Clinical Training of Medical Physicists Specializing in Radiation Oncology

Course description

Through this introductory course, the student will learn the physics and methods of how radiation oncology is formed. Medical physicists play a key role in the provision of the radiotherapy service. The specialist scientific training and expertise of radiotherapy physics staff makes them uniquely qualified to provide essential scientific input on physical processes and technology that underpin the whole radiotherapy process. Radiotherapy physicists design and develop the framework of radiation dosimetry, treatment planning algorithms, quality assurance of treatment and other equipment, and many aspects of the treatment process, radiation safety, etc. They provide expert advice on the development of new treatment techniques and on the optimisation of treatment processes and treatments for individual patients. They play a leading role in the implementation, development, safe utilisation, and optimisation of advances in technology and techniques. Therefore, they enable the multi-disciplinary team of radiation oncologists, radiotherapy physicists, radiotherapy technologists, and others to practice safe, state-of-the-art radiotherapy.

General Objectives of the Residency Program

- To prepare the medical physics resident for certification in the field of radiation oncology physics by an appropriate certification board such as the International Medical Physics Certificate Board (IMPCB) certification exam

- To provide in-depth training in all aspects of radiation oncology physics practice that will allow the graduates to contribute to the high level of quality of medical care to the radiation oncology patients, including improving the efficiency of clinical flow, implementing a novel treatment modality and as initiating new treatment protocols in the clinic.

- To give the residents the opportunity to participate in special clinical projects consisting of implementing new treatment procedures or integrating a novel technology in the state-of-the-art radiation oncology centers.

- To provide residency training under the supervision of experienced radiation oncology physicists in both clinical and academic institutions.

- To equip the residents with the required competency in a broad range of topics through clinical performance in different rotations.

Specific Objectives of the Residency Program

- To provide medical physicists with knowledge and clinical experience related to Radiation Oncology
- To develop personal and key skills in radiation protection management in a radiotherapy department
- To develop the skills and expertise required in radiation dosimetry for external beam therapy
- To provide residents with knowledge and competencies relating to external beam therapy
- To provide physicists with the required knowledge and competency to perform radiotherapy treatment planning
- To provide the resident with the knowledge and competencies required in brachytherapy
- To provide Residents with knowledge and competencies relating to the professional aspects of their roles and responsibilities and principles and practice of quality management in a radiotherapy department**.**
- To develop key skills in research, development and teaching in Radiation Oncology Physics as part of a multidisciplinary team

Learning Outcomes

- To practice the physics of radiation oncology independently
- To apply the highest professionalism in clinical practice
- To deal with modern technologies in the field of radiation oncology
- To design, test and improve treatment plans for external and topical radiotherapy
- To perform quality management and control with regard to radiotherapy procedures
- To Write the specifications of radiotherapy devices and examining their operation and calibration
- To be able to get a certification in the field of radiation oncology physics such as the International Medical Physics Certificate Board (IMPCB) certification exam.

Program Length

- **4 Terms**

Term 1.(Module 1:(7%), Module 2:(10%) and Module 3:(10%).
Term 2.(Module 4:(21%).
Term 3. Module 5:(15%) and Module 6:(10%).
Term 4. Module 7:(12%) and Module 8:(15%).

Course schedule

Day	Date	Topic	Instructor
		Module 1. Clinical Introduction	
		1.1 Clinical Aspects of Radiobiology	
		• Demonstrate an understanding of fractionation scheme.	
		• Perform modified fractionation scheme examples.	
		• Perform calculations to account for gaps between fractions	
		• Perform calculations to convert dose between brachytherapy LDR/HDR and external beam radiation therapy.	
		• Re-treatment examples	
		• Awareness of rationale behind treatment options with respect to LET– protons, heavy ions, etc	
		• Dose constraints of normal tissue for treatment planning.	
		• Demonstrate an understanding of Biological Treatment Planning – parameters for different tumour types and potential for individualised treatment.	
		• Understanding of limitations of utilising radiobiology calculations in the clinic.	
		• Understand the radiobiological rationale for combination therapy (e.g. chemotherapy and radiotherapy) and report on patient case studies.	
		1.2 Introduction to Radiation Oncology	
		• **Role of RT in cancer treatment (vs. other modalities)**	
		• **Aim of radiotherapy**	
		○ Tissue tolerances	
		○ Required accuracy	
		○ Therapeutic gain	
		○ Palliative vs. curative	
		○ Clinical “target”	
		• **Cancer disease and radiation oncology**	
		○ Demonstrate an understanding of the nature and effects of a tumour on an organ and its function. ○ Identify the main routes of spread of disease and metastases for common cancer sites.	
		○ Identify abnormal size and function of organs due to	

		primary tumours and metastases on radiological, PET and nuclear medicine images.	
		o Demonstrate an understanding of the clinical decision making process of cancer diagnosis of a patient (i.e. relation of presenting symptoms to tumour type).	
		o Demonstrate an understanding of tumour grading and staging.	
		• **Review the anatomical and physiological changes to the body/organ due to radiotherapy treatment**	
		Sub-module 1.3: Anatomy	
		• **Cancer and radiation oncology**	
		o Demonstrate an understanding of the nature and effects of a tumour on an organ and its function	
		o Identify the main routes of spread of disease and metastases for common cancer sites.	
		o Identify abnormal size and function of organs due to primary tumours and metastases on radiological, PET and nuclear medicine images.	
		o Demonstrate an understanding of the clinical decision-making process of cancer diagnosis of a patient (i.e. relation of presenting symptoms to tumour type).	
		o Demonstrate an understanding of tumour grading and staging.	
		• **Review the anatomical and physiological changes to the body/organ due to radiotherapy treatment**	
		• Identify key anatomical features on CT cross sectional images through body sections.	
		Sub-module 1.4 Patient Related Clinical Experiences	
		The medical physicist is expected to gain clinical experiences in the following patient-related clinical experiences and compile a short report: • Ward round	
		• Mould room	
		• New patient/review/follow up clinics	
		• Patient case studies	
		• Simulator and/or CT	
		• Treatment planning room	
		• Radiation treatment	
		• Operating theatre	
		• Imaging Department/s	
		Module 2: Radiation Safety And Protection	
		Sub-module 2.1: Principal requirements	
		• Analyze and understand the policies for protection and safety as laiddown in the QA programme of the local department and compare tonational legislation, the International BSS and recommendations by the ICRP	
		• Compile a list of all local documents on radiation protection and compare with relevant international	

		standards	
		• **Interpret legislative requirements in the local department such as given by:** o number and type of treatment units and/or radioactive sources	
		o patient and machine workload	
		o concerns of previous reviews (if existing)	
		• **Write and/or critically review local radiation safety related administrative and management procedures.**	
		Sub-module 2.2: Local organization	
		•Evaluate the application of current laws, regulations and recommendations as applied locally	
		•Describe the local organization of radiation protection:	
		o responsibilities	
		o process of authorization	
		o number and individuals having responsibilities for the application of protection standards	
		o number and individuals involved in occupational exposures	
		• List local license publications applying to treatment units and explain them with respect to conditions and limitations	
		• Read instructions on radiation protection provided to staff and patients	
		Sub-module 2.3: Procedures	
		• Demonstrate an understanding of selection, calibration, and principles of survey meters	
		• Perform radiation survey of an area using appropriate dose-rate equipment	
		• Demonstrate an understanding of selection, calibration, and principles of individual radiation monitors	
		• Compile the steps relevant to radiation protection to be performed during acceptance tests and commissioning of a treatment facility	
		• Understand the various interlocks required on radiotherapy equipment, including remote afterloading brachytherapy equipment	
		• Compile and monitor local relevant operation instructions for equipment and facilities	
		• Translate examples of existing operating instructions from major world language into local language if applicable	
		Module 2. Radiation Safety and Protection	
		Sub-module 2.4: Safety of radiation sources	
		• Perform an inventory of all sources in the department	
		• Compare your own inventory with the department's keeping and record system	
		• Compile relevant international (IEC) or national standards for source equipment applicable to radiotherapy	
		• Demonstrate an understanding and perform a design	

		of a safety system/code of practice for radiation sources, covering:	
		□ Storage security and safety	
		□ Source inventory system	
		□ A book keeping system for tracking source movement, such as for delivery, storage, release for clinical application, disposal	
		□ Labelling	
		□ Transportation □ Local legislative requirements and international recommendations on quality and safety standards of radiation sources • Demonstrate a safe operation of source related equipment • Perform leak tests on radioactive sources • Demonstrate an understanding on potential hazards and risks, with particular emphasis on brachytherapy • Conduct radiation risk assessment • Design radiation emergency procedures, including o Fire o Brachytherapy equipment malfunction o Loss of radioactive source • Perform: o Regular source inventory check o Leakage test of sources o Testing on integrity of the: □ Treatment interlocks of afterloading equipment □ Area radiation monitoring and warning systems • Supervise/monitor and record the transfer of sources • Advise on: o Compliance with legislative requirements, including licence application o Safety and protection measures o Proper use of protective equipment and handling tools • Report of incident involving radiation o Prepare record and documentation • Investigate how principles of waste disposal operate locally • Exercise the return procedure of empty packages • Exercise the return procedure of a disused source	
		Sub-module 2.5: Radiation Protection Design of Treatment Rooms	
		• Demonstrate an understanding on the: o Local legislative requirements on radiation safety and protection o International standards and recommendations o Nature of source and equipment to be installed o Nature and types of the treatment services to be provided	

		o Source strengths to be used o Projected patient load o Room layout requirements taking into consideration the requirements for sterility, patient flow, work flow, staff manoeuvre, and supply logistics • Perform radiation risk assessment on the facility • Determine the: o Radiation shielding requirements taking into consideration: – Room layout – Types of treatments to be performed – Projected patient load – Types and activities of the sources – Occupancy factors o Appropriate shielding materials for: – Door/entrance – Walls – Ceiling – Floor o Required thickness for the shielding structures o Radiation warning signs and signals o Ancillary and accessory safety equipment, including: – Radiation monitoring and alarm system – Door interlock – Closed circuit television o Safety interlock system • Calculate the radiation dose levels for: o Areas of interest o Staff o Other personnel • Advise on shielding design for a new or modified building • Conduct radiation survey and monitoring • Assess results, draw conclusion on the safe integrity of the treatment room and recommend course of action Prepare reports and documentation	
		Sub-module 2.6: Protection against medical exposure, occupational and public exposure	
		• Demonstrate familiarity with the specific application of radiation protection principles to medical, occupational and public exposure such as o Responsibilities o Justification o Optimization o ALARA principle • Understand methods to minimise dose to sites of risk such as o Foetus o Gonads o Lens o Spinal cord	

		o Pacemaker • Perform calibration checks by o using an internationally accepted code of practice for external beam radiotherapy and for source strength determination o performing cross-checks of dose calculations • Compile relevant information given to the workers about their obligations and responsibilities for their own protection and the protection of others • Demonstrate a knowledge of all controlled areas in the department • Demonstrate an understanding of principles and practice for personal dosimeters o exposure assessment o monitoring period and frequency of reading o rules for returning and changing o rules for damage or if lost o record keeping • Oversee a personal dosimetry system. • Perform calculations for dose or exposure from beta particles and gamma sources. • Perform radiation protection area surveys surrounding radiation facilities	
		Sub-module 2.7: Emergency Situations	
		• Investigate risk factors of radiation • Discuss radiation emergency plans o responsibilities o for each type of sealed sources o for any other credible radiation emergency which could arise in the local radiation oncology department o availability of equipment and tools • Carry out a formal risk assessment of a procedure • Plan and practice contingency measures, e.g. equipment malfunction, lost source, spill • Discuss decontamination procedures after a spill of liquid radionuclide • Be familiar with response procedures in the event of unnecessary dose to one or more individuals • Be familiar with response procedures in the event of machine malfunction, sealed source loss or misuse, unsealed source loss, misuse or spillage.	
		Sub-module 2.8: Radiation Safety in Brachytherapy	
		• Demonstrate an understanding of: • Principles and practice of radiation safety and protection in brachytherapy under normal and emergency situations • Local legislative requirements and international recommendations on quality and safety standards of brachytherapy equipment and procedures • Potential hazards and risks in brachytherapy • Safety requirements of:	

		◦ Legislation ◦ Guidelines/code of practice • Functionality and properties of radiation monitoring and protection equipment/tools • Conduct radiation risk assessment • Design: • A system of radiation protection for protection of: ◦ Staff ◦ Patient ◦ Other personnel • A safety system for radiation sources, covering: ◦ Storage security and safety ◦ Source inventory system ◦ A logging system for tracking source movement, including: • Delivery • Storage • Release for clinical application • Disposal ◦ Transportation • Local radiation safety rules, instructions, and operational procedures/guidelines • Radiation emergency procedures, including: ◦ Fire ◦ Brachytherapy equipment malfunction ◦ Loss of radioactive source • Perform: • Radiation monitoring/surveys of: ◦ Rooms ◦ Staff ◦ Patients • Regular source inventory check • Leakage test of sources • Testing on integrity of the: ◦ Treatment interlocks of afterloading equipment ◦ Area radiation monitoring and warning systems • Supervise/monitor and record the transfer of sources • Advice on: • Compliance with legislative requirements, including: ◦ Licence application • Safety and protection measures • Proper use of protective equipment and handling tools • Report of incident involving radiation o Prepare record and documentation	
		Sub-module 2.9: Radiation Protection Design of BrachytherapyTreatment Rooms	
		• Demonstrate an understanding on the: • Local legislative requirements on radiation safety and protection • International standards and recommendations • Nature and types of the treatment services to be	

		provided • Types and strengths of the radioactive sources to be used • Nature of equipment to be installed • Projected patient load • Room layout requirements taking into consideration the requirements for sterility, patient flow, work flow, staff manoeuvre, and supply logistics • Perform radiation risk assessment on the facility • Determine the: • Radiation shielding requirements taking into consideration: □ Room layout □ Types of treatments to be performed □ Projected patient load □ Types and activities of the sources □ Occupancy factors • Appropriate shielding materials for: □ Door/entrance □ Walls □ Ceiling □ Floor • Required thickness for the shielding structures • Radiation warning signs and signals • Ancillary and accessory safety equipment, including: □ Radiation monitoring and alarm system □ Door interlock □ Closed circuit television • Safety interlock system • Calculate the radiation dose levels for: • Areas of interest • Staff • Other personnel • Conduct radiation survey and monitoring • Assess results, draw conclusion on the safe integrity of the treatment room and recommend course of action • Prepare reports and documentation	
		Module 3. Radiation Dosimetry for External Beam Therapy	
		Sub-module 3.1: Dosimetry Operations Using Ionization Chambers	
		• **Demonstrate understanding of the following:**	
		• Selection criteria for type of ionization chamber • The quantity and unit to be measured • Influence effects on the measured quantity (air density, recombination, polarity, warm-up, stem effects, leakage, humidity) • Correction factors for: o influence effects o radiation quality o Perturbation effects such as caused by the chamber	

		cavity, chamber wall, central electrode, or by the replacement of medium by the chamber • Perform dose measurements with a range of ionization chambers to demonstrate understanding and correct application of the characteristics given above.	
		Sub-module 3.2: Dosimetry Operations Using Methods	
		Other Than Ionization Chambers To develop capability in the appropriate use of a range of dosimeters for dose measurements in radiotherapy beams. Capable to perform dose measurements in radiotherapy beams using a range of dosimeters. • Demonstrate an understanding of the advantages and disadvantages of using particular detectors for absolute and relative dosimetry measurements. • Perform measurements with TLDs and demonstrate an understanding of aspects such as: o Commonly available TLDs (shapes, sizes and materials). o Common examples of TLD measurements: eye, TBI etc. o TLD measurements: preparation, precautions etc. o Basic structure and function of the photomultiplier tube. o QA in TLD measurements • Perform measurements with Solid State dosimeters and demonstrate an understanding of aspects such as: o Design of diodes, photon/electron diodes, shielding, pre-irradiation, energy dependence. o Typical bias voltages and output currents. • Perform measurements with films including radiographic and radiochromic films, and demonstrate an understanding of aspects such as: o Basic structure and function of film types. o Basic structure and function of a film processor. o Basic structure and function of a film densitometer/scanner. o Perform a calibration of film in terms of absorbed dose o QA for film dosimetry.	
		Sub-module 3.3: Absolute Absorbed Dose Measurements	
		• Demonstrate a familiarity with the use of the IAEA TRS398 Code of Practice (or another accepted protocol) • Explain differences to other protocols • Determine the radiation quality for different types of radiation (depending on availability) • Perform a determination of absorbed dose under reference conditions using the TRS 398 Code of Practice and associated spreadsheets as provided by the IAEA for different types of beams (depending on availability)	

		• Perform a cross calibration procedure in particular for electrons. • Analyse the uncertainty of dose calibration.	
		Sub-module 3.4: Relative Dose Measurements	
		Dosimeter related issues • Demonstrate an understanding of the appropriate use of dosimeters for relative dose measurements • Demonstrate an understanding of factors influencing a dose measurement und non-reference conditions Phantom related issues • Demonstrate an understanding of the requirements on dosimeters and phantoms for measurements in phantoms • Explain correction factors required for non water-equivalent phantom materials (differential for photons and electrons) Auxiliary related issues • Demonstrate familiarity with the operation of a water phantom system including knowledge of statistical analysis, correction facilities, hard copy print out etc that may be provided with the system • Demonstrate an understanding of the design criteria and purpose of common dosimetric accessories such as intercomparison jigs or blocks, calibration blocks etc. TPS related issues • Determine at least the following items in a water phantom: o Percentage depth dose o Beam profiles o TAR/TPR/TMR o scatter factors (collimator scatter factor, phantom scatter factor) • Determine the following items (if used) in a solid phantom (using different dosimetry equipment): o Real wedge transmission factor o Total scatter factors o Collimator scatter factors o Compensator factor o Electron cutout factor o Tray transmission factor • Perform measurements with film (if available) in a solid phantom. • Demonstrate an understanding of the uncertainties involved in the measurements. Analyse the uncertainty of data.	
		Sub-module 3.5: Patient Dose Verification	
		• Participate in an existing programme or design a new programme for patient dose verification. • Transfer the beam configuration of a specific patient	

		treatment plan to an appropriate phantom, measure absolute dose at selected points of interest and compare results to calculated doses. • Understand and use quantitative methods to describe the degree of compliance by using tolerance and/or action levels, e.g. the Gamma- Index method. • List the decision-making process behind acceptance and rejection of a treatment plan.	
		Sub-module 3.6: In-vivo Dosimetry	
		• Review and improve/implement an in-vivo dosimetry programme in line with national and international best practice. • Undertake a literature review on the advantages and disadvantages of an in-vivo dosimetry programme and choice of dosimeter. • Demonstrate an understanding of advantages and disadvantages of different methods • Perform in-vivo dosimetry measurements (including writing a case study report) for such examples as: o lens of the eye o in field measurements for	
		Sub Module 3.7: QA in Dosimetry	
		• Demonstrate a familiarity with QA recommendations for radiation dosimetry equipment such as: o Electrometer o thermometer o barometer o water phantom o TLD system o Film densitometer/scanner • Perform acceptance, commissioning and QC checks for dosimetry equipment (including ionization chambers, TLD, solid state detectors, film) according to a QA programme. • Review and improve/implement a QA programme for dosimetry equipment. • Check the traceability to a PSDL for a calibration factor used for absolute dose determination • Demonstrate a familiarity with the IAEA TLD audit system • Review the requirements for quality assurance of an in-vivo dosimetry programme • Demonstrate a familiarity with the method to express uncertainties in dose measurement.	
		Module 4: Radiation Therapy – External Beam	
		Sub-module 4.1: Treatment and Imaging Equipment	
		• Demonstrate an understanding of the operation of: □ orthovoltage X ray therapy unit	

		□ Co-60 unit □ linear accelerators and any ancillary equipment (e.g. EPID, mMLC) □ simulators and any ancillary equipment CT scanner □ Other imaging modalities used (e.g. MRI, ultrasound) □ treatment planning system □ record and verification system □ Image transfer network	
		Sub-module 4.2: Specifications and Acquisition of New Equipment	
		• Demonstrate an understanding on process involved in equipment requisition and acquisition • Review and report on department needs on: □ Patient load □ Equipment technology □ Functionality □ Performance □ Compatibility □ Training □ Maintenance service □ Building and building services □ Delivery and installation • Analyse local and external restrictions placed on new equipment acquisition. • Compile and compare local legislative requirements and international recommendations on safety of equipment. • Perform: □ Market research on equipment technology □ Technology assessment □ Review of procurement documentation • Participate in multidisciplinary meetings with professionals and technical staff to decide on the department's requirements for new equipment. • Prepare/perform in collaboration with other professionals and technical staff: □ Tender specification □ Tender evaluation □ Tender recommendation	
		Sub-module 4.3: Quality Assurance of External Beam Equipment –Acceptance Testing	
		• Demonstrate an understanding of the: □ concept and principles of an acceptance testing programme including: ■ Safety aspects ■ Mechanical aspects ■ Dosimetry measurements □ methods, procedures, and tools for acceptance testing of equipment and its accessories. • Assess the properties and characteristics of the equipment, including specification and functionality of equipment.	

		• Design methods and test procedures/protocols and worksheets for an acceptance testing programme, including o Functionality o Beam characteristics o Integrity of accessories o Network integration and data transfer o Safety features • Develop and prepare test and measurement protocols and worksheets • Participate in acceptance testing of an o orthovoltage therapy unit o megavoltage therapy unit o treatment simulator (simulator/simulator CT, CT/CT-simulator). • Prepare and/or review acceptance test report and recommendations	
		Sub-module 4.4: Quality Assurance of External Beam Equipment II – Commissioning	
		• Review quality and legislative standards. • Demonstrate an understanding of the methods, procedures, and tools for commissioning of equipment and its accessories. • Design methods, procedures and work programme for commissioning to prepare equipment for clinical application including: o Prepare test and measurement protocols and worksheets including • Safety aspects • Mechanical aspects • Dosimetry measurements o Network integration and data transfer o Scheduling of training • Participate in commissioning of an orthovoltage and megavoltage therapy unit (refer to Dosimetry and External Beam Treatment Planning modules, modules 3 and 5, for related competencies), including o The acquisition of all radiation beam data required for treatment. o Verifying the accuracy of treatment procedures. • Participate in commissioning of a treatment simulator (simulator/simulator-CT, CT/CT-simulator). • Prepare and/or review commissioning report and documentation including □ Sources and magnitude of errors □ Establishing baseline values for subsequent QC tests • Report on the progress of commissioning to a multidisciplinary team.	
		Sub-module 4.5: Quality Assurance of External Beam Equipment III– QC	
		• Compare and contrast of local QC programme with international guidelines and best practice, specifying issues	

		such as: □ Parameters to be tested and the tests to be performed; □ Specific equipment to be used to perform the tests; □ Geometry of the tests; □ Frequency of the tests; □ Staff group or individual performing the tests, as well as the individual supervising and responsible for the standards of the tests and for actions that may be necessary if problems are identified; □ Expected resultsTolerance and action levels; □ Actions required when the tolerance levels are exceeded. • Design a QC programme including daily, weekly, monthly and annual checks for: □ Orthovoltage therapy unit □ Megavoltage therapy unit □ treatment simulator (simulator/simulator-CT and/or CT- simulator/CT). • Perform QC tests on orthovoltage unit, such as: □ Dose output checks □ Safety checks and interlocks □ Energy checks (HVL) □ Applicator factor checks □ Depth dose measurements • Perform weekly, monthly and annual QC checks on a megavoltage therapy unit such as o Weekly ■ Safety checks ■ Weekly X ray dose output checks ■ Weekly electron dose output checks ■ Optical distance indicator ■ Isocentre indicator checks including reticule ■ Laser checks ■ Light field checks including field sizes ■ Jaw sag tests ■ Couch movements ■ Couch isocentric rotation o Monthly* ■ Safety checks and interlocks ■ Gantry and collimator angle indicators ■ Full laser checks ■ Isocentre indication ■ Optical distance indicator ■ Jaw symmetry ■ X ray depth dose constancy ■ X ray flatness and symmetry ■ X ray field size checks ■ Electron depth dose curves ■ Electron profile flatness and symmetry o Annual* ■ Safety checks	

		■ Mechanical isocentre determination ■ Radiation isocentre determination ■ Radiation/Mechanical isocentre coincidences ■ Optical systems ■ Couch mechanical tests ■ X ray beam depth dose curves ■ X ray beam profiles ■ Fixed wedge depth dose curves ■ Fixed wedge profiles ■ Fixed wedge transmission factors ■ Collimator scatter factor determination ■ Phantom scatter factor determination ■ Block transmission checks ■ MLC leaf QA checks ■ MLC leaf calibrations ■ Electron depth dose curves ■ Electron output factors • Perform QC on ancillary equipment o Portal imaging o Record and verification system and related networking • Perform weekly, monthly and annual QC checks on a simulator/simulator-CT, such as: o Weekly* ■ Optical distance indicator ■ Isocentre indicator checks including reticule, ■ Laser checks, ■ Light field checks including field sizes o Monthly* ■ Safety checks, ■ Gantry and collimator angle indicators ■ Full laser checks ■ Isocentre indication ■ Optical distance indicator ■ Accuracy of the delineators ■ Beam quality checks o Annual* ■ Isocentre determination ■ Optical systems ■ Couch tests ■ Delineator calibrations ■ Beam kV tests ■ Beam mA tests ■ Participate in full annual QA programme for simulator • Perform QC tests on CT scanner, such as: o Mechanical and optical checks o Safety o Test of CT number to electron density data • After maintenance to external beam equipment, perform subsequent verification to ensure accurate delivery	

		of radiation dose to patients. * Or as required for local conditions	
		Sub-module 4.6: Operational procedures for external beam equipment	
		• Compare local operational procedures for all external beam equipment with the manufacturer's operational manual, information compiled during commissioning and relevant safety standards. • Write operational procedures for external beam equipment based on the manufacturer's operational manual, information compiled during commissioning and relevant safety standards. • Conduct tutorials for operators of equipment based on written documentation to ensure technical and safety instructions and equipment limitations are understood. • Translate examples of existing operating instructions into local language.	
		Sub-module 4.7: Treatment Techniques	
		• Demonstrate an understanding of and observe the differences betweenfixed source-to-surface (SSD) distance and isocentric treatment techniques • Demonstrate an understanding of the use of certain beam combinationsfor different treatment sites and the use of weighting and normalisation. • Demonstrate an understanding of the advantages of and observe theuse of the following beam modifiers: ° Beam shaping devices ° Wedge filters ° Bolus ° Compensators • Demonstrate an understanding of the advantages of and observe thefollowing treatment techniques: ° field matching of various radiation beam types and energies ° rotational ° 3D conformal radiotherapy ° non-coplanar beams ° IMRT methods: static, dynamic ° TBI ° TSEI ° IGRT ° Radiosurgery ° Stereotactic radiotherapy • Demonstrate an understanding of the advantages of advancedtreatment techniques such as: ° Intraoperative radiotherapy ° Particle beam treatments ° Tomotherapy • Describe the methods (if possible) and difficulties of field matchingand re-treatment with advanced treatment techniques.	
		Sub-module 4.8: Patient Positioning and Treatment Verification	

		• Demonstrate an understanding of the purpose of and observe: o Basic patient set-up and movement tracking systems o The manufacturing and use of immobilisation devices o An immobilised patient from mould room to treatment machine o Imaging systems for patient positioning from simulation totreatment verification o Simulator to verify plans before treatment o Various methods of port film/EPI evaluation to assess patientpositioning accuracy and precision. o Lasers from real/virtual simulation to treatment. o Verification of patient positioning and dose delivery with IMRT o Verification of patient positioning with non-coplanar fields o Patient set-up and delivery of stereotactic radiosurgery treatment. o Stereotactic and advanced immobilisation devices o Advanced patient set-up and movement tracking systems (e.g.IGRT, respiratory gating) • Demonstrate an understanding of uncertainties, tolerance and actionlevels of one or more treatment techniques listed above. • Use a record and verify system. • Perform a literature review on immobilisation for one treatment site. • Manufacture a patient immobilisation device. • Explain discrepancies between portal images, simulator verificationimages and DRRs. • Perform dose delivery verification of a patient's treatment planutilising a phantom and an appropriate dosimeter for a: o Conventional treatment technique o IMRT.	
		Module 5: External Beam Treatment Planning	
		Sub-module 5.1: Procurement of treatment planning computer	
		• Demonstrate an understanding of the process involved in equipment requisition and acquisition • Review and report on department needs on: □ Equipment technology □ Functionality □ Performance □ Compatibility □ Training □ Maintenance service □ Building and building services □ Delivery and installation • Perform: □ Market research on equipment technology □ Technology assessment □ Review of procurement documentation • Submit project proposal and budgetary request	

		• Prepare/perform within a multidisciplinary team □ Tender specification □ Tender evaluation □ Tender recommendation	
		Sub-module 5.2: Quality Assurance in Treatment Planning	
		• Demonstrate an understanding of: □ The treatment planning process □ The potential sources and magnitude of errors associated with: ■ Patient data ■ Beam data ■ Manual and computer dosimetry calculation algorithms ■ Treatment planning equipment □ The operation, functionality, performance specification and inventory items of an RTPS □ Merits and limitations of the range of dose calculation algorithms □ The principles and design of a treatment planning QA programme • Design the protocols of a QA programme for a treatment planning computer based on the recommendations as specified in IAEA Technical Report Series No. 430 or an equivalent international recommendation as adopted by the department, including: □ Acceptance testing against equipment specification, including: ■ Inventory check ■ Functionality test of hardware and software	
		Sub-module 5.3: Planning computer system administration	
		• Develop and implement the following guidelines, policies and administrative measures for a treatment planning computer system: □ System security □ Assign user rights □ Operational rules and guidelines □ Data protection □ Release of new or updated planning data for clinical use □ Release of new or upgraded computer hardware and software for clinical use □ Import and export of data • Perform: □ System and data backup □ system upgrades/updates • Manage/monitor: □ Software & hardware inventory □ System operation and application □ Training programme	

		□ Data storage and archival □ Maintenance □ Upgrades/updates □ Operational and functional abnormalities • Identify and report any deviations or functional abnormalities and arrange for corrective measures/actions • Maintenance of: □ Planning data library and manuals □ Logbook and/or record for: ■ Treatment plans ■ Operational/functional incidents and/or abnormalities ■ All upgrades and updates ■ Maintenance	
		Sub-module 5.4: Acquisition of patient data	
		• Demonstrate an understanding of the following: □ Patient treatment set up and positioning procedures □ The purpose, importance and dosimetric considerations of patient immobilisation in external beam therapy □ Accuracy and limitations of immobilization devices □ Mould making procedures □ Patient data required for treatment planning Methods for acquisition of patient data, including: ■ Manual methods ■ Simulator ■ CT/CT-Simulator ■ MRI ■ PET/CT-PET Magnitude and sources of uncertainties involved in the: ■ Image data ■ Contouring of target volumes and critical tissue structures of interest Treatment margins needed for contouring the target volumes and organs at risk for a variety of treatment sites Application of the ICRU concepts in contouring: ■ Target volumes ■ Normal organs at risk ■ Treatment margins • Transfer of patient image data to treatment planning systems • Perform image registration and contouring, including: □ Contouring of the treatment targets and organs of interest for a variety of treatment sites with: ■ Radiographs ■ CT images ■ MR images ■ Fused CT, MRI, and PET images □ Margins to compensate/accommodate inter-fraction	

		and intra- fraction treatment errors. □ Image reconstruction □ 2-D and 3-D display of contoured body and tissue structures □ Generation of digital reconstruction radiograph (DRR) □ Identification of planning contours reference points for dose assessment and treatment set up • Provide supervision/support/advice on: □ patient immobilization and patient data acquisition procedures □ Acquisition and application of patient data for treatment planning □Image transfer and registration	
		Sub-module 5.5: Treatment Planning	
		• Demonstrate an understanding of the: □ Characteristics, applications, accuracy and limitations of the: ■ External beam treatment machines ■ Radiation beam data ■ Patient image data □ Dose and dose fractionation schemes of a variety of treatments □ Principles, methods and procedures of: ■ Treatment planning ■ Dose calculation and optimization ■ Treatment simulation □ Local medical legal requirements for record and documentation in radiotherapy. □ ICRU and the local systems of dose prescription, recording and reporting in external beam therapy. □ Content, format and patient identification system of the department dose prescription chart and treatment record for a variety of treatments and the level of compliance with ICRU recommendations. □ Content and format of department treatment plan for a variety of treatments and the level of compliance with ICRU recommendations. □ Tolerance dose of a variety of normal tissue structures and organs □ Criteria and procedures for accepting treatment plans of a variety of treatment sites □ Radiation beam arrangements for a variety of treatments □ Choice of beam modality and energy for clinical applications. □ Sources and magnitude of errors involved in manual and computer planning including dose calculation grid resolution. □ Effect and purpose of: ■ Beam parameters on dose (e.g. field size, off axis,	

		weighting, normalisation, FSD, energy, photon/electron) ■ Beam modifiers (e.g. shielding, asymmetric jaws, MLC, wedges, compensators, bolus etc) on dose ■ Tissue inhomogeneity and the shape of body contour on dose and correction methods ■ Normalisation on isodose curves ■ Errors and contrast media in patient image data on dose ■ Organ and patient motions on dose and correction methods • Perform by manual and/or computer methods for a variety of treatments and patient set up conditions: □ Dose distribution and MU or treatment time calculations for treatments using: ■ Orthovoltage X ray beams ■ Megavoltage photon beams ■ Electron beams ■ Combination of photon and electron beams □ Planning of treatments using: ■ Abutting fields ■ Arc therapy ■ Irregular fields ■ Wedged fields ■ Oblique incident beams ■ Tissue inhomogeneity correction ■ Beam modifiers/compensators ■ 3-D conformal radiotherapy ■ Total body irradiation ■ Total skin electron irradiation ■ Stereotactic techniques ■ Image guided radiotherapy techniques ■ Motion compensation radiotherapy techniques ■ Adaptive radiotherapy techniques □ Forward and/or inverse planning and dose optimization of: ■ Intensity modulated radiotherapy • Demonstrate the use of a variety of tools in treatment planning, including: □ Beam's eye view □ 3D volumetric isodose displays □ Digital reconstructed radiographs □ Inverse dose planning and optimization based on physical dose and biological indices • Investigate for a variety of treatment sites, including prostate, lung and head and neck tumours, the sources and magnitude of: □ Inter-fraction treatment errors □ Intra-fraction treatment errors • Describe the effects and implications of treatment errors on dose distribution • Describe techniques that can be used to minimize	

		inter-fraction and intra-fraction geometric errors for different treatment sites • Perform assessment and acceptance of treatment plans using a variety of evaluation tools, including: □ Dose criteria for plan acceptance □ Dose to the target volumes and critical organs □ 3D volumetric dose distribution □ Dose volume histograms □ Dose conformity indices □ Biological indices • Perform quality control of individual treatment plans, including: □ Review/design: • QC workflow, procedures and protocols for treatment plans and treatment charts • Tolerance limits for interventional action for a range of plans. □ Use of independent dosimetry calculation systems for checking of treatment plans on dose/MU calculation □ Prepare appropriate QC or phantom plans for dosimetry verification by measurement or computer simulation of a variety of treatment plans, including: ■ Intensity modulated radiotherapy ■ Motion compensated radiotherapy □ Checking of the integrity of treatment data transfer to the treatment machine □ Evaluate in-vivo dosimetry measurement data against treatment planning calculations and interpret implications • Prepare documentation of individual treatment plans • Develop or support the development and commissioning of new planning techniques for existing or new treatments, including: □ Dosimetry evaluation and verification of new treatment plans by: ■ Verifying treatment plans with phantom dosimetry measurement data ■ Acquisition or design and construction of suitable dosimetry verification phantoms ■ Design treatment delivery and QC procedures □ Introduction/implementation of new technology in treatment planning □ Provide training/demonstration to staff on new techniques/procedures • Supervise and support the physics aspects of treatment planning including: □ Continue improvement of the treatment planning process and work flow □ Preparation and implementation of the work procedures and protocols for treatment planning and simulation, record and documentation to meet clinical needs □ Advice/recommend on proper and efficient use and	

		limitations of: ■ Beam data and the dose calculation algorithms ■ RTPS and accessory equipment □ Provide any planning data as required.	
		Module 6: Brachytherapy	
		Sub-module 6.1: Procurement	
		• Demonstrate an understanding on process involved in brachytherapy equipment requisition and acquisition • Review and report on department needs on: □ Equipment technology □ Functionality □ Performance □ Compatibility □ Training □ Maintenance service □ Building and building services □ Delivery and installation • Perform: □ Market research on brachytherapy equipment technology □ Technology assessment □ Review of procurement documentation • Submit project proposal and budgetary request • Prepare/perform □ Tender specification □ Tender evaluation □ Tender recommendation	
		Sub-module 6.2: Quality Assurance in Brachytherapy I - Acceptance Testing	
		Development and performance of test procedures and protocols for acceptance testing of brachytherapy equipment • Observe the installation of new equipment • Demonstrate an understanding of the: □ Concept and principles of a brachytherapy QA programme □ Local legislative requirements and international recommendations on safety of brachytherapy and remote afterloading equipment □ Properties and characteristics of the brachytherapy sources □ Specification, quality standard and operation characteristics of: • Brachytherapy sources • Treatment applicators • Afterloading brachytherapy equipment, including LDR, HDR, PDR □ Specification, functionality and dosimetry algorithm of brachytherapy treatment planning computer □ Sources and magnitude of errors associated with: • Manual and afterloading brachytherapy	

		• Brachytherapy treatment planning computer • Dosimetric data of radioactive sources □ Methods and procedures for testing of: ■ Remote afterloading brachytherapy equipment ■ Brachytherapy source ■ Treatment planning computer □ Use of test and measurement equipment required for acceptance testing □ Tolerance limits for each acceptance test • Design methods and test procedures/protocols and worksheets for a brachytherapy acceptance testing programme including: □ Inventory check □ Radioactive source, including: • Activity • Uniformity • Leakage • Physical integrity □ Afterloading equipment, including: • Functionalities of: ► Treatment planning computer ► Remote afterloading system • Integrity of treatment applicators and connectors • Source positioning accuracy • Dosimetric accuracy • Network integration and data transfer • Safety features • Develop and prepare test and measurement protocols and worksheets • Using established protocols and worksheets, perform acceptance testing of: □ Brachytherapy source □ Afterloading treatment equipment • Prepare and/or review acceptance test report and recommendations	
		Sub-module 6.3: Quality Assurance in Brachytherapy II – Commissioning	
		• Demonstrate an understanding of the: □ Operation and characteristics of brachytherapy services and equipment □ Performance assessment and testing of brachytherapy equipment and accessories □ Methods and procedures for commissioning of: ■ Remote afterloading brachytherapy equipment ■ Brachytherapy source ■ Treatment planning computer □ Use of test and measurement equipment required for commissioning procedures • Design methods, procedures and work programme for commissioning of a remote afterloader system and treatment planning system, including:	

		□ Configuration of the: ■ Treatment planning computer system, including: ► Patient demographic data ► Security and backup system ► Brachytherapy source data ► Calculation parameters ► Treatment plan report format ► Record and archival ► Export of treatment data ■ Remote afterloading treatment machine, including: ► Treatment control ► In-vivo dose monitoring system ► Security and backup system ► Import of treatment data ► Treatment record □ Verification against measurements and/or independent methods of: ■ Treatment planning computer system, including: ► Image registration tools ► Integrity of input devices, including the digitizer ► Treatment planning, including: ■ Dose ■ Dose distribution ■ DVH ■ Source geometry ■ Treatment time calculations ■ Correction for: □ Decay □ Attenuation ■ Treatment plan output and transfer ► Afterloading treatment machine, including: ■ Integrity of: □ Data transfer from treatment planning system □ Source transfer through the applicators and catheters ■ Accuracy of: □ Source positioning □ Dwell time ■ Multichannel applicator indexing system ■ Treatment and safety features and interlock systems, including: □ Applicator, catheters, and connectors □ Treatment termination □ Door □ Radiation warning indication systems □ Video monitoring system □ Backup power system □ Automatic source retraction system • Prepare test and measurement protocols and worksheets • Perform commissioning of a: □ Remote afterloading treatment system	

		□ Treatment planning computer system • Establishing baseline values for subsequent QC tests • Prepare and/or review commissioning report and documentation • Prepare/review operational procedures for treatment delivery	
		Sub-module 6.4: Quality Assurance in Brachytherapy III - QualityControl	
		• Demonstrate an understanding of the: □ Operation characteristics and functionalities of brachytherapy equipment and sources □ Acceptance testing and commissioning of brachytherapy equipment and sources □ Sources and magnitude of errors in brachytherapy □ Methods and procedures for QC in brachytherapy □ Equipment required for QC measures □ Tolerance limits and action levels • Design a series of QC measures for brachytherapy covering: □ Quality control of: ■ Treatment planning system ► Input and output devices ► Patient and image data ► Treatment dose and time calculation tools ► Computer network ► Individual patient plan (refer to sub-module on Treatment Planning below) ■ Integrity of radiation sources and their applicators ■ Afterloading treatment system: ► Safety and interlock ► Power failure backup systems ► Integrity of: □ Treatment applicators □ Connectors □ Multichannel indexing system □ Source transfer ► Source position and dwell time accuracy ► Dose monitoring system ► Data transfer ■ Treatment delivery, monitoring of: ► Applicators/source position ► Critical organ dose • Develop and prepare QC test and measurement protocols and worksheets • Perform QC on a: □ Remote afterloading treatment system □ Brachytherapy treatment planning system □ Brachytherapy source □ Brachytherapy treatment □ Dosimetry equipment • Prepare and/or review QC reports and documentation	

		Sub-module 6.5: Calibration of Brachytherapy Sources	
		• Demonstrate an understanding of the: □ Dosimetry properties of brachytherapy sources □ Dosimetry protocols for calibration of brachytherapy sources, including the procedures and recommendations as given in IAEA TECDOC 1274 □ Properties and functionalities of the calibration equipment □ Uncertainties involved in determination of source strength by measurement and calculation methods • Design calibration worksheet • Calibrate the strength of a variety of brachytherapy sources using: □ Well-type ionisation chamber □ Thimble ionisation chamber • Compare source strength as given in vendor certificate with measurement. □ Demonstrate an understanding of remedial action if exceeds tolerance level. • Prepare: □ Source data for treatment planning □ Calibration report	
		Sub-module 6.6: Acquisition of Image and Source Data for Treatment Planning	
		• Demonstrate an understanding of the methods and procedures for: □ Localization and reconstruction of brachytherapy sources □ Acquisition of the relevant patient anatomical information and source (using dummy sources) geometry for treatment planning using: ■ Radiotherapy treatment simulator ■ Mobile C-arm X ray unit ■ CT scanner ■ MRI ■ Ultrasound scanner □ Measurement of dose and dose distribution of sources • Supervise/advice on the acquisition of patient image/data for treatment planning using X-ray, CT, and/or ultrasound for: □ Fractionated or permanent interstitial implant treatment for a variety of sites, including: ■ Prostate ■ Breast ■ Tongue □ Intraluminal treatment, including: ■ Bronchus ■ Oesophagus □ Intracavitary treatment, including: ■ Cervix ■ Nasopharynx	

		• Perform for a variety of treatment sites: □ Transfer of image data to the treatment planning system □ Reconstruction of source geometry at the treatment planning computer from: ■ Orthogonal or stereo-shift X ray film via digitizer ■ CT, MR and/or ultrasound images □ Image registration using treatment planning system □ Contouring of treatment volume and critical structures of interest	
		Sub-module 6.7: Treatment Planning	
		• Demonstrate an understanding of the: □ Characteristics and merits of brachytherapy sources □ Physical principles, methods and merits of: ■ Manual brachytherapy ■ Remote afterloading treatment techniques: ► LDR ► HDRPDR □ Radiobiological principles relevant to brachytherapy □ Effects on dose of: ■ Source configuration ■ Inter-source heterogeneity ■ Source encapsulation ■ Treatment applicators □ Principles and properties of a variety of source configuration and dosimetry systems for implant and intracavitary brachytherapy, including methods and algorithms used for: ■ Reconstruction of source geometry ■ Dose calculation ■ Treatment plan optimization □ Patient and source data required for treatment planning □ Limitations and uncertainties associated with manual and computer planning □ ICRU system of dose specification □ Local treatment protocols for a variety of sites: ■ Treatment techniques ■ Dose fractionation ■ Tolerance doses of organs of interest • Perform: □ Source reconstruction with: ■ Radiographic images ■ Fluoroscopic images ■ CT images □ Treatment planning and dose calculation by manual and computer methods of a variety of brachytherapy treatments, including: ■ Intra-cavitary implant, including manual and/or afterloading treatment of cervical cancer based on commonly used source configuration and dosimetry systems, including:	

		► Manchester system ► Paris System ■ Interstitial implant, including manual or afterloading treatment of: ► Prostate implant based on commonly used dosimetry systems, including: ■ Manchester system ■ Paris system ► Breast implant ► Tongue implant ■ Intra-luminal treatment, including treatment of: ► Bronchus ► Oesophagus ► Nasopharynx ■ Intra-vascular treatment ■ Surface mould/plaque, including treatment of: ► Eye ► Skin cancer □ Dose/plan optimization based on a combination of: ■ Dose prescription/specification ■ Source configuration/distribution ■ Dwell time □ Calculation on radiobiological equivalence of treatment schemes, including: ■ Protracted brachytherapy to fractionated treatments ■ LDR and HDR brachytherapy ■ Total dose of adding external beam radiotherapy • Prepare treatment chart/data • Quality control of individual patient treatment plans, including independent checking of: □ Integrity of input data □ Dose □ Dose distribution □ Treatment chart □ Integrity of treatment data transfer from planning computer to afterloading treatment unit	
		Sub-module 6.8: Source Preparation	
		• Demonstrate an understanding of: □ Operation of a radiation source inventory and custody system □ System of work in a sealed source preparation room □ Principles and design of treatment applicators □ Procedures for safe handling and preparation of brachytherapy sources □ Source loading configurations for a variety of treatment protocols • Prepare for manual and/or afterloading treatments □ Treatment applicators and/or catheters for: ■ Intra-cavitary treatments ■ Intra-luminal treatments ■ Interstitial treatments	

		■ Surface treatments □ Implantation tools, such as treatment templates □ Brachytherapy sources for a variety of treatments, sources such as: ■ Cobalt-60 ■ Palladium-103 ■ Iodine-125 ■ Cesium-137 ■ Iridium-192 ■ Gold-198 • Supervise/advise on the cleaning and sterilization of sources and treatment applicators • Loading of the brachytherapy sources into treatment applicators according to treatment plans/protocols • QC of individual source loading • Issue and receipt of brachytherapy sources • Management of radiation sources, including: □ Acquisition □ Custody □ Disposal • Handle records and documentation	
		Module 7: Professional Studies and Quality Management	
		Sub-module 7.1: Professional Awareness **Career Planning**	
		• Demonstrate an understanding of the scope of practice and career structure of Radiation Oncology Physicists. • Demonstrate an understanding of the opportunities and restrictions in career progression. • Draw a tree diagram summarising your Medical Physics department's staff structure, including your position. • Define your own career plan. Professional Organisation Activities • Demonstrate an awareness of the professional organisation including the structure of your professional organisation including identifying key office bearers and administrative staff. • Attend and actively participate in professional activities. • Review website of medical physics professional organisations • Demonstrate an awareness of topical issues affecting your profession and professional organisation. • Demonstrate an awareness of the organisations representing your professional body and other allied organisations and locate the relevant websites. • Demonstrate of the awareness of international agencies and professional bodies as related to Radiation Oncology Physics. Professional Issues	

		i. Ethics • Demonstrate an understanding of your professional organisation and hospital's policies and procedures on professional and clinical ethics. • Demonstrate an awareness of the code of conduct and mission statement for your professional organisation and hospital. • Understand the requirements for ethics clearance for clinical research projects. • Understand the requirements of privacy of staff and patient information. ii. Legal Issues • Outline the objectives, definition and requirements of/for legal issues at your institution/s (e.g. hospital and university if relevant) and in your state and country as related to Radiation Oncology Medical Physicists. This should include the policies on conflict of interest and legislation and regulatory matters. • Outline the requirements of radiation incident reporting. • Awareness of data protection legislation. iii. Intellectual Property • Understand the types of intellectual property. • Outline the objectives, definition and requirements of/for intellectual property at your institution/s (e.g. hospital and university if relevant). • Outline ownership of material produced as a result of your research at your institution. • Demonstrate an awareness of vendor intellectual property requirements in the workplace, including software licensing and warranties. Continual Professional Development • Demonstrate an awareness of the objective of CPD. • Demonstrate an awareness of legislation and/or professional organisation requirements for CPD.	
		Sub-module 7.2: Communication **Oral Skills**	
		• Attend a course on □ Oral presentation competencies, □ Mentoring competencies, and/or □ Conducting professional meetings. • Actively participate in physics department meetings (chair a meeting if possible). • Actively participate in Radiation Oncology Department technical meetings e.g. reviewing patients' set-up and treatment techniques. • Scientific presentation at meeting of Medical Physicists, multi- disciplinary professionals or an audience	

		containing members of the general public. • Medical Physics tutoring for other Radiation Oncology professionals. Examples include Radiation Safety lectures and tutorials to Radiation Oncology Registrars. • Actively participate in project progress meetings during equipment commissioning. • Presentation of research results at a national and/or international conference/meeting. • Communicate with a patient (in a mock or real scenario), such as the purpose and method of in-vivo dosimetry to a patient you are about to perform a measurement on. • Provide accurate, clear, clinical medical physics advice regarding patient set-up, planning or treatment to other Radiation Oncology Professionals (via in-vivo dosimetry, specialised treatment techniques, consultation in the simulator room, etc). Written Skills • Demonstrate understanding of professional issues such as legal consequences of information documented and forwarded via email, confidentiality, sensitivity and permission to use data. • Demonstrate understanding of appropriate format and style of professional written communication, including email, memos and letters. • Keep a logbook • Write an example of a professional letter, email and memo that you could send to a key manager in the Radiation Oncology Department addressing a medical physics issue. • Write a brief technical report on a patient case study e.g. in vivo dosimetry, specialised treatment technique or patient treated with brachytherapy. • Write a business case to management regarding new or replacement radiotherapy equipment. • Write or review a protocol for a new or revised treatment technique commissioned by Department. • Write a progress and/or final report for commissioning of new radiotherapy equipment to Radiation Oncology Department. Comprehension Skills □ Participate in department meetings to review journal papers □ Present a review of an international technical protocol to Physics Department	
		Sub-module 7.3: General Management	
		• Participate in project management of the installation and/or commissioning of a therapy unit. • Manage a budget for a small research project • Supervise and mentor technical staff to successfully complete a project on schedule. • Manage a section of the department for a period of	

		time including liaising with other professional groups. • Manage a treatment planning system or linear accelerator (i.e. managing decisions on occasion necessary in short time frames). • Supervise the maintenance of therapy and simulation units, such as: □ Participate in trouble-shooting equipment faults for a period of time. □ Assume responsibility for each unit for a period of time, including being a contact point for equipment faults and liaising with engineers. □ Write a report and/or present to the physics department case studies outlining the equipment fault, its cause and required verification measurements required to ensure accurate dose delivery. □ Understand differences between units from different manufacturers. • Attend a course onTime management □ Conflict resolution □ Performance management	
		Sub-module 7.4: Information Technology	
		• Demonstrate understanding of electronic communication standards (e.g. Ethernet, FTP, DICOM, DICOM-RT, HL7, etc) • Demonstrate understanding of types and applications of databases in Radiation Oncology • Demonstrate understanding of information technology systems related to Radiation Oncology (e.g. Patient administration systems (PAS), MIMS (database for drugs), pathology, PACS (picture archiving), Incident Management System (IMS)) including various level of user rights. • Demonstrate understanding of professional IT issues such as privacy, confidentiality, sensitivity and permission to use data. • Demonstrate understanding of storage media and how to use them. • Set-up two computers to be able to communicate via DICOM using freeware DICOM tools. • Interface peripheral devices to PCs and treatment planning system (e.g. printers, scanners, fax, USB, serial, parallel, etc). • Perform data reporting, analysis and presentation using Microsoft Office applications (e.g. Work, Excel, PowerPoint) • Demonstrate understanding and ability to use tools for backing up radiotherapy and PC data. • Demonstrate understanding and ability to use Radiation Oncology Information Technology systems such as Record and verify system, data acquisition, linear accelerators, internet, TLD reader	

		software and treatment planning system.	
		Sub-module 7.5: Quality management systems	
		• Explain the meaning of relevant terms such as quality, quality process, quality assurance, quality control or quality audit • Demonstrate an understanding of the role of quality management in radiotherapy • Discuss key elements of a quality management system: o documentation of quality policy o documentation of quality procedures (quality manual)Analyze the patient work flow • Design the structure of a quality manual and apply it to a representative selection of items • Participate in a relevant course (either at the management or at the professional level)	
		Sub-module 7.6: Quality management for the implementation of new equipment	
		• Demonstrate an understanding of generic steps with the clinical implementation such as o clinical needs assessment o specification, purchase process o acceptance tests o commissioning o periodic tests • Exercise the implementation of at least one radiation facility (external beam therapy facility, afterloading facility) including beam calibration • Exercise the implementation of further items of equipment used in radiotherapy such as o equipment for imaging (simulator, CT, etc) o dosimetry systems o beam modifying and shaping equipment o network equipment • Demonstrate an understanding of the key steps of the commissioning of a computerized planning system • Demonstrate an understanding of a representative selection of steps required for the commissioning of a computerized planning system • Perform a patient specific quality assurance check of a computerized planning system	
		Module 8: Research, Development and Teaching	
		Sub-module 8.1: Research and Development	
		• Participate in a research and/or development project in Radiation Oncology including tasks such as: o Define an area for research, including the specific question which is being asked, in consultation with other physicists in the department. o Formulate hypotheses. o Review the literature in the area effectively and	

		critically and provide this in a written report (including the clinical benefits of the research or development). o Continually monitor current advances in research and development in the chosen area of research. o Determine a project plan for the project including, milestones, necessary experiments and analysis and time frames. o Select and use appropriate equipment and scientific methodology. o Assess and quantify uncertainty in experimental methods. o Publication or presentation of results at a national or international level. o Write a reply to reviewers' comments and make necessary changes. o Liaise with research/technical assistants. o Defend research results to an audience. • Write a small to medium research grant application. • Participate in the improvement of the Medical Physics service. • In consultation with other department members, determine a collaborative project within the department that you can be involved with. • Apply relevant medical physics knowledge to assist with clinical trials, statistical methods and mathematical modelling in association with medical staff, data managers and/or statisticians, such as. o Provide dosimetry advice to Radiation Oncologists regarding a clinical trial, as well as: ■ Demonstrate an understanding of the characteristics of clinical trials, including those currently being conducted locally and ■ Awareness of the role of multidisciplinary professionals in the execution and evaluation of Clinical Trials. o Collaborate with medical staff, data managers and statisticians by assisting with the use of statistical methods and mathematical modelling in Radiation Oncology.	
		Sub-module 8.2: Teaching	
		• Attend a general course (if available) on how to teach scientific material. • Develop familiarity with teaching techniques, including understanding the needs of particular audiences. • Teach radiation and general physics (including radiation safety) to different audiences (e.g. radiation therapists, medical staff, students, junior physicists, etc.) • Attend a general course (if available) on mentoring or clinical supervision for health professionals. • Understand the differences between individual and group learning.	

		• Understand the requirements of adult education and professional development.	

	MODULE 1. CLINICAL INTRODUCTION
Objective	**To provide medical physicists with knowledge and clinical experience related to Radiation Oncology.**
Competencies Addressed in this Module.	• **A basic understanding of the clinical aspects of Radiobiology** • **A basic understanding of cancer and radiation oncology suitable for medical physicists** • A basic knowledge anatomy for medical physicists • Operating procedures of Radiation Oncology and other clinical departments
Expected Time Commitment	**7 % of entire program** **(51 day)**
Sub-modules	1.1 CLINICAL ASPECTS OF RADIOBIOLOGY 1.2 Introduction to Radiation Oncology 1.3 Anatomy 1.4 Patient Related Clinical Experiences
Pre-requisite Knowledge	PODGORSAK, E.B., (Ed.) Review of Radiation Oncology Physics: A Handbook for Teachers and Students, International Atomic Energy Agency, Vienna, (2005). Chapter 14
Core Reading List	BOMFORD, C.K., KUNKLER, I.H., Walter and Miller's Textbook of Radiotherapy, 6th edn, Churchill Livingstone/Elsevier Science Ltd, Edinburgh (2002). HALL, E., GIACCIA, A.J., Radiobiology for the Radiologist, 6th edn, Lippincott Wilkins & Williams, Philadelphia, USA (2006). PEREZ, C., BRADY, L., (Eds), Principles and practice of radiation oncology, Lippincott Williams & Wilkins, Philadelphia, (2004). STEEL, G., Basic Clinical Radiobiology, 3rd edn, Arnold Press (2002). Applied Sciences of Oncology CDs
	Module 1. Clinical Introduction
	Sub-module 1.1: Clinical Aspects of Radiobiology
Objective	To gain a basic understanding of the clinical aspects of radiobiology
Competency Addressed	A basic understanding of the clinical aspects of Radiobiology
Pre-requisite Knowledge	Nil

Recommended Items of Training	• Demonstrate an understanding of fractionation scheme. • Perform modified fractionation scheme examples. • Perform calculations to account for gaps between fractions. • Perform calculations to convert dose between brachytherapy LDR/HDR and external beam radiation therapy. • Re-treatment examples • Awareness of rationale behind treatment options with respect to LET – protons, heavy ions, etc • Dose constraints of normal tissue for treatment planning. • Demonstrate an understanding of Biological Treatment Planning – parameters for different tumour types and potential for individualised treatment. • Understanding of limitations of utilising radiobiology calculations in the clinic. • Understand the radiobiological rationale for combination therapy (e.g. chemotherapy and radiotherapy) and report on patient case studies.
	Module 1. Clinical Introduction
	Sub-module 1.2: Introduction to Radiation Oncology
Objective	To develop a basic understanding of cancer disease and the use of radiation oncology.
Competency Addressed	**A basic understanding of cancer and radiation oncology suitable for medical physicists.**

Recommended Items of Training	• Role of RT in cancer treatment (vs. other modalities)
	• Aim of radiotherapy
	  o Tissue tolerances
	  o Required accuracy
	  o Therapeutic gain
	  o Palliative vs. curative
	  o Clinical “target”
	• Cancer disease and radiation oncology
	  o Demonstrate an understanding of the nature and effects of a tumour on an organ and its function.
	  o Identify the main routes of spread of disease and metastases for common cancer sites.
	  o Identify abnormal size and function of organs due to primary tumours and metastases on radiological, PET and nuclear medicine images.
	  o Demonstrate an understanding of the clinical decision making process of cancer diagnosis of a patient (i.e. relation of presenting symptoms to tumour type).
	  o Demonstrate an understanding of tumour grading and staging.
	• Review the anatomical and physiological changes to the body/organ due to radiotherapy treatment

	Module 1. Clinical Introduction
	Sub-module 1.3: Anatomy
Objective	To develop a basic knowledge of anatomy including surface anatomy and cross sectional anatomy with particular emphasis on the anatomy required for radiotherapy.
Competency addressed	**A basic knowledge of anatomy for medical physicists.**
Assumed knowledge	**Introductory course in Anatomy & Physiology**

Recommended Items Of Training	• Cancer and radiation oncology
	  ○ Demonstrate an understanding of the nature and effects of a tumour on an organ and its function.
	  ○ Identify the main routes of spread of disease and metastases for common cancer sites.
	  ○ Identify abnormal size and function of organs due to primary tumours and metastases on radiological, PET and nuclear medicine images.
	  ○ Demonstrate an understanding of the clinical decision making process of cancer diagnosis of a patient (i.e. relation of presenting symptoms to tumour type).
	  ○ Demonstrate an understanding of tumour grading and staging.
	• Review the anatomical and physiological changes to the body/organ due to radiotherapy treatment
	• Identify key anatomical features on CT cross sectional images through body sections.

	Module 1: Clinical Introduction
	Sub Module 1.4: Patient Related Clinical Experiences
Objective	To provide the Resident with broad patient-related experiences and an understanding of the role of multidisciplinary professionals in Radiation Oncology.
Experience Gained	The medical physicist is expected to gain clinical experiences in the following patient-related clinical experiences and compile a short report: • Ward round • Mould room • New patient/review/follow up clinics • Patient case studies • Simulator and/or CT • Treatment planning room • Radiation treatment • Operating theatre • Imaging Department/s

Recommended Items Of Training	During these patient related experiences, the medical physicist must gain an understanding of the: • Need for patient care, rapport, privacy and confidentiality during patient related experiences. • Appropriate hygiene/infection control procedures • Effect on patient quality of life • Need for introducing oneself to the patient. • Patient-staff interactions • Interactions and roles and responsibilities of multi-disciplinary professionals involved in patient management. • Interactions with/within Radiation Oncology Department • Patient's and their carers reactions to procedures and management • Role of a Physicist in the section/department (where relevant). **Ward Round** • Attend at least two ward rounds with different Radiation Oncologists. • Demonstrate an understanding of the purpose of the ward round • Note the reasons for the patient's admission and their conditions • Understand why only a low percentage of radiation oncology patients need to be admitted to the ward **New Patient-Clinic** • Attend each clinic and at least two patients in each clinic • Understand the purpose of the clinic • Understand the reasons for the patient's attendance • Be aware of clinic outcomes (blood tests, further investigations required, further appointments) • For review patients, note the overall prescription required and the dose and fractionation to date. Be aware of clinical reactions noted and the patient's reaction. **Mould Room** • Attend the manufacture of treatment aids (bolus, shielding, immobilisation devices etc.) of at least four different types • Demonstrate an understanding of the patient diagnosis and the proposed treatment technique. • Demonstrate an understanding of the use of the treatment aid for this patient • Demonstrate an understanding of the physics principles which may be involved with this aid and an awareness of the effect that this aid has on the treatment. • Demonstrate an understanding of potential health hazards that may be involved with the manufacture of this aid and associated safety procedures, including consideration of alternative solutions (other materials or techniques). **Simulator** • Attend a simulator unit or CT scanner for a period of at least three days. • Observe patient advice being provided. • Observe the issues involved in positioning a patient accurately.

	Compare this with taking physics dosimetry measurements. • Demonstrate an understanding of the patient's diagnosis, investigations, intent for simulation, treatment rationale and prescription over a range of treatment techniques. **Treatment Planning Room** • Attend the treatment planning room for a period of one week • Demonstrate an understanding of the intent of the procedure based on the diagnosis, rationale or treatment, anatomy and any special conditions • Demonstrate an understanding of the planning process from the obtaining of patient geometric and anatomical data through to validation and transfer to the treatment unit. • Demonstrate an understanding of dose optimisation. • Perform a four-field treatment plan. • Demonstrate a familiarisation with the standard planning protocols used. **Radiation Treatment** • Attend at least one radiation treatment unit for a period of one week. • Identify and understand the components of the treatment record • Observe the issues involved in positioning a patient accurately. Compare this with taking physics dosimetry measurements. • Demonstrate an awareness of the patient diagnosis, prescription, dose delivered to date and current reactions • Compare any port films taken against the intended treatment plan. Consider the impact that any discrepancies might have. • Relate one's own knowledge of the underlying physics principles to the treatment **Case Studies** • Follow at least three patients (representing different treatment sites) from clinic through to treatment. **Operating Room** • Demonstrate understanding of the differences between treatment options (surgery vs. radiotherapy) for cancer patients and the limitations of surgery. • Attend theatre for Oncology-related procedures (e.g.. tumour excision, brachytherapy seed implant, etc) • Perform correct scrub technique. **Imaging** • This should include both radiology and nuclear medicine • Compile a list of procedures performed for potential radiotherapy patients. • Observe simple and complex diagnostic studies performed on patients (including Oncology patients).

	• Observe a Specialist reporting on patient images (including Oncology patients). • Observe a member of staff advising a patient on radiation safety aspects. • Observe the use of image transfer and display systems. • Observe the use of shielding in the department. • Observe the safe handling of radioisotopes. • Observe the use of imaging (e.g. gamma camera, PET, SPECT) and support equipment (e.g. phantoms, dosimeters). • Demonstrate an understanding of the department's research and development activities.

	MODULE 2: RADIATION SAFETY AND PROTECTION
Objective	To develop personal and key skills in radiation protection management in a radiotherapy department
Competencies Addressed in this Module	• Understanding of and the ability to apply the principal requirements of radiation protection management. • Ability to assess local radiation protection guidelines and to interpret new guidelines. • Knowledge and skills necessary to perform radiation safety and protection procedures according to local requirements. • Knowledge and skills necessary to perform radiation safety and protection procedures for radiation sources according to local requirements. • Ability to perform the role of a radiation safety officer in a Radiation Oncology department. • Ability to manage disused sources and waste. • Ability to: o Design room shielding in treatment facilities. o Calculate the thickness of the shielding structure • Perform radiation survey and monitoring • Knowledge and skills required to provide protection in relation to medical, occupational and public exposure • Ability to reach correct decisions in emergency situations. • Ability to perform the role of a radiation safety officer or source custodian in brachytherapy and to take appropriate safety and quality control procedures in brachytherapy treatment • Conduct of radiation risk assessment, design of room and source shielding in brachytherapy treatment facilities. Radiation survey and monitoring
Expected time commitment	**7 % of entire program** **(51 day)**
Sub-modules	2.1 Principal requirements 2.2 Local organization 2.3 Procedures 2.4 Safety of radiation sources 2.5 Radiation Protection Design of Treatment Rooms 2.6 Protection against medical, occupational and public exposure 2.7 Emergency situations 2.8 Radiation Safety in Brachytherapy 2.9 Radiation Protection Design of Brachytherapy Treatment Rooms
Prerequisite Knowledge	PODGORSAK, E.B., (Ed.) Review of Radiation Oncology Physics: A Handbook for Teachers and Students, International Atomic Energy Agency, Vienna, (2005). Chapter 4, 16

Core Reading List	INTERNATIONAL ATOMIC ENERGY AGENCY, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, IAEA, Vienna (1996). INTERNATIONAL ATOMIC ENERGY AGENCY, Regulations for the Safe Transport of Radioactive Material, 2005 Edition Safety Requirements Details IAEA Safety Standards Series, No. TS-R-1, IAEA, Vienna (2005).
	INTERNATIONAL ATOMIC ENERGY AGENCY, Applying Radiation Safety Standards in Diagnostic Radiology and Interventional Procedures Using X Rays, IAEA Safety Reports Series No. 39, IAEA, Vienna (2006). INTERNATIONAL ATOMIC ENERGY AGENCY, Setting up a Radiotherapy Programme: Clinical, Medical Physics, Radiation Protection and Safety Aspects, IAEA, Vienna (2008).
Supplementary Reading List	INTERNATIONAL ATOMIC ENERGY AGENCY, Lessons Learned from Accidental Exposures in Radiotherapy IAEA Safety Reports Series No. 17, IAEA, Vienna (2000).
	Module 2. Radiation Safety and Protection
	Sub-module 2.1: Principal requirements
Objective	To develop an understanding of the principal requirements required for local radiation protection management
Competencies addressed	Understanding of and the ability to apply the principal requirements of radiation protection management.
Recommended Items of Training	• Analyze and understand the policies for protection and safety as laid down in the QA programme of the local department and compare to national legislation, the International BSS and recommendations by the ICRP • Compile a list of all local documents on radiation protection and compare with relevant international standards • Interpret legislative requirements in the local department such as given by: o number and type of treatment units and/or radioactive sources o patient and machine workload o concerns of previous reviews (if existing) • Write and/or critically review local radiation safety related administrative and management procedures.
	Module 2. Radiation Safety and Protection
	Sub-module 2.2: Local organization
Objective	To develop an understanding and overview of local protection regulations and publications

Competency addressed	Ability to assess local radiation protection guidelines and to interpret new guidelines.

Recommended Items of Training	• Evaluate the application of current laws, regulations and recommendations as applied locally
	• Describe the local organization of radiation protection:
	  o responsibilities
	  o process of authorization
	  o number and individuals having responsibilities for the application of protection standards
	  o number and individuals involved in occupational exposures

	• List local license publications applying to treatment units and explain them with respect to conditions and limitations • Read instructions on radiation protection provided to staff and patients
	Module 2. Radiation Safety and Protection
	Sub-module 2.3: Procedures
Objective	To develop personal and key skills for performing local radiation safety and protection programmes and procedures
Competency addressed	Knowledge and skills necessary to perform radiation safety and protection procedures according to local requirements.
Recommended Items of Training	• Demonstrate an understanding of selection, calibration and principles of survey meters • Perform radiation survey of an area using appropriate dose-rate equipment • Demonstrate an understanding of selection, calibration and principles of individual radiation monitors • Compile the steps relevant to radiation protection to be performed during acceptance tests and commissioning of a treatment facility • Understand the various interlocks required on radiotherapy equipment, including remote afterloading brachytherapy equipment • Compile and monitor local relevant operation instructions for equipment and facilities • Translate examples of existing operating instructions from major world language into local language if applicable
	Module 2. Radiation Safety and Protection
	Sub-module 2.4: Safety of radiation sources
Objective	To develop personal and key skills in the handling of radiation sources used in Radiation Oncology.

Competencies addressed	• Knowledge and skills necessary to perform radiation safety and protection procedures for radiation sources according to local requirements. • Ability to perform the roles of a radiation safety officer in Radiation Oncology • Ability to manage disused sources and waste.
Recommended Items of Training	• Perform an inventory of all sources in the department • Compare your own inventory with the department's keeping and record system • Compile relevant international (IEC) or national standards for source equipment applicable to radiotherapy • Demonstrate an understanding and perform a design of a safety system/code of practice for radiation sources, covering: ° Storage security and safety ° Source inventory system ° A book keeping system for tracking source movement, such as for delivery, storage, release for clinical application, disposal ° Labelling
	° Transportation ° Local legislative requirements and international recommendations on quality and safety standards of radiation sources • Demonstrate a safe operation of source related equipment • Perform leak tests on radioactive sources • Demonstrate an understanding on potential hazards and risks, with particular emphasis on brachytherapy • Conduct radiation risk assessment • Design radiation emergency procedures, including o Fire o Brachytherapy equipment malfunction o Loss of radioactive source • Perform: o Regular source inventory check o Leakage test of sources o Testing on integrity of the: – Treatment interlocks of afterloading equipment – Area radiation monitoring and warning systems • Supervise/monitor and record the transfer of sources • Advise on: o Compliance with legislative requirements, including licence application o Safety and protection measures o Proper use of protective equipment and handling tools • Report of incident involving radiation o Prepare record and documentation • Investigate how principles of waste disposal operate locally • Exercise the return procedure of empty packages • Exercise the return procedure of a disused source
	Module 2. Radiation Safety and Protection
	Sub-module 2.5: Radiation Protection Design of Treatment Rooms

Objective	To develop the skills required for all radiation protection measures for radiation treatment rooms for external beam therapy and brachytherapy
Competencies addressed	Ability to: • Design room shielding in treatment facilities. • Calculate the thickness of the shielding structure • Perform radiation survey and monitoring
Recommended Items Of Training	• Demonstrate an understanding on the: o Local legislative requirements on radiation safety and protection o International standards and recommendations o Nature of source and equipment to be installed o Nature and types of the treatment services to be provided o Source strengths to be used o Projected patient load o Room layout requirements taking into consideration the requirements for sterility, patient flow, work flow, staff manoeuvre, and supply logistics • Perform radiation risk assessment on the facility
	• Determine the: o Radiation shielding requirements taking into consideration: – Room layout – Types of treatments to be performed – Projected patient load – Types and activities of the sources – Occupancy factors o Appropriate shielding materials for: – Door/entrance – Walls – Ceiling – Floor o Required thickness for the shielding structures o Radiation warning signs and signals o Ancillary and accessory safety equipment, including: – Radiation monitoring and alarm system – Door interlock – Closed circuit television o Safety interlock system • Calculate the radiation dose levels for: o Areas of interest o Staff o Other personnel • Advise on shielding design for a new or modified building • Conduct radiation survey and monitoring • Assess results, draw conclusion on the safe integrity of the treatment room and recommend course of action • Prepare reports and documentation
	Module 2. Radiation Safety and Protection

	Sub-module 2.6: Protection against medical exposure, occupational and public exposure
Objective	To develop key skills to organize provisions required for protection against medical exposure, occupational and public exposure
Competencies addressed	Knowledge and skills required to provide protection in relation to medical, occupational and public exposure
Recommended Items of Training	• Demonstrate familiarity with the specific application of radiation protection principles to medical, occupational and public exposure such as o Responsibilities o Justification o Optimization o ALARA principle • Understand methods to minimise dose to sites of risk such as o Foetus o Gonads o Lens o Spinal cord o Pacemaker
	• Perform calibration checks by o using an internationally accepted code of practice for external beam radiotherapy and for source strength determination o performing cross-checks of dose calculations • Compile relevant information given to the workers about their obligations and responsibilities for their own protection and the protection of others • Demonstrate a knowledge of all controlled areas in the department • Demonstrate an understanding of principles and practice for personal dosimeters o exposure assessment o monitoring period and frequency of reading o rules for returning and changing o rules for damage or if lost o record keeping • Oversee a personal dosimetry system. • Perform calculations for dose or exposure from beta particles and gamma sources. • Perform radiation protection area surveys surrounding radiation facilities
	Module 2. Radiation Safety and Protection
	Sub-module 2.7: Emergency Situations
Objective	To develop key skills to reach correct decisions in case of emergencies
Competency addressed	Ability to reach correct decisions in emergency situations.

Recommended Items of Training	• Investigate risk factors of radiation
	• Discuss radiation emergency plans
	  o responsibilities
	  o for each type of sealed sources
	  o for any other credible radiation emergency which could arise in the local radiation oncology department
	  o availability of equipment and tools
	• Carry out a formal risk assessment of a procedure
	• Plan and practice contingency measures, e.g. equipment malfunction, lost source, spill
	• Discuss decontamination procedures after a spill of liquid radionuclide
	• Be familiar with response procedures in the event of unnecessary dose to one or more individuals
	• Be familiar with response procedures in the event of machine malfunction, sealed source loss or misuse, unsealed source loss, misuse or spillage.

	Module 2. Radiation Safety and Protection
	Sub-module 2.8: Radiation Safety in Brachytherapy
Objective	Training on safe handling and use of brachytherapy sources.
Competency Addressed	Ability to perform the role of a radiation safety officer or source custodian in brachytherapy and to take appropriate safety and quality control procedures in brachytherapy treatment

Recommended Items of Training	• Demonstrate an understanding of: • Principles and practice of radiation safety and protection in brachytherapy under normal and emergency situations • Local legislative requirements and international recommendations on quality and safety standards of brachytherapy equipment and procedures • Potential hazards and risks in brachytherapy • Safety requirements of: ° Legislation ° Guidelines/code of practice • Functionality and properties of radiation monitoring and protection equipment/tools • Conduct radiation risk assessment • Design: • A system of radiation protection for protection of: ° Staff ° Patient ° Other personnel • A safety system for radiation sources, covering: ° Storage security and safety ° Source inventory system ° A logging system for tracking source movement, including: • Delivery • Storage • Release for clinical application • Disposal ° Transportation • Local radiation safety rules, instructions, and operational procedures/guidelines • Radiation emergency procedures, including: ° Fire ° Brachytherapy equipment malfunction ° Loss of radioactive source • Perform: • Radiation monitoring/surveys of: ° Rooms ° Staff ° Patients • Regular source inventory check • Leakage test of sources • Testing on integrity of the: ° Treatment interlocks of afterloading equipment ° Area radiation monitoring and warning systems • Supervise/monitor and record the transfer of sources • Advice on: • Compliance with legislative requirements, including: ° Licence application • Safety and protection measures • Proper use of protective equipment and handling tools • Report of incident involving radiation o Prepare record and documentation

	Module 2. Radiation Safety and Protection
	Sub-module 2.9: Radiation Protection Design of Brachytherapy Treatment Rooms
Objective	Training on radiation shielding design of brachytherapy treatment room.
Competency Addressed in this Sub-module	Conduct of radiation risk assessment, design of room and source shielding in brachytherapy treatment facilities. Radiation survey and monitoring
Recommended Items of Training	• Demonstrate an understanding on the: • Local legislative requirements on radiation safety and protection • International standards and recommendations • Nature and types of the treatment services to be provided • Types and strengths of the radioactive sources to be used • Nature of equipment to be installed • Projected patient load • Room layout requirements taking into consideration the requirements for sterility, patient flow, work flow, staff manoeuvre, and supply logistics • Perform radiation risk assessment on the facility • Determine the: • Radiation shielding requirements taking into consideration: ° Room layout ° Types of treatments to be performed ° Projected patient load ° Types and activities of the sources ° Occupancy factors • Appropriate shielding materials for: ° Door/entrance ° Walls ° Ceiling ° Floor • Required thickness for the shielding structures • Radiation warning signs and signals • Ancillary and accessory safety equipment, including: ° Radiation monitoring and alarm system ° Door interlock ° Closed circuit television • Safety interlock system • Calculate the radiation dose levels for: • Areas of interest • Staff • Other personnel • Conduct radiation survey and monitoring • Assess results, draw conclusion on the safe integrity of the treatment room and recommend course of action • Prepare reports and documentation

	MODULE 3. RADIATION DOSIMETRY FOR EXTERNAL BEAM THERAPY
Objectives	To develop the skills and expertise required in radiation dosimetry for external beam therapy.
Competencies Addressed in this Module	• Capability in the understanding and use of ionisation chambers for relative and absolute determination of absorbed dose to water in radiotherapy beams. • Capable to perform dose measurements in radiotherapy beams using a range of dosimeters. • Capable to perform absorbed dose determination in external beam radiotherapy • Capable to perform relative dose measurements in external beam radiotherapy. • To be able to perform and analyse dose verification measurements in a • Able to monitor the accuracy of dose planned and delivered to Individual patients, patient groups, in standard treatment techniques and in special or new treatment techniques. • Ability to manage a QA programme for all dosimetry equipment
Time commitment	**10 % of entire program** **(72 day)**
Pre-requisite Knowledge	[1] PODGORSAK, E.B., (Ed.) Review of Radiation Oncology Physics: A Handbook for Teachers and Students, International Atomic Energy Agency, Vienna, (2005). Chapters 2, 3, 6, 8, 9
Sub-modules	3.1 Dosimetry Operations using Ionization Chambers 3.2 Dosimetry Operations using Other Methods 3.3 Absolute Absorbed Dose Measurements 3.4 Relative Dose Measurements 3.5 Patient Dose Verification 3.6 In-vivo Dosimetry 3.7 QA in Dosimetry
Core Reading List	INSTITUTE OF PHYSICS AND ENGINEERING IN MEDICINE AND BIOLOGY, The IPEMB code of practice for the determination of absorbed dose for x-rays below 300 kV generating potential (0 035 mm Al - 4 mm Cu; 10 - 300 kV generating potential), Phys. Med. Biol. **41** (1996) 2605-2625. INTERNATIONAL ATOMIC ENERGY AGENCY, Absorbed Dose Determination in External Beam Radiotherapy: An International Code of Practice for Dosimetry Based on Standards of Absorbed Dose to Water ,Technical Reports Series No. 398, IAEA, Vienna (2000). INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Fundamental Quantities and Units for Ionizing Radiation, ICRU Rep. 60, Bethesda, MD (1998). INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, Guide to the expression of uncertainty in measurement, 2nd ed. [Published by ISO in the name of BIPM, IEC, IFCC, IUPAC, IUPAP and OIML], ISO, Geneva (1995).

	PODGORSAK, E.B., (Ed.) Review of Radiation Oncology Physics: A Handbook for Teachers and Students, International Atomic Energy Agency, Vienna, (2005). VAN DYK, J., (Ed.) The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists, Medical Physics Publishing, Madison WI, (1999).
Supplementary Reading List	ATTIX, F.H., Introduction to Radiological Physics and Radiation Dosimetry, John Wiley & Sons, New York (1986). INTERNATIONAL ATOMIC ENERGY AGENCY, Absorbed Dose Determination in Photon and Electron Beams: An International Code of Practice, Technical Reports Series No. 277, IAEA, Vienna (1987). INTERNATIONAL ATOMIC ENERGY AGENCY, The Use of Plane-parallel Chambers in High-energy Electron and Photon Beams: An International Code of Practice, Technical Reports Series No. 381, IAEA, Vienna (1997). INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Tissue Substitutes in Radiation Dosimetry and Measurement, ICRU Rep. 44, Bethesda, MD (1989). INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Dosimetry of High-Energy Photon Beams Based on Standards of Absorbed Dose to Water, ICRU Rep. 64, Bethesda, MD (2001). JOHNS, H.E., CUNNINGHAM, J.R., The Physics of Radiology, 4th edn, Thomas, Springfield (1983). KATHREN, R.L., Radiation Protection, Medical Physics Handbooks 16, Adam Hilger (1985). KHAN, F.M., The Physics of Radiation Therapy, 2nd edn, Lippincott, Williams & Wilkins (2003). KLEVENHAGEN, S.C., Physics and Dosimetry of Therapy Electron Beams, Medical Physics Publishing (1993). METCALFE, P., KRON, HOBAN, P., The Physics of Radiotherapy X-rays from Linear Accelerators, Medical Physics Publishing, Madison, WI (1997). WILLIAMS, J.R., THWAITES, D.I., (Eds), Radiotherapy Physics in Practice, 2nd edn., Oxford University Press, (2000). Manual for Beam Data Acquisition System Manuals supplied for all the electrometers and ionization chambers in the department Manuals for relevant radiation dosimetry equipment
	Module 3. Radiation Dosimetry for External Beam Therapy
	Sub-module 3.1: Dosimetry Operations Using Ionization Chambers
Objective	• To develop the capability in the understanding and use of ionisation chambers for the determination of absorbed dose to water in radiation fields.
Competency addressed	Capability in the understanding and use of ionisation chambers for relative and absolute determination of absorbed dose to water in radiotherapy beams.

Recommended	• Demonstrate understanding of the following: • Selection criteria for type of ionization chamber
Items of Training	• The quantity and unit to be measured • Influence effects on the measured quantity (air density, recombination, polarity, warm-up, stem effects, leakage, humidity) • Correction factors for: o influence effects o radiation quality o Perturbation effects such as caused by the chamber cavity, chamber wall, central electrode, or by the replacement of medium by the chamber • Perform dose measurements with a range of ionization chambers to demonstrate understanding and correct application of the characteristics given above.
	Module 3. Radiation Dosimetry for External Beam Therapy
	Sub-module 3.2: Dosimetry Operations Using Methods Other Than Ionization Chambers
Objective	To develop capability in the appropriate use of a range of dosimeters for dose measurements in radiotherapy beams.
Competency addressed	Capable to perform dose measurements in radiotherapy beams using a range of dosimeters.
Recommended Items of Training	• Demonstrate an understanding of the advantages and disadvantages of using particular detectors for absolute and relative dosimetry measurements. • Perform measurements with TLDs and demonstrate an understanding of aspects such as: o Commonly available TLDs (shapes, sizes and materials). o Common examples of TLD measurements: eye, TBI etc. o TLD measurements: preparation, precautions etc. o Basic structure and function of the photomultiplier tube. o QA in TLD measurements • Perform measurements with Solid State dosimeters and demonstrate an understanding of aspects such as: o Design of diodes, photon/electron diodes, shielding, pre-irradiation, energy dependence. o Typical bias voltages and output currents. • Perform measurements with films including radiographic and radiochromic films, and demonstrate an understanding of aspects such as: o Basic structure and function of film types. o Basic structure and function of a film processor. o Basic structure and function of a film densitometer/scanner. o Perform a calibration of film in terms of absorbed dose o QA for film dosimetry.
	Module 3. Radiation Dosimetry for External Beam Therapy
	Sub-module 3.3: Absolute Absorbed Dose Measurements

Objective	To use ionisation chambers to perform absolute determination of absorbed dose to water under reference conditions in radiotherapy beams following a standard dosimetry protocol.

Competencies addressed	Capable to perform absorbed dose determination in external beam radiotherapy.
Recommended Items of Training	• Demonstrate a familiarity with the use of the IAEA TRS398 Code of Practice (or another accepted protocol) • Explain differences to other protocols • Determine the radiation quality for different types of radiation (depending on availability) • Perform a determination of absorbed dose under reference conditions using the TRS 398 Code of Practice and associated spreadsheets as provided by the IAEA for different types of beams (depending on availability) • Perform a cross calibration procedure in particular for electrons. • Analyse the uncertainty of dose calibration.
	Module 3. Radiation Dosimetry for External Beam Therapy
	Sub-module 3.4: Relative Dose Measurements
Objective	To develop the expertise in the appropriate use of a range of dosimetry systems and phantom materials for the measurement of relative dose and dose distributions in radiotherapy beams.
Competencies addressed	Capable to perform relative dose measurements in external beam radiotherapy.
Recommended Items of Training	**Dosimeter related issues** • Demonstrate an understanding of the appropriate use of dosimeters for relative dose measurements • Demonstrate an understanding of factors influencing a dose measurement und non-reference conditions **Phantom related issues** • Demonstrate an understanding of the requirements on dosimeters and phantoms for measurements in phantoms • Explain correction factors required for non water-equivalent phantom materials (differential for photons and electrons) **Auxiliary related issues** • Demonstrate familiarity with the operation of a water phantom system including knowledge of statistical analysis, correction facilities, hard copy print out etc that may be provided with the system • Demonstrate an understanding of the design criteria and purpose of common dosimetric accessories such as intercomparison jigs or blocks, calibration blocks etc. **TPS related issues** • Determine at least the following items in a water phantom: o Percentage depth dose o Beam profiles o TAR/TPR/TMR

	○ scatter factors (collimator scatter factor, phantom scatter factor) • Determine the following items (if used) in a solid phantom (using different dosimetry equipment): ○ Real wedge transmission factor ○ Total scatter factors ○ Collimator scatter factors ○ Compensator factor ○ Electron cutout factor ○ Tray transmission factor • Perform measurements with film (if available) in a solid phantom. • Demonstrate an understanding of the uncertainties involved in the measurements. • Analyse the uncertainty of data.
	Module 3. Radiation Dosimetry for External Beam Therapy
	Sub-module 3.5: Patient Dose Verification
Objective	To develop the expertise to perform a dose verification procedure
Competency addressed	Ability to perform and analyse dose verification measurements in a phantom in order to decide on acceptance of a treatment plan.
Recommended Items of Training	• Participate in an existing programme or design a new programme for patient dose verification. • Transfer the beam configuration of a specific patient treatment plan to an appropriate phantom, measure absolute dose at selected points of interest and compare results to calculated doses. • Understand and use quantitative methods to describe the degree of compliance by using tolerance and/or action levels, e.g. the Gamma-Index method. • List the decision making process behind acceptance and rejection of a treatment plan.
	Module 3. Radiation Dosimetry for External Beam Therapy
	Sub-module 3.6: In-vivo Dosimetry
Objective	To be able to understand, participate and improve/implement an in-vivo dosimetry programme for individual patients, patient groups, standard treatment techniques, and special or new treatment techniques.
Competency addressed	Ability to monitor the accuracy of dose planned and delivered to Individual patients, patient groups, in standard treatment techniques and in special or new treatment techniques.
Recommended Items of Training	• Review and improve/implement an in-vivo dosimetry programme in line with national and international best practice. • Undertake a literature review on the advantages and disadvantages of an in-vivo dosimetry programme and choice of dosimeter. • Demonstrate an understanding of advantages and disadvantages of different methods • Perform in-vivo dosimetry measurements (including writing a case study report) for such examples as: ○ lens of the eye ○ in field measurements for

	▪ orthovoltage X ray beams ▪ megavoltage X ray beams ▪ electron beams
	Module 3. Radiation Dosimetry for External Beam Therapy
	Sub Module 3.7: QA in Dosimetry
Objective	To be able to understand and follow recommendations for quality assurance of dosimetry equipment in a radiotherapy department.
Competencies addressed	Ability to manage a QA programme for all dosimetry equipment
Recommended Items of Training	• Demonstrate a familiarity with QA recommendations for radiation dosimetry equipment such as: o Electrometer o thermometer o barometer o water phantom o TLD system o Film densitometer/scanner • Perform acceptance, commissioning and QC checks for dosimetry equipment (including ionization chambers, TLD, solid state detectors, film) according to a QA programme. • Review and improve/implement a QA programme for dosimetry equipment. • Check the traceability to a PSDL for a calibration factor used for absolute dose determination • Demonstrate a familiarity with the IAEA TLD audit system • Review the requirements for quality assurance of an in-vivo dosimetry programme • Demonstrate a familiarity with the method to express uncertainties in dose measurement.

	MODULE 4: RADIATION THERAPY – EXTERNAL BEAM
Objective	**To provide residents with knowledge and competencies relating to external beam therapy.**
Competencies Addressed in this Module	• Demonstrate an understanding of the physical principles and range of equipment in Radiation Oncology for treatment and imaging. • To be able to prepare specifications and advice for new equipment in association with other professional and technical staff. • To be able to design and perform acceptance testing procedures for: o Orthovoltage therapy unit o Megavoltage therapy unit o Simulator/Simulator-CT and o CT scanner/CT-simulator. • To be able to design and perform commissioning procedures for : o Orthovoltage therapy unit. o Megavoltage therapy unit. o Simulator/Simulator-CT and o CT scanner/CT-simulator • To be able to design and perform quality control (to provide ongoing monitoring and assessment of acceptable performance) for: o Orthovoltage therapy unit o Megavoltage therapy unit o Simulator/Simulator-CT and o CT scanner/CT-simulator • To be able to prepare operational procedures for the use of external beam equipment. • Demonstrate an understanding of the purpose, advantages and challenges of a range of beam modifiers and treatment techniques in modern radiotherapy. • Demonstrate an understanding of the purpose, advantages and challenges of a range of devices and methods used for patient and tumour localisation. • Perform measurements to verify dose delivery accuracy for external beam treatment techniques.
Time commitment	**18 % of entire program** **(129 day)**
Pre-requisite knowledge	PODGORSAK, E.B., (Ed.) Review of Radiation Oncology Physics: A Handbook for Teachers and Students, International Atomic Energy Agency, Vienna, (2005). Chapters 5, 10, 12, 15.

Sub-modules	4.1 Treatment and Imaging Equipment 4.2 Specification and Acquisition of New Equipment 4.3 Quality Assurance of External Beam Equipment I – Acceptance Testing
	4.4 Quality Assurance of External Beam Equipment II – Commissioning 4.5 Quality Assurance of External Beam Equipment III – Quality Control 4.6 Operational Procedures for External Beam Equipment 4.7 Treatment Techniques 4.8 Patient Positioning and Treatment Verification.
Core Reading List	INTERNATIONAL ATOMIC ENERGY AGENCY, Setting up a Radiotherapy Programme: Clinical, Medical Physics, Radiation Protection and Safety, IAEA, Vienna (2008). VAN DYK, J., (Ed.) The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists, Medical Physics Publishing, Madison WI, (1999). VAN DYK, J., (Ed.) The Modern Technology of Radiation Oncology, Vol. 2, Medical Physics Publishing, Madison, WI, (2005). WILLIAMS, J.R., THWAITES, D.I., (Eds), Radiotherapy Physics in Practice, 2nd edn., Oxford University Press, (2000).

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	Module 4: Radiation Therapy – External Beam
	Sub-module 4.1: Treatment and Imaging Equipment
Objective	To understand the operation of the main items of equipment used in Radiation Oncology for treatment and imaging.
Competency Addressed	An understanding of the physical principles and range of equipment in Radiation Oncology for treatment and imaging.
Recommended Items of Training	• Demonstrate an understanding of the operation of: ◦ orthovoltage X ray therapy unit ◦ Co-60 unit ◦ linear accelerators and any ancillary equipment (e.g. EPID, mMLC) ◦ simulators and any ancillary equipment

	◦ CT scanner ◦ Other imaging modalities used (e.g. MRI, ultrasound) ◦ treatment planning system ◦ record and verification system ◦ Image transfer network
	Module 4: Radiation Therapy – External Beam
	Sub-module 4.2: Specifications and Acquisition of New Equipment
Objective	To develop the expertise to prepare specifications for new therapy and imaging equipment and to advise on equipment acquisition, as part of a multidisciplinary team.
Competency Addressed	To be able to prepare specifications and advice for new equipment in association with other professional and technical staff.
Recommended Items of Training	• Demonstrate an understanding on process involved in equipment requisition and acquisition • Review and report on department needs on: ◦ Patient load ◦ Equipment technology ◦ Functionality ◦ Performance ◦ Compatibility ◦ Training ◦ Maintenance service ◦ Building and building services ◦ Delivery and installation • Analyse local and external restrictions placed on new equipment acquisition. • Compile and compare local legislative requirements and international recommendations on safety of equipment. • Perform: ◦ Market research on equipment technology ◦ Technology assessment ◦ Review of procurement documentation • Participate in multidisciplinary meetings with professionals and technical staff to decide on the department's requirements for new equipment. • Prepare/perform in collaboration with other professionals and technical staff: ◦ Tender specification ◦ Tender evaluation ◦ Tender recommendation
	Module 4: Radiation Therapy – External beam
	Sub-module 4.3: Quality Assurance of External Beam Equipment – Acceptance Testing

Objective	To develop the experience to perform and design acceptance testing procedures for orthovoltage and megavoltage therapy units and simulators.
Competencies Addressed	• To be able to design and perform acceptance testing procedures for an orthovoltage therapy unit. • To be able to design and perform acceptance testing procedures for a megavoltage therapy unit. • To be able to design and perform acceptance testing procedures for a. ° Simulator/Simulator-CT and/or ° CT scanner/CT-simulator
Recommended Items of Training	• Demonstrate an understanding of the: ° concept and principles of an acceptance testing programme including: ▪ Safety aspects ▪ Mechanical aspects ▪ Dosimetry measurements ° methods, procedures and tools for acceptance testing of equipment and its accessories. • Assess the properties and characteristics of the equipment, including specification and functionality of equipment. • Design methods and test procedures/protocols and worksheets for an acceptance testing programme, including o Functionality o Beam characteristics o Integrity of accessories o Network integration and data transfer o Safety features • Develop and prepare test and measurement protocols and worksheets • Participate in acceptance testing of an o orthovoltage therapy unit o megavoltage therapy unit o treatment simulator (simulator/simulator CT, CT/CT-simulator). • Prepare and/or review acceptance test report and recommendations
	Module 4: Radiation Therapy – External Beam
	Sub-module 4.4: Quality Assurance of External Beam Equipment II – Commissioning
Objective	To develop the experience to perform and design commissioning procedures for orthovoltage and megavoltage therapy units and treatment simulators.

Competencies Addressed	• Ability to design and perform commissioning procedures for an orthovoltage therapy unit.
	• Ability to design and perform commissioning procedures for a megavoltage therapy unit.
	• Ability to design and perform commissioning procedures for a.
	  o Simulator/Simulator-CT and/or
	  o CT scanner/CT-simulator

Recommended Items of Training	• Review quality and legislative standards.
	• Demonstrate an understanding of the methods, procedures and tools for commissioning of equipment and its accessories.
	• Design methods, procedures and work programme for commissioning to prepare equipment for clinical application including:
	  o Prepare test and measurement protocols and worksheets including
	  • Safety aspects
	  • Mechanical aspects
	  • Dosimetry measurements
	  o Network integration and data transfer
	  o Scheduling of training
	• Participate in commissioning of an orthovoltage and megavoltage therapy unit (*refer to Dosimetry and External Beam Treatment Planning modules, modules 3 and 5, for related competencies*), including
	  o The acquisition of all radiation beam data required for treatment.
	  o Verifying the accuracy of treatment procedures.
	• Participate in commissioning of a treatment simulator (simulator/simulator-CT, CT/CT-simulator).
	• Prepare and/or review commissioning report and documentation including
	  ° Sources and magnitude of errors
	  ° Establishing baseline values for subsequent QC tests
	• Report on the progress of commissioning to a multidisciplinary team.

	Module 4. Radiation Therapy – External Beam
	Sub-module 4.5: Quality Assurance of External Beam Equipment III – QC
Objective	To design and perform a quality control programme for an orthovoltage and megavoltage therapy unit and treatment simulators.

Competencies Addressed	• Ability to design and perform quality control to provide ongoing monitoring and assessment of acceptable performance) for an orthovoltage therapy unit
	• Ability to design and perform quality control to provide ongoing monitoring and assessment of acceptable performance) for a megavoltage therapy unit
	• Ability to design and perform quality control to provide ongoing monitoring and assessment of acceptable performance) for a.
	  o Simulator/Simulator-CT and/or
	  o CT scanner/CT-simulator

Recommended Items of Training	• Demonstrate an understanding of the role of a QC programme. • Compare and contrast of local QC programme with international guidelines and best practice, specifying issues such as: ° Parameters to be tested and the tests to be performed; ° Specific equipment to be used to perform the tests; ° Geometry of the tests; ° Frequency of the tests; ° Staff group or individual performing the tests, as well as the individual supervising and responsible for the standards of the tests and for actions that may be necessary if problems are identified; ° Expected results;

	° Tolerance and action levels; ° Actions required when the tolerance levels are exceeded. • Design a QC programme including daily, weekly, monthly and annual checks for: ° Orthovoltage therapy unit ° Megavoltage therapy unit ° treatment simulator (simulator/simulator-CT and/or CT-simulator/CT). • Perform QC tests on orthovoltage unit, such as: ° Dose output checks ° Safety checks and interlocks ° Energy checks (HVL) ° Applicator factor checks ° Depth dose measurements • Perform weekly, monthly and annual QC checks on a megavoltage therapy unit such as o Weekly ▪ Safety checks ▪ Weekly X ray dose output checks ▪ Weekly electron dose output checks ▪ Optical distance indicator ▪ Isocentre indicator checks including reticule ▪ Laser checks ▪ Light field checks including field sizes ▪ Jaw sag tests ▪ Couch movements ▪ Couch isocentric rotation o Monthly* ▪ Safety checks and interlocks ▪ Gantry and collimator angle indicators ▪ Full laser checks ▪ Isocentre indication ▪ Optical distance indicator ▪ Jaw symmetry ▪ X ray depth dose constancy ▪ X ray flatness and symmetry ▪ X ray field size checks ▪ Electron depth dose curves ▪ Electron profile flatness and symmetry o Annual* ▪ Safety checks ▪ Mechanical isocentre determination ▪ Radiation isocentre determination ▪ Radiation/Mechanical isocentre coincidences ▪ Optical systems ▪ Couch mechanical tests ▪ X ray beam depth dose curves ▪ X ray beam profiles ▪ Fixed wedge depth dose curves ▪ Fixed wedge profiles ▪ Fixed wedge transmission factors ▪ Collimator scatter factor determination ▪ Phantom scatter factor determination ▪ Block transmission checks

	• MLC leaf QA checks

	▪ MLC leaf calibrations ▪ Electron depth dose curves ▪ Electron output factors • Perform QC on ancillary equipment o Portal imaging o Record and verification system and related networking • Perform weekly, monthly and annual QC checks on a simulator/simulator-CT, such as: o Weekly* ▪ Optical distance indicator ▪ Isocentre indicator checks including reticule, ▪ Laser checks, ▪ Light field checks including field sizes o Monthly* ▪ Safety checks, ▪ Gantry and collimator angle indicators ▪ Full laser checks ▪ Isocentre indication ▪ Optical distance indicator ▪ Accuracy of the delineators ▪ Beam quality checks o Annual* ▪ Isocentre determination ▪ Optical systems ▪ Couch tests ▪ Delineator calibrations ▪ Beam kV tests ▪ Beam mA tests ▪ Participate in full annual QA programme for simulator • Perform QC tests on CT scanner, such as: o Mechanical and optical checks o Safety o Test of CT number to electron density data • After maintenance to external beam equipment, perform subsequent verification to ensure accurate delivery of radiation dose to patients. * Or as required for local conditions
	Module 4. Radiation Therapy – External Beam
	Sub-module 4.6: Operational procedures for external beam equipment
Objective	To develop operational procedures for external beam equipment.
Competencies Addressed	To be able to prepare operational procedures for the use of external beam equipment.

Recommended Items of Training	• Compare local operational procedures for all external beam equipment with the manufacturer's operational manual, information compiled during commissioning and relevant safety standards. • Write operational procedures for external beam equipment based on the manufacturer's operational manual, information compiled during commissioning and relevant safety standards. • Conduct tutorials for operators of equipment based on written documentation to ensure technical and safety instructions and equipment limitations are understood.
	• Translate examples of existing operating instructions into local language.
	Module 4. Radiation Therapy – External Beam
	Sub-module 4.7: Treatment Techniques
Objective	To develop an understanding and experience a range of external beam treatment techniques.
Competencies Addressed	Demonstrate an understanding of the purpose, advantages and challenges of a range of beam modifiers and external beam treatment techniques in modern radiotherapy.
Recommended Items of Training	• Demonstrate an understanding of and observe the differences between fixed source-to-surface (SSD) distance and isocentric treatment techniques • Demonstrate an understanding of the use of certain beam combinations for different treatment sites and the use of weighting and normalisation. • Demonstrate an understanding of the advantages of and observe the use of the following beam modifiers: ° Beam shaping devices ° Wedge filters ° Bolus ° Compensators • Demonstrate an understanding of the advantages of and observe the following treatment techniques: ° field matching of various radiation beam types and energies ° rotational ° 3D conformal radiotherapy ° non-coplanar beams ° IMRT methods: static, dynamic ° TBI ° TSEI ° IGRT ° Radiosurgery ° Stereotactic radiotherapy • Demonstrate an understanding of the advantages of advanced treatment techniques such as: ° Intraoperative radiotherapy ° Particle beam treatments ° Tomotherapy • Describe the methods (if possible) and difficulties of field matching and re-treatment with advanced treatment techniques.

	Module 4. Radiation Therapy – External Beam
	Sub-module 4.8: Patient Positioning and Treatment Verification
Objective	To understand methods of monitoring and controlling sources and levels of uncertainty in geometry and dose during patient treatment delivery.
Competencies Addressed	• Demonstrate an understanding of the purpose, advantages and challenges of a range of devices and methods used for patient and tumour localisation.
	• Perform measurements to verify dose delivery accuracy for external beam treatment techniques.
Recommended Items of Training	• Demonstrate an understanding of the purpose of and observe: o Basic patient set-up and movement tracking systems o The manufacturing and use of immobilisation devices o An immobilised patient from mould room to treatment machine o Imaging systems for patient positioning from simulation to treatment verification o Simulator to verify plans before treatment o Various methods of port film/EPI evaluation to assess patient positioning accuracy and precision. o Lasers from real/virtual simulation to treatment. o Verification of patient positioning and dose delivery with IMRT o Verification of patient positioning with non-coplanar fields o Patient set-up and delivery of stereotactic radiosurgery treatment. o Stereotactic and advanced immobilisation devices o Advanced patient set-up and movement tracking systems (e.g. IGRT, respiratory gating) • Demonstrate an understanding of uncertainties, tolerance and action levels of one or more treatment techniques listed above. • Use a record and verify system. • Perform a literature review on immobilisation for one treatment site. • Manufacture a patient immobilisation device. • Explain discrepancies between portal images, simulator verification images and DRRs. • Perform dose delivery verification of a patient's treatment plan utilising a phantom and an appropriate dosimeter for a: o Conventional treatment technique o IMRT.

	MODULE 5: EXTERNAL BEAM TREATMENT PLANNING
Objective	To provide physicists with the required knowledge and competency to perform radiotherapy treatment planning.
Competencies Addressed in this Module	• Capability to make budgetary requests and acquire, through a tendering process, a suitable treatment planning computer for external beam planning • Capability to perform acceptance testing of a radiotherapy treatment planning system (RTPS) • Capability to commission an RTPS • Capability to conduct quality control (QC) of a RTPS • Ability to perform the duties of a treatment planning computer system administrator • Ability to acquire and use patient image data for treatment planning. • Ability to estimate the uncertainties involved in the patient data acquired and to correct/accommodate such errors in treatment planning • Performance of manual treatment planning and dose calculation • Use of treatment planning computers for treatment planning and dose optimisation evaluation • Planning of new treatment techniques • Performance of QC of individual treatment plans
Expected time commitment	**20 % of entire program** **(144 day)**
Pre-requisite Knowledge	PODGORSAK, E.B., (Ed.) Review of Radiation Oncology Physics: A Handbook for Teachers and Students, International Atomic Energy Agency, Vienna, (2005). Chapters 5 - 12.
Sub-modules	5.1 Procurement of a treatment planning computer 5.2 Quality Assurance in treatment planning 5.3 Planning computer system administration. 5.4 Acquisition of patient anatomical information. 5.5 Treatment planning
Core Reading List	INTERNATIONAL ATOMIC ENERGY AGENCY, Commissioning and QA of Computerised Treatment Planning Systems for Radiation Treatment of Cancer, Technical Reports Series No. 430, IAEA, Vienna (2004). INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Quantities and Units in Radiation Protection Dosimetry, ICRU Rep. 51, Bethesda, MD (1993). INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Prescribing, Recording, and Reporting Electron Beam Therapy, ICRU Rep. 71, Bethesda, MD (2004). KHAN, F.M., The Physics of Radiation Therapy, 2nd edn, Lippincott, Williams & Wilkins (2003). MOULD, R.F., Radiotherapy Treatment Planning, 2nd edn, Institute of Physics Publishing (1985).

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	Module 5: External Beam Treatment Planning
	Sub-module 5.1: Procurement of treatment planning computer
Objective	To develop the competency necessary to acquire a treatment planning computer.

Competency Addressed	Capability to make budgetary requests and acquire, through a tendering process, a suitable treatment planning computer for external beam planning
Recommended Methods Of Training	• Demonstrate an understanding of the process involved in equipment requisition and acquisition • Review and report on department needs on: ° Equipment technology ° Functionality ° Performance ° Compatibility ° Training ° Maintenance service ° Building and building services ° Delivery and installation • Perform: ° Market research on equipment technology ° Technology assessment ° Review of procurement documentation • Submit project proposal and budgetary request • Prepare/perform within a multidisciplinary team ° Tender specification ° Tender evaluation ° Tender recommendation
	Module 5: External Beam Treatment Planning
	Sub-module 5.2: Quality Assurance in Treatment Planning
Objective	To develop the ability and skill to design and implement the physical aspects of a QA programme for treatment planning.
Competencies Addressed in this Sub-module	• Capability to perform acceptance testing of a radiotherapy treatment planning system (RTPS) • Capability to commission an RTPS • Capability to conduct quality control (QC) of a RTPS
Recommended Items Of Training	• Demonstrate an understanding of: ° The treatment planning process ° The potential sources and magnitude of errors associated with: ▪ Patient data ▪ Beam data ▪ Manual and computer dosimetry calculation algorithms ▪ Treatment planning equipment ° The operation, functionality, performance specification and inventory items of an RTPS ° Merits and limitations of the range of dose calculation algorithms ° The principles and design of a treatment planning QA programme • Design the protocols of a QA programme for a treatment planning computer based on the recommendations as specified in IAEA Technical Report Series No. 430 or an equivalent international recommendation as adopted by the department, including: ° Acceptance testing against equipment specification, including: ▪ Inventory check ▪ Functionality test of hardware and software

	▪ Geometric and dosimetric accuracy ▪ Network integration and data transfer ◦ Commissioning for photon and electron beam planning, including: ▪ Configuration of: 🕒 Computer system 🕒 Patient demographic data 🕒 Security and backup system 🕒 Treatment machine 🕒 Beam data required, including transfer/input of measured beam data into computer system (see module 3 Radiation Dosimetry for External Beam Therapy for related items of training) 🕒 Calculation parameters 🕒 Treatment plan report 🕒 Record and archival 🕒 Calibration 🕒 Display and output format ▪ Verification against measurements and/or independent methods of: 🕒 Image registration and contouring tools 🕒 CT density 🕒 Beam data transferred from acquisition system 🕒 Beam models in standard and extreme conditions 🕒 Dosimetry calculations, including MU calculations 🕒 Treatment plans, including: ▪ Dose ▪ Dose distribution ▪ DVH ▪ Anatomical geometry ▪ Beam geometry ▪ Inhomogeneity correction 🕒 Plan output and transfer ◦ Quality control of: ▪ RTPS system ▪ Input and output devices ▪ Backup system ▪ Beam data ▪ Patient and image data ▪ Body and organ contouring ▪ Dose calculation tools ▪ Individual patient plan (refer to sub-module 5.5 Treatment Planning below) ▪ Computer network • Identify and recommend: ◦ QC test and measurement equipment required ◦ Tolerance limits and action levels for each QC test • Develop and prepare worksheets for the tests and measurements • Using the established protocols and worksheets, perform: o Acceptance testing o Commissioning o Quality control • Report any deviations or functional abnormalities and propose corrective actions • Review and update QA protocols and procedures on a regular basis

	• Prepare:

	◦ Acceptance test report and recommendation ◦ Commissioning report ◦ QC report ◦ Planning data manual
	Module 5: External Beam Treatment Planning
	Sub-module 5.3: Planning computer system administration
Objective	To develop the ability and skill to assume the functions of a treatment planning computer system administrator.
Competency Addressed	Ability to perform the duties of a treatment planning computer system administrator
Recommended items of training	• Develop and implement the following guidelines, policies and administrative measures for a treatment planning computer system: ◦ System security ◦ Assign user rights ◦ Operational rules and guidelines ◦ Data protection ◦ Release of new or updated planning data for clinical use ◦ Release of new or upgraded computer hardware and software for clinical use ◦ Import and export of data • Perform: ◦ System and data backup ◦ system upgrades/updates • Manage/monitor: ◦ Software & hardware inventory ◦ System operation and application ◦ Training programme ◦ Data storage and archival ◦ Maintenance ◦ Upgrades/updates ◦ Operational and functional abnormalities • Identify and report any deviations or functional abnormalities and arrange for corrective measures/actions • Maintenance of: ◦ Planning data library and manuals ◦ Logbook and/or record for: ▪ Treatment plans ▪ Operational/functional incidents and/or abnormalities ▪ All upgrades and updates ▪ Maintenance ▪

	Module 5: External Beam Treatment Planning
	Sub-module 5.4: Acquisition of patient data
Objective	To provide training on acquisition of patient data for treatment planning.
Competencies Addressed	• Ability to acquire and use patient image data for treatment planning. • Ability to estimate the uncertainties involved in the patient data acquired and to correct/accommodate such errors in treatment planning
Recommended Items Of Training	• Demonstrate an understanding of the following: ◦ Patient treatment set up and positioning procedures ◦ The purpose, importance and dosimetric considerations of patient immobilisation in external beam therapy ◦ Accuracy and limitations of immobilization devices ◦ Mould making procedures ◦ Patient data required for treatment planning Methods for acquisition of patient data, including: · Manual methods · Simulator · CT/CT-Simulator · MRI · PET/CT-PET Magnitude and sources of uncertainties involved in the: · Image data · Contouring of target volumes and critical tissue structures of interest Treatment margins needed for contouring the target volumes and organs at risk for a variety of treatment sites Application of the ICRU concepts in contouring: · Target volumes · Normal organs at risk · Treatment margins • Transfer of patient image data to treatment planning systems • Perform image registration and contouring, including: ◦ Contouring of the treatment targets and organs of interest for a variety of treatment sites with: · Radiographs · CT images · MR images · Fused CT, MRI, and PET images ◦ Margins to compensate/accommodate inter-fraction and intra-fraction treatment errors. ◦ Image reconstruction ◦ 2-D and 3-D display of contoured body and tissue structures ◦ Generation of digital reconstruction radiograph (DRR) ◦ Identification of planning contours reference points for dose assessment and treatment set up • Provide supervision/support/advice on:

	◦ patient immobilization and patient data acquisition procedures ◦ Acquisition and application of patient data for treatment planning ◦ Image transfer and registration
	Module 5: External Beam Treatment Planning
	Sub-module 5.5: Treatment Planning
Objective	To be competent in external beam treatment planning and dose calculation.
Competencies Addressed	• Perform manual treatment planning and dose calculation • Use a treatment planning computers for treatment planning, dose optimisation and evaluation • Planning of new treatment techniques Perform QC of individual treatment plans
Recommended Items Of Training	• Demonstrate an understanding of the: ◦ Characteristics, applications, accuracy and limitations of the: ▪ External beam treatment machines ▪ Radiation beam data ▪ Patient image data ◦ Dose and dose fractionation schemes of a variety of treatments ◦ Principles, methods and procedures of: ▪ Treatment planning ▪ Dose calculation and optimization ▪ Treatment simulation ◦ Local medical legal requirements for record and documentation in radiotherapy. ◦ ICRU and the local systems of dose prescription, recording and reporting in external beam therapy. ◦ Content, format and patient identification system of the department dose prescription chart and treatment record for a variety of treatments and the level of compliance with ICRU recommendations. ◦ Content and format of department treatment plan for a variety of treatments and the level of compliance with ICRU recommendations. ◦ Tolerance dose of a variety of normal tissue structures and organs ◦ Criteria and procedures for accepting treatment plans of a variety of treatment sites ◦ Radiation beam arrangements for a variety of treatments ◦ Choice of beam modality and energy for clinical applications. ◦ Sources and magnitude of errors involved in manual and computer planning including dose calculation grid resolution. ◦ Effect and purpose of: ▪ Beam parameters on dose (e.g. field size, off axis, weighting, normalisation, FSD, energy, photon/electron) ▪ Beam modifiers (e.g. shielding, asymmetric jaws, MLC, wedges, compensators, bolus etc) on dose ▪ Tissue inhomogeneity and the shape of body contour on dose and correction methods ▪ Normalisation on isodose curves ▪ Errors and contrast media in patient image data on dose ▪ Organ and patient motions on dose and correction methods

	• Perform by manual and/or computer methods for a variety of treatments and patient set up conditions:
	  ◦ Dose distribution and MU or treatment time calculations for treatments using:
	  ▪ Orthovoltage X ray beams
	  ▪ Megavoltage photon beams
	  ▪ Electron beams
	  ▪ Combination of photon and electron beams
	  ◦ Planning of treatments using:
	  ▪ Abutting fields
	  ▪ Arc therapy
	  ▪ Irregular fields
	  ▪ Wedged fields
	  ▪ Oblique incident beams
	  ▪ Tissue inhomogeneity correction
	  ▪ Beam modifiers/compensators
	  ▪ 3-D conformal radiotherapy
	  ▪ Total body irradiation
	  ▪ Total skin electron irradiation
	  ▪ Stereotactic techniques
	  ▪ Image guided radiotherapy techniques
	  ▪ Motion compensation radiotherapy techniques
	  ▪ Adaptive radiotherapy techniques
	  ◦ Forward and/or inverse planning and dose optimization of:
	  ▪ Intensity modulated radiotherapy
	• Demonstrate the use of a variety of tools in treatment planning, including:
	  ◦ Beam's eye view
	  ◦ 3D volumetric isodose displays
	  ◦ Digital reconstructed radiographs
	  ◦ Inverse dose planning and optimization based on physical dose and biological indices
	• Investigate for a variety of treatment sites, including prostate, lung and head and neck tumours, the sources and magnitude of:
	  ◦ Inter-fraction treatment errors
	  ◦ Intra-fraction treatment errors
	• Describe the effects and implications of treatment errors on dose distribution
	• Describe techniques that can be used to minimize inter-fraction and intra-fraction geometric errors for different treatment sites
	• Perform assessment and acceptance of treatment plans using a variety of evaluation tools, including:
	  ◦ Dose criteria for plan acceptance
	  ◦ Dose to the target volumes and critical organs
	  ◦ 3D volumetric dose distribution
	  ◦ Dose volume histograms
	  ◦ Dose conformity indices
	  ◦ Biological indices
	• Perform quality control of individual treatment plans, including:
	  ◦ Review/design:
	  • QC workflow, procedures and protocols for treatment plans and treatment charts
	  • Tolerance limits for interventional action for a range of plans

	◦ Use of independent dosimetry calculation systems for checking of treatment plans on dose/MU calculation ◦ Prepare appropriate QC or phantom plans for dosimetry verification by measurement or computer simulation of a variety of treatment plans, including: ▪ Intensity modulated radiotherapy ▪ Motion compensated radiotherapy ◦ Checking of the integrity of treatment data transfer to the treatment machine ◦ Evaluate in-vivo dosimetry measurement data against treatment planning calculations and interpret implications • Prepare documentation of individual treatment plans • Develop or support the development and commissioning of new planning techniques for existing or new treatments, including: ◦ Dosimetry evaluation and verification of new treatment plans by: ▪ Verifying treatment plans with phantom dosimetry measurement data ▪ Acquisition or design and construction of suitable dosimetry verification phantoms ▪ Design treatment delivery and QC procedures ◦ Introduction/implementation of new technology in treatment planning ◦ Provide training/demonstration to staff on new techniques/procedures • Supervise and support the physics aspects of treatment planning including: ◦ Continue improvement of the treatment planning process and work flow ◦ Preparation and implementation of the work procedures and protocols for treatment planning and simulation, record and documentation to meet clinical needs ◦ Advice/recommend on proper and efficient use and limitations of: ▪ Beam data and the dose calculation algorithms ▪ RTPS and accessory equipment ◦ Provide any planning data as required.

	MODULE 6: BRACHYTHERAPY
Objective	To provide the resident with the knowledge and competencies required in brachytherapy.
Competencies Addressed in this Module	• Capability to make budgetary requests and acquire, through a tendering process, suitable brachytherapy treatment and ancillary equipment • Capability to develop and perform acceptance testing of brachytherapy equipment • Capability to develop test procedures and protocols and to perform commissioning of brachytherapy equipment • Capability to design and develop the test procedures and protocols and to perform quality control (QC) on brachytherapy equipment • Capability to calibrate brachytherapy sources • Ability to supervise/advise on the use of imaging equipment to obtain/verify patient anatomical information and radiation source geometry for treatment planning/dose calculation • Capable of inputting patient and radiation source data to treatment planning system for planning • Ability to perform manual dose calculations in brachytherapy • Ability to use a treatment planning computer to generate an acceptable treatment plan • Ability to perform QC of individual treatment plans • Safe handling of brachytherapy sources and preparation of treatment applicators
Expected time commitment	**15 % of entire program** **(108 day)**
Pre-requisite Knowledge	PODGORSAK, E.B., (Ed.) Review of Radiation Oncology Physics: A Handbook for Teachers and Students, International Atomic Energy Agency, Vienna, (2005). Chapters 2 and 13
Sub-modules	6.1 Procurement 6.2 Quality Assurance in Brachytherapy I - Acceptance testing 6.3 Quality Assurance in Brachytherapy II - Commissioning 6.4 Quality Assurance in Brachytherapy III - Quality control 6.5 Calibration of Brachytherapy sources 6.6 Image and source data for treatment planning 6.7 Treatment Planning 6.8 Source preparation

Core Reading List	BALTAS, D., SAKELLIOU, L., ZAMBOGLOU, N., The Physics of Modern Brachytherapy, Taylor and Francis (2006). INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Dose and Volume Specification for Reporting Intracavity Therapy in Gynecology, ICRU Rep. 38, Bethesda, MD (1985). INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Dose and Volume Specification for Reporting Interstitial Therapy, ICRU Rep. 58, Bethesda, MD (1997). http://www.icru.org/index.php?option=com_content&task=view&id=68. KHAN, F.M., The Physics of Radiation Therapy, 2nd edn, Lippincott,
	Williams & Wilkins (2003). MASSEY, J.B., POINTON, R.S., WILKINSON, J.M., The Manchester System and the BCRU recommendations for brachytherapy source specification, Br J Radiol **58** (1985) 911-3.

Supplementary Reading List	AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Specification of Brachytherapy Source Strength: Report of the AAPM Radiation Therapy Committee Task Group No. 32, AAPM Rep. 21, New York (1987). http://www.aapm.org/pubs/reports/RPT_21.pdf. AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Remote Afterloading Technology: Report of the AAPM Radiation Therapy Committee Task Group No. 41, AAPM Rep. 41, New York (1993). http://www.aapm.org/pubs/reports/RPT_41.pdf. AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Comprehensive QA for Radiation Oncology, AAPM Rep. 46, New York (1994). http://www.aapm.org/pubs/reports/RPT_46.pdf. AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Dosimetry of Interstitial Brachytherapy Sources: Report of the AAPM Radiation Therapy Committee Task Group No. 43, AAPM Rep. 51, New York (1995). http://www.aapm.org/pubs/reports/RPT_51.pdf. AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Code of practice for Brachytherapy Physics: Report of the AAPM Radiation Therapy Committee Task Group No. 56, AAPM Rep. 59, New York (1997). http://www.aapm.org/pubs/reports/RPT_59.pdf. AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, High Dose Rate Brachytherapy Treatment Delivery: Report of the AAPM Radiation Therapy Committee Task Group No. 59, AAPM Rep. 61, New York (1998). http://www.aapm.org/pubs/reports/rpt_61.PDF. AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Intravascular Brachytherapy Physics: Report of the AAPM Radiation Therapy Committee Task Group No. 60, AAPM Rep. 66, New York (1999). http://www.aapm.org/pubs/reports/rpt_66.PDF. AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Permanent Prostate Seed Brachytherapy: Report of the AAPM Radiation Therapy Committee Task Group No. 64, AAPM Rep. 68, New York (1999). http://www.aapm.org/pubs/reports/rpt_68.PDF. AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Update of AAPM Task Group 43 Report: A review AAPM protocol for brachytherapy dose calculations, AAPM Rep. 84, New York (2004). http://www.aapm.org/pubs/reports/rpt_84.PDF. AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Recommendations of the AAPM regarding the impact of Implementing the 2004 Task Group 43 Report on Dose Specification for 103Pd and 125I Interstitial Brachytherapy, AAPM Rep. 89, New York (2005). http://www.aapm.org/pubs/reports/RPT_89.pdf. GODDEN, T.J., Physical Aspects of Brachytherapy, Adam Hilger (1988). HOSKIN, P., COYLE, C., (Eds), Radiotherapy in Practice-Brachytherapy, Oxford University Press, (2005). INSTITUTE OF PHYSICS AND ENGINEERING IN MEDICINE, The Design of Radiotherapy Treatment Room Facilities, IPEM Rep. 75, York (1997). JOSLIN, C.A., FLYNN, A., HALL, E.J., (Eds), Principles and Practice of Brachytherapy: Using Afterloading Systems, Arnold, (2001).

	THOMADSEN, B., Achieving Quality in Brachytherapy, Medical Science Series, Institute of Physics, Philadelphia (1999). VAN DYK, J., (Ed.) The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists, Medical Physics Publishing, Madison WI, (1999).
	Module 6: Brachytherapy
	Sub-module 6.1: Procurement
Objective	To develop the competency on acquisition of brachytherapy equipment technology.
Competency Addressed	Capability to make budgetary requests and acquire, through a tendering process, suitable brachytherapy treatment and ancillary equipment
Suggested Methods of Training	• Demonstrate an understanding on process involved in brachytherapy equipment requisition and acquisition • Review and report on department needs on: ° Equipment technology ° Functionality ° Performance ° Compatibility ° Training ° Maintenance service ° Building and building services ° Delivery and installation • Perform: ° Market research on brachytherapy equipment technology ° Technology assessment ° Review of procurement documentation • Submit project proposal and budgetary request • Prepare/perform ° Tender specification ° Tender evaluation ° Tender recommendation
	Module 6: Brachytherapy
	Sub-module 6.2: Quality Assurance in Brachytherapy I - Acceptance Testing
Objective	To develop competency on acceptance testing aspects of QA in brachytherapy.
Competency Addressed	Development and performance of test procedures and protocols for acceptance testing of brachytherapy equipment
Recommended Items of Training	• Observe the installation of new equipment • Demonstrate an understanding of the: ° Concept and principles of a brachytherapy QA programme ° Local legislative requirements and international recommendations

	on safety of brachytherapy and remote afterloading equipment ◦ Properties and characteristics of the brachytherapy sources ◦ Specification, quality standard and operation characteristics of: • Brachytherapy sources • Treatment applicators • Afterloading brachytherapy equipment, including LDR, HDR, PDR ◦ Specification, functionality and dosimetry algorithm of brachytherapy treatment planning computer ◦ Sources and magnitude of errors associated with: • Manual and afterloading brachytherapy • Brachytherapy treatment planning computer • Dosimetric data of radioactive sources ◦ Methods and procedures for testing of: ▪ Remote afterloading brachytherapy equipment ▪ Brachytherapy source ▪ Treatment planning computer ◦ Use of test and measurement equipment required for acceptance testing ◦ Tolerance limits for each acceptance test • Design methods and test procedures/protocols and worksheets for a brachytherapy acceptance testing programme including: ◦ Inventory check ◦ Radioactive source, including: • Activity • Uniformity • Leakage • Physical integrity ◦ Afterloading equipment, including: • Functionalities of: 🕓 Treatment planning computer 🕓 Remote afterloading system • Integrity of treatment applicators and connectors • Source positioning accuracy • Dosimetric accuracy • Network integration and data transfer • Safety features • Develop and prepare test and measurement protocols and worksheets • Using established protocols and worksheets, perform acceptance testing of: ◦ Brachytherapy source ◦ Afterloading treatment equipment • Prepare and/or review acceptance test report and recommendations
	Module 6: Brachytherapy
	Sub-module 6.3: Quality Assurance in Brachytherapy II – Commissioning
Objectives	To provide training on commissioning of brachytherapy equipment and services.

Competencies Addressed in this sub-module	Development of test procedures and protocols for, and to perform, commissioning of brachytherapy equipment

Recommended Items of Training	• Demonstrate an understanding of the:
	  ◦ Operation and characteristics of brachytherapy services and equipment
	  ◦ Performance assessment and testing of brachytherapy equipment and accessories
	  ◦ Methods and procedures for commissioning of:
	  ▪ Remote afterloading brachytherapy equipment
	  ▪ Brachytherapy source
	  ▪ Treatment planning computer
	  ◦ Use of test and measurement equipment required for commissioning procedures
	• Design methods, procedures and work programme for commissioning of a remote afterloader system and treatment planning system, including:
	  ◦ Configuration of the:
	  ▪ Treatment planning computer system, including:
	  🕓 Patient demographic data
	  🕓 Security and backup system
	  🕓 Brachytherapy source data
	  🕓 Calculation parameters
	  🕓 Treatment plan report format
	  🕓 Record and archival
	  🕓 Export of treatment data
	  ▪ Remote afterloading treatment machine, including:
	  🕓 Treatment control
	  🕓 In-vivo dose monitoring system
	  🕓 Security and backup system
	  🕓 Import of treatment data
	  🕓 Treatment record
	  ◦ Verification against measurements and/or independent methods of:
	  ▪ Treatment planning computer system, including:
	  🕓 Image registration tools
	  🕓 Integrity of input devices, including the digitizer
	  🕓 Treatment planning, including:
	  ▪ Dose
	  ▪ Dose distribution
	  ▪ DVH
	  ▪ Source geometry
	  ▪ Treatment time calculations
	  ▪ Correction for:
	  ◦ Decay
	  ◦ Attenuation
	  ▪ Treatment plan output and transfer
	  🕓 Afterloading treatment machine, including:
	  ▪ Integrity of:
	  ◦ Data transfer from treatment planning system
	  ◦ Source transfer through the applicators and catheters
	  ▪ Accuracy of:
	  ◦ Source positioning

	◦ Dwell time ▪ Multichannel applicator indexing system ▪ Treatment and safety features and interlock systems, including: ◦ Applicator, catheters, and connectors ◦ Treatment termination ◦ Door ◦ Radiation warning indication systems ◦ Video monitoring system ◦ Backup power system ◦ Automatic source retraction system • Prepare test and measurement protocols and worksheets • Perform commissioning of a: ◦ Remote afterloading treatment system ◦ Treatment planning computer system • Establishing baseline values for subsequent QC tests • Prepare and/or review commissioning report and documentation • Prepare/review operational procedures for treatment delivery
	Module 6: Brachytherapy
	Sub-module 6.4: Quality Assurance in Brachytherapy III - Quality Control
Objective	To provide training on quality control of brachytherapy equipment and sources
Competencies Addressed	Design, development and performance of test procedures and protocols for QC of brachytherapy equipment

Recommended Items of Training	• Demonstrate an understanding of the:
	  ° Operation characteristics and functionalities of brachytherapy equipment and sources
	  ° Acceptance testing and commissioning of brachytherapy equipment and sources
	  ° Sources and magnitude of errors in brachytherapy
	  ° Methods and procedures for QC in brachytherapy
	  ° Equipment required for QC measures
	  ° Tolerance limits and action levels
	• Design a series of QC measures for brachytherapy covering:
	  ° Quality control of:
	  ▪ Treatment planning system
	  🕓 Input and output devices
	  🕓 Patient and image data
	  🕓 Treatment dose and time calculation tools
	  🕓 Computer network
	  🕓 Individual patient plan (refer to sub-module on Treatment Planning below)
	  ▪ Integrity of radiation sources and their applicators
	  ▪ Afterloading treatment system:
	  🕓 Safety and interlock
	  🕓 Power failure backup systems
	  🕓 Integrity of:
	  ° Treatment applicators
	  ° Connectors

	° Multichannel indexing system
	  ° Source transfer
	  🕓 Source position and dwell time accuracy
	  🕓 Dose monitoring system
	  🕓 Data transfer
	  ▪ Treatment delivery, monitoring of:
	  🕓 Applicators/source position
	  🕓 Critical organ dose
	• Develop and prepare QC test and measurement protocols and worksheets
	• Perform QC on a:
	  ° Remote afterloading treatment system
	  ° Brachytherapy treatment planning system
	  ° Brachytherapy source
	  ° Brachytherapy treatment
	  ° Dosimetry equipment
	• Prepare and/or review QC reports and documentation

	Module 6: Brachytherapy
	Sub-module 6.5: Calibration of Brachytherapy Sources
Objective	To provide training on measurement of the strength of brachytherapy sources.
Competency Addressed	Capability to calibrate brachytherapy sources.

Recommended Items of Training	• Demonstrate an understanding of the:
	  ° Dosimetry properties of brachytherapy sources
	  ° Dosimetry protocols for calibration of brachytherapy sources, including the procedures and recommendations as given in IAEA TECDOC 1274
	  ° Properties and functionalities of the calibration equipment
	  ° Uncertainties involved in determination of source strength by measurement and calculation methods
	• Design calibration worksheet
	• Calibrate the strength of a variety of brachytherapy sources using:
	  ° Well-type ionisation chamber
	  ° Thimble ionisation chamber
	• Compare source strength as given in vendor certificate with measurement.
	  ° Demonstrate an understanding of remedial action if exceeds tolerance level.
	• Prepare:
	  ° Source data for treatment planning
	  ° Calibration report

	Module 6: Brachytherapy
	Sub-module 6.6: Acquisition of Image and Source Data for Treatment Planning
Objective	• To provide competency training on acquisition of patient image and source data for brachytherapy treatment planning.
Competencies Addressed	• Ability to supervise/advise on the use of imaging equipment to obtain/verify patient anatomical information and radiation source geometry for treatment planning/dose calculation • Capability of inputting patient and radiation source data to treatment planning system for planning

Recommended Items of Training	• Demonstrate an understanding of the methods and procedures for:
	  ◦ Localization and reconstruction of brachytherapy sources
	  ◦ Acquisition of the relevant patient anatomical information and source (using dummy sources) geometry for treatment planning using:
	  ・ Radiotherapy treatment simulator
	  ・ Mobile C-arm X ray unit
	  ・ CT scanner
	  ・ MRI
	  ・ Ultrasound scanner
	  ◦ Measurement of dose and dose distribution of sources
	• Supervise/advice on the acquisition of patient image/data for treatment planning using X-ray, CT, and/or ultrasound for:
	  ◦ Fractionated or permanent interstitial implant treatment for a variety of sites, including:
	  ・ Prostate
	  ・ Breast
	  ・ Tongue
	  ◦ Intraluminal treatment, including:
	  ・ Bronchus
	  ・ Oesophagus
	  ◦ Intracavitary treatment, including:
	  ・ Cervix
	  ・ Nasopharynx
	• Perform for a variety of treatment sites:
	  ◦ Transfer of image data to the treatment planning system
	  ◦ Reconstruction of source geometry at the treatment planning computer from:
	  ・ Orthogonal or stereo-shift X ray film via digitizer
	  ・ CT, MR and/or ultrasound images
	  ◦ Image registration using treatment planning system
	  ◦ Contouring of treatment volume and critical structures of interest

	Module 6: Brachytherapy
	Sub-module 6.7: Treatment Planning
Objective	Provide training in brachytherapy treatment planning and dose calculation.
Competencies Addressed	• Ability to perform manual dose calculations in brachytherapy • Ability to use a treatment planning computer to generate an acceptable treatment plan • Ability to perform QC of individual treatment plans

Recommended Items of Training	• Demonstrate an understanding of the:
	  ◦ Characteristics and merits of brachytherapy sources
	  ◦ Physical principles, methods and merits of:
	  ・ Manual brachytherapy
	  ・ Remote afterloading treatment techniques:
	  🕓 LDR
	  🕓 HDR

	⏲ PDR ◦ Radiobiological principles relevant to brachytherapy ◦ Effects on dose of: ▪ Source configuration ▪ Inter-source heterogeneity ▪ Source encapsulation ▪ Treatment applicators ◦ Principles and properties of a variety of source configuration and dosimetry systems for implant and intracavitary brachytherapy, including methods and algorithms used for: ▪ Reconstruction of source geometry ▪ Dose calculation ▪ Treatment plan optimization ◦ Patient and source data required for treatment planning ◦ Limitations and uncertainties associated with manual and computer planning ◦ ICRU system of dose specification ◦ Local treatment protocols for a variety of sites: ▪ Treatment techniques ▪ Dose fractionation ▪ Tolerance doses of organs of interest • Perform: ◦ Source reconstruction with: ▪ Radiographic images ▪ Fluoroscopic images ▪ CT images ◦ Treatment planning and dose calculation by manual and computer methods of a variety of brachytherapy treatments, including: ▪ Intra-cavitary implant, including manual and/or afterloading treatment of cervical cancer based on commonly used source configuration and dosimetry systems, including: ⏲ Manchester system ⏲ Paris System ▪ Interstitial implant, including manual or afterloading treatment of: ⏲ Prostate implant based on commonly used dosimetry systems, including: ▪ Manchester system ▪ Paris system ⏲ Breast implant ⏲ Tongue implant ▪ Intra-luminal treatment, including treatment of: ⏲ Bronchus ⏲ Oesophagus ⏲ Nasopharynx ▪ Intra-vascular treatment ▪ Surface mould/plaque, including treatment of: ⏲ Eye ⏲ Skin cancer ◦ Dose/plan optimization based on a combination of: ▪ Dose prescription/specification ▪ Source configuration/distribution ▪ Dwell time ◦ Calculation on radiobiological equivalence of treatment schemes,

	including:

	▪ Protracted brachytherapy to fractionated treatments ▪ LDR and HDR brachytherapy ▪ Total dose of adding external beam radiotherapy • Prepare treatment chart/data • Quality control of individual patient treatment plans, including independent checking of: ◦ Integrity of input data ◦ Dose ◦ Dose distribution ◦ Treatment chart ◦ Integrity of treatment data transfer from planning computer to afterloading treatment unit
	Module 6: Brachytherapy
	Sub-module 6.8: Source Preparation
Objectives	To provide training on preparation of sealed radiation sources for brachytherapy.
Competency Addressed	Safe handling of brachytherapy sources and preparation of treatment applicators

Recommended Items of Training	• Demonstrate an understanding of:
	  ◦ Operation of a radiation source inventory and custody system
	  ◦ System of work in a sealed source preparation room
	  ◦ Principles and design of treatment applicators
	  ◦ Procedures for safe handling and preparation of brachytherapy sources
	  ◦ Source loading configurations for a variety of treatment protocols
	• Prepare for manual and/or afterloading treatments
	  ◦ Treatment applicators and/or catheters for:
	  ▪ Intra-cavitary treatments
	  ▪ Intra-luminal treatments
	  ▪ Interstitial treatments
	  ▪ Surface treatments
	  ◦ Implantation tools, such as treatment templates
	  ◦ Brachytherapy sources for a variety of treatments, sources such as:
	  ▪ Cobalt-60
	  ▪ Palladium-103
	  ▪ Iodine-125
	  ▪ Cesium-137
	  ▪ Iridium-192
	  ▪ Gold-198
	• Supervise/advise on the cleaning and sterilization of sources and treatment applicators
	• Loading of the brachytherapy sources into treatment applicators according to treatment plans/protocols
	• QC of individual source loading
	• Issue and receipt of brachytherapy sources
	• Management of radiation sources, including:
	  ◦ Acquisition
	  ◦ Custody
	  ◦ Disposal
	• Handle records and documentation

	MODULE 7: PROFESSIONAL STUDIES AND QUALITY MANAGEMENT
Objectives	To provide Residents with: • knowledge and competencies relating to the professional aspects of their roles and responsibilities and principles and practice of quality management in a radiotherapy department**.**
Competencies Addressed in this Module	• Professional awareness. • High level of oral and written communication, and interpretation skills. • Appropriate level of general management skills. • Knowledge and basic skills in information technology. • Design of the structure of a quality management system • Design and performance of a quality assurance programme required for the clinical implementation of new equipment.
Expected time commitment	**8 % of entire program** **(58 day)** (Note: management and communication skills must be developed throughout all years of training and skills are interwoven within all modules)
Pre-Requisite Knowledge	LEER, J.W.H., MCKENZIE, A., SCALLIET, P., THWAITES, D.I., Practical guidelines for the implementation of a quality system in radiotherapy – ESTRO booklet #4.(1998). http://www.estroweb.org/estro/index.cfm. PODGORSAK, E.B., (Ed.) Review of Radiation Oncology Physics: A Handbook for Teachers and Students, International Atomic Energy Agency, Vienna, (2005). VAN DYK, J., (Ed.) The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists, Medical Physics Publishing, Madison WI, (1999).
Sub-Modules	7.1 Professional Awareness 7.2 Communication 7.3 General Management 7.4 Information Technology 7.5 Quality Management Systems 7.6 Quality Management for the Implementation of New Equipment
Supplementary Reading List	• ESTRO publications (various). http://www.estroweb.org/estro/index.cfm • http://www.edu.uwo.ca/conted/mentor/index.asp • ISO • QART • Lowe W. Networking for Dummies. Wiley, 2005. • Robbins A. Unix in a Nutshell. 4th Edition. O'Reilly Media. 2005. • Venables J. Communication Skills for Engineers and Scientists. 3rd Edition. Institute of Chemical Engineers. 2202. • National Health and Medical Research Council (Australia). Communicating with patients: advice for medical practitioners 2004. Available at http://www.nhmrc.gov.au/documents/_files/e58.pdf

	Module 7: Professional Studies and Quality Management
	Sub-module 7.1: Professional Awareness
Objective	To demonstrate an understanding of and participate in (if possible) activities related to professional awareness.
Competency Addressed	Professional awareness.

Recommended Items of Training	**Career Planning** • Demonstrate an understanding of the scope of practice and career structure of Radiation Oncology Physicists. • Demonstrate an understanding of the opportunities and restrictions in career progression. • Draw a tree diagram summarising your Medical Physics department's staff structure, including your position. • Define your own career plan. **Professional Organisation Activities** • Demonstrate an awareness of the professional organisation including the structure of your professional organisation including identifying key office bearers and administrative staff. • Attend and actively participate in professional activities. • Review website of medical physics professional organisations • Demonstrate an awareness of topical issues affecting your profession and professional organisation. • Demonstrate an awareness of the organisations representing your professional body and other allied organisations and locate the relevant websites. • Demonstrate of the awareness of international agencies and professional bodies as related to Radiation Oncology Physics. **Professional Issues** **i. Ethics** • Demonstrate an understanding of your professional organisation and hospital's policies and procedures on professional and clinical ethics. • Demonstrate an awareness of the code of conduct and mission statement for your professional organisation and hospital. • Understand the requirements for ethics clearance for clinical research projects. • Understand the requirements of privacy of staff and patient information. **ii. Legal Issues** • Outline the objectives, definition and requirements of/for legal issues at your institution/s (e.g. hospital and university if relevant) and in your state and country as related to Radiation Oncology Medical Physicists. This should include the policies on conflict of interest and legislation and regulatory matters. • Outline the requirements of radiation incident reporting. • Awareness of data protection legislation.

	iii. Intellectual Property • Understand the types of intellectual property. • Outline the objectives, definition and requirements of/for intellectual property at your institution/s (e.g. hospital and university if relevant). • Outline ownership of material produced as a result of your research at your institution. • Demonstrate an awareness of vendor intellectual property requirements in the workplace, including software licensing and warranties. **Continual Professional Development** • Demonstrate an awareness of the objective of CPD. • Demonstrate an awareness of legislation and/or professional organisation requirements for CPD.
	Module 7: Professional Studies and Quality Management
	Sub-module 7.2: Communication
Objective	To be a good communicator within a multi-disciplinary team, with patients and the general public.
Competencies Addressed	Oral and written communication and interpretation skills.

Recommended Items of Training	**Oral Skills**
	
	• Attend a course on
	  ◦ Oral presentation competencies,
	  ◦ Mentoring competencies, and/or
	  ◦ Conducting professional meetings.
	• Actively participate in physics department meetings (chair a meeting if possible).
	• Actively participate in Radiation Oncology Department technical meetings e.g. reviewing patients' set-up and treatment techniques.
	• Scientific presentation at meeting of Medical Physicists, multi-disciplinary professionals or an audience containing members of the general public.
	• Medical Physics tutoring for other Radiation Oncology professionals. Examples include Radiation Safety lectures and tutorials to Radiation Oncology Registrars.
	• Actively participate in project progress meetings during equipment commissioning.
	• Presentation of research results at a national and/or international conference/meeting.
	• Communicate with a patient (in a mock or real scenario), such as the purpose and method of in-vivo dosimetry to a patient you are about to perform a measurement on.
	• Provide accurate, clear, clinical medical physics advice regarding patient set-up, planning or treatment to other Radiation Oncology Professionals (via in-vivo dosimetry, specialised treatment techniques, consultation in the simulator room, etc).

	Written Skills • Demonstrate understanding of professional issues such as legal consequences of information documented and forwarded via email, confidentiality, sensitivity and permission to use data. • Demonstrate understanding of appropriate format and style of professional written communication, including email, memos and letters. • Keep a logbook • Write an example of a professional letter, email and memo that you could send to a key manager in the Radiation Oncology Department addressing a medical physics issue. • Write a brief technical report on a patient case study e.g. *in vivo* dosimetry, specialised treatment technique or patient treated with brachytherapy. • Write a business case to management regarding new or replacement radiotherapy equipment. • Write or review a protocol for a new or revised treatment technique commissioned by Department. • Write a progress and/or final report for commissioning of new radiotherapy equipment to Radiation Oncology Department. **Comprehension Skills** ° Participate in department meetings to review journal papers ° Present a review of an international technical protocol to Physics Department
	Module 7: Professional Studies and Quality Management
	Sub-module 7.3: General Management
Objective	To develop capability in managing equipment, a project and/or staff, including liaising with other professional groups.
Competency Addressed	Appropriate level of general management skills
Recommended Items of Training	• Participate in project management of the installation and/or commissioning of a therapy unit. • Manage a budget for a small research project • Supervise and mentor technical staff to successfully complete a project on schedule. • Manage a section of the department for a period of time including liaising with other professional groups. • Manage a treatment planning system or linear accelerator (i.e. managing decisions on occasion necessary in short time frames). • Supervise the maintenance of therapy and simulation units, such as: ° Participate in trouble-shooting equipment faults for a period of time. ° Assume responsibility for each unit for a period of time, including being a contact point for equipment faults and liaising with engineers. ° Write a report and/or present to the physics department case studies outlining the equipment fault, its cause and required verification measurements required to ensure accurate dose delivery. ° Understand differences between units from different manufacturers. • Attend a course on

	◦ Time management ◦ Conflict resolution ◦ Performance management
	Module 7: Professional Studies and Quality Management
	Sub-module 7.4: Information Technology
Objective	To be competent with personal computers (PC), interfacing, networking, data storage, and knowledge of Radiation Oncology information technology systems.
Competency Addressed	Knowledge and basic skills in information technology.
Recommended Items of Training	• Demonstrate understanding of electronic communication standards (e.g. Ethernet, FTP, DICOM, DICOM-RT, HL7, etc) • Demonstrate understanding of types and applications of databases in Radiation Oncology • Demonstrate understanding of information technology systems related to Radiation Oncology (e.g. Patient administration systems (PAS), MIMS (database for drugs), pathology, PACS (picture archiving), Incident Management System (IMS)) including various level of user rights. • Demonstrate understanding of professional IT issues such as privacy, confidentiality, sensitivity and permission to use data. • Demonstrate understanding of storage media and how to use them. • Set-up two computers to be able to communicate via DICOM using freeware DICOM tools. • Interface peripheral devices to PCs and treatment planning system (e.g. printers, scanners, fax, USB, serial, parallel, etc). • Perform data reporting, analysis and presentation using Microsoft Office applications (e.g. Work, Excel, PowerPoint) • Demonstrate understanding and ability to use tools for backing up radiotherapy and PC data. • Demonstrate understanding and ability to use Radiation Oncology Information Technology systems such as Record and verify system, data acquisition, linear accelerators, internet, TLD reader software and treatment planning system.
	Module 7: Professional Studies and Quality Management
	Sub-module 7.5: Quality management systems
Objective	To develop an understanding of the principal requirements and elements for a quality management system**.**
Competencies Addressed	Competent in designing the structure of a quality management system.
Recommended Items of Training	• Explain the meaning of relevant terms such as quality, quality process, quality assurance, quality control or quality audit • Demonstrate an understanding of the role of quality management in radiotherapy • Discuss key elements of a quality management system: o documentation of quality policy o documentation of quality procedures (quality manual)

	• Analyze the patient work flow • Design the structure of a quality manual and apply it to a representative selection of items • Participate in a relevant course (either at the management or at the professional level)
	Module 7: Professional Studies and Quality Management
	Sub-module 7.6: Quality management for the implementation of new equipment
Objective	To develop the skill in quality management required for the clinical implementation of new equipment.
Competency Addressed	Competent in designing and performing a quality assurance programme required for the clinical implementation of new equipment.
Recommended Items of Training	• Demonstrate an understanding of generic steps with the clinical implementation such as o clinical needs assessment o specification, purchase process o acceptance tests o commissioning o periodic tests • Exercise the implementation of at least one radiation facility (external beam therapy facility, afterloading facility) including beam calibration • Exercise the implementation of further items of equipment used in radiotherapy such as o equipment for imaging (simulator, CT, etc) o dosimetry systems o beam modifying and shaping equipment o network equipment • Demonstrate an understanding of the key steps of the commissioning of a computerized planning system • Demonstrate an understanding of a representative selection of steps required for the commissioning of a computerized planning system • Perform a patient specific quality assurance check of a computerized planning system

	MODULE 8: RESEARCH, DEVELOPMENT AND TEACHING
Objective	To develop key skills in research, development and teaching in Radiation Oncology Physics as part of a multidisciplinary team.
Core Competencies Addressed in this Module	• Ability to carry out research and development in Radiation Oncology Physics and instrumentation. • Ability to be an effective member of the Radiation Oncology research team. • Ability to teach radiation and general physics.
Expected Time Commitment	**15 % of entire program** **(108 day)**
Sub-Modules	8.1 Research and Development 8.2 Teaching
Core Reading List	AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, A guide to the teaching of clinical radiological physics to residents in diagnostic and therapeutic radiology, AAPM Rep. 64, New York (1999). http://www.aapm.org/pubs/reports/rpt_64.PDF. AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Quality assurance for clinical trials: A primer for Physicists. 2004 AAPM Rep. 86, New York (2004). http://www.aapm.org/pubs/reports/rpt_86.PDF. ICH/CPMP, Good Clinical Practice : Consolidated Guidelines, International Conference on Harmonisation of Technical Requirements for Registration of Pharmaceuticals for Human Use Rep. E6 (R1) (1996). http://www.ich.org/cache/compo/276-254-1.html.
Supplementary Reading List	ARPANSA, Code of Practice for the Exposure of Humans to Ionizing Radiation for Research Purposes, Radiation Protection Series Rep. 8, ARPANSA. http://www.arpansa.gov.au/rps8.htm. CROWLEY, J., ANKERST, D.P., (Eds), Handbook of Statistics in Clinical Oncology, 2nd edn., Chapman & Hall/CRC, (2006). HALL, E., GIACCIA, A.J., Radiobiology for the Radiologist, 6th edn, Lippincott Wilkins & Williams, Philadelphia, USA (2006). ICH/CPMP, Statistical Principles for Clinical Trials, International Conference on Harmonisation of Technical Requirements for Registration of Pharmaceuticals for Human Use Rep. E9 (1998). http://www.ich.org/cache/compo/276-254-1.html. STEEL, G., Basic Clinical Radiobiology, 3rd edn, Arnold Press (2002). VAN DYK, J., (Ed.) The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists, Medical Physics Publishing, Madison WI, (1999). VAN DYK, J., (Ed.) The Modern Technology of Radiation Oncology, Vol. 2, Medical Physics Publishing, Madison, WI, (2005). WIGG, D.R., Applied Radiobiology and Bio effect Planning, Medical Physics Publication (2001). WOODWORD, M., Epidemiology: Study Design and Data Analysis, 2nd edn, Chapman & Hall/CRC (2005). WOOLFE, J., How to write a PhD Thesis, http://www.phys.unsw.edu.au/~jw/thesis.html

	Internet articles/resources re: clinical trials http://www.nhmrc.gov.au/ethics/human/issues/trials.htm http://www.tga.gov.au/docs/html/ich13595.htm http://www.arpansa.gov.au/rps8.htm http://www.edu.uwo.ca/conted/mentor/index.asp
	Module 8: Research, Development and Teaching
	Sub-module 8.1: Research and Development
Objectives	To develop: • Attributes required to be an effective member of a Radiation Oncology research team, and scientific skills and acumen in research and development by contributing to a scientific project related to Radiation Oncology.
Competency Addressed	Ability to carry out research and development in Radiation Oncology Physics and instrumentation either individually or as a member of a team

Recommended Items of Training	• Participate in a research and/or development project in Radiation Oncology including tasks such as:
	  ○ Define an area for research, including the specific question which is being asked, in consultation with other physicists in the department.
	  ○ Formulate hypotheses.
	  ○ Review the literature in the area effectively and critically and provide this in a written report (including the clinical benefits of the research or development).
	  ○ Continually monitor current advances in research and development in the chosen area of research.
	  ○ Determine a project plan for the project including, milestones, necessary experiments and analysis and time frames.
	  ○ Select and use appropriate equipment and scientific methodology.
	  ○ Assess and quantify uncertainty in experimental methods.
	  ○ Publication or presentation of results at a national or international level.
	  ○ Write a reply to reviewers' comments and make necessary changes.
	  ○ Liaise with research/technical assistants.
	  ○ Defend research results to an audience.
	• Write a small to medium research grant application.
	• Participate in the improvement of the Medical Physics service.
	• In consultation with other department members, determine a collaborative project within the department that you can be involved with.
	• Apply relevant medical physics knowledge to assist with clinical trials, statistical methods and mathematical modelling in association with medical staff, data managers and/or statisticians, such as.
	  ○ Provide dosimetry advice to Radiation Oncologists regarding a clinical trial, as well as:
	  ▪ Demonstrate an understanding of the characteristics of clinical trials, including those currently being conducted locally and
	  ▪ Awareness of the role of multidisciplinary professionals in the execution and evaluation of Clinical Trials.
	  ○ Collaborate with medical staff, data managers and statisticians by assisting with the use of statistical methods and mathematical modelling in Radiation Oncology.

	Module 8: Research, Development and Teaching
	Sub-module 8.2: Teaching
Objective	To develop the attributes required to be an effective educator and mentor in radiation oncology physics.
Competency Addressed	• Ability to teach radiation and general physics.
Recommended Items of Training	• Attend a general course (if available) on how to teach scientific material. • Develop familiarity with teaching techniques, including understanding the needs of particular audiences. • Teach radiation and general physics (including radiation safety) to different audiences (e.g. radiation therapists, medical staff, students, junior physicists, etc.) • Attend a general course (if available) on mentoring or clinical supervision for health professionals. • Understand the differences between individual and group learning. • Understand the requirements of adult education and professional development.

A+	**90-100**	One could scarcely expect better from a student at this level
A	**80-89**	Superior work which is clearly above average
B	**70-79**	Good work, meeting all requirements, and eminently satisfactory
C	**60-69**	Competent work, meeting requirements
D	**50-59**	Fair work, minimally acceptable
F	**below 50**	Fail