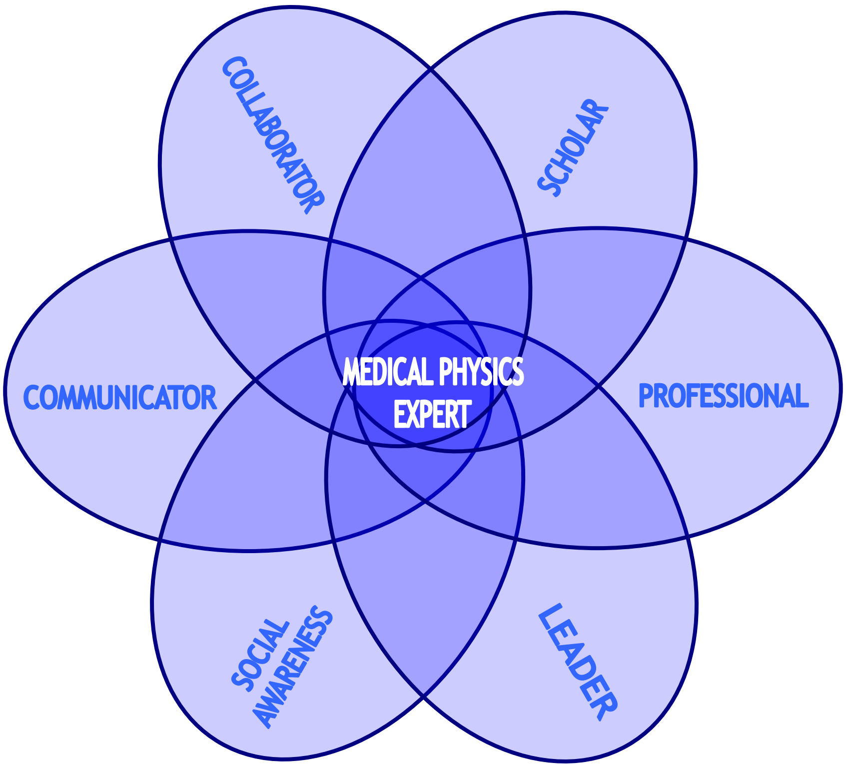
CORE CURRICULUM FOR MEDICAL PHYSICISTS

VOLUME 2 - RADIOTHERAPY



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KNOWLEDGE, SKILLS AND COMPETENCIES SPECIFIC FOR RADIOTHERAPY

1. Fundamentals of oncology and radiotherapy

Short description:
In order to effectively communicate and operate within the multi-disciplinary team a basic understanding of the fundamentals of cancer development, diagnostics and treatment is required. Also, typical radiotherapy dose schemes, typical normal tissue tolerances and typical local control and survival probabilities must be known. The knowledge enables better application of the medical physicist's function in contemporary radiotherapy.

Competences:
- demonstrate a basic understanding of the development of cancer, the nature of the various forms of cancers, their molecular and cellular features as well as diagnostics of cancer;
- demonstrate knowledge of the various treatment options;
- ability to participate in a multidisciplinary radiation oncology team with respect to communication and exchange of relevant patient information;
- demonstrate knowledge of Radiotherapy treatment options including their clinical outcomes;
- ability to integrate knowledge of multi-modal therapy into the planning of radiation therapy of cancer patients.

Core curriculum items:
- carcinogenesis;
- oncogenes and supressorgenes;
- major signalling pathways of importance for repsonse to radiation;
- pathways of tumour dissemination;
- principles of diagostics and staging of cancer;
- principles of surgical, medical and radiation oncology;
- Understand the balance between high technical quality of possible treatments and life expectancy of the patient/medical considerations.
- AAPM Recommendations, TG-40, TG-56 and TG-100 (www.aapm.org)

Minimum time to be spent on this topic: 1 ECTS

2. *Overview of radiation physics*

Short description:

The medical physicist in radiotherapy should have a good knowledge of radiation physics in order to understand the manner in which ionising radiation is applied in medical diagnostics and radiotherapy. Since X-rays of energies ranging from kV to several MV, gamma-rays of several MeV and a variety of particle radiations, including protons and heavy ions, are nowadays applied in medical diagnostics and radiotherapy, a broad knowledge of nuclear and atomic physics is required for the medical physicist in radiotherapy. The interaction of matter and radiation lies at the basis of understanding the advantages and limitations of various diagnostic and therapeutic techniques. Therefore, knowlegde of the underlying physical processes should be emphasized.

Competences:

- ability to recognise the difference between the physical interactions of indirectly and directly ionising radiation;
- ability to specify the different mechanisms that generate ionising radiation, including radioactive decay;
- ability to describe the different mechanisms of energy loss by various types of radiation through various media;
- demonstrate an understanding of the basic concepts of dosimetry and working principles of several dosimeters;
- ability to quantitatively describe radiation fields applied in radiodiagnostics and radiotherapy;
- ability to quantitatively describe the various radioactive sources used in nuclear medicine for diagnostics and radiotherapy;

- ability to identify a physical problem and to develop an experimental procedure to resolve it using appropriate measurement equipment;
- ability to estimate measurement uncertainties and their classification.

Core curriculum items:

- ionising radiation;
- generation of X-ray;
- radioactivity (units and quantities);
- Poisson statistics;
- interaction of photons with matter;
- scattering and attenuation of a photon beam in matter;
- interaction of electrons, heavy charged particles and neutrons (slow and fast);
- linear energy transfer (LET);

- overview of medical uses of radiation;
- radiation sources and source types (e.g. sealed, unsealed, applications);
- overview of clinical specification of radiotherapy beams
- characteristics of photon and electron beams
- behaviour of electrons and photons near surfaces

Minimum time to be spent on this topic: 3 ECTS

3. *External beam radiotherapy*

3.1 Treatment equipment

Short description:

The medical physicist in radiotherapy is reponsible for the maintenance as well as the safe and effective operation of radiotherapy equipment. External beam radiotherapy devices include all treatment units used to irradiate the patient with kV and MV X-ray beams, gamma rays or electron beams.

All contemporary treatment machines have integrated imaging systems to localise the target on-line before the treatment or even to track its motion during treatment (image-guided radiotherapy, IGRT, and adaptive RT).

Competences:

- demonstrate an understanding of the physics and principles of all treatment units and in-room imaging equipment (e.g., CBCT, kV and MV imaging, MR imaging on the MR-linac), the sources of interlocks, and the sources of deviations in dosimetric or mechanical parameters;
- ability to operate treatment units and in-room imaging equipment safely;
- ability to understand and have technical discussions with engineers (e.g., concerning recalibration or replacement of parts);
- ability to perform acceptance testing, commissioning and quality control of treatment units and in-room imaging equipment;
- ability to specify, justify and rank the criteria for specifying and selecting treatment units and in-room imaging devices.
- ability to perform acceptance and commissioning tests and set up a QA programme for all imaging modalities used in radiation therapy to evaluate performance, image quality and geometric accuracy and dose to the patient;
- ability to observe and assess the engineering maintenance of the imaging equipment.
- demonstrate knowledge on when the machine is out of specifications, and the ability to decide on whether or not to use equipment in those situations
- ability to discuss measurement theory and manage sources of uncertainties associated with treatment equipment.

Core curriculum Items:

- X-ray units for kV-radiation;
- design and operation of linear accelerators and other systems for MV X-ray and electron beams (standard linacs, tomotherapy unit, robotic linacs, mobile linacs for intra-operative radiation therapy);
- acceptance testing and commissioning of a linear accelerator;
- periodic maintenance including mechanical and physical quality control of the linac and its parts such as MLC, EPID and conebeam CT;
- stereotactic irradiation devices;
- imaging systems ON treatment units: electronic portal imaging devices, kV-MV cone beam CT, MRI;
- imaging systems AT treatment units: opto-electronic systems, stereoscopic X-ray imaging systems, in-room CT, radiofrequency-based and ultrasound devices;

Minimum time to be spent on this topic: 3 ECTS

3.2 Treatment techniques

Short description:

Radiotherapy during the last decades has developed from simple 2D techniques via 3D conformal radiotherapy to intensity-modulated radiotherapy (IMRT), using either static beam directions or rotational techniques. It has also developed a closer reliance on imaging during each stage of the process (Image Guided Radiotherapy (IGRT)).

Competences:

- demonstrate understanding of the capabilities and limitations of all different irradiation techniques;
- demonstrate understanding of all current and state-of-the-art electron and photon treatment techniques for all relevant treatment sites;
- ability to develop and implement new treatment techniques, from commissioning to treatment simulation, planning, verification and quality assurance;
- ability to choose the most appropriate technique according to the tumor site and intent of the treatment;
- ability to compare national and international treatment protocols for different irradiation techniques with those used at the institution.
- ability to evaluate the magnitudes, sources, and implications of day-to-day treatment variability;

Core Curriculum Items:

- conventional 3D techniques: wedges, bolus, beam shaping, beam combinations, weighting and normalization, field matching; co-planar and non-coplanar
- IMRT: fixed-gantry: MLC-based static or dynamic delivery, rotating-gantry: serial and helical tomotherapy, intensity-modulated arc therapy (VMAT/Rapid Arc);
- special techniques: stereotactic radiosurgery (SRS) and radiotherapy (SRT), intraoperative radiation therapy (IORT), total body irradiation (TBI), total skin electron irradiation (TSEI), gated irradiation of mobile targets; Cyberknife system and techniques, Gammaknife system and techniques, MRI-linac and techniques.
- corresponding knowledge and skills will need to be acquired for new and upcoming techniques;
- orthovoltage and contact therapy treatment;
- management of uncertainties;

Minimum time to be spent on this topic: 3 ECTS

3.3 Treatment simulation and planning

Short description:

Treatment simulation and planning consist of all procedures used to determine the optimal irradiation plan for a patient. The first step is the immobilisation and simulation of the patient. Except for simple cases, treatment planning is now performed with computerised treatment planning systems (TPS), which rely on computer hardware, software and networking. Detailed knowledge of the effect of beam arrangements, modification devices, beam weights, normalisation, optimisation techniques and dose prescription is necessary to produce a good treatment plan. Plan evaluation methods are essential to clinically accept the treatment plan. The medical physicist in radiotherapy plays a key role and is responsible for the entire treatment planning procedure, i.e. in the optimization and evaluation of dose distribution. He/she is also responsible for ensuring the effective use and operation of the devices used to simulate the treatment which include CT and MRI.

Competences:

1. demonstrate an understanding of and familiarity with the use of the CT devices;
2. demonstrate an understanding of immobilisation devices and their application;
3. demonstrate an understanding of the application of MRI in treatment planning;
4. ability to acquire multimodality imaging data and perform image fusion for target volume delineation and planning;

5. demonstrate knowledge of the hardware, software components and networking of a TPS;
6. ability to import and to model measured beam data into the TPS;
7. ability to perform the commissioning and quality control of the TPS;
8. demonstrate knowledge of algorithms / models to calculate the dose distribution for photon and electron beams and their limitations regarding inhomogeneities;

9. ability to create treatment plans for a variety of different irradiation techniques;
10. ability to produce treatment plans for simple techniques, using appropriate beam modifiers
11. ability to create treatment plans for IMRT, VMAT, stereotactic radiosurgery and stereotactic radiotherapy;
12. ability to perform plan optimisation and evaluation using uniformity criteria, constraints, DVHs and biological parameters (TCP, NTCP);
13. demonstrate an understanding of the consequences of treatment-related adverse effects and how this influences treatment planning;

14. ability to perform manual monitor unit or time calculations for MV and kV X-ray beams, and electron beams for a variety of clinical situations. taking into account field-size factors, and other relevant factors;
15. ability to perform an independent check of the individual patient plan, using both pre-treatment dosimetry and a secondary dose calculation system.
16. demonstrate working knowledge of the ICRU terminology regarding the target volumes and organs at risks;
17. ability to specify, justify and rank the criteria for specifying and selecting a TPS.

Core Curriculum Items:

1. immobilisation devices and their application;
2. principles of CT and / or MRI simulation;
3. localisation / simulation procedures;
4. multimodality image registration and fusion for target volume delineation and planning;
5. hardware and software components of a treatment planning system (TPS) and networking (dicom, dicom RT etc.);

6. specification of dose and volumes, margin decisions, including international recommendations (ICRU 50, 62, 83);
7. Dose calculation algorithms (correction-based, model-based and Monte Carlo) for photon and electron beams;
8. monitor unit calculation for fixed-SSD and isocentric approaches;
9. computer-supported plans for all different irradiation techniques;
10. virtual simulation and tools: BEV, DRR; DCR *(*Digitally composited radiographs);
11. effect of various beam arrangements, beam modification devices (wedges if still applied, , MLCs, bolus) and beam weights on dose distribution;
12. IMRT and VMAT planning: forward vs. inverse planning, fluence optimisation;
13. Automated planning, Multi Criteria Optimazation
14. plan optimisation and evaluation methods: uniformity criteria, constraints, DVHs and biological parameters (TCP, NTCP);
15. 4D TPS;
16. recording and reporting dosimetric parameters according to international recommendations;
17. management of implanted devices (prosthesis, dental filings, expander valves, pace makers) in the treatment plan, including the effects of high Z materials on the dose calculation;
18. archiving, back-up and restore of plans;
19. To observe the activities performed in the mouldroom for one day, including fabrication of all different immobilization devices;
20. To study different possible immobilization devices and achievable geometric accuracy / reproducibility, especially for stereotactic treatments.

Minimum time to be spent on this topic: 4 ECTS

3.4 Treatment verification

Short description:

Treatment verification includes all procedures to verify the different parts of the treatment: patient positioning, target localisation, data transfer from the treatment planning system to the treatment unit through the record and verify system and dosimetric verification of the irradiation plan. Patient set-up and target localisation before treatment can be verified with different IGRT techniques with on-line or off-line correction protocols, using MV or kV images, CBCT, MRI or body surface scanners . Techniques have been developed to minimise the effects of organ motion due to breathing during treatment. Procedures have been developed to adjust the treatment during the radiotherapy course, as a result of the changing patient anatomy: adaptive radiotherapy.

The dosimetric verification of the irradiation plan may include pre-treatment verification in a phantom and in-vivo dosimetry during treatment. In-vivo dosimetry may include verification of the delivered dose in single points or planar dosimetry, like transit dosimetry with portal imaging.

Competences :

- ability to implement different IGRT techniques;
- ability to implement the techniques to control respiratory motion;
- ability to assess intra and inter-fraction set-up errors and target motion;
- ability to apply different set-up and IGRT correction protocols;
- ability to set tolerances and action levels;
- ability to perform pre-treatment dosimetric verification of standard and sophisticated RT plans;
- ability to implement and apply different approaches for adaptive radiotherapy including a “plan of the day” strategy.
- demonstrate knowledge of different approaches and appropriate detectors to perform in-vivo dosimetry;
- ability to use a record and verify system.

Core Curriculum Items:

- patient alignment and set-up on the CT/MR and on treatment units;
- IGRT techniques at the treatment unit using MV, kV, CBCT and MRI images to optimise the set-up and target localisation;
- geometric setup protocols based on bony anatomy and based on tumor position (multiple 2D and 3D);
- adaptive RT techniques (image acquisition for adaptive treatment, image registration, deformable image registration, dose summation, workflow, usefulness in practice for different treatment sites);
- techniques to control breathing motion during treatment (respiratory gating, breath hold and tumor tracking);

- basic dosimetry source data;
- dosimetric verification of all external treatment plans
- in-vivo dosimetry;

- record and verify systems;
- tolerance and action levels.

Minimum time to be spent on this topic: 5 ECTS

4. *Brachytherapy*

Short description:
Brachytherapy (BT) is a technique that uses sealed radioactive sources which are placed inside the tumour or in close proximity to it. It has been used widely for many years to treat a large variety of tumours. Due to the nature of the modality, specialist dosimetry protocols and procedures have to be applied, measurement systems and treatment planning systems are specifically designed.

a) In recent years, Brachytherapy has undergone important changes. 3D-Image Guided Brachytherapy has become a common technique in most of the applications (utilising CT, MR, US).

Competences :

- demonstrate an understanding of the basic operation of the commercially available afterloading systems and low-dose rate permanent seed implant systems;
- ability to assess the advantages and limitations of the locally available afterloading systems and BT sources;
- ability to participate in the overall clinical process of brachytherapy from operating theatre through simulator localisation, treatment planning and treatment delivery;
- ability to discuss the use of the different closed/sealed brachytherapy sources;
- demonstrate an understanding of the dosimetry systems for intracavitary brachytherapy and interstitial brachytherapy (GEC—ESTRO, Manchester, Paris, image based dosimetry);
- understanding the clinical application of imaging for brachytherapy
- demonstrate understanding of the use and limitations of optimisation techniques in brachytherapy treatment planning;
- ability to perfom independent verifications of the calculated treatment times of intracavity insertions and interstitial implants using manual methods;

- ability to apply calibration protocols for the BT sources used locally, and to determine the uncertainties of the measurement;
- ability to assess the functional characteristics of the source calibration equipment, and to perform quality control of this equipment;
- demonstrate an understanding of the TG 43 dose calculation algorithm and modern model based algorithms;
- ability to setup a quality control program of the brachytherapy sources, applicators and equipment, including the TPS;
- ability to handle basic radiation safety procedures, such as leakage tests on the sources, disposal of sources, prevention and actions in case of source loss;
- ability to discuss national and international regulations for the use and transport of radioactive materials.

Core curriculum items:

Equipment

- sources: radionuclide types and source design;
- applicators;
- after-loading systems: low dose rate (LDR), high dose rate (HDR), pulsed dose rate (PDR), permanent seed implant LDR;
- source calibration equipment;
- imaging systems for brachytherapy.

Source specification
- quantities and units: activity, reference air kerma rate (RAKR), exposure rate, etc.;
- “source strength” determination according to national and international protocols, including IAEA recommendations;
- interpretation of the source calibration certificate from the manufacturer;
- dosimetry measurement methods.

Treatment techniques and methods
- permanent and temporary implants;
- standard applications;
- classical implantation and dose calculation systems (LDR), e.g.: interstitial, the “Paris System” and intracavitary, the “Manchester System”;
- extension to other dose rate categories: HDR, PDR;
- special brachytherapy techniques, e.g.: permanent prostate seeds, stereotactic brain implants, eye plaques, partial breast irradiation, intra operative HDR.

Treatment planning and dose calculation
- dose calculation algorithms, TG 43, model based algorithms, Monte Carlo, acuros;
- general structure of brachytherapy planning systems;
- source and points position reconstruction algorithms: radiographic films, CT and other image based algorithms;
- optimisation algorithms for HDR, PDR, LDR;
- dose-Volume Histograms in BT, DVH-related planning evaluation parameters;
- treatment planning optimisation and evaluation; Uniformity criteria and constraints.

Specification of dose and volumes
- according to national and international protocols, including ICRU 38 and ICRU 58, GEC ESTRO and ABS recommendations.

Quality Assurance
- equipment specifications, commissioning and QC of after-loading equipment (LDR, HDR, PDR), treatment planning systems (reconstruction algorithms and calculation algorithms), sources and applicators, imaging systems in BT, dosimetry systems, networks, etc.;
- national and international recommendations and local protocols;
- overall QA of the BT treatment process;
- verification, checking and QA of individual patients treatment plans;
- in-vivo dosimetry in brachytherapy;
- Radiation Protection and Radioactive substances regulation.

Minimum time to be spent on this topic: 5 ECTS

5. *Dosimetry*

Short description :
Accurate dose determination is an essential task of the radiotherapy medical physics group. The medical physicist is responsible for the determined dose and the correct use of dosimetry devises and protocols. In practise, dosimetry is mainly performed by other members of the physics groups. However, it is essential that the concept of absorbed dose and kerma, and dosimetric quantities and units should be well understood. The medical physicist in radiotherapy should be familiar with the principle of the calibration chain from the national primary standard to hospital field instrument and understand the physics and techniques of the different dosimetry detectors involved. Determination of the absorbed dose in a clinical beam under reference conditions by applying a national or international recommended protocol is an important issue; determination of dose in non-reference conditions should be understood. The medical physicist in radiotherapy should be familiar with the different measurement systems that are available for dosimetry and quality control in the hospital; a critical understanding of their advantages and limitations is required to be able to select the most appropriate system for each dosimetric problem. This appreciation should include acceptance testing, calibration and quality control of these measurement systems as well as estimetation of the (statistical) uncertainty of measurements. Dosimetry audits are an important step in a well designed quality control program.

Furthermore, the medical physicist in radiotherapy performs an essential role to ensure that radiotherapy is delivered as expected by characterising the beams produced by the treament machines. Basic dosimetry of conventional photon and electron beams, in isocentric and fixed-SSD approaches, is the first step for the implementation of the treatment planning system and of any manual dose calculation. Ongoing quality control using similar methodologies ensures that assumed treatment beam models remain valid.

Competences:
- demonstrate a working knowledge of the terminology used in clinical dosimetry;
- demonstrate a good understanding of the fundamental theoretical and practical aspects of all reference dosimetry for megavolt photon-and electron beams and brachytherapy sources and orthovolt-and contact therapy beams. If necessary, some of these applications must be learned during internships in other institutions.
- demonstrate knowledge of dosimetric standards and traceability;
- ability to understand and apply the relevant national or international Codes of Practice for the determination of absorbed dose to the water (NCS);
- ability to choose and utilize the appropriate phantom;
- ability to perform absorbed dose measurements in clinical situations;
- ability to select the most appropriate detector to use to measure absolute dose and relative dose distributions in different irradiation conditions for photons and for electrons beams;
- ability to set up a system for In-Vivo dosimetry;
- ability to set up a program for acceptance testing, calibration and quality control of the measurement systems.
- ability to estimate measurement uncertainties and their categories;
- ability to calibrate ionisation chambers and diodes;
- ability to perform constancy checks (eg. strontium-90 based) on ionisation chamber dosimeters;
- ability to perform absolute and relative dose measurements (output factors, PDD, beam profiles, etc.) in air, in water and solid phantoms for photon and electron beams using different equipment (ionisation chambers, diodes, film, TLD);
- demonstrate understanding of the influence of relative dosimetry on treatment parameters;
- demonstrate understanding of the influence of beam modifiers on the beam characteristics;
- ability to acquire beam data for the treatment planning system;
- ability to design experiments to assess dosimetric uncertainties

Core curriculum items:

Principles of dosimetry:
- concept of absorbed dose and kerma;
- the cavity theory;
- relationship between different dosimetric quantities and units.

Physics, techniques and instrumentation of radiation detector systems:
- calibration chain for dosimetry detectors;
- dosimetric standards and traceability;
- properties of dosimeters;
- evaluation of uncertainties;
- ionisation chambers;
- semiconductors;
  Other detectors are optional, such as, GafChromic film dosimetry; thermoluminescence dosimetry; diamond dosimeters;
  alanine dosimetry system;
  scintillation detectors;
  gel dosimetry;
  calorimetry;
  chemical dosimetry.

Dose determination and quality control in clinical practice:
- terminology used in clinical dosimetry (e.g.: PDD, TMR, TPR, OAR);
- dosimetry recommendations based on air-kerma standards and on absorbed dose in water;
- application of a protocol for absorbed dose determination in a clinical beam;
- determination of the absorbed dose under non-reference conditions (e.g., extended SSD, off-axis)
- in-vivo dosimetry;
- dosimetry audits;
- measurement systems and phantoms used for dosimetry and quality control;
- choice of dosimetry systems;
- technical specification, acceptance testing, calibration and QC of practical systems;
- definition of “reference conditions” in fixed-SSD and isocentric approaches;
- beam quality specification (quality index for photons, range and energy parameters for electron beams);
- in-air and in-phantom characteristics of clinical beams;
- absolute and reference dosimetry. Absorbed dose in reference conditions: national and international protocols (e.g. IAEA);
- relative dosimetry:
  - central axis dose distribution in water,
  - output factors: effects of head scatter and phantom scatter, dependence on treatment parameters,
  - 3D dose distribution: beam profiles (penumbra region, flatness, symmetry, etc.),
  - effects of beam modifiers: hard wedges, virtual wedges, compensators, bolus etc;
- requirements and methods of data acquisition for treatment planning;
- measurement theory;

Time to be spent on this topic: 8 ECTS

6. *Particle therapy*

Short description:
Due to their favourable physical and radiobiological properties, beams of ions (protons and heavier ions) are expected to have an increasing role in radiotherapy for certain indications. In fact, several proton facilities have been installed in the Neterlands. Medical physicists in radiotherapy will play a key role in developing and installing particle therapy facilities, in performing and controlling the technical and clinical operation of the equipment, in performing the treatment plans and check and in technological, physical, biological and clinical research on the further development of particle therapy. In addition, they will play an important role in the comparison of proton and photon plans. Therefore, they should be familiar with the physical and technological aspects of particle therapy.

Competences:
- ability to demonstrate a deep understanding of the electronic and nuclear interactions of ions with matter;
- ability to derive from the physical characteristics of ion beams, implications on the technical equipment for accelerating and delivering ion beams, radiation protection of patients, staff and equipment, dosimetric measurements, quality assurance, treatment planning, radiobiology and therapeutic strategies;
- ability to evaluate the performance parameters of ion therapy equipment;
- ability to demonstrate an understanding of the operation of ion accelerators and beam transport components;
- ability to demonstrate an understanding of the techniques of field formation with ion beams including intensity modulation and organ motion compensation;
- ability to discuss the concepts of treatment planning for therapeutic ion beam irradiation including biological optimisation;
- ability to discuss the concepts of dosimetry and quality assurance of ion beams;

Core curriculum items:
- electronic and nuclear interactions of ion beams with matter;
- particular biological effects of ion beams;
- accelerators for ion beams;
- therapeutic ion beam deliveries;
- field formation (passive, active) and intensity modulation;
- motion compensation techniques in ion therapy;
- dosimetry of ion beams;
- quality assurance for therapeutic ion beam deliveries;
- range measurements and in-vivo dosimetry by positron emission tomography;
- treatment planning for ion therapy including biological optimisation.

Minimum time to be spent on this topic: 3 ECTS

7. Image guided tumour ablation without ionizing radiation

Short description:
Increasingly, ablative techniques are used in oncology that are not based on ionizing radiation. Examples of such techniques are High-Intensity Focused Ultrasound (HIFU), Photo-Dynamic Therapy (PDT), Radio Frequency Ablation (RFA), hyperthermia and cryotherapy. While these techniques currently tend to be developed and used outside the realm of radiotherapy, their approach has substantial similarity to brachytherapy. These ablative treatments are used to achieve optimal coverage of the tumor, while minimizing involvement of surrounding tissue. Image guidance, target definition and dose monitoring are common features of all techniques. An understanding of the relation between tumor cell kill and the probability of achieving local control is essential.
For this reason, the expertise of the medical physicist trained in radiotherapy can be valuable, and therefore in turn, this medical physicist must acquire a basic knowledge of the physical principles of these techniques.

Mimimum time to be spent on this topic: 1 ECTS

Optional:

- Internship at department applying clinically image guided tumour ablation treatments (HIFU, RFA, PDT, hyperthermia, cryotherapy).

8. Radiobiology and Radiobiological modelling

Short description:
To understand the basis of radiation treatment and therapy strategies, the medical physicist is required to have a good knowledge of radiobiology and its clinical implications. A comprehensive understanding of radiobiological modelling is needed, to safely utilise the existing models. The medical physicist is aware of the use and limits of mathematical modelling in radiation oncology, its implementation in treatment planning systems and in altered fractionation regimens and outcome analysis.
Modern radiation oncology also increasingly utilises multi-modality treatment which is a combination of radiotherapy and chemotherapy. Therefore, the medical physicists in radiotherapy have to be trained in the fundamentals of cellular and molecular biology as well as tumour and radiation biology.

Competences and skills:
- ability to demonstrate the understanding of the radiobiological background of treatment strategies in radiation therapy;
- ability to critically perform fractionation calculations, response calculations (NTCP/TCP), effective dose calculations and volume effect corrections using established models;
- ability to critical assess radiobiological calculations performed by commercial treatment planning systems;
- demonstrate an understanding of the limitations in existing models and the parameters established from published data as well as the underlying biological rational and limitation of the model;
- ability to perform detailed dose-response analysis from clinical data and patient series;
- ability to critically make use of novel modelling and statistical strategies;
- ability to demonstrate the understanding of the fundamentals of cellular, molecular and radiation biology of tumour and normal tissue;
- demonstrate a basic understanding of the mechanisms involved in novel drugs commonly used in combination with radiation;
- ability to practically apply radiobiological knowledge to the fields of radioprotection as well as to diagnostic and therapeutic application of ionising radiation.

Core curriculum items:
- the linear quadratic (LQ) model;
- models for DNA damage;
- effects of fractionation, dose rate, radiosensitation and reoxygenation;
- therapeutic ratio, tumour control probability, normal tissue complication probability, tolerance doses;
- fundamentals of cellular and molecular biology;
- the physical and biological background of the effect of electromagnetic, electron and heavy particle irradiation to living cells;
- deterministic and stochastic effects of ionising radiation;
- the response of tumours and normal tissue to therapeutic levels of radiation;
- early and late radiation effects;
- dose-volume effects.

Minimum time to be spent on this topic: 3 ECTS

9. Miscellaneous

- Meetings of NVKF, the working group Radiotherapeutic Medical physicists (RKF) and NVRO must be attended;
- Participation in a conference organised by ESTRO, ASTRO, AAPM, HPA or other organisations related to NVKF or international organisations in medical physics.

Optional
- Internship with and study of hyperthermia (obtain understanding of physical and biological backgrounds, diagnostics, and technical realisation);
- Active participation in a national or international committee (for example, a subcommittee of NVKF or NCS).

Assessment of the amount of time to be spent on this topic: 1 ECTS