intraoperative Radiotherapy (IORT)

A. Prerequisite Skills

- a. Radiation Safety Treatment machine operation
- b. Human Anatomy –common bony landmarks
- c. Introduction to custom shielding used in Radiation Therapy.
- d. Introduction to electron beam dosimetry.

B. Knowledge Base

- a. Dosimetry of electron beams
- b. Clinical Basis for TSEI- and IORT
- c. Equipment
- d. Dosimetry issues in TSEI- and IORT
 - i. Field uniformity
 - ii. Beam energy/penetration
 - iii. Field Shaping
 - 1. Collimation and patient alignment (IORT).
 - 2. Collimation and energy adjustment (TSEI).
- e. Beam Data for TSEI- and IORT -hand calculation

C. Clinical Processes

- a. Clinical indications and conditions treated
- b. Simulation and Field shaping
- c. MU calculations
- d. In-vivo dose measurement
- e. Custom compensation

D. Commissioning of a TSEI Program

- a. General electron beam commissioning
- b. Specifics related to TSEI- commissioning.

Learning Opportunities:

Perform measurements of:

- Effect of SSD change on electron beam characteristics.
- Electron beam collimation and effects of surface shielding.
- Obliquity effects.

ummary of Resident's activities:						
			_			
yes	no					
Date			_			

Module: Intraoperative Radiation Therapy (IORT)

I. Objective: Provide the resident with the fundamental knowledge and practical training for proficiency in intraoperative radiation therapy (IORT).

II. Didactic Activities:

Task	Mentor Sign/Date
1. Review/read Chapter 14 in Kahn (3 rd ed.),	
2. Read AAPM report (TG-72)	
3. Attend 1.5 hours of class provided in physics residents' syllabus.	

III. Clinical Activities:

The resident will work with one of the physicists and/or therapists on the steps listed below for five cases.

A. Pre-treatment

- Observe location of all treatment applicators
- Verify the warm-up and/or monthly quality assurance calculations
- Review IORT dosimetry book in operating room
- Prepare required documents for treatment

B. Treatment

- Observe/assist with docking of unit
- Perform MU calculation based on physician's directive (verified by physicist)
- Monitor treatment delivery
- Complete all necessary documentation

Patient Cases

Type:	Case #1	Case #2	Case #3	Case #4	Case #5
Patient Initials:					
Mentor sign:					
Date:					

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.)

IV. Machine-related Quality Assurance/Calibration/Safety

The resident will work with the therapist/physicist to perform the daily QA. The resident will work with the physicist to actively participate in tasks associated with the monthly QA.

Tasks:	Case #1	Case #2	Case #3
Perform daily QA			
Perform monthly QA			
Assist in annual QA:		N/A	N/A

Assist in annual QA:		N/A	N/A
Note: Collect documentation (electronic or po	aper) for the variou	us steps (i.e., printo	outs, etc.)
Summary of Resident's activities:			
Competency attainedyes	no		
Mentor's Signature	Date		

Module: Total Skin Electron Irradiation (TSEI)

(This module may be truncated if adequate number cases are not available due to change in clinical practice at UHCMC. Residents will participate in available cases).

<u>I. Objective</u>: Provide the resident with the fundamental knowledge and practical training for proficiency in the Total Skin Electron Irradiation (TSEI).

II. Didactic Activities:

Task	Mentor Sign/Date
1. Review/read Chapter 14, section 8 in Kahn (3 rd ed.), AAPM Report 23 (TG-30), Chapter 17B in Modern Technology of Radiation Oncology (Van Dyke, 1999).	
2. Attend 1.5 hours of class provided in physics residents' syllabus.	

III. Clinical Activities:

The resident will work with one of the physicists and/or dosimetrists to observe the steps below for one TSEI case and perform the same steps listed below for three additional cases.

A. Pre-treatment

- Review physician prescription
- Perform dosimetry calculations with special attention to energy selection and determination
- Perform chart check (Mosaiq, treatment chart)

B. Treatment

- Assist with in-vivo dosimetry set-up
- Provide treatment day physics assistance
- Perform final physics chart check

Reading List:

- 1. Perez & Brady, "Principles and Practice of Radiation Oncology", Lippincott, 2nd ed, 1992, Chapters 10 and 22
- 2. Khan, F.M., "The Physics of Radiation Therapy", Williams & Wilkins (1984)
- 3. Chapter 14, particularly section 14.8.
- 4. Clinical Electron-Beam Dosimetry, Reprinted from Medical Physics (Vol. 18, Issue 1) (1991) Radiation Therapy Committee Task Group #25.
- 5. Intraoperative radiation therapy using mobile electron linear accelerators: Report of AAPM Radiation Therapy Committee Task Group No. 72. (2006).
- 6. Commissioning of a mobile electron accelerator for intraoperative radiotherapy; M. D. Mills, et al. J. Appl. Clin. Med. Phys. **2**, 121 (2001).
- 7. Use of routine quality assurance procedures to detect the loss of a linear accelerator primary scattering foil; M. G. Davis, C. E. Nyerick, J. L. Horton, and K. R. Hogstrom; Med. Phys. **23**, 521 (1996)A study of the effect of cone shielding in intraoperative radiotherapy; Nikos Papanikolaou and Bhudatt Paliwal, Med. Phys. **22**, 571 (1995).
- 8. The dosimetric properties of an intraoperative radiation therapy applicator system for a Mevatron-80; Charles E. Nelson, Richard Cook, and Susan Rakfal; Med. Phys. **16**, (1989). The dosimetric properties of an

applicator system for intraoperative electron-beam therapy utilizing a Clinac–18 accelerator; Edwin C. McCullough and Joseph A. Anderson Med. Phys. **9**, (1982).

- 9. Total Skin Electron Therapy: Technique and Dosimetry(1987)
- 10. Multiple scattering theory for total skin electron beam design; John A. Antolak and Kenneth R. Hogstrom; Med. Phys. **25**, (1998).
- 11. Spatial distribution of bremsstrahlung in a dual electron beam used in total skin electron treatments: Errors due to ionization chamber cable irradiation; Indra J. Das, John F. Copeland, and Harry S. Bushe; Med. Phys. **21**, (1994).
- 12. Dosimetric study of total skin irradiation with a scanning beam electron accelerator; Subhash C. Sharma and David L. Wilson; Med. Phys. **14**, (1987).
- 13. Physical aspects of a rotational total skin electron irradiation; E. B. Podgorsak, C. Pla, M. Pla, P. Y. Lefebvre, and R. Heese; Med. Phys. 10, (1983).
- 14. A literature review is strongly suggested for this topic.

Patient Cases (3)

	Observed Case	Case #1	Case #2	Case #3
Patient Initials:				
Mentor sign:				
Date:				

Note: Collect documentation (electronic or paper) for the various steps (i.e., printouts, etc.)

Mentor's Assessment (TBI, TSEI, IORT):

The resident will provide a written report of principles and process of Total Body Irradiation (TBI), Total Skin Electron Irradiation (TSEI) and Intraoperative Irradiation (IORT) with an overview and detailed descriptions of the relevant underlying principles for each major step. Some emphasis should also be placed on practical issues in establishing TBI and IORT programs. The report should also contain data acquired through measurements or experiment as well as analysis thereof. Finally, the resident will take an oral exam and/or give a presentation. An understanding of the principles behind the processes as well as comprehension of other relevant information from the reading lists must be demonstrated.

Summary of Resident's activities:			
Competency attained	yes	no	
Mentor's Signature	Date		

12. Dedicated Research (elective, rotation #12)

Name of the Resident:		
Start date:	Completion date:	
Name of the Mentor:		
the skills necessary for solving th	nds to prepare the resident for identifying clinical oriented problems. The resident will work under the direct supervisoroblem(s)/topic(s) and highly expected to publish meaningful states.	ion of the research
Assessment:		
the purpose of the research, m directions. An understanding of t	on report of the research topic and research performance. The report of the research topic (s) as well as comprehension of other relevanted. Finally, the resident will take an oral exam and/or give a present topic (s) as well as comprehension of other relevanted.	usions, and future t information from
Mentor's and/or Director's Asses	ssment:	
List of Publications:		
Summary of Resident's activities	:: 	
		
Oral Exampas	ssedfailed	
Mentor's Signature	Date	
Director's Signature	Date	

Appendix D – List of Residents Admitted

Provide a reverse chronological list of residency program admissions for the past 5 years.

Ref#	Start Year		Date	Institution	CA	CAMPEP accreditation			
		Degrees			Graduate	Certificate	Not Accredited		
18	2025	PhD	6/25	University of Minnesota	Yes				
17	2025	MS	6/25	University of Miami	Yes				
16	2024	PhD	6/24	University of Texas Southwestern		Yes			
15	2024	MS	6/24	Hofstra University	Yes				
14	2023	MS	06/23	University of Miami	Yes				
13	2023	MS	06/23	University of Wisconsin-Madison	Yes				
12	2022	MS	06/22	Purdue Univeristy	Yes				
11	2022	MS	06/22	Georgia Institute of Technology	Yes				
10	2021	MS	06/21	Duke University	Yes				
9	2020	MS	06/20	Univ. of Toledo	Yes				
8	2020	MS	06/20	Duke University	Yes				
7	2019	PhD	06/19	Ohio State/ Univ. of Toledo	Yes				
6	2018	PhD	06/18	Univ. of Miami	Yes				
5	2018	PhD	06/18	Case/ Cleveland State Univ.	Yes				
4	2017	MS	06/17	Univ. of Toledo	Yes				
3	2016	PhD	06/14	Duke University	Yes				
2	2016	PhD	06/16	Univ. of Toledo	Yes				
1	2015	PhD	06/15	Univ. of Florida	Yes				

If Resident's degree is NOT from a CAMPEP-accredited program, indicate where required didactic courses were taken.

Ref#	Course	Institution
	Radiological physics and dosimetry	
	Radiation protection and safety	
	Fundamentals of medical imaging	
	Radiobiology	
	Anatomy and physiology	
	Radiation therapy physics	

Ref#	Course	Institution
	Radiological physics and dosimetry	

Radiation protection and safety	
Fundamentals of medical imaging	
Radiobiology	
Anatomy and physiology	
Radiation therapy physics	

$\ \ \, \textbf{Appendix} \,\, \textbf{E} - \textbf{List of Current Residents} \\$

Provide an alphabetical list of current residents in your program.

Resident	Supervisor	Year Entered	Funding Source
Nur Izzati Huda Zulkarnain-Lemke	Alex Price	2025	University Hospitals
Martin Vera Santiago	Alex Price	2025	University Hospitals
Meiying Xing	Alex Price	2024	University Hospitals
Kyle O'Carroll	Alex Price	2024	University Hospitals

$Appendix \ F-Program \ Graduates$

Provide a reverse chronological list of residency program graduates for the past 10 years.

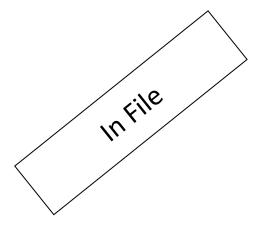
Name	Time in Program (dates)	Supervisor	Current Occupation	Board Certification
Beatriz Guevara	2023-2025	Yiran Zheng/ Alex Price	Clinical Physicist	ABR
Kenneth Gregg	2023-2025	Yiran Zheng/ Alex Price	Clinical Physicist	ABR
Elizabeth Jaye	2022-2024	Tarun Podder/ Yiran Zheng	Clinical Physicist	ABR
Jonathan Arrue	2022-2024	Tarun Podder/ Yiran Zheng	Clinical Physicist	ABR
Ala Amini	2021-2023	Tarun Podder	Clinical Physicist	ABR
Theodore Arsenault	2020-2022	Tarun Podder	Clinical Physicist	ABR
Kristopher Lyons	2020-2022	Tarun Podder	Clinical Physicist	ABR
Christian Langmack	2019-2021	Tarun Podder	Clinical Physicist/ Assistant Professor	ABR
Tanvir Baig	2018-2020	Tarun Podder	Clinical Physicist/ Assistant Professor	ABR
Keying Xu	2018-2020	Tarun Podder	Clinical Physicist/ Assistant Professor	ABR
Jessica Muenkel	2017-2019	Tarun Podder	Clinical Physicist	ABR
XhengZheng Xu	2016-2018	Tarun Podder	Clinical Physicist/ Assistant Professor	ABR
Greogory Warrell	2016-2018	Tarun Podder	Clinical Physicist	ABR
Soyoung Lee	2015-2017	Tarun Podder	Clinical Physicist/ Assistant Professor	ABR
Justin Cantley	2014-2016	Tarun Podder	Clinical Physicist	ABR
David Albani	2012-2016	Barry Wessels	Clinical Physicist	ABR
Charles Rhodes	2011-2014	Barry Wessels	Clinical Physicist	ABR
Jeffery Fabien	2010-2013	Barry Wessels	Clinical Physicist	ABR
Yiran Zheng	2010-2012	Barry Wessels	Clinical Physicist/ Associate Professor	ABR
Liviu Anton	2010-2012	Barry Wessels	Clinical Physicist	ABR

Appendix G - Faculty and Staff

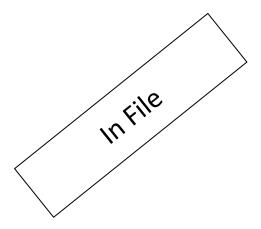
Alphabetical List of Faculty/Staff

Name (abbreviation)	Degree	Designation	Certificatio n	Primary Clinical Interest
Theodore Arsenault (TA)	M.S.	Physicist III	ABR	EBRT/SBRT, Proton
Samah Ferjani (SF)	M.S.	Physicist II	ABR	EBRT, HDR
Ande Bao (AB)	Ph.D.	Associate Professor	ABR	EBRT, IGRT
Valdir Colussi (VC)	Ph.D.	Associate Professor	ABR	EBRT/ SBRT, IORT, TBI, HDR
Paul Geis (PG)	Ph.D.	Assistant Professor	ABR	EBRT, Radiation Safety, Professionalism & Ethics
Frederick Jesseph (FJ)	M.S.	Physicist III	ABR	Proton Therapy, EBRT, Radiation Safety
Rojano Kashani (RK)	Ph.D.	Associate Professor	ABR	EBRT/SBRT
Brian Krancevic (BK)	M.S.	Physicist III	ABR	EBRT, Gamma Knife
Kristopher Lyons (KL)	M.S.	Physicist III	ABR	EBRT, IGRT
Marcel Marcu (SMM)	M.S.	PRN	ABR	EBRT
Gisele Pereira (GP)	Ph.D.	Assistant Professor	ABR	EBRT/ SBRT, IORT, TBI, GK
Alex Price (ATP)	Ph.D.	Assistant Professor	ABR	EBRT/ SBRT/ ART
Angela Smith (AS)	M.S.	Physicist III	ABR	EBRT
Runyon Woods (RW)	M.S.	Physicist III	ABR	SRS/SBRT/Brachy
Kadji Herve Germain (KHG)	M.S.	Physicist II	ABR	EBRT
Kenneth Gregg (KG)	M.S.	Physicist II	ABR	EBRT, Proton, HDR
Yuxia Zhang (YZ)	M.S.	Instructor (part time)	ABR	EBRT/ SBRT, Gamma Knife
Beatriz Guevara	M.S.	Physicist II	ABR	EBRT, SBRT, ART
Kai-Cheng Chuang	Ph.D.	Physicist III	ABR	EBRT, SRS, SBRT

Appendix H – Sample Interview Evaluation Form



Appendix I – Sample Offer Letter



Appendix J1 – Resident's Rotation Evaluation Form

Clinical Medical Physics Residency University Hospitals Cleveland Medical Center Department of Radiation Oncology

Resident's Rotation Evaluation (by Mentor)

Resident	Date	:	
Rotation Topic			
Reviewer/ mentor			
Written Report Grade (if applic	cable)		
Unsatisfactory	Satisfactory	Superior	
1 2 3	4 5 6	7 8	9 10
Examination (Presentation and Unsatisfactory	Oral) Grade	Superior	
1 2 3	4 5 6	7 8	9 10
		, , ,	, 10
commendable?			
Rotation Engagement: In what ways did the resident dem	nonstrate initiative, curiosity, or con	mmitment during the rota	ation?

Skill Development: Are there specific areas in which the resident could further de	welon, such as clinical decision making, communication
technical skills, or time management?	velop, such as chinical decision-making, communication
_	
Professional Growth:	
Are there ways the resident could enhance their interactions w	with patients, staff, or the healthcare team?
· · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·
Recommendations	
Teconimendations_	
Overall recommended grade (Pass, Fail, or Conditional Pas	s)
Remediation (if Conditional Pass)	
Kemediation (ii Conditional Fass)	
G' kan	Ditai
Signature	Date:

Appendix J2 – Clinical Rotation Evaluation Form

Clinical Medical Residency Program Department of Radiation Oncology University Hospitals Cleveland Medical Center

Clinical Rotation Evaluation (by Resident)

Name of the Clinical Rotation: _						
Name of the Mentor:						
			1 – 1	lowest,	5 - highes	st
Contents			(Circle o			
Design of rotation	N/A	1	2	3	4	5
Relevance	N/A	1	2	3	4	5
Adequacy	N/A	1	2	3	4	5
Equipment	N/A	1	2	3	4	5
Software/ computer	N/A	1	2	3	4	5
Facility/ environment	N/A	1	2	3	4	5
Opportunity to learn	N/A	1	2	3	4	5
Mentor's knowledge	N/A	1	2	3	4	5
Mentor's availability	N/A	1	2	3	4	5
Clarity of instruction	N/A	1	2	3	4	5
Mentor's help	N/A	1	2	3	4	5
Additional Comments and Sug Positive Aspects Mentor Feedback: What aspects you find particularly effective or	of the mentor's gui	idance, in	struction,	or availa	ability dic	I
Rotation Strengths: What parts of worked well and contributed to y	_		nent, soft	ware, or	facilities	

Mentor Development: Are there specific ways the mentor could improve their guidance, instruction, of availability?
Rotation Enhancements: What changes or improvements would you suggest for the
rotation design, equipment, software, or facilities?

Appendix J3 – Residency Program Evaluation Form

Clinical Medical Residency Program Department of Radiation Oncology University Hospitals Cleveland Medical Center

Residency Program Evaluation (by Resident at the end of residency training)

Contents			1 – 1	owest	- 1 1	
				owest, .	5 - highe	st
D				le one)		
Design of clinical rotations	N/A	1	2	3	4	5
Relevance	N/A	1	2	3	4	5
Adequacy	N/A	1			4	5
Equipment	N/A	1	2	3	4	5
Software/ computer	N/A	1	2	3	4	5
Facility/ environment	N/A		2	3	4	5
Opportunity to learn	N/A	1	2	3	4	5
Evaluation methods	N/A	1	2	3	4	5
Clarity of instruction	N/A	1 1	2	3	4	5
Mentor's help	N/A	1	2	3	4	5
Associate director's role	N/A	1	2	3	4	5
Director's role	N/A	1	2	3	4	5
Help in critical issues	N/A	1	2	3	4	5
Overall standard of the program	N/A	1	2	3	4	5
Additional Comments and Suggestion Design and content of the rotation:						

Appendix J4 – Quarterly Review of the Resident

Clinical Medical Residency Program Department of Radiation Oncology University Hospitals Cleveland Medical Center

Quarterly Progress Report (by Director & Resident)

Resident's Name:	
Start Date:	
Evaluation Period:	
Conference Participation:	
Didactic Course (if applicable):	
Progress of Recommended Readings:	
Clinical Participation:	
Program Director Comments:	
Program Director's signature & date	Resident's signature & date