HELLENIC REPUBLIC
National and Kapodistrian University of Athens

Annex A5

Study Guide of the MSc Program

STUDY GUIDE

Interuniversity Program of Postgraduate Studies in Medical Physics – Radiation Physics (IPPS MP-RP)

Academic year 2022-2023

Contents

OBJECT – PURPOSE

The purpose of the Interuniversity Program for Postgraduate Studies in "Medical Physics – Radiation Physics" (IPPS MP-RP) is to provide a high level of postgraduate education in the scientific field of Medical Physics – Radiation Physics.

The IPPS MP-RP leads to the award of a Master's Degree (MSc) in "Medical Physics – Radiation Physics", after the full and successful completion of studies based on the relevant program of study.

The titles are awarded by the Medical School of the National and Kapodistrian University of Athens with reference to the collaborating institutions.

ORGANIZATIONAL AND ADMINISTRATIVE STRUCTURE

The competent bodies for the operation of the IPPS MP-RP, are:

1. IPPS MP-RP Study Program Committee (SPC): consists of seven (7) members:

   - One (1) representative of the Medical School of the National and Kapodistrian University of Athens
   - One (1) representative of the Department of Medicine of the Aristotle University of Thessaloniki
   - One (1) representative of the Department of Medicine of the University of Ioannina
   - One (1) representative of the Department of Medicine of the University of Crete
   - One (1) representative of the Department of Medicine of the Democritus University of Thrace,

   which are faculty members and are elected by the Assemblies of the Collaborating Medical Schools/ Departments

   - One (1) representative of the National Center for Natural Sciences "Demokritos",
   - One (1) representative of the Greek Atomic Energy Commission,

   The President of the Study Program Committee (SPC), as well as the Director of the IPPS, come from the Medical School, which has the administrative support of the IPPS MP-RP.

2. IPPS MP-RP Coordination Committee (CC): consists of five (5) faculty members of the collaborating Medical Schools/Departments:

   - One (1) representative of the Medical School of the National and Kapodistrian University of Athens
   - One (1) representative of the Department of Medicine of the Aristotle University of Thessaloniki
   - One (1) representative of the Department of Medicine of the University of Ioannina
   - One (1) representative of the Department of Medicine of the University of Crete
   - One (1) representative of the Department of Medicine of the Democritus University of Thrace,

   which have undertaken postgraduate work and are elected by the SPC for a two-year term. CC members are not entitled to any additional remuneration or compensation for their participation in the Committee. President of CC is the Director of IPPS MP-RP. The term of the President of CC can be renewable once. The CC is responsible for monitoring and coordinating the operation of the program and:

   - It recommends to the SPC the distribution of the teaching work among the teachers of the IPPS MP-RP
   - It appoints the supervisor and the members of the three-member committee for the examination of dissertations

- It examines student issues such as applications for the suspension of the studies, extension of studies, etc., and makes recommendations to the SPC.
- It decides with the authorization of the SPC, on the financial management and in particular on the approval of the program's expenses and it certifies the relation between the training needs of the specific program and the requested expenses. According to this, the CC with relevant decision will approve an expense or a set of expenses and will justify the feasibility of their implementation according to the respective educational needs of the program.

3. Director of the IPPS MP-RP and his/her Deputy: is a member of the first level faculty or the level of associate professor, of the same or the related subject as the subject of the IPPS MP-RP. The Director of the IPPS MP-RP is a member and President of the CC. The Director of the IPPS MP-RP is appointed together with his/her Deputy, by decision of the SPC.

   The Director of the IPPS MP-RP makes recommendations to the competent bodies of the Foundation on any issue related to the effective operation of the program. The Director may not have more than two (2) consecutive terms and is not entitled to any additional remuneration for his administrative work as Director. The Director has the following responsibilities:

   a) He/She convenes a meeting of the CC
   b) He/She prepares the agenda of these meetings, taking into account suggestions of the members and bodies of the IPPS MP-RP
   c) He/She appoints elections to replace committee members due to vacancies
   d) He/She is responsible for the preparation of the budget and the report of the Program, which he/she submits to the SPC for approval
   e) He/She is responsible for monitoring the implementation of the budget and issuing payment orders for the expenditure concerned
   f) At the end of his/her term, as well as at the end of the term of CC, he/she prepares a detailed report of the research and educational work of the IPPS MP-RP, as well as of its other activities, with the aim of upgrading studies, making better uses of human resources, optimizing existing infrastructure and making socially beneficial use of the available resources of the IPPS MP-RP.

   The Deputy Director of the IPPS MP-RP is a Professor or Associate Professor and fulfills the duties of the Director in case of his/her absence.

   The IPPS MP-RP is supported by the Secretariat of the Program which is located at the Medical School of National and Kapodistrian University of Athens and is under the supervision of the Secretariat of the Medical School of National and Kapodistrian University of Athens. The Secretariat of the IPPS MP-RP has as its task the secretarial support of the Program, such as the preparation of the admission process for the candidates, the maintenance of the financial data of the Program, the secretarial support of the SPC and CC, the registration of scores, etc.

CATEGORIES AND NUMBER OF POSTGRADUATE STUDENTS

For the award of the Master's Degree, the following students shall be accepted upon selection: holders of Physics degrees issued by national Higher Education Institutes (AEI), of the School of Applied Mathematics and Natural Sciences (SEMFE) of the National Technical University of Athens (NTUA) with a specialization in Applied Physics or foreign peer institutes, the diplomas or degrees of which are recognized by the Hellenic National Academic Recognition Information Center (NARIC). In addition, holders of a degree from Departments of Higher Education Institutes (AEI)/ Technological Educational Institutes (TEI) of the country or foreign peer institutes, recognized by NARIC, in the field of health and biology sciences, are also accepted.

Only one per year shall be admitted as supernumerary members of the EEP, EDIP, and ETEP categories in accordance with the legislation in force.

The IPPS MP-RP accepts up to twenty-five (25) students per academic year and is scheduled to employ a total of about fifty (50) teachers, of whom 80% are from the collaborating University Departments/ Faculties, the National Centre of Natural Sciences "Demokritos" and the Greek Atomic Energy Commission and 20% from Universities and Research Centers in Greece and abroad, as well as visiting renowned scientists from the country or abroad who have a position or qualifications as a professor or researcher in a research center and visiting postdoctoral researchers, Greek or foreign young scientists, holders of a Ph.D. degree (the categories of teachers are described in detail in article 10). This corresponds to two (2) teachers per student.

SELECTION OF POSTGRADUATE STUDENTS

The selection of students is made in accordance with the current legislation and the provisions of the Postgraduate Studies Regulation.

Every May, by decision of the Study Program Committee (SPC), an announcement for the admission of postgraduate students to the IPPS MP-RP is published and posted on the website of the IPPS MP-RP and the collaborating Departments and Institutions.

This announcement also states the number of students whose dissertations will be supervised during the third academic semester by each Medical School/ Department of the collaborating Universities (indicatively: 3 postgraduate students each from the Collaborating Departments of Medicine and the rest by the Medical School of National and Kapodistrian University of Athens).

Candidates must indicate in their initial application the Medical Schools in which they wish to prepare their thesis in order of preference.

The relevant applications with the necessary supporting documents are submitted to the Secretariat of the IPPS MP-RP, within a deadline specified in the announcement and may be extended by a decision of the SPC.

The necessary supporting documents are:

1. Application form
2. Curriculum vitae (CV)
3. Copy of degree or certificate of completion of studies
4. Certificate of analytical score of undergraduate courses
5. Publications in peer-reviewed journals, if any
6. Evidence of professional or research activity, if any
7. Phototype of two sides of the identity card (ID)
8. Reference Letters
9. Very good command in English, Level B2

Graduates from foreign institutions must submit their recognition or start the process of recognition of the basic degree by the Hellenic National Academic Recognition Information Center (NARIC), in accordance with art. 34, para. 7 of Law 4485/17 and art. 101, par. 5 of Law 4547/18.

The selection of the candidates is carried out by a selection committee – which consists of at least one representative from each institution and is appointed by the CC – based on the following criteria:

- Degree grade at a rate of 10%
- Performance in undergraduate courses and diploma thesis related to the subject of IPPS MP-RP at a rate of 10%
- Research activity – Publications at a rate of 10%

- Reference Letters at a rate of 10%
- Oral Interview at a rate of 30%
- Performance in the entrance exam for the IPPS MP-RP (when held) at a rate of 30%. In case that entrance exams are not held, this percentage is divided among the rest criteria according to their rate.

The selection committee is responsible for the evaluation of postgraduate candidates and ranks them in order of success. Based on the overall criteria, the CC, after a recommendation of the selection committee, compiles the student evaluation table and submits it for approval to SPC.

The candidates selected shall be registered at the Secretariat of the IPPS MP-RP before the beginning of the IPPS courses.

Candidates with the same rank are accepted as supernumerary at a rate not exceeding 10% of the maximum number of entrants.

In the case of non-registration of one or more selected candidates, the runners-up, if any, will be invited to enroll in the Program, based on their order in the approved evaluation table.

STUDY DURATION

The duration of study at the IPPS MP-RP leading to the acquisition of the Master of Science degree is set at three (3) academic semesters, in which the time of preparation of the thesis is included.

The maximum time allowed for the completion of studies is set at five (5) academic semesters, under certain conditions (health reasons, pregnancy or postpartum, professional reasons, completion of experiments in research diplomas) upon application of the postgraduate student to the coordinating committee and decision of the SPC.

The SPC, in exceptional cases, decides, after a written request of the student, to suspend the attendance for up to two (2) academic semesters (twelve months), following a relevant recommendation by the CC.

COURSES CURRICULUM AND CREDITS

The IPPS in MP-RP starts in the winter semester of each academic year. In case of inability to start in the winter semester, it may be transferred to the spring semester, by the decision of the Study Program Committee (SPC).

A total of ninety (90) credit units (ECTS) are required to obtain a Master of Science degree. During the studies, postgraduate students are required to attend and successfully examine all courses, as well as to prepare a postgraduate thesis.

The courses are taught in person and through distance learning at a rate of up to 35% of the courses, and take place on a weekly basis at the premises of the Medical School of National and Kapodistrian University of Athens, the National Center for Natural Sciences "Demokritos" and the Greek Atomic Energy Commission, under the supervision and organization of the Medical School of National and Kapodistrian University of Athens.

The 3rd Semester (preparation and writing the thesis) takes place at the Medical School or Medical Department chosen by the student.

Lectures of the courses are given in Greek. In case of invited speakers from abroad and in the organization of seminars with invited speakers from abroad, the language can be English. In addition, after a decision of the SPC and in case there are students whose mother tongue is other than Greek, the courses may be held in English

A. The course schedule is as follows:

1st Semester (13 teaching weeks)

Courses	Teaching hours/week	ECTS
Atomic and Nuclear Physics	1.5	3
Ionizing Radiation Sources	1.5	2
Interaction of ionizing radiation with matter	3	5
Detection and Measurement of ionizing radiation	2.5	4
Medical Statistics, Computing and Image Processing	3	4
Parts of Biology, Anatomy, Physiology, and Physics of the human body	2.5	3
Radiation Dosimetry	3.5	5
Biological effects of ionizing radiation	2.5	4
Total	**20**	**30**

2nd Semester (13 teaching weeks)

Courses	Teaching hours/week	ECTS
Diagnostic and Interventional Radiology	3.5	5
Diagnostic and Therapeutic applications of Nuclear Medicine	4	6
Therapeutic applications of ionizing radiation (Radiotherapy, Brachytherapy)	5	7
Physical principles and medical applications of non-ionizing radiation	3	5
Radiation Protection of ionizing radiation	4.5	7
Total	**20**	**30**

3rd Semester

The 3rd semester (30 credits) includes the preparation and writing of a thesis, as well as the students' examination thereon before a three-member examination board, to be held in open session. Only students who have successfully completed all their obligations of the 1st and 2nd semesters may start preparing their thesis.

B. Analytical Syllabus

1st Semester

PART A.1: ATOMIC AND NUCLEAR PHYSICS, IONIZING RADIATION SOURCES, INTERACTIONS OF IONIZING RADIATION WITH MATTER, DETECTION AND MEASUREMENT OF IONIZING RADIATION

A.1.1: COURSE CONTENT

Subsection	Content	Learning Objective (No)
A.1.1. Atomic and Nuclear Physics	**Introduction to Quantum Mechanics** Black body (Planck), photoelectric effect, Compton scattering, Matter wave (De Broglie), Uncertainty Principle. **Atomic Physics and radiation** Rutherford – Bohr model, quantum mechanical approach, spin-orbit conjunction, magnetic dipole moment and Zeeman effect, exclusion principle and periodical system, X-rays, LASER. **Nuclear physics & Radiation** Nuclear structure and nuclei's properties (mass, radius, spin and magnetic dipole moment, MRI), binding energy and stability, radioactivity and radioactive transitions (α, β, γ, internal conversion, electron capture, natural radioactivity, radioactivity law, specific radioactivity), nuclear interactions, radionuclide production.	L.O. A.1.1.01 L.O. A.1.1.02
A.1.2. Ionizing radiation sources	Operation principles of X-ray tubes. X-ray tube spectrum. Filters and devices conforming the X-ray beam. X-rays in the body. Linear accelerator, Betatron, Radiation sources, Co-60 Sources, CyberKnife, Tomotherapy Environmental radioactivity: physical and technical radionuclides in the environment Nuclear Reactors Industrial Sources (radiography, irradiators, etc.)	L.O. A.1.2.01 L.O. A.1.2.02 L.O. A.1.2.03 L.O. A.1.2.04
A.1.3. Interactions of ionizing radiation with matter	**Photons interactions with matter** Photoelectric effect, Thomson scattering, Rayleigh scattering, Compton scattering, Klein-Nishina coefficient, electrons' energy distribution from Compton scattering, energy distribution of electron – positron pair production. **Particles attenuation and absorption with matter** Energy absorption, linear attenuation coefficient and exponential attenuation, half value layer, thin and wide beam, mass attenuation coefficient, energy transfer and absorption coefficient, total attenuation coefficient, the relative importance of the different mechanisms of interactions. **Charged particles interactions with matter** Heavy charged particles interactions with matter, electrons interactions with matter, electrons energy distribution,	L.O. A.1.3.01 L.O. A.1.3.02 L.O. A.1.3.03 L.O. A.1.3.04

	stopping power, restricted stopping power and linear energy transfer (LET). **Neutrons interaction with matter** Neutrons classification as kinetic energy function, neutrons interactions with heavy charged particles, neutrons penetration, mean free path, energy transfer from neutrons to matter, KERMA, neutrons fluence measurements and spectrum distribution with neutron activation method. Medical applications: analysis with neutron activation, therapy with neutron capture.	
A.1.4. Detection and measurements of ionizing radiation	**Instrumentation** Principle of detection ionizing radiation. Detectors' characteristics (sensitivity, response, output, etc.), ionization chamber, proportional chamber Geiger-Muller, multi wired proportional chamber (MWPC), drift chambers, scintillators, organic – inorganic scintillators, semiconductor detectors, silicon detectors, contact p-n and p-i-n [HPGE], high spatial resolution detectors, micro-zone detectors, neutron detectors. **Detectors electrical signal processing** Photomultiplier (structure, functionality, parameters) pre-amplifier, amplifier, differential and integration of signal, single channel analyzer (SCA), multi-channel analyzer (MCA), analog – digital conversion (ADC), time – digital conversion (TDC), nuclear instrumentation modules (NIM), CAMAC, VME-BUS, FAST-BUS, time of flight (TOF) techniques. Measurements of radioactive samples, statistics of radioisotopic measurements. Scintillators, γ-radiation detectors, γ-spectroscopy.	L.O. A.1.4.01 L.O. A.1.4.02 L.O. A.1.4.03 L.O. A.1.4.04 L.O. A.1.4.05

A.1.2: LEARNING OBJECTIVES

Subsection	**Learning Objectives (LO)**	
	No.	**Description** After completing the subsection, the student will be able to:
A.1.1. Atomic and Nuclear Physics	L.O. A.1.1.01	describe the basic principles of quantum physics and calculate physical parameters (energy, spin, etc) utilizing equations derived from quantum physics.
	L.O. A.1.1.02	explain the mechanisms at the atomic and nuclear level that lead to the emission of radiation.
A.1.2.Ionizing Radiation Sources	L.O. A.1.2.01	describe the mechanisms of X-ray production.
	L.O. A.1.2.02	describe the various natural and artificial radiation sources, detailing their respective radiation production mechanisms.
	L.O. A.1.2.03	explicate radioactivity concept and analyze radioactive decay mechanisms, while conducting activity calculations for samples of radioactive samples.

	L.O. A.1.2.04	comprehend the relevant physical quantities that characterize the distribution of emitted radiation, and perform measurements related to the fluence, the energy fluence, and other parameters used in describing emitted radiation.
A.1.3. Interactions of ionizing radiation with matter	L.O. A.1.3.01	possess knowledge and capability to articulate, with precision, the fundamental mechanisms governing the interaction of photons and particle ionizing radiation with matter, both to specialized and non-specialized audiences.
	L.O.A.1.3.02	evaluate the relative importance of each interaction mechanism depending on the energy and type of radiation.
	L.O.A.1.3.03	perform calculations pertaining to the energy deposition of diverse radiation types within matter, contingent upon the specific interaction phenomenon, the nature of the radiation (electromagnetic or particle), and its energy.
	L.O.A.1.3.04	elucidate the fundamental mechanisms governing the attenuation and absorption of ionizing radiation in matter and estimate the transmitted and absorbed radiation when it passes through a given material.
A.1.4. Detection and measurements of ionizing radiation	L.O. A.1.4.01	describe and explain the basic principles of ionizing radiation detection
	L.O. A.1.4.02	describe the basic types and the principle of operation of ionizing radiation detectors.
	L.O. A.1.4.03	evaluate and select the appropriate type of detector depending on the type of radiation source used in medical and non-medical applications.
	L.O. A.1.4.04	apply appropriate methods for the detection and measurement of ionizing radiation.
	L.O. A.1.4.05	assess the uncertainty associated with radiation measurements, identify the relevant influencing parameters, and propose potential avenues for enhancement.

PART A.2: MEDICAL STATISTICS, COMPUTING & IMAGE PROCESSING

A.2.1 COURSE CONTENT

Subsection	**Content**	**Learning Objective (No)**
A.2.1. Medical Statistics	**Probability** Definition & basic theory, random variables, distribution's parameters, binomial distribution, Poisson distribution, normal distribution, normal distribution of many variables, central limit theorem. **Statistics** Random sampling, methods of sampling, data processing, matrices, histograms, reliability intervals, correlation, linear and non - linear regression, t – test procedures, test $\chi 2$, test of good adjustment, non -	L.O. A.2.1.01 L.O. A.2.1.02 L.O. A.2.1.03 L.O. A.2.1.04

	parametrical tests, analysis of variability, multi - factorial analysis of variability, multi analyzing of regression. **Statistical processing of experimental data.** **Demonstration of statistical package (SPSS).**	
A.2.2. Computing	**PACS και Virtual Reality** **Introduction to Monte Carlo techniques** **Mathematical models in physiology and medicine:** The idea of modeling – introduction, motives, examples, the principle of induction. Methods and techniques of modeling: categories of mathematical models (stochastic and non-stochastic, compartmental models, control system models, etc), models' parameters (clearance rate, distribution volume, etc). Estimation of parameter-adjustment of models: estimation methods, tests, identification, validation. **Computational techniques and models** **Case studies:** Examples.	L.O. A.2.2.01 L.O. A.2.2.02
A.2.3. Image Processing	Introduction to Biomarkers. Introduction to Medical Imaging Systems and Medical Images. Detection of signal/image and digitization (methodology of signal and image sampling). Deterioration sources of signals/images (noise, signal to noise ratio). Measuring methods of the precision of the information of signal/image (PSF, LSF, etc.). Recovery/processing of signals/images information (filters, etc.). Processing of images from different imaging systems with emphasis on techniques and algorithms for the improvement, segmentation and three-dimensional imaging of medical information. Clinical applications of medical image processing with emphasis on alignment and fusion of medical images in radiotherapy.	L.O. A.2.3.01 L.O. A.2.3.02 L.O. A.2.3.03 L.O. A.2.3.04 L.O. A.2.3.05

A.2.2: LEARNING OBJECTIVES

Subsection	**Learning Objectives (LO)**	
	No.	**Description** After completing the subsection, the student will be able to:
A.2.1. Medical Statistics	L.O. A.2.1.01	describe and explain, with precision, the basic concepts of probability theory and statistics.
	L.O. A.2.1.02	apply appropriate statistical methods to data processing, and perform calculations of statistical quantities that describe experimental data.
	L.O. A.2.1.03	use appropriate software packages for statistical data processing.

	L.O. A.2.1.04	demonstrate familiarity with commonly used sampling methodologies as well as statistical tests such as t-tests and χ2-tests, etc.
A.2.2. Computing	L.O. A.2.2.01	describe and explain mathematical models used in physiology and medicine.
	L.O. A.2.2.02	apply appropriate computational techniques and models to estimate the relevant parameters.
A.2.3. Image Processing	L.O. A.2.3.01	describe and explain the procedures for detecting signals/images and digitizing them during medical imaging.
	L.O. A.2.3.02	discern and explain the sources of information alteration of the signals/images during medical imaging (including noise, resolution, etc.).
	L.O. A.2.3.03	describe the parameters on which image quality depends and suggest techniques and algorithms for improvement during medical imaging.
	L.O. A.2.3.04	describe the clinical applications of medical image processing to both specialized and non – specialized audiences.
	L.O. A.2.3.05	Evaluate and explain all modern methods used in clinical practice to align and fuse medical images obtained by either identical or different imaging systems.

PART A.3: INTRODUCTION TO BIOLOGY, ANATOMY, PHYSIOLOGY & PHYSICS OF THE HUMAN BODY

A.3.1: COURSE CONTENT

Subsection	**Content**	**Learning Objective (No)**
A.3.1. Anatomy	General for the tissues, organs – systems, skeleton, musculature, skin - breasts, circulatory system (heart - vessels), respiratory system, gastrointestinal tract, urinary system, reproductive system, peripheral nervous system, central nervous system, sensory organs.	L.O. A.3.1.01
A.3.2. Physiology	Introduction – Nervous system, Endocrine system, Blood, Respiratory system, Circulatory system, Digestive system, Urinary system.	L.O. A.3.2.01
A.3.3. Biology	Structure of biomolecules (nucleic acids and proteins). General description of animal cell (organelles, membrane structure). The nucleus and its functions (structure of chromatin and chromosomes, karyotype). Replication and transcription of DNA. DNA's lesions and repair mechanisms. Cell cycle (phases of the cell cycle and setting points of cell proliferation). Apoptosis Cell division (mitosis, decrease). Carcinogenesis, oncogenes and tumor suppressor genes. Telomeres and telomerase.	L.O. A.3.3.01 L.O. A.3.3.02 L.O. A.3.3.03 L.O. A.3.3.04
A.3.4. Physics of human body	**Optics**	L.O. A.3.4.01 L.O. A.3.4.02

Lenses, human's eye, mechanism of vision, refractive abnormalities, microscopy and electron microscopy, clinical applications.	L.O. A.3.4.03

A.3.1: LEARNING OBJECTIVES

Subsection	**Learning Objectives (LO)**	
	No.	**Description** After completing the subsection, the student will be able to:
A.3.1. Anatomy	L.O. A.3.1.01	possess knowledge and describe the various organs and systems of the anatomy of the human body.
A.3.2. Physiology	L.O. A.3.2.01	understand and describe the physiology of the various systems of the human body and assess their respective contributions to the functions of the human body.
A.3.3. Biology	L.O. A.3.3.01	describe the structure of cells and biomolecules.
	L.O. A.3.3.02	provide knowledge of potential DNA damage occurrences, analyze the corresponding repair mechanisms, and assess the cellular viability pertaining to the impact of various types of lesions.
	L.O. A.3.3.03	possess the capability to explain the process of cell division, along with the diverse phases associated with it.
	L.O. A.3.3.04	explain the causes and mechanisms of carcinogenesis and acquired a comprehensive understanding of the pivotal roles played by oncogenes and tumor suppressor genes.
A.3.4. Physics of human body	L.O. A.3.4.01	describe the anatomy of the human eye and the mechanism of vision.
	L.O. A.3.4.02	possess knowledge of the categories of refractive errors, their etiology and the corresponding clinical approaches used for treatment.
	L.O. A.3.4.03	understand the principle of operation of the microscope and electron microscope and possess knowledge for typical uses in clinical practice.

PART A.4: RADIATION DOSIMETRY

A.4.1: COURSE CONTENT

Subsection	Content	Learning Objective (No)
A.4.1. Radiation Dosimetry	**Radiation fields – Dosimetric quantities** Stochastic and deterministic quantities (physical meaning, definition, units). Relations between basic dosimetric quantities. **Dose calculations** Doses at interfaces - Particle equilibrium – Region build-up - Fano theorem - Cavity theory. Calculations of doses in a material from measurements of exposure or dose in another material. Transport of ionizing radiation. Analytical calculations of diffusion in patients (diffusion equations, method of spherical harmonics). **Microdosimetry - Quantities** **Dosimetric measurements** Electronic conductivity detectors: Integration type dosimeters. Choice of detector and phantom. Special cases.	L.O. A.4.1.01 L.O. A.4.1.02 L.O. A.4.1.03 L.O. A.4.1.04 L.O. A.4.1.05

A.4.2: LEARNING OBJECTIVES

Subsection	Learning Objectives (LO)	
	No.	**Description** After completing the subsection, the student will be able to:
A.4.1. Radiation Dosimetry	L.O. A.4.1.01	understand the physical parameters employed in the dosimetry of ionizing radiation and acquired comprehensive knowledge regarding the units of measurement associated with each quantity, along with the ability to describe the differences between stochastic and deterministic quantities.
	L.O. A.4.1.02	explain the relationships between the basic dosimetric quantities and understand the various cavity theories employed for the dose calculation in a material.
	L.O. A.4.1.03	perform dose calculations on a homogeneous material.
	L.O. A.4.1.04	describe with clarity the concept of microdosimetry and quantities involved.
	L.O. A.4.1.05	implement appropriate dosimetry equipment and apply corresponding protocols for dose measurements.

PART A.5: BIOLOGICAL EFFECTS OF IONIZING RADIATION

A.5.1: COURSE CONTENT

Subsection	Content	Learning Objective (No)
A.5.1. Biological effects of ionizing radiation	Cell-cycle phases and radioensitivity. Organizing of normal tissues and their classification by radiobiological terms. Early and late tissue reactions. Cell kinetics of malignant neoplasms and parameters. Cell survival curves after irradiation. Repair nonfatal actinic damage. Fragmentation of the dose – reoxygenation – redistribution of the cell cycle, endogenous radiosensitivity.	L.O. A.5.1.01 L.O. A.5.1.02 L.O. A.5.1.03 L.O. A.5.1.04 L.O. A.5.1.05

A.5.2: LEARNING OBJECTIVES

Subsection	Learning Objectives (LO)	
	No.	**Description** After completing the subsection, the student will be able to:
A.5.1. Biological effects of ionizing radiation	L.O. A.5.1.01	describe the cell cycle and its phases, and estimate the endogenous radiosensitivity in each cell cycle phase.
	L.O. A.5.1.02	explain the radiosensitivity of the various tissues of the human body and classify them from a radiobiological point of view.
	L.O. A.5.1.03	describe the cellular kinetics of malignant neoplasms, understand the parameters related to it, and explain them to a specialized or non – specialized audience.
	L.O. A.5.1.04	evaluate the repair mechanisms involved in non-lethal cellular damage and elucidate the key parameters upon which they depend.
	L.O. A.5.1.05	explain cell survival curves after irradiation and describe the influence exerted by oxygen, dose fractionation, and cell cycle redistribution on cell survival.

LABORATORY EXERCISES OF 1ST SEMESTER

A I. Detection and measurement of ionizing radiation

Usage of Ge detectors - Receive data. Analysis of spectra of Ge.

A. II. Biology

Usage of microscope and electrophoresis of nucleic acids.

A. III. Dosimetry

1. Films and radiocromic films
2. TLD dosimeters
3. Whole body counter
4. Calibration of dosimeters applied in diagnostic applications

A. IV. Biological effects of ionizing radiation

Irradiation of peripheral blood samples at a source of ^{60}Co from 0 up to 4Gy. Incubation of samples for 48h. Creation of cytogenetic preparations. Analysis under an optical microscope. Evaluation-assessment of absorbed radiation dose (biodosimetry).

2nd SEMESTER

PART B.1: DIAGNOSTIC AND INTERVENTIONAL RADIOLOGY

B.1.1: COURSE CONTENT

Subsection	Content	Learning Objective (No)
B.1.1. Classical Radiodiagnostics	High Voltage Generators – Fluctuation. Description ray machine	L.O. B.1.1.01 L.O. B.1.1.02 L.O. B.1.1.03
	Bucky	
	Reinforcing plates, image intensifiers	
	Radiographic film	
	Developer	
	X-ray - Geometrical characteristics of radiographic image	
	Mobile - Portable X-ray machines	
	Classical fluoroscopy	
	Dentists – Orthopantomograph	
	Mammography	
	CBCT systems	
B.1.2. X-ray image and modern radiodiagnostic techniques	Quality characteristics of radiographic image	L.O. B.1.2.01 L.O. B.1.2.02 L.O. B.1.2.03
	Angiographic systems – DSA	
	Process of digital radiological image	
	Image digitization	
	Computational tomography	
	Digital detectors in radiology (panels)	
B.1.3. Computed Tomography (CT)	Principles of CT	L.O. B.1.3.01 L.O. B.1.3.02 L.O. B.1.3.03
	Multislice CT	
	Advanced CT techniques	
	CT radiation dose	
	CT dose effects	
	Radiation protection in CT	
	Quality Assurance in CT	
B.1.4. Composition of the human body	Photo densitometry	L.O. B.1.4.01
	Whole body counter gamma radiation	
	Neutron activation Analysis	

	Other techniques	
B.1.5. Computed Tomography – Medical Section	The Central Nervous System, the Thorax, the Upper-lower Abdomen.	L.O. B.1.5.01

B.1.2: LEARNING OBJECTIVES

Subsection	**Learning Objectives (LO)**	
	No.	**Description** After completing the subsection, the student will be able to:
B.1.1. Classical Radiodiagnostics	L.O. B.1.1.01	describe the principle of operation of high-voltage generators and comprehend the parameters upon which the spectrum of emitted radiation relies.
	L.O. B.1.1.02	describe the different parts of a radiological system and understand the operation principles of a radiological system.
	L.O. B.1.1.03	describe the operation and the use of different types of radiological systems employed in clinical practice and discern the distinctions and similarities among these various types.
B.1.2. X-ray Image and modern radiodiagnostic techniques	L.O. B.1.2.01	possess knowledge of the qualitative characteristics of a radiological image, assess radiological images and provide effective options for improvement.
	L.O. B.1.2.02	describe with clarity the digital radiological processing.
	L.O. B.1.2.03	understand the operation principle of digital detectors and be able to explain the benefits of utilizing them in radiology.
B.1.3. Computed tomography (CT)	L.O. B.1.3.01	possess knowledge, and ability to describe the operation principle and types of CT, be able to distinguish and evaluate the differences between various kinds of CT.
	L.O. B.1.3.02	understand the physical quantities used for dose estimation in CT systems and evaluate the parameters that affect the absorbed dose in a CT system.
	L.O. B.1.3.03	acquire comprehension and the ability to evaluate the radiation exposure related to diverse CT examinations, appraise the radiation exposure associated with a CT scan, and provide recommendations concerning the necessary measures for radiation protection to a patient.
B.1.4. Composition of human body	L.O. B.1.4.01	describe the methods used to determine the composition of the human body.
B.1.5. Computed Tomography – Medical Section	L.O. B.1.5.01	understand and describe in detail the clinical use of CT systems, and recognize the parameters of each imaging protocol of a CT system.

PART B.2: DIAGNOSTIC AND THERAPEUTIC APPLICATIONS OF NUCLEAR MEDICINE

B.2.1: COURSE CONTENT

Subsection	**Content**	**Learning Objective (No)**

B.2.1. Physics of Nuclear Medicine	**Introduction in Nuclear Medicine** Principles, parameters and operation of: γ-camera, Tomographic γ-camera (SPECT), positron emission tomography (PET), dose calibrator, hybrid systems, probes. **Departmental analysis – Kinetic tracer** Dilution principle, identify tumor sites, composition of human body, measurements of blood flow, laboratory applications (uptake thyroid, blood volume, red cell survival, kinetics of colloids, glomerular filtration rate. **Internal Dosimetry** MIRD Methodology, absorbed dose calculation, absorbed fraction dose, reciprocity dose theorem, reversible absorbed dose.	L.O. B.2.1.01 L.O. B.2.1.02 L.O. B.2.1.03
B.2.2. Physics of in-vitro Nuclear Medicine	Radio-immunoassay. Quality control of radio-immunoassay.	L.O. B.2.2.01
B.2.3. In-vivo radiopharmaceutical preparations	**Radiochemistry in Nuclear Medicine**	L.O. B.2.3.01
	Radioisotopes production.	L.O. B.2.3.02
	Quality control of radiopharmaceutical – preparations	L.O. B.2.3.03
	Hospital preparation of radiopharmaceuticals. Labeled biomolecules.	L.O. B.2.3.04
	Technetium radiopharmaceuticals. **Quality assurance programs** Manufacture of PET radiopharmaceuticals. Manufacture FDG. Radiopharmaceuticals generators (Tc, Rb, etc.). Iodine production (I-131, I-124). **Radiopharmaceuticals production – Calculation and dose fragmentation** **Scintigraphic techniques (protocols)** Acquisition modes of scintigraphic image in different organs. Techniques of implementing the various dynamic studies. Techniques of implementing the external measurements (probes, sentinel).	
B.2.4. Diagnostic and therapeutic applications of Nuclear Medicine – Medical Section	Central Nervous System. Respiratory system. Kidneys - Urinary system. Digestive system. Circulatory system (heart - pottery). Pediatrics. PET in brain. Endocrine system. Skeletal system.	L.O. B.2.4.01

Hematopoietic system.

Obstetrics-Gynecology (sentinel node).

PET in Oncology.

Therapy, applications.

B.2.2: LEARNING OBJECTIVES

Subsection	Learning Objectives (LO)	
	No.	**Description** After completing the subsection, the student will be able to:
B.2.1. Physics of Nuclear Medicine	L.O. B.2.1.01	understand, describe the principle of operation of imaging systems used in Nuclear Medicine, and possess the knowledge to comprehend and elucidate the techniques of diverse types of Nuclear Medicine imaging systems.
	L.O. B.2.1.02	describe the basic principle and applications of partitional analysis.
	L.O. B.2.1.03	apply the internal dosimetry methodology for the calculation of absorbed dose from medical exposures in Nuclear Medicine.
B.2.2. Physics of in-vitro Nuclear Medicine	L.O. B.2.2.01	describe the radioanalysis techniques and relevant quality control procedures.
B.2.3. In vivo radiopharmaceutical preparations	L.O. B.2.3.01	describe and explain the production techniques of radioisotopes used in diagnostic and therapeutic procedures and the relevant quality assurance programs.
	L.O. B.2.3.02	describe the procedures for the preparation of radiopharmaceuticals for diagnostic and therapeutic purposes and the calculation and fractionation of doses.
	L.O. B.2.3.03	apply methods for the calculation and segmentation of doses in Nuclear Medicine.
	L.O. B.2.3.04	describe the scintigraphic techniques applied in Nuclear Medicine, possess the ability to discern the characteristics of a scintigraphic image, assess its quality, and propose recommendations for its enhancement.
B.2.4. Diagnostic and therapeutic applications of Nuclear Medicine – Medical Section	L.O. B.2.4.01	describe the diagnostic and therapeutic applications of Nuclear Medicine.

PART B.3: THERAPEUTIC APPLICATIONS OF IONIZING RADIATION

B.3.1: COURSE CONTENT

Subsection	**Content**	**Learning Objective (No)**
B.3.1. Radiobiological base of radiotherapy	Introduction to Radiotherapy (RT) of malignant neoplasms. The aim of RT, therapeutic index, neoplasms and normal tissues. Effects of ionizing radiation on biological materials (cells, damage DNA). Isoeffects standards NSD, TDF, CRE-historical background and their establishment. Linear-square model, establishment, equations. The ratio α / β. Tissues' sensitivity on dose's fragmentation. Total time RT. Calculations isoeffect doses for late effects and local tumor control, clinical applications.	L.O. B.3.1.01 L.O. B.3.1.02 L.O. B.3.1.03 L.O. B.3.1.04 L.O. B.3.1.05

	Schemes of modified dose fragmentation. Clinical studies and applications. Causes of RT failure. Efforts to improve the therapeutic index. Hyperthermia. 3-dimensional RT, dose-volume histograms. Analysis of clinical trials- clinical radiobiology- statistical methods and applications.	
B.3.2. Basic principles of external photon radiotherapy	Units and quantities for photon field description. Inverse square law. Diffusion of photon field to phantom or/and patient. Parameters of radiation field. Depth dose distribution in water with fixed source surface distance (SSD) technique. Depth dose distribution in water with fixed isocenter source distance (SAD) technique. Off-axis ratios and beam profiles. Dose distributions in water phantoms. Doses distributions in patients using a single field irradiation.	L.O. B.3.2.01 L.O. B.3.2.02
B.3.3. Dosimetry protocols in radiotherapy	Ionization chamber measurements in external photon beam radiotherapy. Protocols for measurements in external photon beam radiotherapy. Depth dose measurements in water using an ionization chamber in electrons field. Corrections at measuring point. Efficiency in depth and parameters affecting it. Protocol dosimetry in brachytherapy applications (AAPM TG-43).	L.O. B.3.3.01
B.3.4. Treatment planning	Designation and definitions of tumor-target and critical organs. Dose determination. Patient's (anatomic) data. Simulator - CT - MRI. Production of isodose curves. Wedge filters. Combining fields. Isocenter technique. Determination of tumor-target's dose. Block beam's formation. Skin dose. Separation of neighboring fields. Treatment verification. Correction of contour's inhomogeneity. Correction of tissue inhomogeneity. Tissue compensators.	L.O. B.3.4.01 L.O. B.3.4.02 L.O. B.3.4.03

	Patient's set up. Parameters of dose calculation and practical applications.	
B.3.5. Radiotherapy with electrons-Clinical and practical dosimetry	Electron interactions with matter. Loss of energy, stopping power, scattering, range. Depth dose distributions in water Isodose curves. Dose distributions in homogeneous and heterogeneous materials. Feasibility of combining fields. Corrections.	L.O. B.3.5.01 L.O. B.3.5.02
B.3.6. Brachytherapy	Radioactive sources. Callibration of radioactive sources. Dosimetric characterization of radioactive sources. The technological basis of brachytherapy and selected applications (low dose rate, permanent implant, high dose rate automatic afterloading sources, Interstitial, intracavity). Brachytherapy planning.	L.O. B.3.6.01 L.O. B.3.6.02 L.O. B.3.6.03
B.3.7. Modern Techniques	IMRT, VMAT. IGRT. Proton beams. Stereotactic radiosurgery – radiotherapy.	L.O. B.3.7.01
B.3.8. Medical Section	Cancer in Greece and in general (epidemiology). General principles of cancer pathology. Cancer metastases (lymph node and vascular). Staging (TNM). **Principles of radiotherapy** Hyperthermia (combined with radiotherapy). Whole body and half body radiotherapy. Brain radiosurgery (stereotactic) . Stereotactic conformal radiotherapy (whole body). Intrasurgery radiotherapy. Electrons (indications, techniques). Brachytherapy (intracavity, Interstitial). **Techniques** Lymphoma (techniques). Head and Neck Cancer (techniques). Skin cancer (technical). Prostate and bladder cancer (techniques). Lung Cancer (techniques). **Radiotherapy using radionuclides**	L.O. B.3.8.01 L.O. B.3.8.02

B.3.2: LEARNING OBJECTIVES

Subsection	Learning Objectives(LO)	
	No.	**Description** After completing the subsection, the student will be able to:
B.3.1. Radiobiological base of radiotherapy	L.O. B.3.1.01	Possess the knowledge and describe the goal of radiotherapy to both specialized and non-specialized audiences, the concept of therapeutic index, and the actions of ionizing radiation on biological materials.
	L.O. B.3.1.02	acquire understanding and the ability to apply the isoactive standards NSD, TDF, CRE.
	L.O. B.3.1.03	possess the knowledge and the ability to apply the linear-square model for the assessment of radiobiological effective dose.
	L.O. B.3.1.04	apply the knowledge to solve problems related to modified dose fragmentation schemes.
	L.O. B.3.1.05	compare and combine different dose fractionation schemes in clinical radiotherapy practice.
	L.O. B.3.1.06	possess the ability to evaluate, estimate and sum the radiobiological impact of varying radiotherapy dose fractionation regimens.
	L.O. B.3.1.07	evaluate, compare, combine and propose methods to improve the therapeutic index.
	L.O. B.3.1.08	demonstrate with clarity conclusions, the knowledge, reasoning and logical assumptions supporting them, to audiences comprising both specialists and non – specialists.
B.3.2. Basic principles of external photon radiotherapy	L.O. B.3.2.01	describe and explain the units, sizes and parameters used to describe photon fields.
	L.O. B.3.2.02	acquire the understanding of the functioning of radiotherapy systems utilized in external radiotherapy, and possess the ability to describe their mechanisms to both specialist and non – specialist audience.
	L.O. B.3.2.03	understand and describe depth dose distributions for the various techniques applied in radiotherapy.
	L.O. B.3.2.04	suggest the most suitable radiation beam quality in relation to the location of the target volume, explain depth dose distributions form different techniques used in radiotherapy.
B.3.3. Dosimetry protocols in radiotherapy	L.O. B.3.3.01	possess knowledge and describe current dosimetry protocols in radiotherapy.
	L.O. B.3.3.02	apply and evaluate/assess the dose using special phantoms and suitable detector.
	L.O. B.3.3.03	apply protocols for dosimeter calibration to measure dose in radiotherapy applications.
	L.O. B.3.3.04	apply the most suitable radiotherapy protocol related to the size of the target and radiation beam quality.
	L.O. B.3.3.05	recommend suitable dosimeters for comprehensive dosimetric control of a contemporary radiotherapy system.

B.3.4. Treatment planning	L.O. B.3.4.01	Possess knowledge and describe the process of planning a treatment and the parameters to be considered.
	L.O. B.3.4.02	compare and analyze radiotherapy plans.
	L.O. B.3.4.03	describe the process of determining the dose at the target volume.
	L.O. B.3.4.04	describe the concept of dose volume histograms used to estimate radiotherapy plans.
	L.O. B.3.4.05	compare different radiotherapy plans, and describe the procedure for determining the dose to the target volume.
	L.O. B.3.4.06	possess knowledge and explain the CT and MRI simulations utilized in radiotherapy.
B.3.5. Radiotherapy with electron beams- Clinical and practical dosimetry	L.O. B.3.5.01	possess knowledge, describe and explain the basic principles behind the use of electrons in radiation therapy.
	L.O. B.3.5.02	understand, distinguish and describe the depth dose distribution of electrons in water.
	L.O. B.3.5.03	determine the optimal energy of the electron beam based on the depth of the tumor undergoing radiotherapy.
	L.O. B.3.5.04	distinguish the benefit of using electrons to deliver the therapeutic radiation dose and suggest in which clinical cases electrons should be used over photons.
B.3.6. Brachytherapy	L.O. B.3.6.01	Describe and explain to both specialist and non – specialist audiences, the technological basis of brachytherapy and its applications.
	L.O. B.3.6.02	describe the procedure for calibration and dosimetric characterization of radioactive sources used in brachytherapy.
	L.O. B.3.6.03	describe and explain the process of planning a brachytherapy.
	L.O. B.3.6.04	evaluate and explain the differences between external radiotherapy and brachytherapy.
B.3.7. Modern techniques	L.O. B.3.7.01	possess knowledge about modern radiotherapy techniques IMRT, VMAT, IGRT, describe and explain them to both specialist and non – specialist audiences.
	L.O. B.3.7.02	describe and explain to both specialist and non – specialist audiences the radiotherapeutic technique of Stereotactic Radiosurgery – Radiotherapy.
	L.O. B.3.7.03	propose and support to both specialist and non – specialist audiences the benefits of each radiotherapy technique.
B.3.8. Medical section	L.O. B.3.8.01	understand and describe the general principles of cancer pathology.
	L.O. B.3.8.02	describe, compare and apply the clinical radiotherapy techniques in respect to the pathology of the cancer.

PART B.4: PHYSICAL PRINCIPLES AND MEDICAL APPLICATIONS OF NON-IONIZING RADIATION

B.4.1: COURSE CONTENT

Subsection	**Content**	**Learning Objective (No)**
B.4.1. Ultrasounds	Basic Principles.	L.O. B.4.1.01
	Interaction with tissues.	L.O. B.4.1.02
	Production and detection.	L.O. B.4.1.03
	Imaging methods.	
	Ultrasound Doppler.	
	Image quality and artifacts.	
	Biological Effects.	
	Quality control.	
	Clinical applications	
B.4.2. Magnetic Resonance	Basic principles of magnetic resonance.	L.O. B.4.2.01
	Effect of magnetic fields in nuclei, hydrogen nuclei density imaging, spectroscopy NMR.	L.O. B.4.2.02
	Basic principles of imaging (oblique fields, spin-echo, gradient echo, 2D and 3D techniques).	L.O. B.4.2.03 L.O. B.4.2.04
	Display and parameters which determine the signal-to-noise ratio, and image quality analysis.	L.O. B.4.2.05
	Technical errors (artifacts).	
	Magnetic resonance angiography (basic principles, techniques 2D vs 3D, TONE, magnetization transfer, phase contrast, MIP, and black blood angiography).	
	In vivo magnetic resonance spectroscopy (protons, phosphorus-31, etc.).	
	Spectroscopic imaging (spectroscopic imaging), fast spin and gradient echo, and functional MRI (functional MRI).	
	Imaging techniques (real-time MRI)-echo planar imaging and MRI angiography.	
	Security, protection from MRI	
B.4.3. Lasers	Physical principles of laser production, laser technology, biomedical applications, specific medical laser installations, laser interaction mechanisms with tissue, medical applications, dosimetry and safety. Principles of photodynamic.	L.O. B.4.3.01 L.O. B.4.3.02 L.O. B.4.3.03 L.O. B.4.3.04

B.4.2: LEARNING OBJECTIVES

Subsection	Learning Objectives (LO)	
	No.	Description After completing the subsection, the student will be able to:
B.4.1. Ultrasounds	L.O. B.4.1.01	describe and explain the basic principles governing the production and detection of ultrasound.
	L.O. B.4.1.02	possess knowledge and explain to both specialist and non – specialist audiences the biological effects of ultrasounds.
	L.O. B.4.1.03	describe and apply the basic methods of medical imaging using ultrasound.
B.4.2. Magnetic Resonance	L.O. B.4.2.01	understand and describe the basic principle at the phenomenon of magnetic resonance.
	L.O. B.4.2.02	possess knowledge and explain the basic principles of magnetic resonance imaging.
	L.O. B.4.2.03	possess knowledge and describe the current imaging techniques using magnetic resonance.
	L.O. B.4.2.04	possess knowledge, describe and implement appropriate radiation protection measures when using MRI systems.
	L.O. B.4.2.05	evaluate the implementation and effectiveness of radiation protection measures and propose procedures for their improvement.
B.5.3. Lasers	L.O. B.4.3.01	understand and explain the physical principles of laser radiation production.
	L.O. B.4.3.02	possess knowledge and apply all current applications of laser systems in medicine.
	L.O. B.4.3.03	Understand and apply appropriate radiation protection measures during the use of laser systems in medicine.
	L.O. B.4.3.04	evaluate the implementation and effectiveness of radiation protection measures and propose procedures for their improvement.

PART B.5: RADIATION PROTECTION

B.5.1: COURSE CONTENT

Subsection	Content	Learning Objective (No)
B.5.1. Guidelines for radiation protection	Principles, Legislative framework (IAEA, EC, National).	L.O. B.5.1.01 L.O. B.5.1.02
B.5.2. Overview	Shielding, exposure and dose calculations of photon beams, neutrons and charged particles.	L.O. B.5.2.01
B.5.3. Radiation protection in medical applications	**Diagnostic and interventional radiology** Design Laboratory (requirements and an example calculating the shielding and the sources). Radiation protection of workers and population.	L.O. B.5.3.01 L.O. B.5.3.02 L.O. B.5.3.03

	Optimization of patient's radiation protection.	L.O. B.5.3.04
	Quality assurance.	L.O. B.5.3.05
	Nuclear Medicine (diagnostic and therapeutic)	
	Design Laboratory (requirements and an example calculating the shielding and the sources).	
	Radiation protection of workers and population.	
	Optimization of patient's radiation protection.	
	Quality assurance.	
	Radiotherapy (teletherapy, brachytherapy)	
	Design Laboratory (requirements and an example calculating the shielding and the sources).	
	Radiation protection of workers and population.	
	Optimization of patient's radiation protection.	
	Quality assurance.	
	Safety and management of radioactive sealed sources.	
B.5.4. Radiation protection in industrial and research applications	Design Laboratory (requirements and an example calculating the shielding and the sources). Radiation protection of workers and population. Optimization of patient's radiation protection. Quality assurance. Safety and management of radioactive sources.	L.O. B.5.4.01 L.O. B.5.4.02 L.O. B.5.4.03
B.5.5. Radiation workers monitoring	Quantities / definitions. External monitoring. Internal monitoring. Special workers categories. Protocols (EC, ANSI, ISO).	L.O. B.5.5.01 L.O. B.5.5.02
B.5.6. Nuclear Reactors	**Overview** Operating principle – Introduction to reactors theory and control reactors. Fission, releasing energy, chain reaction - Parts of the reactor and their role - Cycle neutron, critical mass - and control activity is the reactor - Reactor Types - The cycle of nuclear fuel. **The reactor as radiation source** Direct and secondary radiation - Fission and activation products, Radioactive waste-Radiological effects during normal operation and accidents. **Reactor safety** Study of accidents, risk analysis, safety in design. Site selection. Multiple barriers, defense in depth. Technological protection measures, control-Radiological Safety organization for accidents. Emergency plans. Equipment – Authorities role. Licenses. Controls. **Impact on environment and population**	L.O. B.5.6.01 L.O. B.5.6.02 L.O. B.5.6.03 L.O. B.5.6.04

	Reactor' normal function. Releases to the environment. Workers and population monitoring in an accident case. Impacts. Dispersion in the atmosphere and doses to the population).	
B.5.7. Environmental radioactivity	Natural environmental radioactivity: sources, exposure pathways, doses. Artificial environmental radioactivity: sources, exposure pathways, doses. National environmental radioactivity monitoring system.	L.O. B.5.7.01
B.5.8. Emergency exposures	Emergency plan to radiological hazards. Radiological / nuclear accidents. Instant warning systems.	L.O. B.5.8.01

B.5.2: LEARNING OBJECTIVES

Subsection	**Learning Objectives (LO)**	
	No.	**Description** After completing the subsection, the student will be able to:
B.5.1. Guidelines for radiation protection	L.O. B.5.1.01	possess knowledge, describe the basic principles of radiation protection and apply them in everyday practice.
	L.O. B.5.1.02	understand and apply the basic requirements of the legislation for the proper operation of laboratories where ionizing radiation is used.
B.5.2.Overview	L.O. B.5.2.01	understand and apply the required formalisms to calculate exposures, doses and required shielding.
B.5.3. Radiation protection in medical applications	L.O. B.5.3.01	understand and apply the requirements regarding the design of laboratories for medical applications of radiation sources and the appropriate shielding of their spaces.
	L.O. B.5.3.02	implement appropriate measures for the radiation protection of worker, the general public and the patients, evaluate and propose strategies for the optimization of radiation protection.
	L.O. B.5.3.03	possess knowledge and implement appropriate quality assurance systems in organizations where medical exposures take place, evaluate existing quality assurance programs and propose methods for the enhancement.
	L.O. B.5.3.04	manage radioactive waste arising from Nuclear Medicine practices, conduct measurements and calculations of radioactive residue activity, assessing radiation impact on exposed individuals and the general population upon release.
	L.O. B.5.3.05	possess knowledge and manage safely the radioactive sources used in medical exposures.
B.5.4. Radiation protection in industrial and research applications	L.O. B.5.4.01	understand and apply the requirements concerning the design of labs of industrial and research applications of radiation sources and the appropriate shielding of their spaces.
	L.O. B.5.4.02	evaluate and implement appropriate measures for the radiation protection of workers and the general public, conduct measurements and calculations of radiation exposure of workers

		and the general population from industrial and research applications using ionizing radiation.
	L.O. B.5.4.03	implement and assess appropriate quality assurance systems in organizations where exhibitions are held for industrial or research purposes.
B.5.5. Radiation workers monitoring	L.O. B.5.5.01	understand and explain the quantities used in personnel dosimetry.
	L.O. B.5.5.02	possess knowledge and describe external and internal dosimetry procedures.
B.5.6. Nuclear reactors	L.O. B.5.6.01	describe with clarity, the principle of operation of nuclear reactors.
	L.O. B.5.6.02	understand and explain concepts related to the operation and use of nuclear reactors as radiation sources.
	L.O. B.5.6.03	possess knowledge and explain issues related to the impact of the operation of nuclear reactors on the environment and population.
	L.O. B.5.6.04	explain and analyze issues related to the safe operation of nuclear reactors, and be able to describe the general population the measures to be taken in case of emergency.
B.5.7. Environmental radioactivity	L.O. B.5.7.01	recognize and describe sources, routes of exposure and doses related to the natural and artificial radioactivity of the environment.
B.5.8. Emergency exposures	L.O. B.5.8.01	describe and explain to both specialist and non – specialist audiences, the main parts and actions included in the radiological agent emergency response plan, possess knowledge of historical nuclear accidents worldwide and be able to elucidate the underlying causes that led to each incident.

LABORATORY EXERCISES OF 2ND SEMESTER

B. I. Radiation Protection

1. Detectors/counters calibration for medical applications.
2. Calculation of doses and effective doses in radiology.
3. Practical radiation protection studies (diagnostic radiology, nuclear medicine, radiotherapy) – Exercises.

B. II. Radiotherapy

1. Linear accelerator.
2. Treatment planning.

B. III. Nuclear Medicine

1. γ-camera quality control.
2. Hot-cells.
3. RIA.

B. IV. Diagnostic radiology

1. X-ray tube and developer quality control.
2. Digital detectors.

B. V. Physics of Non-Ionizing radiation

Laboratory exercise with pulsed ultraviolet and infrared lasers and their biomedical application.

B. VI. Environmental Radioactivity

1. Radon.
2. α- spectroscopy.
3. Emergency.

B. VII. Radiation Protection of Non-Ionizing radiation

1. Measurements of non-ionizing radiation.
2. Measurements of cell phones radiation.
3. Measurements of base radiation.

SPECIAL LECTURES

1. Nuclear Energy: Modern applications
2. Radiation and pregnancy
3. Metrology of ionizing radiation
4. Installations for management and storage of radioactive waste
5. Transportation of radioactive material
6. Chernobyl accident and its consequences
7. Organization and methodology of research

EXAMINATIONS – STUDENT'S ASSESSMENT

The educational work of each academic year is structured in two (2) semesters of study, the winter and the spring, each of which includes thirteen (13) weeks of teaching and four (4) weeks of examinations. In case a student fails in the courses of the winter and spring semesters, he/she must re-sit in September.

The attendance of the courses/lab exercises, etc., is mandatory.

In case of a course not being held, it will be substituted. The date and time of substitution are posted on the website of IPPS MP-RP.

In the case that the percentage of student absences exceeds 20% per course / or in all courses, the issue of the student's deletion arises. This issue is examined by the CC, which provides an opinion on the matter to the SPC.

The evaluation of postgraduate students and their performance in the courses they are required to attend is carried out at the end of each semester with written examinations and / or with assignments throughout the semester. The method of evaluation is determined by the teachers of each course. Grading is done on a scale of 1-10. The grades of the courses are submitted to the Secretariat of the IPPS within twenty (20) days from the end of the examination period.

In order to obtain a Master's degree, each postgraduate student must attend and be successfully examined in all the courses offered by the IPPS and prepare a postgraduate thesis, thus collecting ninety (90) ECTS.

If a postgraduate student fails the examination of a course or courses, so that according to the provisions of the Postgraduate Studies Regulation, it is considered that he/she has not successfully completed the program, he/she is examined, upon application, by a three-member committee of faculty members/researchers of the Collaborating Institutions, whose members have the same or related subject to the examined course and are appointed by the SIC. The person in charge of the teacher examination is excluded from the committee.

In the third (3rd) semester of the Program, students are obliged to draft their postgraduate thesis. The Coordinating Committee, following a request from the candidate in which the proposed title of the thesis, the proposed supervisor and a summary of the proposed thesis are attached, designates the supervisor and sets up the three-member examination committee for the approval of the thesis, one of its members of which he is also the supervisor.

The supervisor and the other two members of the three-member examination committee come from all categories of teachers of the IPPS, holders of a PhD degree, in accordance with the current legislation.

The subject of the master's thesis must have a research character and novelty.

A necessary condition for starting the preparation of the thesis is the successful fulfillment of all the student's obligations in the 1st and 2nd semesters.

The language of the postgraduate thesis can be Greek or English.

The Master's thesis must be submitted computer-typed and printed on one side of the page, on good quality white A4 size paper, with adequate margins on all sides and with 1.5 body spacing while footnotes (or notes end) single. For footnotes (or endnotes) it is recommended to use the same font but a smaller font size than in the main text. Headings of chapters, sub-chapters and paragraphs may use a different font than that of the main text. In general, the format of the work should be simple.

In its final form, the thesis is filed bound in a single volume. The cover/title page of the paper must contain, in order from top to bottom: the logos of the collaborating institutions, the title of the IPPS, "Medical Physics – Radiation Physics", the title of the thesis, the full name of the postgraduate student, the name of the supervisors as well as the names of the members of the examination committee and the time of its submission. The size of the postgraduate thesis is at the discretion of the student in collaboration with the supervisor and is related to the requirements and specificities of the subject. The scientific completeness of the work is evaluated more than its size. A size of 50 to 150 pages is indicated, including any appendices, bibliography, tables and diagrams, etc., without these limits being limiting.

In order for the work to be approved, the student must present it to the examination committee in an open session.

Grading is done on a scale of 1-10.

Postgraduate thesis, if approved by the examination committee, must be posted on the website of the Medical School.

Also, the thesis is submitted electronically to the Digital Repository "PERGAMOS", in accordance with the decisions of the Senate of National and Kapodistrian University of Athens.

OBLIGATIONS AND RIGHTS OF POSTGRADUATE STUDENTS

1. Postgraduate students have all the rights and benefits provided for students of the 1st cycle of study (meal card, student ticket, reduced costs of participation in certain cultural and recreational events, insurance through the University) except the right to provide free textbooks.

The Institution is obliged to ensure that students with disabilities and/or special needs have access to the proposed texts and teaching. The Accessibility Unit of National and Kapodistrian University of Athens was established and operates with the decision of the University Senate dated February 23, 2006 and the decision of the Rector's Council dated March 22, 2006. Its task is to ensure in practice equal access to academic studies for students with different abilities and requirements, through the provision of adaptations to the environment, Supportive IT Technologies and Access Services.

2. Postgraduate students are invited to participate and attend seminars of research groups, discussions of bibliographic information, visits of laboratories, conferences / workshops with a subject related to that of the IPPS, lectures or other scientific events of the IPPS, etc.

3. For the student of the IPPS MP-RP with the highest average grade in the courses of the first two semesters (in case of a tie with the highest grade in the course of Nuclear Medicine Physics) a scholarship equal to the tuition fees of all three semesters is provided, provided that they do not exceed the total amount of 2,000 euros, within the framework of the Prize in memory of Professor Charalambos Proukakis, founder of the Laboratory of Medical Physics of the Medical School of National and Kapodistrina University of Athens and of the IPPS "Medical Physics – Radiation Physics" in 1994.

4. The SPC, following the recommendation of the CC, may decide to delete postgraduate students:

- if they exceed the maximum number of absences
- if they have failed a course or courses examination and have not successfully completed the program
- if they exceed the maximum duration of study at the MSc, as defined in this Regulation,
- if they have violated the written provisions regarding the treatment of disciplinary offenses by the competent disciplinary bodies,
- automatically at the request of postgraduate students,
- if they do not pay the prescribed tuition fee

5. Students of IPPS MP-RP are exempted from tuition fees, whose individual income, if they have the same income, and the equivalent family available income do not independently exceed one hundred percent (100%) of the individual, and the family seventy percent (70%) of the national median disposable equivalent income, according to the most recent data published each time by the Hellenic Statistical Authority (EL.STAT.). This exemption is granted for participation in a single IPPS. In any case, the exempted students do not exceed the percentage of thirty percent (30%) of the total number of students admitted to the IPPS MP-RP. If the beneficiaries exceed the percentage of the previous paragraph, they are selected in order of ranking starting from those with the lowest income (article 35, par. 2, Law 4485/17).

6. At the end of each semester, each course and each teacher are evaluated by the postgraduate students. The results of the evaluation of the students regarding the entire Postgraduate Program and its activities will be posted on the website of the program. The results of the evaluation of each teacher will be shared to him/ her.

7. The inauguration takes place in the context of the Assembly of the Medical School in the presence of the President of the Medical School.

8. A Postgraduate Degree is not awarded to a student whose first-cycle degree from a foreign institution has not been recognized by the Hellenic National Academic Recognition Information Center (NARIC), according to Law 3328/2005 (A΄ 80).

9. Postgraduate students can apply for a diploma supplement

10. For their participation in the IPPS MP-RP, postgraduate students pay tuition fees amounting to two thousand euros (€ 2,000) corresponding to seven hundred and fifty euros (€ 750) for each of the first two semesters and five hundred euros (€ 500) for the third semester corresponding to the Master's thesis. The fee is paid at the beginning of each semester.