Postgraduate Double Degree Master's Program

Clinical Medical Physics

INTERNATIONAL MASTER
CLINICAL MEDICAL PHYSICS

Module Guide

Ruprecht-Karls-Universität Heidelberg
Medizinische Fakultät Heidelberg

Pontificia Universidad Católica, Santiago, Chile
Facultad de Física

Study form :	full-time postgraduate study program in Medical Physics, including on-site and online modules
Degree:	Master of Science (MSc.)
Credit Points:	120 ECTS
Course start:	winter term - March (Chile) = summer semester (Germany)
Course duration:	2 years (4 semesters)
Languages:	English, Spanish
Tuition fee:	EUR 1,800 per semester at Heidelberg University CLP 2,660 per year at Universidad Pontificia Católica de Chile (PUC) plus 46,500 CLP ($95) registration fee; PUC students also pay a 26,500 CLP subscription fee

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Module Guide

„Clinical Medical Physics“

Contents:

1. Study program at a glance

The International Master "Clinical Medical Physics" (CMP) is designed as full-time study program and comprises on-site modules and online-modules ending up with an attendance phase during semesters 1-3. The first two semesters take place on-site at PUC in Santiago de Chile. The third semester comprises online modules offered by the online MSc program "Advanced Physical Methods in Radiotherapy" (APMR). In parallel practical work sessions (M12) are provided by PUC at associated hospitals in Chile. During the fourth semester the final Master's Thesis can either be written at PUC or at UHD.

Since March 2015 the practical work sessions (M12) take place during semester 2, thus M6 "Physics of Medical Imaging" is now part of semester 3. The CMP program structure at a glance is shown in tables 1 and 2.

The aim of this Medical Physics Master's program is to guarantee in depth training in the field of Medical Physics to face the growing need of qualified specialists especially in Latin America. CMP is aimed at applicants from higher or further education institutions with a Bachelor degree (or similar) in a subject related to physics or medical physics or physical technology whereas further credits points have been gained through postgraduate studies or a diploma in physics, biomedical engineering or equivalent engineering studies. The final aim is the "Master of Science"-degree (MSc.) which will be awarded by the Ruprecht-Karls Universität Heidelberg (hereafter referred to UHD) and the Pontificia Universidad Católica, Santiago de Chile (hereafter referred to PUC) as double degree.

CMP Program Structure (until March 2015)

Semester	Module	Location	ECTS/Module	Total ECTS / Semester
Semester 1	M1: General Anatomy and Physiology	PUC	6 ECTS	30 ECTS / 50Cr
	M2: Physics of Radiation and Dosimetry	PUC	6 ECTS	
	M3: Radiobiology, Radiation Protection, and Legal Framework	PUC	6 ECTS	
	M4.1: Optional Course*	PUC	6 ECTS	
	M4.2: Optional Course*	PUC	6 ECTS	
Semester 2	M5: Physics and Special Techniques of Radiotherapy	PUC	6 ECTS	30 ECTS / 50Cr
	M6: Physics of Medical Imaging	PUC	6 ECTS	
	M7: Statistics	PUC	6 ECTS	
	M8.1: Optional Course*	PUC	6 ECTS	
	M8.2: Optional Course*	PUC	6 ECTS	
Semester 3	M9: Intensity Modulated Radiotherapy (IMRT)	UHD	7,5 ECTS	30 ECTS / 50Cr
	M10: Image Guided Radiotherapy (IGRT) and Adaptive Radiotherapy (ART)	UHD	7,5 ECTS	
	M11: Advanced Dosimetry and Quality Assurance	UHD	7 ECTS	
	M12: Practical Work	PUC	8 ECTS	
Semester 4	MT: Master 's Thesis	PUC, UHD, other institutions	30 ECTS	30 ECTS / 50Cr
			Σ120 ECTS	**Σ120 ECTS / 200 CR**
Prerequisites: BSc in Physics or equivalent (180 ECTS); one year of professional experience in the field of Medical Physics prior to semester 3; English and Spanish language proficiency				

Table 1: CMP Program Structure (until March 2015) = Model plan of study

CMP Program Structure (since March 2015)

Semester	Module	Location	ECTS/Module	Total ECTS / Semester
Semester 1	M1: General Anatomy and Physiology	PUC	6 ECTS	30 ECTS / 50Cr
	M2: Physics of Radiation and Dosimetry	PUC	6 ECTS	
	M3: Radiobiology, Radiation Protection, and Legal Framework	PUC	6 ECTS	
	M4.1: Optional Course*	PUC	6 ECTS	
	M4.2: Optional Course*	PUC	6 ECTS	
Semester 2	M5: Physics and Special Techniques of Radiotherapy	PUC	6 ECTS	32 ECTS / 53,4Cr
	M7: Statistics	PUC	6 ECTS	
	M8.1: Optional Course*	PUC	6 ECTS	
	M8.2: Optional Course*	PUC	6 ECTS	
	M12: Practical Work	PUC	8 ECTS	
Semester 3	M6: Medical Imaging	PUC	6 ECTS	28 ECTS / 46,6Cr
	M9: Intensity Modulated Radiotherapy (IMRT)	UHD	7,5 ECTS	
	M10: Image Guided Radiotherapy (IGRT) and Adaptive Radiotherapy (ART)	UHD	7,5 ECTS	
	M11: Advanced Dosimetry and Quality Assurance	UHD	7 ECTS	
Semester 4	MT: Master 's Thesis	PUC, UHD, other institutions	30 ECTS	30 ECTS / 50Cr
			Σ120 ECTS	**Σ120 ECTS / 200 CR**
Prerequisites: BSc in Physics or equivalent (180 ECTS); one year of professional experience in the field of Medical Physics prior to semester 3; English and Spanish language proficiency				

Table 2: CMP Program Structure (since March 2015) = Model plan of study

Legend:

On-site module at PUC
Online module at UHD
Practical Work
Thesis

ECTS: European Credit Transfer System (credit points)

Cr: Chilean Credit Points

6 ECTS = 10 Cr

***Optional courses (elective modules M4.1; 4.2 and M8.1; 8.2):**

- W1: Medical Imaging
- W2: Advanced Techniques in Magnetic Resonance Imaging
- W3: Electronics for Physicists
- W4: Classic Optics
- W5: Atomic- and Molecular Physics
- W6: Devices and Accessories in Radiation Therapy
- W7: Electromagnetism
- W8: Modern Physics

On demand and upon agreement by the Chilean Examination Committee (Comité de Postgrado) further elective courses can be chosen.

1.1 Prerequisites

The „Comité de Postgrado“ of PUC will decide on the equivalence of educational requirements as well as the equivalence of qualified degrees in accordance with the UHD Admissions Committee.

Applicants need a certificate of qualification for university matriculation, relevant sub-related qualification for university matriculation, a foreign higher education entrance qualification or a higher education entrance qualification recognized as equivalent by the competent state authorities in Baden –Württemberg.

Furthermore, students shall have proof of an above-average degree in a physical or physical-technical subject, in biomedical engineering or an equivalent engineering program or in a medical-engineering program or in courses with largely similar contents at a German or foreign university with a standard course duration of no less than three years of study or a degree recognized as equivalent in Baden-Württemberg, with above-average results.

Overall, at least 180 ECTS credits must be demonstrated in one of the above mentioned programs. In case of less than 180 ECTS for the completed university degree, the missing credit points can be adduced through further education or other degrees or long-time practical experience in Medical Physics or medical-engineering subject. Credits from other countries not referring to ECTS have to be transferred for equivalence.

Professional working experience of at least one year is required prior to semester 3. Furthermore, evidence of outstanding English- and Spanish language proficiency shall be provided (see section 3 of admission regulations of Sept. 10^{th} 2012).

1.2 Quality objectives

According to the mission statement and the constitution, Heidelberg University's degree programs are based on subject-specific, interdisciplinary and practical goals for comprehensive academic education and for the students' future careers.

The goals are

- development of professional competence with a distinct research orientation.
- development of transdisciplinary dialogue competence[1].
- development of practical problem-solving competence.
- development of personal and social skills.

1.3 Program objectives

Within the scope of the Master's study program the CMP students will

- ✓ either gain or consolidate and refine their fundamental medical knowledge in e.g. the fields of anatomy, physiology and medical imaging.
- ✓ revise and deepen knowledge in the field of radiation physics, radiation biology and radiation protection.
- ✓ gain theoretical and practical knowledge in radiation therapy physics as well as in specific radiation therapy techniques.
- ✓ revise and deepen knowledge in statistics as well as in the two subjects physics or mathematics, which will be offered as electives.
- ✓ acquire a robust, basic, theoretical and practical understanding of advanced radiotherapy techniques like IMRT, IGRT and ART.
- ✓ acquire a robust, basic, theoretical and practical understanding of medical imaging techniques for radiotherapy.
- ✓ demonstrate knowledge of recent developments in e.g. IMRT, IGRT and ART and apply this knowledge in the treatment of patients.
- ✓ acquire an in-depth understanding of e.g. dosimetry and quality assurance tailored to include the most recent radiation therapy techniques.
- ✓ demonstrate the practical ability to carry out research and clinical tasks independently on modern radiotherapy units for e.g. IMRT, IGRT and ART.
- ✓ develop and improve independent learning, organizational and team-working skills.
- ✓ become confident in the use of information communication technology (ICT) and recognize the role technology-enhanced teaching and learning plays in continuing personal professional development.

[1] The term transdisciplinary is used here to designate teachers' and students' ability to think beyond the boundaries of a subject area, and to identify and handle interdisciplinary topics, i.e. combining the knowledge and skills of one subject with those of another subject.

1.4 Grading System and Credit Points

The German grading system (GN) differs from the Chilean grading system (CN). The following list includes a conversion between the German and Chilean grading systems:

German grading of examinations (GN)	Chilean grading of examinations (CN)
1	7.0
1.1	6.9
1.2	6.8
1.3	6.7
1.4	6.6
1.5	6.5
1.6	6.4
1.7	6.3
1.8	6.2
1.9	6.1
2.0	6.0
2.1	5.9
2.2	5.8
2.3	5.7
2.4	5.6
2.5	5.5
2.6	5.4
2.7	5.3
2.8	5.2
2.9	5.1
3.0	5.0
3.1	4.9
3.2	4.8
3.3	4.7
3.4	4.6
3.5	4.5
3.6	4.4
3.7	4.3
3.8	4.2
3.9	4.1
4.0	4.0

The grades for individual examination components shall be determined by the respective examiners.

The following grades shall be used:

- with an average of 1.5 (GN) or 6.5 (CN) = very good = outstanding performance;
- with an average above 1.5 – 2.5 (GN) or 6.5 – 5.5 (CN) = good = performance exceeding average;
- with an average above 2.5 – 3.5 (GN) or 5.5 – 4.5 (CN) = satisfactory = performance meeting average requirements;
- with an average above 3.5 (GN) or 4.5 (CN) to 4.0 (GN and CN) = adequate = performance meets the minimum criteria;
- with an average above 4.0 (GN and CN) = fail = performance does not meet the minimum criteria due to significant shortcomings.

For a more differentiated assessment, individual grades may be raised or lowered to intermediate values by 0.3 points; in so doing, grades 0.7 and 4.3 (GN) or 7.3 and 3.7 (CN) shall be ruled out.

Examination results have been passed if it has been graded at least as "adequate" (4.0 GN and CN). A module examination has been passed if all associated part module examinations have been passed. In addition, a weighted grade average of at least 3.5 (GN) or 4.5 (CN) per semester must be attained. The module grade shall be based on the arithmetic mean of the part module examination grades.

When determining module grades and the overall grade, only the first decimal place shall be taken into account; all other decimal figures shall be deleted without rounding. The total grade is specified in the Chilean and German grading system.

Students, who have successfully passed the relevant examination results, in addition to the final grade, shall also be given an ECTS grade based on the following calculation:

- A the top 10%
- B the next 25%
- C the next 30%
- D the next 25%
- E the next 10%

1.5 On-site semesters 1 and 2

The first and second semester take place in the frame of conventional on-site lectures at the Faculty for Physics at PUC. Theoretical and practical basics of Medical Physics will be conveyed by Chilean teachers (modules see tables 1 and 2). Each module comprises two to three written exams whereas the last exam will be named as final module exam and will be awarded with higher credits than the intermediary exams.

1.6 Online semester 3

During the third semester German and international experts will provide recorded video lectures in advanced topics in Radiotherapy. This mode of study concerns modules 9 to 11 and affects approx. 20% of the total study duration of the Master’s. The educational concept of online lectures is based on the Blended Learning approach, which means that the lectures combine attendance phases with e-learning activities.

Studying online on the CMP program entails a range of carefully developed learning objects and activities that accommodate the different ways of learning. Students are offered flexibility of stand-alone web-based materials, self-paced activities and study units with collaborative tasks and synchronous (live) online sessions. New topics are introduced within study units by the subject experts in prerecorded video lectures complemented by easily accessible text-based content. Self-tests feature after each submodule to encourage self-monitoring of progress at regular intervals during the semester designed to signal to the student and tutor possible areas of improvement. Sharing views, raising relevant issues and presenting selected homework assignments takes place in the themed asynchronous (time-delayed) discussions and synchronous (same time) online study sessions. Online guest lectures delivered by experts in medical physics from across the globe feature regularly and allow for international outreach. The software Adobe Connect (AC; hosted by the “Deutsches Forschungsnetz”) is used for these online meetings. Recorded video lectures and any other learning activities are offered through the Virtual Learning Environment (VLE) hosted by the institutional Moodle platform. Moodle is an educational platform allowing to set up whole study programs and to manage the individual lectures.

Different collaborative tools “activity modules” can be used in Moodle as follows:

- **Calendar:** Enables the coordination and processing of online meetings with students and other learning activities.
- **Choice activity module:** teachers ask a question and provide a pool of different possible answers from which students shall choose individually. This tool is useful to carry out a quick poll in order to get the opinion of a group.

- **Self-Test:** pool of questions with a variety of possible answers from which students have to choose the right ones. Teachers ask questions and provide several answers from which students have to choose the right ones (multiple-choice questions). Alternatively, teachers can provide open questions. The self-tests allow students to get an idea about the module exams to come and to teachers to test the acquired knowledge of the students. They take place at the end of each of the submodules of M9, M10 and M11.
- **Discussion Forum***:* activity module to carry out asynchronous discussions over a certain period of time in subject related themes.
- **Assignments:** at this activity homework based exercises are made available to students. It enables teachers to communicate tasks, collect work and provide grades and feedback.
- **Wiki:** Wikis offer the possibility in a collaborative way to easily create and edit documents via the web browser, to add content which can be changed and discussed.
- **Glossar:** enables the creation of a glossary either from student and/or teachers side.
- **Surveys:** activity module to create module and study program evaluations for educational quality purposes. This task has been taken over by the University's own evaluation system (Evasys).

1.6.1 Attendance phases during semester 3

The online-semester starts with a two week's induction either online or on-site in Chile in which the online-modules M9, M10 und M11 are introduced as well as the VLE Moodle. After five months of studying online attendance phases take place either in Chile or in Heidelberg comprising workshops, seminars and hands-on training. The on-site courses are offered at the Heidelberg Center for Latin America in Santiago de Chile or at the German Cancer Research Center (DKFZ) and the University Hospital in Heidelberg, Germany. During the on-site phases students will find themselves working side by side with experts having longstanding experience in IMRT, treatment planning and radiobiological modelling.

1.6.2 Internships

Parallel to online-modules, students will participate in internships at Hospitals with modern Radiotherapy units. Internships are an important part of the study program allowing students to apply their acquired theoretical knowledge independently under the supervision of longstanding experts in radiotherapy. 6 internships referring to module contents of M9 to M11 will be offered by the Clinica Alemana as well as the Cancer Center of Santiago, Chile.

Internship Topics (M12):

<u>Mandatory courses</u> (obligatory):

- P1: Dosimetry and Quality Assurance of LINACS
- P2: Radiation Treatment Planning
- P3: Intensity-modulated Radiation Therapy (IMRT)

<u>Compulsory electives</u>, at least one of the following must be chosen:

- PW1: Brachytherapy
- PW2: Medical Imaging MRI, CT
- PW3: Radiation Protection

2. Overview of Modules and Module Leaders

Program Leaders: B. Sanchez, PhD (PUC); Prof. J. Debus, MD, PhD (UHD); Prof. W. Schlegel, PhD (UHD)

MODULE	Person responsible for modules	Contents	Attendance	Online	ECTS
Module 1: General Anatomy and General Physiology	PUC: Prof. Oscar Inzunza, MD Departamento de Radiología, Hospital Clínico UC.	M1.1 Anatomic nomenclature	x		6
		M1.2 Bones and bone marrow	x		
		M1.3 Brain and SNC	x		
		M1.4 Thorax	x		
		M1.5 Abdominal System	x		
		M1.6 Respiratory System	x		
		M1.7 Digestive System	x		
		M1.8 Renal System	x		
		M1.9 Reproductive System	x		
		M1.10 Circulatory System	x		
Module 2: Physics of Radiation and Dosimetry	PUC: Paola Caprile, PhD Beatriz Sanchez, PhD	M2.1 Radioactivity	x		6
		M2.2 Interaction of Radiation with Matter	x		
		M2.3 Principles of Dosimetry	x		
		M2.4 Radiation Detectors	x		
		M2.5 Absolute Dose Determination	x		
		M2.6 Monitor Units and Dose Calculation	x		
		M2.7 Measurement Uncertainties (GUM)	x		
Module 3: Radiobiology, Radiation Protection and Legal Framework	PUC: Paola Caprile, PhD Beatriz Sanchez, PhD	M3.1 Radiation Effects	x		6
		M3.2 Quantities and Units	x		
		M3.3 Equipment	x		
		M3.4 Types of Radiation Exposure	x		
		M3.5 Safety in the Design of Radiation Sources	x		
		M3.6 Radiation Safety Standards	x		
		M3.7 Potential Exposure and Emergency Plans	x		
		M3.8 General Shielding Calculations	x		
		M3.9 Governmental Regulation	x		
		M3.10 Health Care Management	x		

		M3.11 Radiation Injury and Repair	x		
		M3.12 Survival Curve Theory	x		
		M3.13 Modifiers of Radiation Response	x		
		M3.14 Radiobiology of Tumour and Normal Tissues	x		
		M3.15 Biological Modelling: TCP/NTCP	x		
		M3.16 Radiation Pathology and Carcinogenesis	x		
Optional Modules: Modules 4.1 and 4.2 8.1 and 8.2	PUC: Paola Caprile, PhD Edgardo Dorner, PhD Ignacio Espinoza, PhD Beatriz Sanchez, PhD	W1: Medical Imaging W2: Advanced Techniques in Magnetic Resonance Imaging W3: Electronics for Physicists W4: Classic Optics W5: Atom and Molecular Physics W6: Devices and Accessories in Radiation Therapy W7: Electromagnetism W8: Modern Physics	x		24
Module 5: Physics and Special Techniques of Radiation therapy	PUC: Paola Caprile, PhD Ignacio Espinoza, PhD Beatriz Sanchez, PhD	M5.1 Principles of Radiation Producing Devices	x		6
		M5.2 Photon and Electron Radiation Beams	x		
		M5.3 Calibration Protocols	x		
		M5.4 Commissioning	x		
		M5.5 Treatment Planning and Dose Modelling	x		
		M5.6 Quality Assurance in Radiotherapy	x		
		M5.7 Brachytherapy	x		
		M5.8 SRT, TBI, TSEI, IORT	x		
		M5.9 Basic Aspects of Conformal Radiotherapy	x		
		M5.10 Fundamentals of IMRT and IGRT	x		
		M5.11 Hadron beam Therapy	x		
Module 6: Physics of Medical Imaging	PUC: Edgardo Dorner, PhD	M6.1 X-Ray Imaging	x		6
		M6.2 Ultrasound	x		
		M6.3 MRI	x		
		M6.4 Nuclear Medicine	x		
		M6.5 Quality Assurance in Medical Imaging	x		
Module 7: Statistics	PUC: Prof. Ana Araneda, PhD	M7.1 Overview and Descriptive Statistics	x		6
		M7.2 Probability	x		
		M7.3 Random Variables	x		
		M7.4 Introduction of Interferences: Population, Point Estimation, Intervals Estimation, Test of Hypotheses, Applications	x		

Module 9: Intensity Modulated Radiotherapy (IMRT) ONLINE	UHD / DKFZ[2]: M. Bangert, PhD PD F. Sterzing, MD	M9.1 Introduction to M9	x	x	7.5
		M9.2 Introduction IMRT		x	
		M9.3 IMRT – Clinical Application		x	
		M9.4 Advanced Techniques of Application		x	
		M9.5 Workshop	x		
Module 10: Image Guided Radiotherapy (IGRT) and Adaptive Radiotherapy (ART) ONLINE	UHD / DKFZ[2]: T. Moser, PhD, PD F. Sterzing, MD	M10.1 Introduction to M10	x	x	7.5
		M10.2 IGRT Techniques		x	
		M10.3 Clinical Applications of IGRT		x	
		M10.4 Moving Target Volumes and Adaptive Radiotherapy (Medicine/Physics)		x	
		M10.5 Workshop	x		
Module 11: Advanced Dosimetry and Quality Assurance ONLINE	UHD / DKFZ[2]: M. Martisikova, PhD B. Rhein, PhD S. Barthold-Beß, PhD	M11.1 Introduction to M11	x	x	7
		M11.2 Fundamentals of Dosimetry		x	
		M11.3 Dosimetry for Advanced Radiotherapy Techniques		x	
		M11.4 Quality Assurance		x	
		M11.5 Workshop	x		
Module 12: Practical Work	PUC: Teachers from the medical physics group	P1: Dosimetry and Quality Assurance for Lincas (Teletherapy Units) (Compulsory)	x		8
		P2: Treatment Planning (Compulsory)	x		
		P3: IMRT/ ART (Compulsory)	x		
		PW1: Source Calibration Brachytherapy (Optional)	x		
		PW2: Imaging MR/CT (Optional)	x		
		PW3: kV Dosimetry and QA (Optional)	x		
Master's Thesis					30
					Σ **120**

[2] Deutsches Krebsforschungszentrum Heidelberg

3. Module descriptions

Modules containing elements from Physics, Electrical Engineering and Medicine each have module leaders and lecturers from these fields. This ensures that later interdisciplinary activities are optimally reflected in the content of the course.

Module 1: General Anatomy and General Physiology

The primary aim of module 1 is to convey foundation-level knowledge of the anatomy and physiology of the human body. In addition, it gives students an understanding of anatomic landmarks, neighbouring organs and the different weightings of organ structures (e.g. risk structures). Common histopathology is also covered, with a focus on cancer.

Module 2: Physics of Radiation and Dosimetry

The "Clinical Medical Physics" Master's programme focuses on the treatment of cancer using radiotherapy. Such treatment requires that an exact dose always be administered to the patient. This module teaches the basic physical processes that occur during treatment with ionising radiation. Students learn how to reliably measure doses using fundamental physical interactions. In addition to the theoretical basics of dosimetry, students gain practical experience using computer-aided experiments.

Module 3: Radiobiology, Radiation Protection and Legal Framework

This module focuses on the consequences of using ionising radiation. The basics of carcinogenesis are first covered. Students then learn about cell repair mechanisms and the effect of ionising radiation at cell level. Basic safety standards and the fundamental legal frameworks relating to radiation protection, as well as the biological effects on the body are also taught.

Module 4 and Module 8: Optional Modules

During the first and second semesters, students have the opportunity to select one compulsory elective subject per semester from the various subjects offered by the PUC. This ensures a degree of flexibility in the Master's programme and motivates students to define what they learn for themselves. The range of subjects concentrates on topics from General Physics, such as Optics, Atomic and Molecular Physics, and on specialised topics such as Radiophysics and Medical Imaging. Upon agreement with the examinations board in Chile (Comité de Postgrado), students may also choose from other subjects.

Module 5: Physics and Special Techniques of Radiation therapy

This module familiarises students with the physical and technical principles of radiation equipment, particularly with principles relating to equipment which exposes the body to photons or electrons (teletherapy). A particular focus is placed on the quality assurance and calibration of the machines. The detailed information on radiation treatment planning process and dose modelling ensures that students are optimally prepared for a role in a radiotherapy department. Finally, the module considers equipment which involves sources of radiation in the body (brachytherapy) and other specific exposure techniques that are used less frequently in everyday clinical practice but also target the precise cavity near the organ at risk.

Module 6: Physics of Medical Imaging

This module concerns the basics of modern imaging modalities which are used in the field of medicine. The module does not just cover morphological procedures but also looks in detail at the functional imaging of complex processes in the human body. Students should understand the advantages and disadvantages of each imaging modality and become acquainted with their use in diagnoses and in better therapy planning.

Module 7: Statistics

A good understanding of mathematical correlations is required in medical physical practice. Module 7 therefore focuses on the basics of statistical methods. The production, organisation and characterisation of information is conveyed, and used in probability calculations. Probability distributions of discrete and continuous variables, different statistical analyses such as the z-distribution and the t-test and the concept of estimation are covered. Statistical analyses are later applied to biological data and patient data.

Module 9: Intensity Modulated Radiotherapy (IMRT)

Module 9 covers the differences between Intensity-Modulated Radiation Therapy (IMRT) and conventional irradiation methods. A focus is placed on the new methods of optimisation and the special requirements for IMRT dose calculations. In addition, the module addresses the question as to which medical issues, or indicators justify the use of IMRT treatment. It also covers the definitions of target volumes and risks, taking current clinical results into consideration with a critical view of a risk of a second carcinoma. The latest methods of delivery (rotation therapy, tomotherapy) are also presented.

Module 10: Image Guided Radiotherapy (IGRT) and Adaptive Radiotherapy (ART)

Modern techniques of Image-Guided Radiation Therapy (IGRT) and Adaptive Radiation Therapy (ART) are presented in module 10. Topics covered include the integration of different movement patterns (through respiration, peristalsis, etc.) in optimisation, and the final technical implementation of these strategies to compensate interfractional and intrafractional movement. Suitable levels of adaptivity which correspond to certain indicators in combination with patient constraints are explained. In addition to the change in clinical workflow, the module also covers the effects on the definition of target volumes and organs at risk, and the dose description.

Module 11: Advanced Dosimetry and Quality Assurance

This module further develops students' understanding from the foundation-level lectures in Modules 2 and 5 with regards to the modern radiation techniques that were presented in modules 9 and 10. This particularly includes measurement methods used to determine a three dimensional dose distribution and to verify doses as well as the most modern protocols for the calibration of radiation. Modern concepts of quality assurance, based on the "workflow" principle, are also introduced.

Module 12: Practical Work

Practical course in which students can learn, in a clinical setting, different techniques related to the implementation of the radiotherapy chain, as well as some special techniques and various medical imaging modalities. The course is organized in the form of clinical rotations trough collaborators centres. Each centre will have a tutor who is in charge of organizing and evaluating student´s performances.

Module Description - MODULE 1

1	Module code: M1	Module title: General Anatomy and General Physiology		
2	Module type: Mandatory	Semester: 1	Course format: On-site	
3	Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago			
4	Content: M1.1 Anatomic Nomenclature M1.2 Bones and Bone Marrow M1.3 Brain and SNC M1.4 Thorax M1.5 Abdominal System M1.6 Respiratory System M1.7 Digestive System M1.8 Renal System M1.9 Reproductive System M1.10 Circulatory System			
5	Designed for: All students of the Clinical Medical Physics Master's programme			
6	Learning outcomes: Foundation-level knowledge in Anatomy and Physiology, an understanding of anatomic landmarks, neighbouring organs and the different weightings of organ structures.			
7	Prerequisites: a) general prerequisites as stated in the degree programme rules and regulations b) specific prerequisites successful completion of module: -			
8	Assessment: 2 written tests, 1 final examination			
9	Student workload: (in hours)		Lecture	40
			Seminar, project work	10
			Internship	30
			Self-study (before and after the course)	93
			Practice class	
			Examination / Test	7
			Other	
10	ECTS credits: 6 (180 h)			
11	Lecturer / Supervisor: PUC			
12	E-Learning approach: Contact hours			
13	Learning materials: Langman. Embriología médica. 1996 Parker. Anatomía y fisiología humana. 1993. Thibodeau and Patton. Anatomía y fisiología. 1995			
14	Language: Spanish			
15	Examination components	Subject matter / content: Lectures and practical work		
		Weighting (tests, internships, etc.): 2 written tests (120 min each, 25%), 1 final examination (180 min, 50%)		
		Learning aids: -		
16	To be completed prior to examination: -			
17	Calculation of module grade: 100%			
18	Module duration: 1 semester			

19	Availability: once per year	
20	Availability	Period of required attendance: 1 semester
		Online period: -
		Practical work: 1 semester
		Examination: Final examination at the end of the semester
21	Recommended reading:	M. Mallett. Handbook of Anatomy and Physiology for Students of Medical Radiation Technology, 3rd ed. (The Burnell Company/Publishers, Inc., 1990). G.J. Tortora and S.R. Grabowski. Principles of Anatomy and Physiology, 9th ed. (Benjamin Cummings Publishing Company, Inc., San Francisco, CA, 2000). W.J. Bo. Basic Atlas of Sectional Anatomy with Correlated Imaging, 3rd ed. (W.B. Saunders Co., Philadelphia, PA, 1998). W. Lothar. Atlas of Radiological Anatomy, 3rd ed. (William & Wilkins, Baltimore, MD, 1997). R.A. Novelline. Squire's Fundamentals of Radiology, 5th ed. (Harvard University Press, Cambridge, MA, 1997). J.B. Weinstein, J.K.T. Lee, and S.S. Sagel. A Pocket Atlas of Normal CT Anatomy. (Raven Press, New York, NY, 1985). J. Weir and P. Abrahams. An Imaging Atlas of Radiological Anatomy. (Year Book Medical Publishers, Inc., Chicago, IL, 1996).

Module Description MODULE 2

<table>
<tr><td>1</td><td>Module code:
M2</td><td colspan="2">Module title:
Physics of Radiation and Dosimetry</td></tr>
<tr><td>2</td><td>Module type:
Mandatory</td><td>Semester: 1</td><td>Course format:
On-site</td></tr>
<tr><td>3</td><td colspan="3">Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago</td></tr>
<tr><td>4</td><td colspan="3">Content:
M2.1 Radioactivity
M2.2 Interaction of Radiation with Matter
M2.3 Principles of Dosimetry
M2.4 Radiation Detectors
M2.5 Absolute Dose Determination
M2.6 Monitor Units and Dose Calculation
M2.7 Measurement Uncertainties (GUM)</td></tr>
<tr><td>5</td><td colspan="3">Designed for: All students of the Medical Physics Master’s programme</td></tr>
<tr><td>6</td><td colspan="3">Learning outcomes: A deeper understanding of radiation physics and basic knowledge of dosimetry</td></tr>
<tr><td>7</td><td colspan="3">Prerequisites:
a) general prerequisites as stated in the degree programme rules and regulations
b) specific prerequisites
successful completion of module: -</td></tr>
<tr><td>8</td><td colspan="3">Assessment: 2 written tests, 1 written final examination</td></tr>
<tr><td rowspan="7">9</td><td rowspan="7">Student workload:
(in hours)</td><td>Lecture</td><td>50</td></tr>
<tr><td>Seminar, project work</td><td></td></tr>
<tr><td>Internships</td><td></td></tr>
<tr><td>Self-study (before and after the course)</td><td>103</td></tr>
<tr><td>Practice class</td><td>20</td></tr>
<tr><td>Examination / Test</td><td>7</td></tr>
<tr><td>Other</td><td></td></tr>
<tr><td>10</td><td colspan="3">ECTS credits: 6 (180 h)</td></tr>
<tr><td>11</td><td colspan="3">Lecturer / Supervisor: PUC</td></tr>
<tr><td>12</td><td colspan="3">E-Learning approach: Contact hours</td></tr>
<tr><td>13</td><td colspan="3">Learning materials:
IAEA Handbook
IAEA TRS 398</td></tr>
<tr><td>14</td><td colspan="3">Language: Spanish</td></tr>
<tr><td rowspan="3">15</td><td rowspan="3">Examination components</td><td colspan="2">Subject matter / content: Lectures</td></tr>
<tr><td colspan="2">Weighting (tests, internships, etc.): 2 written tests (120 min each, 30%), final examination (150 min, 40%)</td></tr>
<tr><td colspan="2">Learning aids: -</td></tr>
<tr><td>16</td><td colspan="3">To be completed prior to examination: -</td></tr>
<tr><td>17</td><td colspan="3">Calculation of module grade: 100%</td></tr>
<tr><td>18</td><td colspan="3">Module duration: 1 semester</td></tr>
<tr><td>19</td><td colspan="3">Availability: three times per week, first semester</td></tr>
<tr><td rowspan="2">20</td><td rowspan="2">Availability</td><td colspan="2">Period of required attendance: 1 semester</td></tr>
<tr><td colspan="2">Online period: -</td></tr>
</table>

		Practical work: -
		Examination: Final examination at the end of the semester
21	Recommended reading:	Attix F. H., *Introduction to Radiological Physics and Radiation Dosimetry*, Weinheim, Wiley-VCH, 1986. Mayles P., Nahum A. E., Rosenwald J. C. (eds.), *Handbook of Radiotherapy Physics: Theory and Practice*, Boca Raton, CRC Press, 2007. Podgorsak E. B., Radiation *Physics for Medical Physicists*, Berlin, Springer, 2009.

Module Description MODULE 3

1	Module code: M3	Module title: Radiobiology, Radiation Protection and Legal Framework	
2	Module type: Mandatory	Semester: 1	Course format: On-site
3	Degree programme / Faculty: Medical Radiation Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago		
4	Content: M3.1 Radiation Effects M3.2 Quantities and Units M3.3 Equipment M3.4 Types of Radiation Exposure M3.5 Safety in the Design of Radiation Sources M3.6 Radiation Safety Standards M3.7 Potential Exposure and Emergency Plans M3.8 General Shielding Calculations M3.9 Governmental Regulation M3.10 Health Care Management M3.11 Radiation Injury and Repair M3.12 Survival Curve Theory M3.13 Modifiers of Radiation Response M3.14 Radiobiology of Tumour and Normal Tissues M3.15 Biological Modelling: TCP/NTCP M3.16 Radiation Pathology and Carcinogenesis		
5	Designed for: All students of the Clinical Medical Physics Master's programme		
6	Learning outcomes: A deeper understanding of the consequences of using ionising radiation: competencies in radiobiology, radiation protection and the legal frameworks.		
7	Prerequisites: a) general prerequisites as stated in the degree programme rules and regulations b) specific prerequisites successful completion of module: -		
8	Assessment: 2 written examinations, 1 final examination		
9	Student workload: (in hours)	Lecture	50
		Seminar, project work	20
		Internship	10
		Self-study (before and after the course)	93
		Practice class	
		Examination / Test	7
		Other	
10	ECTS credits: 6 (180 h)		
11	Lecturer / Supervisor: PUC		
12	E-Learning approach: Contact hours		
13	Learning materials: Assessment of Occupational exposure due to External Sources of Radiation, IAEA. Safety Standard Series No. RS-G-1.3, 1999. Occupational Radiation Protection. IAEA, Safety Standard Series No. RS-G-1.1, 1999. Mayles P., Nahum A. E., Rosenwald J. C. (eds.), Handbook of Radiotherapy Physics: Theory and Practice. Boca Raton, CRC Press, 2007.		

14	Language: Spanish	
15	Examination components	Subject matter / content: Lectures
		Weighting (tests, internships, etc.): 2 written tests (120 min each, 90% in total), lab report (10%)
		Learning aids: -
16	To be completed prior to examination: -	
17	Calculation of module grade: 100%	
18	Module duration: 1 semester	
19	Availability: three times per week, first semester	
20	Availability	Period of required attendance: 1 semester
		Online period: -
		Practical work: twice per semester
		Examination: Final examination at the end of the semester
21	Recommended reading:	Hall E. J., Giaccia A. J., Radiobiology for the Radiologist, Philadelphia, Lippincott Williams & Wilkins, 2006 Mayles P., Nahum A. E., Rosenwald J. C. (eds.), Handbook of Radiotherapy Physics: Theory and Practice, Boca Raton, CRC Press, 2007 Podgorsak E. B., Radiation Physics for Medical Physicists, Berlin, Springer, 2009 G.D. Fullerton, R.G. Waggener, D.T. Kopp et al. Biological Risks of Medical Irradiation. AAPM Monograph No. 5. (American Institute of Physics, New York, NY, 1980). ICRU Report No. 61. “Nuclear Data for Neutron and Proton Radiotherapy and for Radiation Protection.” (International Commission on Radiation Units and Measurements, Bethesda, MD, 2000). ICRP Report No. 103. “The 2007 recommendations of the International Commission on Radiological Protection.” International Commission on Radiation Units and Measurements, Bethesda, MD, 2000).

Module Description MODULE 5

<table>
<tr><td>1</td><td>Module code:
M5</td><td colspan="3">Module title:
Physics and Special Techniques of Radiation therapy</td></tr>
<tr><td>2</td><td>Module type:
Mandatory</td><td>Semester: 2</td><td colspan="2">Course format:
On-site</td></tr>
<tr><td>3</td><td colspan="4">Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago</td></tr>
<tr><td>4</td><td colspan="4">Content:
M5.1 Principles of Radiation Producing Devices
M5.2 Photon and Electron Radiation Beams
M5.3 Calibration Protocols
M5.4 Commissioning
M5.5 Treatment Planning and Dose Modelling
M5.6 Quality Assurance in Radiotherapy
M5.7 Brachytherapy
M5.8 SRT, TBI, TSEI, IORT
M5.9 Basic Aspects of Conformal Radiotherapy
M5.10 Fundamentals of IMRT and IGRT
M5.11 Hadron beam Therapy</td></tr>
<tr><td>5</td><td colspan="4">Designed for: All students of the Clinical Medical Physics Master’s programme</td></tr>
<tr><td>6</td><td colspan="4">Learning outcomes: A deeper understanding of the physical and technical principles of radiation equipment (teletherapy and other modern forms of therapy). Competencies in quality assurance and the calibration of machines as well as in radiation treatment planning and dose modelling.</td></tr>
<tr><td>7</td><td colspan="4">Prerequisites:
a) general prerequisites as stated in the degree programme rules and regulations
b) specific prerequisites
successful completion of module: -</td></tr>
<tr><td>8</td><td colspan="4">Assessment: 2 written tests, 1 final examination</td></tr>
<tr><td rowspan="7">9</td><td colspan="2" rowspan="7">Student workload:
(in hours)</td><td>Lecture</td><td>50</td></tr>
<tr><td>Seminar, project work</td><td>20</td></tr>
<tr><td>Internship</td><td>-</td></tr>
<tr><td>Self-study (before and after the course)</td><td>103</td></tr>
<tr><td>Practice class</td><td></td></tr>
<tr><td>Examination / Test</td><td>7</td></tr>
<tr><td>Other</td><td></td></tr>
<tr><td>10</td><td colspan="4">ECTS credits: 6 (180 h)</td></tr>
<tr><td>11</td><td colspan="4">Lecturer / Supervisor: PUC</td></tr>
<tr><td>12</td><td colspan="4">E-Learning approach: Contact hours</td></tr>
<tr><td>13</td><td colspan="4">Learning materials: Mayles P., Nahum A. E., Rosenwald J. C. (eds.), Handbook of Radiotherapy Physics: Theory and Practice. Boca Raton, CRC Press, 2007.</td></tr>
<tr><td>14</td><td colspan="4">Language: Spanish</td></tr>
<tr><td rowspan="3">15</td><td rowspan="3">Examination components</td><td colspan="3">Subject matter / content: Lectures</td></tr>
<tr><td colspan="3">Weighting (tests, internships, etc.): 2 written tests (120 min each, 30%), written final examination (40%)</td></tr>
<tr><td colspan="3">Learning aids: -</td></tr>
<tr><td>16</td><td colspan="4">To be completed prior to examination: examinations for modules 1 - 4</td></tr>
<tr><td>17</td><td colspan="4">Calculation of module grade: 100%</td></tr>
<tr><td>18</td><td colspan="4">Module duration: 1 semester</td></tr>
</table>

19	Availability: three times per week, second semester	
20	Availability	Period of required attendance: 1 semester
		Online period: -
		Practical work: -
		Examination: Final examination at the end of the semester
21	Recommended reading:	Attix, F.H., 1986, Introduction to Radiological Physics and Radiation Dosimety, (Wiley-Interscience, New York). Curry, T.S., Dowdey, J.E., Murry, R.C., 1984, Christensen's Introduction to the Physics of Diagnostic Radiology, (Lea and Febiger, Philadelphia). DeVita, V.T., Hellman, S., Rosenburg, S.A., 1985, Cancer: Principles and Practice of Oncology, Volumes I and II, 2nd Ed., (J. B. Lippincott, Philadelphia). Dobbs, J. and Barrett, A., 1985, Practical Radiotherapy Planning, (Arnold, Baltimore). Hendee, W.R., Chaney, E.L., and Rossi, R.P., 1977, Radiologic Physics Equipment and Quality Control, (Year Book Medical Publishers, Chicago). Horton, J.L., 1987, Handbook of Radiation Therapy Physics, (Prentice Hall, Engelwood Cliffs, NJ). Johns, H.E. and Cunningham, J.R., 1983, The Physics of Radiology, 3rd Ed., (Charles C. Thomas, Springfield, IL). Khan, F.M., 1984, The Physics of Radiation Therapy, (Williams & Wilkins, Baltimore). Mizer, S., Schiller, R.R., and Deye, J.A., 1986, Radiation Therapy Simulation Workbook, (Pergamon Press, New York). Van Dyk, J., 2008, The Modern Technology of Radiation Oncology, Volume 2 (Medical Physics Publishing, Wisconsin). Schlegel, W., Bortfeld, T., and Grosu, A.-L., 2006, New Technologies in Radiation Oncology (Springer-Verlag Berlin Heidelberg, Heidelberg).

Module Description MODULE 6

<table>
<tr><td>1</td><td>Module code:
M6</td><td colspan="3">Module title:
Physics of Medical Imaging</td></tr>
<tr><td>2</td><td>Module type:
Mandatory</td><td>Semester: 2 (until March 2015)
Semester 3 (since March 2015)</td><td colspan="2">Course format:
On-site</td></tr>
<tr><td>3</td><td colspan="4">Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago</td></tr>
<tr><td>4</td><td colspan="4">Content:
M6.1 X-Ray Imaging
M6.2 Ultrasound
M6.3 Magnetic Resonance Imaging
M6.4 Nuclear Medicine
M6.5 Quality Assurance in Medical Imaging
M6.1 Mathematical Methods of Medical Imaging
M6.2 Conventional X-Ray Fluoroscopy
M6.3 Digital X-Ray Imaging and Computer Tomography (CT)
M6.4 Ultrasound
M6.5 Imaging in Nuclear Medicine
M6.6 Magnetic Resonance Imaging (MRI) Procedures
M6.7 Quality Assurance Controls in Medical Imaging
M6.8 Imaging for Imagine-Guided Radiotherapy and Observation
M6.9 Movement
M6.10 CT and 4D-CT
M6.11 Imaging Platforms
M6.12 Cone beam CT
M6.13 MV CT
M6.14 2D and 3D Ultrasound
M6.15 Fusion, Registration and Image Distortions
M6.16 Dealing with Movement, Irradiation During Respiration</td></tr>
<tr><td>5</td><td colspan="4">Designed for: All students of the Clinical Medical Physics Master’s programme</td></tr>
<tr><td>6</td><td colspan="4">Learning outcomes: A deeper understanding of the physical principles of imaging. Students should be able to recognise the advantages and disadvantages of individual imaging modalities and apply these to radiotherapy.</td></tr>
<tr><td>7</td><td colspan="4">Prerequisites:
a) general prerequisites as stated in the degree programme rules and regulations
b) specific prerequisites
successful completion of module: -</td></tr>
<tr><td>8</td><td colspan="4">Assessment: 2 written tests, 1 final examination</td></tr>
<tr><td rowspan="7">9</td><td colspan="2" rowspan="7">Student workload:
(in hours)</td><td>Lecture</td><td>50</td></tr>
<tr><td>Seminar, project work</td><td>20</td></tr>
<tr><td>Internship</td><td>-</td></tr>
<tr><td>Self-study (before and after the course)</td><td>103</td></tr>
<tr><td>Practice class</td><td></td></tr>
<tr><td>Examination / Test</td><td>7</td></tr>
<tr><td>Other</td><td></td></tr>
<tr><td>10</td><td colspan="4">ECTS credits: 6 (180 h)</td></tr>
<tr><td>11</td><td colspan="4">Lecturer / Supervisor: PUC</td></tr>
<tr><td>12</td><td colspan="4">E-Learning approach: Contact hours</td></tr>
</table>

13	Learning materials:	
14	Language: Spanish	
15	Examination components	Subject matter / content: Lectures
		Weighting (tests, internships, etc.): 2 written tests (120 min each, 30%), written final examination (40%)
		Learning aids: -
16	To be completed prior to examination: examinations for modules 1 - 4	
17	Calculation of module grade: 100%	
18	Module duration: 1 semester	
19	Availability: three times per week, second semester	
20	Availability	Period of required attendance: 1 semester
		Online period: -
		Practical work: -
		Examination: Final examination at the end of the semester
21	Recommended reading:	N. Bankman. Handbook of Medical Imaging, 1st ed. (Academic Press, San Diego, CA, 2000). H.H. Barrett and K.J. Myers. Foundation of Image Science, 1st ed. (John Wiley and Sons, Hoboken NJ, 2004). H.H. Barrett and W. Swindell. Radiological Imaging: The Theory of Image Formation Detection, and Processing. (Academic Press, New York, NY, 1996). J. Beutel, H.L. Kundel, R.L. Van Metter. Handbook of Medical Imaging, Vol. 1. (Physics and Psychophysics) (SPIE Publications, Bellingham, WA, 2000). J.T. Bushberg, J.A. Seibert, E.M Leidholdt, Jr., J.M. Boone. Boone.The Essential Physics of Medical Imaging, 2nd ed. (Lippincott Williams and Wilkins, Philadelphia, PA, 2001). T.S. Curry, J.E. Dowdey, and R.C. Murry. Christensen’s Introduction to the Physics of Diagnostic Radiology, 4th ed. (Lea & Febiger, Malvern, PA, 1990). P.P. Dendy and B. Heaton. Physics of Diagnostic Radiology. (Institute of Physics Publishing, London, UK, 1999). A. Gottschalk, P.B. Hoffer, and E.J. Potchen. Diagnostic Nuclear Medicine, 2nd ed. Diagnostic Nuclear Medicine, 2nd ed. (Williams and Wilkins, Baltimore, MD, 1988).E.M Haacke, R.W. Brown, M.R. Magnetic Resonance Imaging. Thompson, R. Venkatesan. Physical Principles and Sequence Design. (Wiley-Liss, New York, NY, 1999). B. Hasegawa. The Physics of Medical Imaging, 2nd ed. (Medical Physics Publishing, Madison, WI, 1991).

Module Description MODULE 7

1	Module code: M7	Module title: Introduction to Statistics		
2	Module type: Mandatory	Semester: 2	Course format: On-site	
3	Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago			
4	Content: M7.1 Overview and Descriptive Statistics M7.2 Probability M7.3 Random Variables M7.4 Introduction of Interferences: Population, Point Estimation, Intervals Estimation, Test of Hypotheses, Applications			
5	Designed for: All students of the Clinical Medical Physics Master's programme			
6	Learning outcomes: A basic understanding of statistics, the ability to use probability distributions, estimations and hypothesis tests and to apply these to medical data.			
7	Prerequisites: a) general prerequisites as stated in the degree programme rules and regulations b) specific prerequisites successful completion of module: M1, M2, M3 and a compulsory elective module			
8	Assessment: 3 written examinations, homework, 1 final project (group work), 1 final examination			
9	Student workload: (in hours)		Lecture	50
			Seminar, project work	20
			Internship	-
			Self-study (before and after the course)	103
			Practice class	
			Examination / Test	7
			Other	
10	ECTS credits: 6 (180 h)			
11	Lecturer / Supervisor: PUC			
12	E-Learning approach: Contact hours			
13	Learning materials:			
14	Language: Spanish			
15	Examination components	Subject matter / content: Lectures		
		Weighting (tests, internships, etc.): 3 written tests, homework, 1 final project (totalling 75%), 1 final examination (25%)		
		Learning aids: -		
16	To be completed prior to examination: examinations for modules 1 - 4			
17	Calculation of module grade: Presentation grade = 0.7 x written mid-term exams + 0.2 x homework + 0.1 x project work Final grade = 0.75 x presentation grade + 0.25 x final examination			
18	Module duration: 1 semester			
19	Availability: three times per week, second semester			
20	Availability	Period of required attendance: 1 semester		
		Online period: -		
		Practical work: -		
		Examination: Final examination at the end of the semester		
21	Recommended reading:	Devore, J. L. Probability and Statistics for Engineering and the		

		Sciences, Second Edition, Brooks/Cole: California. 1987 Moore, D. S. The Practice of Statistics. New York: Freeman. 1999. Lyman Off, R. y Longnecker, M. An Introduction to Statistical Methods and Data Analysis, Fifth Edition. Duxbury, California. 2001. Ross, S. Introduction to Probability Models, Second Edition. New York: Academy Press. (2000). Scheaffer, R. L. and Mc Clave, J. T. Probability and Statistics for Engineering, (1990) Third Edition, FWS Kent, Boston. Vardemann, S. Statistics for Engineerinng Problem Solving.(1994) PWS Publishing Co.

Module Description MODULE 9

<table>
<tr><td>1</td><td>Module code:
M9</td><td colspan="3">Module title:
Intensity Modulated Radiotherapy (IMRT)</td></tr>
<tr><td>2</td><td>Module type:
Mandatory</td><td>Semester: 3</td><td colspan="2">Course format:
Online/on-site</td></tr>
<tr><td>3</td><td colspan="4">Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago</td></tr>
<tr><td>4</td><td colspan="4">Content:
M9.1 Introduction to M9 (online/on-site)
M9.2 Introduction IMRT (online)
M9.3 IMRT – Clinical Application (online)
M9.4 Advanced Techniques of Applications (online)
M9.5 Workshop (on-site)</td></tr>
<tr><td>5</td><td colspan="4">Designed for: All students of the Clinical Medical Physics Master’s programme</td></tr>
<tr><td>6</td><td colspan="4">Learning outcomes: To learn the physical and methodical foundations for the application of IMRT, to become acquainted with and gain an overview of current studies and the application of IMRT.</td></tr>
<tr><td>7</td><td colspan="4">Prerequisites:
a) general prerequisites as stated in the degree programme rules and regulations
b) specific prerequisites
successful completion of module: M1-M8</td></tr>
<tr><td>8</td><td colspan="4">Assessment:
• 3 online self-tests (3x 60 min)
• 1 final written test (on-site), duration 4h (=75% of the final grade of M9)
• 2 presentations during M9.5 about the physical and the medical point of view of IMRT (=25% of the final grade of M9)</td></tr>
<tr><td rowspan="7">9</td><td colspan="2" rowspan="7">Student workload:
(in hours)</td><td>Lecture</td><td>60</td></tr>
<tr><td>Seminar, project work</td><td>20</td></tr>
<tr><td>Internship</td><td>-</td></tr>
<tr><td>Self-study (before and after the course)</td><td>100</td></tr>
<tr><td>Practice class (on-site)</td><td>24</td></tr>
<tr><td>Examination / Test</td><td>4 / 3</td></tr>
<tr><td>Other</td><td>14</td></tr>
<tr><td>10</td><td colspan="4">ECTS credits: 7,5 (225 h)</td></tr>
<tr><td>11</td><td colspan="4">Lecturer / Supervisor: UHD and international teaching staff</td></tr>
<tr><td>12</td><td colspan="4">E-Learning approach & e-Learning activities:
• recorded video lectures including pdf scripts (online, asynchronous)
• synchronous online sessions via Adobe Connect (study sessions or expert lectures)
• written assignments, including written feedback by lecturers (online, asynchronous)
• written discussion, moderated by lecturer (online, asynchronous)</td></tr>
<tr><td>13</td><td colspan="4">Learning materials: online access to library of Heidelberg University including e-journals (PMB, Medphys, Green Journal, Red Journal, Radiotherapy, Oncology) and e-books.</td></tr>
<tr><td>14</td><td colspan="4">Language: English</td></tr>
<tr><td rowspan="2">15</td><td rowspan="2">Examination components</td><td colspan="3">Subject matter / content: all content from Module 9</td></tr>
<tr><td colspan="3">Weighting (tests, internships, etc.):
• 1 written final examination, covering M9.2, M9.3, M9.4 (240 min) = 75%
• Presentations of M9.5 (physics: 50%; medicine: 50%) =</td></tr>
</table>

		25%
		Learning aids: -
16	To be completed prior to examination: examinations for modules 1 - 8	
17	Calculation of module grade: 100%	
18	Module duration: 1/3 semester	
19	Availability: once per year	
20	Availability	Period of required attendance: At the beginning of the semester and during the semester for attendance phase
		Online period: whole semester
		Practical work: -
		Examination: Final examination at the end of the semester
21	Recommended reading:	IMAGE- GUIDED IMRT, Springer, Thomas Bortfeld, Rupert Schmidt-Ullrich, Wilfried De Neve, David E. Wazer ADAPTIVE RADIATION THERAPY, Imaging in Medical Diagnosis and Therapy Edited by X. Allen Li Willian R. Hendee, Series Editor 3D CONFORMAL RADIATION THERAPY. Multimedia Introduction to Methods and Techniques, Springer, Wolfgang Schlegel, Andreas Mahr. (Multi-Media DVD)

Module Description MODULE 10

<table>
<tr><td>1</td><td>Module code:
M10</td><td colspan="3">Module title:
Image Guided Radiotherapy (IGRT) and Adaptive Radiotherapy (ART)</td></tr>
<tr><td>2</td><td>Module type:
Mandatory</td><td colspan="2">Semester: 3</td><td>Course format:
Online/on-site</td></tr>
<tr><td>3</td><td colspan="4">Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago</td></tr>
<tr><td>4</td><td colspan="4">Content:
M10.1 Introduction to M10 (online/on-site)
M10.2 IGRT Techniques (online)
M10.3 Clinical Applications of IGRT (online)
M10.4 Moving Target Volumes and Adaptive Radiotherapy (Medicine/Physics)
M10.5: Workshop (on-site)</td></tr>
<tr><td>5</td><td colspan="4">Designed for: All students of the Clinical Medical Physics Master’s programme</td></tr>
<tr><td>6</td><td colspan="4">Learning outcomes: Knowledge of the physical and methodical foundations and techniques for the application of IGRT and ART, knowledge of clinical applications, the range of indications, and IGRT protocols.</td></tr>
<tr><td>7</td><td colspan="4">Prerequisites:
a) general prerequisites as stated in the degree programme rules and regulations
b) specific prerequisites
successful completion of module: M1-M8</td></tr>
<tr><td>8</td><td colspan="4">Assessment:
• 3 online self-tests (3x60 min)
• 1 final written test (on-site), duration 4h (=100% of the final grade of M10)</td></tr>
<tr><td rowspan="7">9</td><td colspan="2" rowspan="7">Student workload:
(in hours)</td><td>Lecture</td><td>60</td></tr>
<tr><td>Seminar, project work</td><td>20</td></tr>
<tr><td>Internship</td><td>-</td></tr>
<tr><td>Self-study (before and after the course)</td><td>100</td></tr>
<tr><td>Practice class</td><td>24</td></tr>
<tr><td>Examination / Test</td><td>4 / 3</td></tr>
<tr><td>Other</td><td>14</td></tr>
<tr><td>10</td><td colspan="4">ECTS credits: 7,5 (225 h)</td></tr>
<tr><td>11</td><td colspan="4">Lecturer / Supervisor: UHD and international teaching staff</td></tr>
<tr><td>12</td><td colspan="4">E-Learning approach & e-Learning activities:
• recorded video lectures including pdf scripts (online, asynchronous)
• synchronous online sessions via Adobe Connect (study sessions or expert lectures)
• written assignments, including written feedback by lecturers (online, asynchronous)
• written discussion, moderated by lecturer (online, asynchronous)</td></tr>
<tr><td>13</td><td colspan="4">Learning materials: online access to library of Heidelberg University including e-journals (PMB, Medphys, Green Journal, Red Journal, Radiotherapy, Oncology) and e-books.</td></tr>
<tr><td>14</td><td colspan="4">Language: English</td></tr>
<tr><td rowspan="3">15</td><td rowspan="3">Examination components</td><td colspan="3">Subject matter / content: all content from Module 10</td></tr>
<tr><td colspan="3">Weighting (tests, internships, etc.):
• 1 written final examination, covering M10.2, M10.3, M10.4 (240 min) = 100%</td></tr>
<tr><td colspan="3">Learning aids: -</td></tr>
<tr><td>16</td><td colspan="4">To be completed prior to examination: examinations for modules 1 - 8</td></tr>
</table>

17	Calculation of module grade: 100%	
18	Module duration: 1/3 semester	
19	Availability: once per year	
20	Availability	Period of required attendance: At the beginning of the semester and during the semester for attendance phase
		Online period: whole semester
		Practical work: -
		Examination: Final examination at the end of the semester
21	Recommended reading:	ADAPTIVE RADIATION THERAPY, Imaging in Medical Diagnosis and Therapy Edited by X. Allen Li Willian R. Hendee, Series Editor IMAGE- GUIDED IMRT, Springer, Thomas Bortfeld, Rupert Schmidt-Ullrich, Wilfried De Neve, David E. Wazer 3D CONFORMAL RADIATION THERAPY. Multimedia Introduction to Methods and Techniques, Springer, Wolfgang Schlegel, Andreas Mahr. (Multi-Media DVD)

Module Description MODULE 11

<table>
<tr><td>1</td><td>Module code:
M11</td><td colspan="3">Module title:
Advanced Dosimetry and Quality Assurance</td></tr>
<tr><td>2</td><td>Module type:
Mandatory</td><td>Semester: 3</td><td colspan="2">Course format:
Online/on-site</td></tr>
<tr><td>3</td><td colspan="4">Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago</td></tr>
<tr><td>4</td><td colspan="4">Content:
M11.1 Introduction to M11 (online/on-site)
M11.2 Fundamentals of Dosimetry (online)
M11.3 Dosimetry for Advanced Radiotherapy Techniques (online)
M11.4 Quality Assurance (online)
M11.5: Workshop (on-site)</td></tr>
<tr><td>5</td><td colspan="4">Designed for: All students of the Clinical Medical Physics Master’s programme</td></tr>
<tr><td>6</td><td colspan="4">Learning outcomes: A deeper understanding of the physical basics and the methods of measurement under reference conditions used to determine the dose to water ratio for exposure to high-energy electrons and photons and ions. Secure knowledge of the application of national and international dosimetry protocols. A secure command of the calculation methods used in dosimetry. Extensive knowledge of quality management relative to the medical physical element of radiotherapy.</td></tr>
<tr><td>7</td><td colspan="4">Prerequisites:
a) general prerequisites as stated in the degree programme rules and regulations
b) specific prerequisites
successful completion of module: M1-M8</td></tr>
<tr><td>8</td><td colspan="4">Assessment:
• 3 online self-tests (3x 60 min)
• 1 final written test (on-site), duration 4h (=100% of the final grade of M11)</td></tr>
<tr><td rowspan="7">9</td><td colspan="2" rowspan="7">Student workload:
(in hours)</td><td>Lecture</td><td>45</td></tr>
<tr><td>Seminar, project work</td><td>20</td></tr>
<tr><td>Internship</td><td>-</td></tr>
<tr><td>Self-study (before and after the course)</td><td>100</td></tr>
<tr><td>Practice class</td><td>24</td></tr>
<tr><td>Examination / Test</td><td>4 / 3</td></tr>
<tr><td>Other</td><td>14</td></tr>
<tr><td>10</td><td colspan="4">ECTS credits: 7 (210 h)</td></tr>
<tr><td>11</td><td colspan="4">Lecturer / Supervisor: UHD and international teaching staff</td></tr>
<tr><td>12</td><td colspan="4">E-Learning approach & e-Learning activities:
• recorded video lectures including pdf scripts (online, asynchronous)
• synchronous online sessions via Adobe Connect (study sessions or expert lectures)
• written assignments, including written feedback by lecturers (online, asynchronous)
• e-training software for dose calibration.</td></tr>
<tr><td>13</td><td colspan="4">Learning materials: IAEA Handbook, Radiation Physics for medical Physicists (E.B. Podgorsak), Springer 2006, IAEA TRS 398, DIN 6800-2</td></tr>
<tr><td>14</td><td colspan="4">Language: English</td></tr>
<tr><td rowspan="2">15</td><td rowspan="2">Examination components</td><td colspan="3">Subject matter / content: all content from Module 11</td></tr>
<tr><td colspan="3">Weighting (tests, internships, etc.):
• 1 written final examination, covering M11.2, M11.3, M11.4 (240 min) = 100%</td></tr>
</table>

		Learning aids: -
16	To be completed prior to examination: at least two online tests, examinations for modules 1 - 8	
17	Calculation of module grade: 100%	
18	Module duration: 1/3 semester	
19	Availability: once per year	
20	Availability	Period of required attendance: At the beginning of the semester and during the semester for attendance phase
		Online period: whole semester
		Practical work: -
		Examination: Final examination at the end of the semester
21	Recommended reading:	"The Dosimetry of Ionizing Radiation". Vol I; Frank H. Attix, Bengt E. Bjärngard "Handbook of Radiotherapy Physics". Edt Taylor and Francis Edited by P.Mayls A. Nahum J-C Rosenwald

Module Description MODULE 12

Mandatory courses (obligatory):

- P1: Dosimetry and Quality Assurance of LINACs
- P2: Radiation Treatment Planning
- P3: Intensity-modulated Radiation Therapy (IMRT)

Compulsory electives, at least one of the following must be chosen:

- PW1: Brachytherapy
- PW2: Medical Imaging MRI, CT
- PW3: Radiation Protection

Module Description MODULE 12 Practical Work, P1

<table>
<tr><td>1</td><td>Module code:
P1</td><td colspan="3">Module title:
Dosimetry and Quality Assurance of LINACS</td></tr>
<tr><td>2</td><td>Module type:
Mandatory</td><td>Semester: 3 (until March 2015)
Semester 2 (since March 2015)</td><td colspan="2">Course format:
On-site</td></tr>
<tr><td>3</td><td colspan="4">Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago</td></tr>
<tr><td>4</td><td colspan="4">Content:
• Calibration of a radiation therapy unit using ionisation chambers and diodes
• Constancy testing of ionisation chambers (i.e. with Strontium 90)
• Performance of absolute and relative dosimetry of photons and electrons using various methods (ionisation chambers, films, TLDs)
• Use of radiation analysis systems (water phantom, Matrix detector, etc.) for quality assurance of LINACs</td></tr>
<tr><td>5</td><td colspan="4">Designed for: All students of the Clinical Medical Physics Master's programme</td></tr>
<tr><td>6</td><td colspan="4">Learning outcomes: Practical experience of dosimetry and quality assurance processes used for radiation therapy equipment</td></tr>
<tr><td>7</td><td colspan="4">Prerequisites:
a) general prerequisites as stated in the degree programme rules and regulations
b) specific prerequisites
successful completion of module: M1-M8</td></tr>
<tr><td>8</td><td colspan="4">Assessment: written report</td></tr>
<tr><td rowspan="7">9</td><td colspan="2" rowspan="7">Student workload:
(in hours)</td><td>Lecture</td><td>-</td></tr>
<tr><td>Seminar, project work</td><td>-</td></tr>
<tr><td>Internship</td><td>20</td></tr>
<tr><td>Self-study (before and after the course)</td><td>25</td></tr>
<tr><td>Practice class</td><td>-</td></tr>
<tr><td>Examination / Test</td><td>-</td></tr>
<tr><td>Other: report</td><td>15</td></tr>
<tr><td>10</td><td colspan="4">ECTS credits: 2 (60 h)</td></tr>
<tr><td>11</td><td colspan="4">Lecturer / Supervisor: PUC</td></tr>
<tr><td>12</td><td colspan="4">E-Learning approach: -</td></tr>
<tr><td>13</td><td colspan="4">Learning materials: -</td></tr>
<tr><td>14</td><td colspan="4">Language: Spanish</td></tr>
<tr><td>15</td><td>Examination components</td><td colspan="3">Subject matter / content: entire content of internship</td></tr>
</table>

		Weighting (tests, internships, etc.): written report
		Learning aids: -
16	To be completed prior to examination: examinations for modules 1 - 8	
17	Calculation of module grade: 100%	
18	Module duration: 1 semester	
19	Availability: once per year	
20	Availability	Period of required attendance: 1 semester
		Online period:
		Practical work: 1 semester
		Examination: 1 written report
21	Recommended reading:	

Module Description MODULE 12 Practical Work, P2

<table>
<tr><td>1</td><td>Module code:
P2</td><td colspan="3">Module title:
Radiation Treatment Planning</td></tr>
<tr><td>2</td><td>Module type:
Mandatory</td><td>Semester: 3 (until March 2015)
Semester 2 (since March 2015)</td><td colspan="2">Course format:
On-site</td></tr>
<tr><td>3</td><td colspan="4">Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago</td></tr>
<tr><td>4</td><td colspan="4">Content:
Discussion of the criteria determining the selection of therapy planning systems
Development of therapy plans for radiotherapy
Selection of required energy from photons or electrons in clinical cases
Use of a computer to develop therapy plans and facilitate analysis of inhomogeneities or wedges
Development of therapy plans using marked images for a group of representative tumours, using elements such as wedges, blocks, MLCs to alter radiation.
Development of treatment plans using step-and-shoot delivery</td></tr>
<tr><td>5</td><td colspan="4">Designed for: All students of the Clinical Medical Physics Master’s programme</td></tr>
<tr><td>6</td><td colspan="4">Learning outcomes: Practical experience of using therapy planning systems, competence in selecting necessary radiation dose.</td></tr>
<tr><td>7</td><td colspan="4">Prerequisites:
a) general prerequisites as stated in the degree programme rules and regulations
b) specific prerequisites
successful completion of module: M1-M8</td></tr>
<tr><td>8</td><td colspan="4">Assessment: written report</td></tr>
<tr><td rowspan="7">9</td><td rowspan="7" colspan="2">Student workload:
(in hours)</td><td>Lecture</td><td>-</td></tr>
<tr><td>Seminar, project work</td><td>-</td></tr>
<tr><td>Internship</td><td>20</td></tr>
<tr><td>Self-study (before and after the course)</td><td>25</td></tr>
<tr><td>Practice class</td><td>-</td></tr>
<tr><td>Examination / Test</td><td>-</td></tr>
<tr><td>Other: report</td><td>15</td></tr>
<tr><td>10</td><td colspan="4">ECTS credits: 2 (60 h)</td></tr>
<tr><td>11</td><td colspan="4">Lecturer / Supervisor: PUC</td></tr>
<tr><td>12</td><td colspan="4">E-Learning approach:</td></tr>
<tr><td>13</td><td colspan="4">Learning materials:</td></tr>
<tr><td>14</td><td colspan="4">Language: Spanish</td></tr>
<tr><td rowspan="3">15</td><td rowspan="3">Examination components</td><td colspan="3">Subject matter / content: entire content of internship</td></tr>
<tr><td colspan="3">Weighting (tests, internships, etc.): written report</td></tr>
<tr><td colspan="3">Learning aids: -</td></tr>
<tr><td>16</td><td colspan="4">To be completed prior to examination: examinations for modules 1 - 8</td></tr>
<tr><td>17</td><td colspan="4">Calculation of module grade: 100%</td></tr>
<tr><td>18</td><td colspan="4">Module duration: 1 semester</td></tr>
</table>

19	Availability: once per year	
20	Availability	Period of required attendance: 1 semester
		Online period:
		Practical work: 1 semester
		Examination: 1 written report
21	Recommended reading:	

Module Description MODULE 12 Practical Work, P3

1	Module code: P3	Module title: Internship: Intensity-modulated Radiation Therapy (IMRT)		
2	Module type: Mandatory	Semester: 3 (until March 2015) Semester 2 (since March 2015)	Course format: On-site	
3	Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago			
4	Content: • Development of IMRT treatment plans and further knowledge of the radiation planning techniques used in various fields of application for special indicators • Analysis of existing treatment plans in view of current physical and medical issues • Investigation of the influence of the accuracy of dose calculations on the applied 3D dose distribution • Development of alternative treatment plans and use of modern rotation techniques			
5	Designed for: All students of the Clinical Medical Physics Master's programme			
6	Learning outcomes: Development and guided practical application of high quality IMRT plans			
7	Prerequisites: a) general prerequisites as stated in the degree programme rules and regulations b) specific prerequisites successful completion of module: M1-M8			
8	Assessment: written report			
9	Student workload: (in hours)			Lecture	-
				Seminar, project work	-
				Internship	20
				Self-study (before and after the course)	25
				Practice class	-
				Examination / Test	-
				Other: report	15
10	ECTS credits: 2 (60 h)			
11	Lecturer / Supervisor: PUC			
12	E-Learning approach:			
13	Learning materials:			
14	Language: Spanish			
15	Examination components	Subject matter / content: entire content of internship		
		Weighting (tests, internships, etc.): written report		
		Learning aids: -		
16	To be completed prior to examination: examinations for modules 1 - 8			
17	Calculation of module grade: 100%			
18	Module duration: 1 semester			
19	Availability: once per year			
20	Availability	Period of required attendance: 1 semester		
		Online period: -		
		Practical work: 1 semester		
		Examination: written report		
21	Recommended reading:			

Module Description MODULE 12 Practical Work, Compulsory Elective, PW1

<table>
<tr><td>1</td><td>Module code:
PW1</td><td colspan="3">Module title:
Source Calibration Brachytherapy</td></tr>
<tr><td>2</td><td>Module type:
Compulsory elective</td><td>Semester: 3 (until March 2015)
Semester 2 (since March 2015)</td><td colspan="2">Course format:
On-site</td></tr>
<tr><td>3</td><td colspan="4">Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago</td></tr>
<tr><td>4</td><td colspan="4">Content:
• Selection of radiation source for brachytherapy and clinical justification for use.
• Storage of the radiation source and safety measures.
• Determination of the air kerma rate using available dosimetry systems, calculation of retention time in basic treatment situations, accompaniment of a complete treatment cycle, treatment planning and dose calculation.
• Investigation of locally used algorithms for dose calculation and the limits of manual calculations of the retention time.
• Use of computers to create dose distributions
• Quality assurance of brachytherapy equipment (applicators, treatment planning systems, homogeneity of the source, calibration of the source).</td></tr>
<tr><td>5</td><td colspan="4">Designed for: All students of the Clinical Medical Physics Master's programme</td></tr>
<tr><td>6</td><td colspan="4">Learning outcomes: First-hand experience of conducting brachytherapy, competence in dose calculation and the creation of dose distributions for brachytherapy</td></tr>
<tr><td>7</td><td colspan="4">Prerequisites:
a) general prerequisites as stated in the degree programme rules and regulations
b) specific prerequisites
successful completion of module: M1-M8</td></tr>
<tr><td>8</td><td colspan="4">Assessment: written report</td></tr>
<tr><td rowspan="7">9</td><td colspan="2" rowspan="7">Student workload:
(in hours)</td><td>Lecture</td><td>-</td></tr>
<tr><td>Seminar, project work</td><td>-</td></tr>
<tr><td>Internship</td><td>20</td></tr>
<tr><td>Self-study (before and after the course)</td><td>25</td></tr>
<tr><td>Practice class</td><td>-</td></tr>
<tr><td>Examination / Test</td><td>-</td></tr>
<tr><td>Other: report</td><td>15</td></tr>
<tr><td>10</td><td colspan="4">ECTS credits: 2 (60 h)</td></tr>
<tr><td>11</td><td colspan="4">Lecturer / Supervisor: PUC</td></tr>
<tr><td>12</td><td colspan="4">E-Learning approach:</td></tr>
<tr><td>13</td><td colspan="4">Learning materials:</td></tr>
<tr><td>14</td><td colspan="4">Language: Spanish</td></tr>
<tr><td rowspan="3">15</td><td rowspan="3">Examination components</td><td colspan="3">Subject matter / content: entire content of internship</td></tr>
<tr><td colspan="3">Weighting (tests, internships, etc.): written report</td></tr>
<tr><td colspan="3">Learning aids: -</td></tr>
<tr><td>16</td><td colspan="4">To be completed prior to examination: examinations for modules 1 - 8</td></tr>
<tr><td>17</td><td colspan="4">Calculation of module grade: 100%</td></tr>
<tr><td>18</td><td colspan="4">Module duration: 1 semester</td></tr>
</table>

19	Availability: once per year	
20	Availability	Period of required attendance: 1 semester
		Online period: -
		Practical work: 1 semester
		Examination: 1 written report
21	Recommended reading:	

Module Description MODULE 12 Practical Work, Compulsory Elective, PW2

<table>
<tr><td>1</td><td>Module code:
PW2</td><td colspan="3">Module title:
Internship: Diagnostic Imaging (X-ray diagnostics, MRI)</td></tr>
<tr><td>2</td><td>Module type:
Compulsory elective</td><td>Semester: 3 (until March 2015)
Semester 2 (since March 2015)</td><td colspan="2">Course format:
On-site</td></tr>
<tr><td>3</td><td colspan="4">Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago</td></tr>
<tr><td>4</td><td colspan="4">Content:
X-ray diagnostics: Execution of control measures for various diagnostic machines which use X-radiation (fluoroscopy, computed tomography, mammography etc.), dose estimations for various imaging techniques, measures of suitable phantoms.
Magnetic resonance imaging (MRI): Familiarity with MRI images taken from healthy patients and different pathologies, completion of phantom measurements using various protocol settings and different imaging sequences, T1 and T2 determination of existing and self-produced data, recognition of typical imaging artefacts and familiarisation with measures taken to correct artefacts.</td></tr>
<tr><td>5</td><td colspan="4">Designed for: All students of the Clinical Medical Physics Master's programme</td></tr>
<tr><td>6</td><td colspan="4">Learning outcomes: Competence in producing and evaluating diagnostic images</td></tr>
<tr><td>7</td><td colspan="4">Prerequisites:
a) general prerequisites as stated in the degree programme rules and regulations
b) specific prerequisites
successful completion of module: M1-M8</td></tr>
<tr><td>8</td><td colspan="4">Assessment: written report</td></tr>
<tr><td rowspan="7">9</td><td colspan="2" rowspan="7">Student workload:
(in hours)</td><td>Lecture</td><td>-</td></tr>
<tr><td>Seminar, project work</td><td>-</td></tr>
<tr><td>Internship</td><td>20</td></tr>
<tr><td>Self-study (before and after the course)</td><td>25</td></tr>
<tr><td>Practice class</td><td>-</td></tr>
<tr><td>Examination / Test</td><td>-</td></tr>
<tr><td>Other: report</td><td>15</td></tr>
<tr><td>10</td><td colspan="4">ECTS credits: 2 (60 h)</td></tr>
<tr><td>11</td><td colspan="4">Lecturer / Supervisor: PUC</td></tr>
<tr><td>12</td><td colspan="4">E-Learning approach:</td></tr>
<tr><td>13</td><td colspan="4">Learning materials:</td></tr>
<tr><td>14</td><td colspan="4">Language: Spanish</td></tr>
<tr><td rowspan="3">15</td><td rowspan="3">Examination components</td><td colspan="3">Subject matter / content: entire content of internship</td></tr>
<tr><td colspan="3">Weighting (tests, internships, etc.): written report</td></tr>
<tr><td colspan="3">Learning aids: -</td></tr>
<tr><td>16</td><td colspan="4">To be completed prior to examination: examinations for modules 1 - 8</td></tr>
<tr><td>17</td><td colspan="4">Calculation of module grade: 100%</td></tr>
<tr><td>18</td><td colspan="4">Module duration: 1 semester</td></tr>
<tr><td>19</td><td colspan="4">Availability: once per year</td></tr>
<tr><td rowspan="4">20</td><td rowspan="4">Availability</td><td colspan="3">Period of required attendance: 1 semester</td></tr>
<tr><td colspan="3">Online period: -</td></tr>
<tr><td colspan="3">Practical work: 1 semester</td></tr>
<tr><td colspan="3">Examination: 1 written report</td></tr>
<tr><td>21</td><td>Recommended reading:</td><td colspan="3"></td></tr>
</table>

Module Description MODULE 12 Practical Work, Compulsory Elective, PW3

1	Module code: PW3	Module title: Radiation Protection	
2	Module type: Compulsory elective	Semester: 3 (until March 2015) Semester 2 (since March 2015)	Course format: On-site
3	Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago		
4	Content: • Identification and use of processes and measurements of radiation protection including the principles of shielding, distance and time. • Dealing with potentially dangerous situations related to radiation protection • Dealing with radioactive waste • Knowledge of national and international laws relating to radiation protection, responsibilities, labelling of radioactive compounds, knowledge of calibration protocols		
5	Designed for: All students of the Clinical Medical Physics Master's programme		
6	Learning outcomes: Safe handling of the processes involved in radiation protection, competence in minimising radiation exposure levels for staff, knowledge of national and international radiation protection laws		
7	Prerequisites: a) general prerequisites as stated in the degree programme rules and regulations b) specific prerequisites successful completion of module: M1-M8		
8	Assessment: written report		

9	Student workload: (in hours)	Lecture	-
		Seminar, project work	-
		Internship	20
		Self-study (before and after the course)	25
		Practice class	-
		Examination / Test	-
		Other: report	15

10	ECTS credits: 2 (60 h)	
11	Lecturer / Supervisor: PUC	
12	E-Learning approach:	
13	Learning materials:	
14	Language: Spanish	
15	Examination components	Subject matter / content: entire content of internship
		Weighting (tests, internships, etc.): written report
		Learning aids: -
16	To be completed prior to examination: examinations for modules 1 - 8	
17	Calculation of module grade: 100%	
18	Module duration: 1 semester	
19	Availability: once per year	
20	Availability	Period of required attendance: 1 semester
		Online period: -
		Practical work: 1 semester
		Examination: written report
21	Recommended reading:	

Module Description MODULE 4 & 8 (M4.1, M4.2 & M8.1, M8.2)

Compulsory elective subjects:

- W1: Medical Imaging
- W2: Additional Magnetic Resonance Imaging Techniques
- W3: Electronics for Physicists
- W4: Classic Optics
- W5: Atomic and Molecular Physics
- W6: Machines and Accessories for Radiotherapy

<u>Module Description MODULE W1</u>

<table>
<tr><td>1</td><td>Module code:
W1</td><td colspan="3">Module title:
Medical Imaging</td></tr>
<tr><td>2</td><td>Module type:
Compulsory elective</td><td>Semester: 1 or 2</td><td colspan="2">Course format:
On-site</td></tr>
<tr><td>3</td><td colspan="4">Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago</td></tr>
<tr><td>4</td><td colspan="4">Content:
W1.1 Introduction to Image Processing
W1.2 Coloured Images
W1.3 Improvement of Image Quality
W1.4 Introduction to Linear Systems
W1.5 Improvement of Image Quality via Frequency
W1.6 Correction of Imaging Artefacts
W1.7 Morphological Image Processing
W1.8 Image Segmentation</td></tr>
<tr><td>5</td><td colspan="4">Designed for: All students of the Clinical Medical Physics Master’s programme</td></tr>
<tr><td>6</td><td colspan="4">Learning outcomes: Deeper understanding of digital image processing in terms of position and frequency, ability to correct unwanted image artefacts, competence in analysing images by isolating individual, relevant objects and recognising the relevant basic forms</td></tr>
<tr><td>7</td><td colspan="4">Prerequisites:
a) general prerequisites as stated in the degree programme rules and regulations
b) specific prerequisites
successful completion of module: -</td></tr>
<tr><td>8</td><td colspan="4">Assessment: 5 individual projects, 1 final project</td></tr>
<tr><td rowspan="7">9</td><td colspan="2" rowspan="7">Student workload:
(in hours)</td><td>Lecture</td><td>50</td></tr>
<tr><td>Seminar, project work</td><td>20</td></tr>
<tr><td>Internship</td><td>-</td></tr>
<tr><td>Self-study (before and after the course)</td><td>103</td></tr>
<tr><td>Practice class</td><td></td></tr>
<tr><td>Examination / Test</td><td></td></tr>
<tr><td>Other: report</td><td>7</td></tr>
<tr><td>10</td><td colspan="4">ECTS credits: 6 (180 h)</td></tr>
<tr><td>11</td><td colspan="4">Lecturer / Supervisor: PUC</td></tr>
<tr><td>12</td><td colspan="4">E-Learning approach: Contact hours</td></tr>
<tr><td>13</td><td colspan="4">Learning materials: -</td></tr>
<tr><td>14</td><td colspan="4">Language: Spanish</td></tr>
</table>

15	Examination components	Subject matter / content: Lectures
		Weighting (tests, internships, etc.): 5 individual projects (totalling 75%), final project (25%)
		Learning aids: -
16	To be completed prior to examination: -	
17	Calculation of module grade: 100%	
18	Module duration: 1 semester	
19	Availability: once per semester	
20	Availability	Period of required attendance: 1 semester
		Online period: -
		Practical work: -
		Examination: Mid-term written tests, final examination at end of the semester
21	Recommended reading:	GONZALEZ, Rafael C. and WOODS, Richard E. Digital image processing. Reading Mass., Addison Wesley, 1992. BRACEWELL. Ronald. Two dimensional imaging. Englewood Cliffs, N.J., Prentice Hall, 1995. CASTLEMAN, K. Digital imagen processing. Englewood Cliffs, N.J., Prentice Hall, 1996. IRARRAZAVAL, Pablo. Análisis de señales. McGraw Hill, 1999. PRATT, William K. Digital image processing. 2 ed. New York, Wiley-Interscience, 1991. RUSS, J. The image processing handbook. Boca Ratón, CRS Press, 1995. SID-AHMED, M. Image processing. New York, McGraw Hill, 1995. TEUBER, J. Digital image processing. Upper Sadle River, N.J., Prentice Hall, 1993.

Module Description MODULE W2

1	Module code: W2	Module title: Additional Magnetic Resonance Imaging Techniques		
2	Module type: Compulsory elective	Semester: 1 or 2	Course format: On-site	
3	Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago			
4	Content: W2.1 Project 1: Defining the Parameters for Standard Sequences W2.2 Project 2: Optimisation of Image Contrasts W2.3 Project 3: Optimising Protocols W2.4 Project 4: Establishing Pulse Sequences W2.5 Project 5: Research and Development of Pulse Sequence Programming on a Philips MR System & W2.6 Project 6: Final project: Development and Implementation of a MR System			
5	Designed for: All students of the Clinical Medical Physics Master's programme			
6	Learning outcomes: Deeper understanding of magnetic resonance imaging, in particular of various techniques used for analysis of MRI images			
7	Prerequisites: a) general prerequisites as stated in the degree programme rules and regulations b) specific prerequisites successful completion of module: -			
8	Assessment: 5 individual projects and 1 final project			
9	Student workload: (in hours)		Lecture	50
			Seminar, project work	20
			Internship	10
			Self-study (before and after the course)	93
			Practice class	
			Examination / Test	
			Other: reports	7
10	ECTS credits: 6 (180 h)			
11	Lecturer / Supervisor: PUC			
12	E-Learning approach: Contact hours			
13	Learning materials:			
14	Language: Spanish			
15	Examination components	Subject matter / content: Lectures		
		Weighting (tests, internships, etc.): 5 internship reports (totalling 75%) and a final report (25%)		
		Learning aids: -		
16	To be completed prior to examination: -			
17	Calculation of module grade: 100%			
18	Module duration: 1 semester			
19	Availability: three times per week, first semester			
20	Availability	Period of required attendance: 1 semester		
		Online period: -		
		Practical work: twice per semester		
		Examination: Final examination at the end of the semester		
21	Recommended reading:			

Module Description MODULE W3

1	Module code: W3	Module title: Electronics for Physicists		
2	Module type: Compulsory elective	Semester: 1 or 2	Course format: On-site	
3	Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago			
4	Content: W3.1 Basic circuitry: function of individual components and their fields of application, basic concepts for networking of such circuits W3.2 Determination of transfer function in a circuit: analytical models and computer simulation model SPICE practical application of various uses of SPICE W3.3 Fundamentals of semi-conductors, their description using formulas to determine the carrier load P-n junction and diodes, bipolar transistor and FET W3.4 Amplifiers: transistor, FET, power amplifier and operation amplifier, differential amplifier and other integrated circuits W3.5 Basic circuits: integration and differentials, use of such circuits, 555 timer component as an experimental introduction to binary circuits. W3.6 Communication components: coaxial cable, fibre optics, comparison of analogue and digital systems,distinguishing small signals from electrical noise, isolation and “floating” systems: measurement of signals in case of simultaneous protection and isolation of a circuit W3.7 Measurement components: components sensitive to IR and X-radiation, electronic and magnetic field, temperature, echo and position W3.8 Control systems and their elements: power, regulation, magnetism, thyristors, power components W3.9 Limits of noise, range of systems for signal measurement in case of noise. W3.10 Internships			
5	Designed for: All students of the Clinical Medical Physics Master’s programme			
6	Learning outcomes: The aim of this course is to achieve understanding of the electronic elements used in small and medium-sized laboratories. Above all, the fundamental principles governing basic electronic circuits will be considered. Focus will be placed on the use of circuits for measurement, data transfer and their use as control systems during research and teaching. A further objective is the development and analysis of such circuits. This shall include simulation.			
7	Prerequisites: a) general prerequisites as stated in the degree programme rules and regulations b) specific prerequisites successful completion of module: -			
8	Assessment: 2 written tests, 1 written report			
9	Student workload: (in hours)		Lecture	50
			Seminar, project work	-
			Internship	20
			Self-study (before and after the course)	103
			Practice class	
			Examination / Test	7
			Other	
10	ECTS credits: 6 (180 h)			
11	Lecturer / Supervisor: PUC			
12	E-Learning approach: Contact hours			
13	Learning materials:			

14	Language: Spanish	
15	Examination components	Subject matter / content: Lectures
		Weighting (tests, internships, etc.): 2 written tests (120 min each, 50%) written report (50%)
		Learning aids: -
16	To be completed prior to examination: -	
17	Calculation of module grade: 100%	
18	Module duration: 1 semester	
19	Availability: once per semester	
20	Availability	Period of required attendance: 1 semester
		Online period: -
		Practical work: -
		Examination: Mid-term written tests, final examination at end of the semester
21	Recommended reading:	Horowitz, P.,and Hill, W. The Art of Electronics. Cambridge University Press, 1989. Smith, R.J. Circuits, Devices and Systems, Wiley, 1992 Neaman, D.A. Electronics Circuit Analysis and Design, McGraw Hill, 2001

Module Description MODULE W4

1	Module code: W4	Module title: Classic Optics	
2	Module type: Compulsory elective	Semester: 1 or 2	Course format: On-site
3	Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago		
4	Content: W4.1 Electromagnetic waves (EM waves): description of electromagnetic waves, plane, cylindrical and spherical wavefronts W4.2 Diffusion of EM waves: reflection, refraction, interfaces, Fresnel equations, optic properties of metals W4.3 Geometrical optics: thick lenses, lense systems, beam guidance, aberration W4.4 Polarisation: linear, circular and elliptical, polarisation, double interfaces, photoelasticity, Faraday effect, Pockels effect and Kerr effect W4.5 Interference: conditions for interference, young experiment, interference stripes, interference measure, thin films and their use W4.6 Diffraction: Fraunhofer diffraction, Fresnel diffraction, Kirchhoff's diffraction formula W4.7 Fourier optics: Fourier transformation, spatial filtering, dark-field, Schlieren imaging W4.8 Coherence, Transparency, Coherence Function W4.9 Holography: basics, holography using reflection and transmission, holographic interferometry (HI) W4.10 Internships: 1) Imaging: optical systems 2) Polarisation: rotation of polarisation, polarimetry, determination of polarisation 3) Fraunhofer diffraction: stripes, diffraction grating, apertures 4) Fresnel diffraction 5) Spatial filters 6) Schlieren imaging, shadowgraphy 7) Holography 8) Interferometry		
5	Designed for: All students of the Clinical Medical Physics Master's programme		
6	Learning outcomes: The aim of this course is to ensure understanding of the basic formalities of classic optics, as well as its diagnostic uses and physical phenomena. In addition, the course will address theoretical developments in coherence optics, and image processing using optical components. Development of fundamental experimental skills required for the use of conventional optical components, as well as the ability to produce holograms. A central aim is the development of competencies in the area of experimental work with coherent light.		
7	Prerequisites: a) general prerequisites as stated in the degree programme rules and regulations b) specific prerequisites successful completion of module: -		
8	Assessment: 2 written tests and 1 written report		
9	Student workload: (in hours)	Lecture	50
		Seminar, project work	-
		Internship	20
		Self-study (before and after the course)	103
		Practice class	
		Examination / Test	7

		Other	
10	ECTS credits: 6 (180 h)		
11	Lecturer / Supervisor: PUC		
12	E-Learning approach: Contact hours		
13	Learning materials:		
14	Language: Spanish		
15	Examination components	Subject matter / content: Lectures	
		Weighting (tests, reports, etc.): 2 written tests (120 min each, 50%) written report (50%)	
		Learning aids: -	
16	To be completed prior to examination:		
17	Calculation of module grade: 100%		
18	Module duration: 1 semester		
19	Availability: once per semester		
20	Availability	Period of required attendance: 1 semester	
		Online period: -	
		Practical work: -	
		Examination: Mid-term written tests, final examination at end of the semester	
21	Recommended reading:	Born, M. & Wolf, E. Principles of Optics, Pergamon, Oxford, 1970. Born, M., Wolf, E., Bhatia, A.B. Principles of Optics: Electromagnetic Theory of and Clemmow, P. C. Propagation, Interference and Diffraction of Light, Cambridge, 1999. Gunther, R.D. Modern Optics. John Wiley & Sons, 1990. Hecht, E. Optica,.Addison Wesley, 3ª Edición, 1998. Jenkins, F.A. & White, H.E. Fundamentals of Optics. McGraw-Hill, 1957. Ostrovski, I.I. Interfeormetry by Holography. Springer Verlag, 1980. Vest, C.M. Holographic Interferometry. John Wiley & Sons, 1979. Welford, W.T. Optics. Oxford Physics series, Second Edition, 1981.	

Module Description MODULE W5

<table>
<tr><td>1</td><td>Module code:
W5</td><td colspan="3">Module title:
Atomic and Molecular Physics</td></tr>
<tr><td>2</td><td>Module type:
Compulsory elective</td><td>Semester: 1 or 2</td><td colspan="2">Course format:
On-site</td></tr>
<tr><td>3</td><td colspan="4">Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago</td></tr>
<tr><td>4</td><td colspan="4">Content:
W5.1 Atomic structure: Schrödinger equation, hydrogen atom, quantum model, spin selection rules, Zeeman and Stark effect, X-ray spectroscopy
W5.2 Molecular structure: atomic potentials, Born-Oppenheimer approximation, electronic energy, rotational energy, spectra
W5.3 Spectral lines: line profile, range, double line broadening, pressure broadening
W5.4 Absorption and emission lines: Boltzmann statistic, Einstein coefficients, absorption coefficients, oscillator power
W5.5 Types of spectroscopy: microwaves, electron spin resonance (ESR and NMR), Raman
W5.6 Spectroscopy of electrons: Auger, photoelectrons, mass spectroscopy
W5.7 Optical spectrometer: optical grid, resolution capacity, glass, monochromator
W5.8: Detectors: photoelectron multiplier, film, CCD, plastic detector material
W5.9: Internships
1. Spectra of discharge lamps
2. Linear forms, Hα, and Hβ
3. Zeeman effect
4. Identification of type of constant electric shock
5. Mass spectrometry (MS)</td></tr>
<tr><td>5</td><td colspan="4">Designed for: All students of the Clinical Medical Physics Master’s programme</td></tr>
<tr><td>6</td><td colspan="4">Learning outcomes: The aim of this course is to familiarise students with the fundamental techniques involved in spectroscopy with particular reference to physics principles and their uses.</td></tr>
<tr><td>7</td><td colspan="4">Prerequisites:
a) general prerequisites as stated in the degree programme rules and regulations
b) specific prerequisites
successful completion of module: -</td></tr>
<tr><td>8</td><td colspan="4">Assessment: 2 written tests, 1 internship report</td></tr>
<tr><td rowspan="7">9</td><td colspan="2" rowspan="7">Student workload: (in hours)</td><td>Lecture</td><td>50</td></tr>
<tr><td>Seminar, project work</td><td>20</td></tr>
<tr><td>Internship</td><td>-</td></tr>
<tr><td>Self-study (before and after the course)</td><td>103</td></tr>
<tr><td>Practice class</td><td></td></tr>
<tr><td>Examination / Test</td><td>7</td></tr>
<tr><td>Other</td><td></td></tr>
<tr><td>10</td><td colspan="4">ECTS credits: 6 (180 h)</td></tr>
<tr><td>11</td><td colspan="4">Lecturer / Supervisor: PUC</td></tr>
<tr><td>12</td><td colspan="4">E-Learning approach: Contact hours</td></tr>
<tr><td>13</td><td colspan="4">Learning materials:</td></tr>
<tr><td>14</td><td colspan="4">Language: Spanish</td></tr>
<tr><td rowspan="2">15</td><td rowspan="2">Examination components</td><td colspan="3">Subject matter / content: Lectures</td></tr>
<tr><td colspan="3">Weighting (tests, reports, etc.): 2 written tests (120 min each, 50%)</td></tr>
</table>

<table>
<tr><td rowspan="2"></td><td rowspan="2"></td><td>written report (50%)</td></tr>
<tr><td>Learning aids: -</td></tr>
<tr><td>16</td><td colspan="2">To be completed prior to examination: -</td></tr>
<tr><td>17</td><td colspan="2">Calculation of module grade: 100%</td></tr>
<tr><td>18</td><td colspan="2">Module duration: 1 semester</td></tr>
<tr><td>19</td><td colspan="2">Availability: once per semester</td></tr>
<tr><td rowspan="4">20</td><td rowspan="4">Availability</td><td>Period of required attendance: 1 semester</td></tr>
<tr><td>Online period: -</td></tr>
<tr><td>Practical work: -</td></tr>
<tr><td>Examination: Mid-term written tests, final examination at end of the semester</td></tr>
<tr><td>21</td><td>Recommended reading:</td><td>Bransten, B. & Joachain, C.H. Physics of Atoms and Molecules. Longman, 1984.
Czanderma, A.W. (Ed.) Method of Surface Analysis. North-Holland, 1989.
Foot, C. Atomic Physics. Oxford University Press, 2003.
R.H. Huddlestone, R.H. & Leonard, S.L. (Eds.) Plasma Diagnostic Techniques. Academic Press,
1965.
Thorne, A.P. Spectrophysics. Chapman and Hall, 1988.</td></tr>
</table>

Module Description MODULE W6

<table>
<tr><td>1</td><td>Module code:
W6</td><td colspan="2">Module title:
Machines and Accessories for Radiotherapy</td></tr>
<tr><td>2</td><td>Module type:
Compulsory elective</td><td>Semester: 1 or 2</td><td>Course format:
On-site</td></tr>
<tr><td>3</td><td colspan="3">Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago</td></tr>
<tr><td>4</td><td colspan="3">Content:
Machines for the production of radiation
Cobalt-60
linear accelerator
X-radiation
Neutrons
Cyclotron/ Synchrotron
Cyberknife
Gamma knife
Tomotherapy
Methods for individual patient simulation and use of imaging to plan therapy
Conducting image-guided therapy
EPID (electronic portal imaging device)
Cone beam CT</td></tr>
<tr><td>5</td><td colspan="3">Designed for: All students of the Clinical Medical Physics Master’s programme</td></tr>
<tr><td>6</td><td colspan="3">Learning outcomes: Knowledge of technical processes involved in the production of ionising radiation and in simulation and radiation planning using existing equipment. Familiarisation with methods used in image-guided radiation therapy.</td></tr>
<tr><td>7</td><td colspan="3">Prerequisites:
a) general prerequisites as stated in the degree programme rules and regulations
b) specific prerequisites
successful completion of module: -</td></tr>
<tr><td>8</td><td colspan="3">Assessment: 2 written tests and a final examination</td></tr>
<tr><td>9</td><td colspan="3">Student workload:
(in hours)<table><tr><td>Lecture</td><td>50</td></tr><tr><td>Seminar, project work</td><td>20</td></tr><tr><td>Internship</td><td>-</td></tr><tr><td>Self-study (before and after the course)</td><td>103</td></tr><tr><td>Practice class</td><td></td></tr><tr><td>Examination / Test</td><td>7</td></tr><tr><td>Other</td><td></td></tr></table></td></tr>
<tr><td>10</td><td colspan="3">ECTS credits: 6 (180 h)</td></tr>
<tr><td>11</td><td colspan="3">Lecturer / Supervisor: PUC</td></tr>
<tr><td>12</td><td colspan="3">E-Learning approach: Contact hours</td></tr>
<tr><td>13</td><td colspan="3">Learning materials:</td></tr>
<tr><td>14</td><td colspan="3">Language: Spanish</td></tr>
<tr><td rowspan="3">15</td><td rowspan="3">Examination components</td><td colspan="2">Subject matter / content: Lectures</td></tr>
<tr><td colspan="2">Weighting (tests, internships, etc.): 2 written tests (120 min each, 30%), written final examination (40%)</td></tr>
<tr><td colspan="2">Learning aids: -</td></tr>
<tr><td>16</td><td colspan="3">To be completed prior to examination: -</td></tr>
<tr><td>17</td><td colspan="3">Calculation of module grade: 100%</td></tr>
</table>

18	Module duration: 1 semester		
19	Availability: once per semester		
20	Availability	Period of required attendance: 1 semester	
		Online period: -	
		Practical work: -	
		Examination: Mid-term written tests, final examination at end of the semester	
21	Recommended reading:	· Greene, D. and Williams, P.C. Linear Accelerators for Radiation Therapy, 2nd ed. Institute of Physics Publishing, London, 1997. · Hazle, J.D. and Boyer, A. (eds.). Imaging in Radiation Therapy. AAPM Monograph No. 24. Medical Physics Publishing, Madison, 1998. · Hendee, W. R., Ibbott, G. S. and Hendee, E. G. Radiation Therapy Physics, 3rd ed. Wiley- Liss, Hoboken, 2004. · Levitt, S. H. (ed.). Technical Basis of Radiation Therapy: Practical Clinical Applications. Springer, Berlin, 2008. · Mayles P., Nahum A. E., Rosenwald J. C. (eds.), Handbook of Radiotherapy Physics: Theory and Practice, Boca Raton, CRC Press, 2007. · Sprawls, P. Magnetic resonance imaging: principles, methods, and techniques. Medical Physics Publishing, Madison, 2000. · Sprawls, P. Physical principles of medical imaging. Medical Physics Publishing, Madison, 1995. · Van Dyk, J., The Modern Technology of Radiation Oncology, Volume 2. Medical Physics Publishing, Wisconsin; 2008 · Wolbarst, A. B., Massman, K. L., Hendee, W. R. Advances in Medical Physics. Medical Physics Pub., Madison, 2008.	

Module Description MODULE MT

<table>
<tr><td>1</td><td>Module code:
MT</td><td colspan="3">Module title:
Master’s Thesis</td></tr>
<tr><td>2</td><td>Module type:
Mandatory</td><td>Semester: 4</td><td colspan="2">Course format:
On-site in Chile or Heidelberg</td></tr>
<tr><td>3</td><td colspan="4">Degree programme / Faculty: Clinical Medical Physics / Medical Faculty, Heidelberg University, Faculty of Physics, PUC, Santiago</td></tr>
<tr><td>4</td><td colspan="4">Content and form:
Independent guided scientific research in form of a written thesis and a final oral presentation (30 min.) and defense (15 min.) on a topic in the area of medical physics. During their dissertation students will be supervised by a subject expert member of the program teaching team. Topic to be selected from modules M1 – M12.</td></tr>
<tr><td>5</td><td colspan="4">Designed for: All students of the Clinical Medical Physics Master’s programme</td></tr>
<tr><td>6</td><td colspan="4">Learning outcomes: Extended competence and skill in a selected area of medical physics; independent scientific enquiry under guidance.</td></tr>
<tr><td>7</td><td colspan="4">Prerequisites:
a) general prerequisites as stated in the degree programme rules and regulations
b) specific prerequisites
successful completion of module: M1-M12</td></tr>
<tr><td>8</td><td colspan="4">Assessment: written thesis (=75%) and final oral presentation (30 min.) and defense (15 min.) (=25%)</td></tr>
<tr><td rowspan="6">9</td><td colspan="2" rowspan="6">Student workload:
(in hours)</td><td>Lecture</td><td></td></tr>
<tr><td>Seminar, project work</td><td>900</td></tr>
<tr><td>Internship</td><td></td></tr>
<tr><td>Self-study (before and after the course)</td><td></td></tr>
<tr><td>Practice class</td><td></td></tr>
<tr><td>Examination / Test</td><td></td></tr>
<tr><td>10</td><td colspan="4">ECTS credits: 30 (900 h)</td></tr>
<tr><td>11</td><td colspan="4">Lecturer / Supervisor: teaching team PUC and UHD according to examination regulation</td></tr>
<tr><td>12</td><td colspan="4">E-Learning approach: -</td></tr>
<tr><td>13</td><td colspan="4">Learning materials: -</td></tr>
<tr><td>14</td><td colspan="4">Language: English</td></tr>
<tr><td rowspan="3">15</td><td rowspan="3">Examination components</td><td colspan="3">Subject matter / content: Lectures</td></tr>
<tr><td colspan="3">Weighting (tests, internships, etc.):
• Written thesis: 75%
• Oral examination (presentation & defense): 25%</td></tr>
<tr><td colspan="3">Learning aids: -</td></tr>
<tr><td>16</td><td colspan="4">To be completed prior to examination: M1-M12</td></tr>
<tr><td>17</td><td colspan="4">Calculation of module grade: 100%</td></tr>
<tr><td>18</td><td colspan="4">Module duration: 1 semester (plus 4 months if requested)</td></tr>
<tr><td>19</td><td colspan="4">Availability: once per semester</td></tr>
<tr><td rowspan="4">20</td><td rowspan="4">Availability</td><td colspan="3">Period of required attendance: 1 semester</td></tr>
<tr><td colspan="3">Online period: -</td></tr>
<tr><td colspan="3">Practical work: -</td></tr>
<tr><td colspan="3">Examination: final examination at end of the semester</td></tr>
<tr><td>21</td><td>Recommended reading:</td><td colspan="3"></td></tr>
</table>

4. Calculation of final CMP grade:

The final grade of the CMP Master's program is calculated as follows:

- Master's Thesis:

  The grade for presentation and defense shall be the arithmetic mean of the individual grades assigned by the two examiners. The overall grade for the Master's thesis shall be based on the weighted individual grades for presentation and defense (25%) and written Master's thesis (75%) (see section 20 of the examination regulation of Aug. 31st 2012).

- Final grade:

  The Master's examination has been passed if all examination components have been graded at least "adequate" (4.0) (see section 13 & 21 of examination regulation of Aug. 31st 2012).

  For calculation of the overall grade two partial grades are formed, which flow into the overall grade with the following weighting:

  1. Average of the equally weighted partial grades from modules 1-12: 60%.
  2. Master's thesis 40% (incl. presentation and defense).

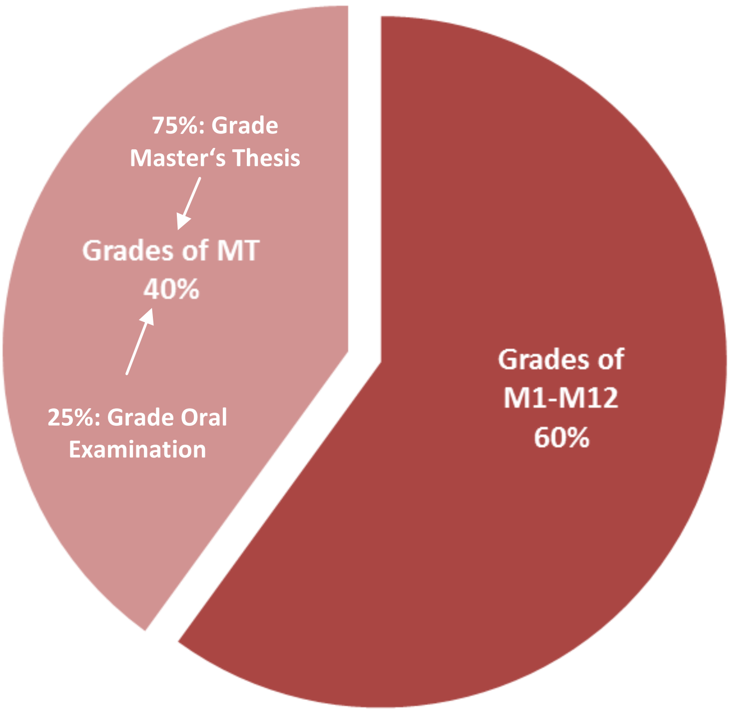

Figure 1: Final CMP Grade

5. Model plan of study

Please see tables 1 and 2 on pages 3 and 4 of the module guide.