Yarmouk University

Faculty of Science

Physics Department

Study Plan for the Master of Science Degree

in Medical Physics

(Thesis Track)

2020

Study Plan for the Master of Science Degree in Medical Physics

(Thesis Track)

First: The applicant to this program is required to have the following:

1. Holds a bachelor's degree in one of the following: medical physics, biomedical physics, physics, or a related field approved by the department.
2. Passing the English language requirements to join the program according to the university regulations.
3. Any other conditions approved by the competent committees and councils.

Second: **The Master of Science Degree in Medical Physics (Non-Thesis) is awarded upon the fulfillment of the following requirements:**

1. Achievements of the conditions specified in the regulations for awarding the master's degree at Yarmouk University No. (3) for the year 2011.
2. Completion of the remedial courses recommended by the Department Graduate Studies Committee.
3. Successfully completing at least 33 credit hours of the courses of 600 level and passing them with a GPA of at least 75% distributed as follows:

   a) **Obligatory Courses**: (18 credit hours) as follows:

No.	Course No. and code	Course Title	Credit Hours
1.	MPHY 602	Anatomy and Physiology for Physicists	1
2.	MPHY 641	Radiation Physics	3
3.	MPHY 642	Radiobiology	2
4.	MPHY 643	Health Physics and Radiation Protection	3
5.	MPHY 644	Physics of Nuclear Medicine	3
6.	MPHY 661	Physics of Radiotherapy (1)	3
7.	MPHY 681	Physics of Medical Imaging (1)	3

b) **Elective Courses** (6 credit hours) chosen from the following:

No.	Course No. and code	Course Title	Credit Hours
1.	PHYS 601	Mathematical Physics	3
2.	PHYS 633	Computational Physics	3
3.	PHYS 641	Nuclear Physics	3
4.	PHYS 649	Nuclear Measurements	3
5.	MPHY 611	Biophysics	3
6.	MPHY 662	Physics of Radiotherapy (2)	3
7.	MPHY 682	Physics of Medical Imaging (2)	3
8.	MPHY 683	Image Processing and Analysis	3
9.	MPHY 691	Special Topics in Medical Physics	3

4. Preparing and successfully passing the defense of a master's Thesis (MPHY 699) which is allocated 9 credit hours. For registration purposes, the Thesis appears as follows:

No.	Course No. and code	Course Title	Credit Hours
1.	MPHY 699A	Thesis	0
2.	MPHY 699B	Thesis	3
3.	MPHY 699C	Thesis	6
4.	MPHY 699D	Thesis	9

Graduate Courses Description

MPHY 602 Anatomy and Physiology for Physicists (1 credit hour)

Course Description

Educate medical physicists in the basic physiology, anatomy and biology relevant to their profession. This includes introduction to medical terminology of human organs and of human diseases. This course describes basic medical anatomy from 3D re-sliced medical images (Axial, Sagittal, Coronal, and oblique reformat) and from 2D projections of medical data (anterior-posterior and posterior-anterior orientations).

Course Objectives

- To give the student necessary information in physiology and anatomy to be an effective member of a medical team
- To give students valuable medical information and terminology for the practice of clinical medical physics

Course Outcomes

1. Explain the medical wording root, suffix, and prefix
2. Define all parts of the human body (directions)
3. Describe the human skin system
4. Describe the human skeletal and muscular systems
5. Describe the digestive and respiratory systems
6. Explain the structure of the Central Nervous System
7. Describe the cardiovascular system
8. Describe the morphology of the human urinary system
9. Explain the physiological process for the different human organs

MPHY 611 Biophysics (3 credit hours)

Course Description

Subject, role, and importance of biophysics. Biophysics – biotechnology. Cellular organization of life. Biomechanics which includes equilibrium in the human body, fluid mechanics, blood circulation and ECG. Heat transport and metabolic processes in the body. Solute transport through biological membranes. Solvent transport. Ion transport and resting potential. Molecular and cellular imaging. Bioelectricity and Signal transport in nerve cells. Overview of experimental methods in examining structure and dynamics of biological systems.

Course Objectives

1. To introduce the students to interdisciplinary biophysics research.
2. To give an insight into the basic concepts of the structure and function of biological systems from molecule to the brain and to give an overview of the latest experimental methods.
3. To emphasize the close connection between biophysics and biotechnologies of the future

Course Outcomes

1. understanding the link between the structure and functions of biological system from molecular to system level
2. understanding fundamental characteristics of the living matter
3. getting insight on how experimental methods and theoretical approaches from physics can give answers related to the structure and functions of biological systems

4. understanding diffusion processes and their role in the transport phenomena across the biological membrane
5. understanding the relationship of the membrane transport mechanisms and the electrical activity of the cell and brain signals.

MPHY 641 Radiation Physics (3 credit hours)

Course Description
The course covers basic concepts and physical and mathematical principles related to the interaction of radiation with matter and the deposition of energy in the material, and includes an in-depth understanding of the basic quantities and units used in the calculation of quantities associated with radiation. Applications will also be focused on the principles used in radiation detection and radiation dosimetry

Course Objectives
1. Introduce the student to the basic mathematical and physical principles necessary to understand the radiation interaction with the matter
2. Introduce the students to the basic quantities and units used in radiation physics
3. Provide students with applications in the field of radiation protection and radiation dosimetry

Course Outcomes
1. Understand the basic principles of the processes associated with radiation interaction with the matter (X-rays, gamma rays, electrons, charged heavy particles, neutrons)
2. Perform basic calculations in the field of radiation protection.
3. be able to study the sources of radiation in nature and its interaction with the matter

MPHY 642 Radiobiology (2 credit hours)

Course Description
Covers the fundamental aspects of radiobiology with specific emphasis on relative biological effectiveness and linear energy transfer, the oxygen effect, radiation carcinogenesis, DNA repair, hereditary effects of radiation, radiation-induced cell killing, cellular responses to radiation including cell cycle effects and activation of cell signal transduction pathways, early and late effects of radiation, and time, dose and fractionation in radiotherapy.

Course Objectives
Enable the student to understand the effect of ionizing radiation on the human body

Course Outcomes
1. Understand the physical, chemical and molecular basis of the effect of radiation on biological systems
2. Describe the radiation principles that form the basis for the use of radiation in the treatment for cancer
3. Understand the possible long-term and short-term effects of radiation on normal tissues and organs and on the whole body

MPHY 643 Health Physics and Radiation Protection (3 credit hours)

Course Description

Physical and biological aspects of the use of ionizing radiation in industrial and academic institutions; physical principles underlying radiation protection devices, biological basis for radiation safety, waste disposal; radiation safety guidelines; devices used in health physics, external and internal radiological safety, Protection from non-ionizing radiation.

Course Objectives

1. Learn the basic quantities and units used in radiation protection.
2. Learn how to apply the concepts of external / internal radiation doses and how to calculate them.
3. Identify the of biological effects of ionizing radiation.
4. Identify of radiation protection methods and how to calculate them.
5. Learn the radiation protection concepts, legislation and regulations.

Course Outcomes

1. Determine the amount of exposure to radiation by calculation or measurement.
2. Calculate the internal dose from different radiation sources.
3. Calculate the external dose from different radiation sources
4. Learn about international agencies that set the regulations and laws related to radiation.
5. Identify theoretical concepts used in radiological safety practices, and consider the ethical consequences of radiological safety regulations.
6. Determine the shielding required to determine the limit of permissible exposure.
7. Understand the biological consequences of radiation exposure.
8. Assess the effectiveness of radiation safety practices in view of the theoretical, economic, political and social perspectives.

MPHY 644 Physics of Nuclear Medicine (3 credit hours)

Course Description

Nuclear physics is a major branch of medical imaging systems. There are three main devices in medical imaging: gamma camera, positron emission, and photon emission. These systems monitor the distribution of radioactive materials within the human body. Images resulting from medical imaging give clinical information about certain functions of human organs. This issue is not available or is not readily available by other medical imaging modalities such as CT and MRI. This course describes the basic concepts of nuclear medical physics and the interaction of the pharmaceutical substance with the body, and describes nuclear imaging devices. In addition, it provides an explanation of aspects related to radioactive materials, including processes of production, absorption and clearance. It then goes on to explain common clinical applications and provides valuable diagnostic information from these applications. These include clinical significance of various organs such as heart, kidney, thyroid, brain, and bones. Finally, he gives a lot of details about major developments in both radioactive materials and nuclear-related devices as in PET / CT and SPECT / CT.

Course Objectives

1. Cover basic principles in nuclear medicine physics and related devices.
2. Description of the medical imaging system in nuclear medicine and its main components for machines (Gamma Camera, SPECT, & PET)
3. Description of common clinical applications associated with nuclear imaging and treatment devices.

Course Outcomes

1. Know basic principles in nuclear medicine physics and how radiation interact with matter.
2. Distinguish between the different types of devices used in nuclear medicine and the knowledge of the principles of its work and its components and the differences between them: imaging scheme (gamma camera), photons emission SPECT, positron emission PET
3. Know the aspects related to radioactive materials in nuclear medicine, including production processes, absorption, and clearance.
4. Know common clinical applications in nuclear medicine and understand the clinical importance of different organs in the human body such as: heart, kidney, thyroid, brain, and bones.
5. Recognizes the significant developments in both radioactive materials and nuclear-related devices as in PET / CT and CT /.

MPHY 661 Physics of Radiotherapy (1) (3 credit hours)

Course Description

Overview of role of radiotherapy and radiobiology. Interaction of x-rays and electrons with body-equivalent materials Operation of x-ray therapy units, cobalt-60 teletherapy units and linear accelerators. Physical aspects of clinical application. Isodose curves and variation with incident radiation energy and modality. Treatment planning and dose calculations for external beam radiation therapy and brachytherapy are emphasized. Treatment planning techniques for single fields, two fields and multiple fields. Beam modifiers. Brachytherapy: Interstitial and intracavity techniques used, high and low dose rate and after-loading procedures. Quality assurance in radiotherapy

Course Objectives

- Introduce the student to the physical principles used in understanding the interaction of X-rays and electrons with living matter.
- Introducing the student to the principle of the devices used in radiotherapy.
- Application of physical principles in the calculation of external doses and therapeutic planning.
- Introduce the treatment using internal radiation sources

Course Outcomes

1. Understand the physical principles of Co-60 machines and linear accelerators
2. Calculate the External doses received by the patient
3. Describe the calibration procedures of Co-60 machines and LINACs and the dosimetric functions associated with the calibration process
4. Use the Isodose curves in designing a treatment plan
5. Understand the principles of quality assurance in radiotherapy
6. Describe the sources used in Brachytherapy
7. Calculate the doses from internal radiation sources

MPHY 662 Physics of Radiotherapy (2) (3 credit hours)

Course Description

Advanced treatment techniques including conformal and intensity modulated radiotherapy.; imaging in radiotherapy; proton and ion beam therapy. Electron therapy. Molecular radiotherapy; radionuclides employed; dosimetry techniques.

Course Objectives

1. To shed the light on the advanced techniques in radiotherapy
2. To give a description of the use of proton beams and ion beams in therapy
3. To discuss the use of the molecular therapy

Course Outcomes

1. To learn about integration of imaging in cancer therapy
2. To learn about future developments in cancer treatment which include: proton and ion beam therapy, electron and molecular therapy.

MPHY 681 Physics of Medical Imaging (1) (3 credit hours)

Course Description

Describe how the main medical imaging modalities work, components used, factors influencing image quality, radiation dose and safety, and image reconstruction techniques. Encompass the following ionizing and non-ionizing radiation medical imaging modalities: X-ray Radiography, Mammography, Fluoroscopy, X-ray Computed Tomography, Nuclear Medicine, Magnetic Resonance Imaging, and Ultrasound.

Course Objectives

1. Cover one of the main subfields of Medical Physics which is Diagnostic Medical Imaging
2. Help the student use medical imaging in research and other subfield of medical physics

Course Outcomes

1. Describe the X-ray radiography and the factors affecting image quality and radiation dose
2. Describe the X-ray mammography and the specialized devices used
3. Describe the X-ray Fluoroscopy machine and its usage
4. Describe X-ray Computed Tomography, image quality, radiation dose, and the image reconstruction techniques
5. Describe Nuclear Medicine Imaging, image quality, and the image reconstruction techniques
6. Describe Magnetic Resonance Imaging, factors affecting image quality, pulse sequences, and safety

Describe Ultrasound imaging, image quality, & safety

MPHY 682 Physics of Medical Imaging (2) (3 credit hours)

Course Description

Advance Description of how the main medical imaging modalities work, components used, factors influencing image quality, radiation dose and safety, and image reconstruction techniques. Encompass the following ionizing and non-ionizing radiation medical imaging modalities: X-ray Radiography, Mammography, Fluoroscopy, X-ray Computed Tomography, Nuclear Medicine, Magnetic Resonance Imaging, and Ultrasound.

Course Objectives

1. Advance Covering in one of the main subfields of Medical Physics which is Diagnostic Medical Imaging
2. Help the student use medical imaging in research and other subfield of medical physics

Course Outcomes

1. Advance description in X-ray radiography and the factors affecting image quality and radiation dose
2. Advance description in X-ray mammography and the specialized devices used

3. Advance description in the X-ray Fluoroscopy machine and its usage
4. Advance description inX-ray Computed Tomography, image quality, radiation dose, and the image reconstruction techniques
5. Advance description in Nuclear Medicine Imaging, image quality, and the image reconstruction techniques
6. Advance description in Magnetic Resonance Imaging, factors affecting image quality, pulse sequences, and safety
7. Advance description in Ultrasound imaging, image quality, & safety

MPHY683 Image Processing and Analysis (3 credit hours)

Course Description

Cover the fundamental components of medical image processing, analysis, and 2D visualization. Applications of several types filters in spatial and frequency domains. Describe image operations, segmentations, registration, and 3D visualization. Implementations of an image processing and analysis application using the visualization toolkit (i.e. VTK) and scriptive languages (i.eTcl/Tk).

Course Objectives

1. Specific covering in the application of medical image processing and analysis
2. Help the student use image processing and analysis in research and in medical physics

Course Outcomes

1- Possess an understanding of the fundamental characteristics of digitals images, image processing, analysis, and 2D display
2- Possess knowledge of basic algorithms for image operations, filtering in spatial and Fourier domains (Convolution, Fast Fourier Transform, Low Pass and High Pass Filters)
3- Image Operations (erosion and dilation, opening, and closing)
4- Possess knowledge of basic algorithms in segmentation, Registration, and 3D Visualization (Surface Shaded Display and Volume Rendering).
5- Ability to explore a range of practical techniques, by developing their own simple processing functions using library facilities and tools such as, e.g., Vtk and Tcl/Tk.
6- Are able to use relevant and suitable methods when carrying out research and development activities in the area of image processing

MPHY 691 Special Topics in Medical Physics (3 credit hours)

Course Description

One of the advanced topics in medical physics, which is not covered in the study plan

Course Objectives

1- Ability to cover other advanced materials in medical physics
2- Provide flexibility in the study plan to cover two sub-sections in medical physics

Course Outcomes

Depends on the course provided by a faculty member which must be determined before giving this course

PHYS 601 Mathematical Physics (3 credit hours)

Course Description

Homogenous boundary value problems, Bessel's functions, Legendre functions and Spherical harmonics, Inhomogeneous boundary value problems, Green's functions for boundary value problems, Complex variables and evaluation of integrals, Integral equations

Course Objectives

To find solutions for the Homogenous boundary value problems, Bessel's functions, Legendre functions and Spherical harmonics, Inhomogeneous boundary value problems, Green's functions for boundary value problems, Complex variables and evaluation of integrals, Integral equations

Course Outcomes

1- To learn new techniques in solving partial differential equations
2- To learn new techniques in solving boundary value problems
3- To apply the new techniques in treating waveguides
4- To learn new techniques in evaluation of integrals
5- To solve physical problems using integral equation technique

PHYS 633 Computational Physics (3 credit hours)

Course Description

using the Linux operating system as a platform for scientific computation due to the GNU free license for most of the tools needed. It includes the installation and maintenance of the UBUNTU or MINT flavors of the Linux OS. Advanced shell programing and its advanced tools like sed, awk and Perl. C++ and FORTRAN compilers and merging the two codes from both languages. Numerical libraries. Advanced numerical techniques: Quantum dynamics and Mote Carlo techniques, large scale minimization techniques using the gradient or conjugate gradient algorithms, fast Fourier transforms and the transfer matrix. Applications in the fields of condensed matter physics, nuclear physics, medical physics, electrodynamics, quantum mechanics and statistical thermodynamics.

Course Objectives

To provide the student with the ability to use the computer to solve advanced teaching and research problems in physics, as well as the ability to model complex physical problems so that they become computational.

Course Outcomes

1- Install Linux from fresh and fix common problems.
2- Write shell codes and use basic tools like sed and Perl.
3- Use the gnu C++ and FORTRAN compilers and their common options.
4- Link the codes written using C++ and FORTRAN and use the numerical libraries.
5- Model a physical problem and write an algorithm to solve it.
6- Study and modify ready codes.

PHYS 641 Nuclear Physics (3 credit hours)

Course Description

Basic nuclear structure, Nuclear decay and radioactivity, Nuclear reactions, Nuclear scattering, Reaction cross sections, Nuclear fission, Nuclear fusion, Nuclear spin and moments, Particle physics, Applications of nuclear physics, Experimental analysis.

Course Objectives

1-Compute some of nuclear properties (Binding Energy, quadrupole moment, magnetic dipole moment, ….).
2- Understand the meaning of shell model and use it to calculate properties of simple nuclei.
3- Understand the physics of scattering (i.e. the process, the geometry, and the reaction cross sections) in nuclear reactions.
4- Compute calculations related to nuclear scattering (energy of elastically and inelastically scattered particles, the scattered angle, the cross section, ...).
5- Distinguish between nuclear fission and nuclear fusion (characteristics, reactors, controlled reactions, and energy).
6- Know some of the techniques used to obtain information about spin quantum number and moments.
7- Know Quark model, particle interactions and particle families.
8- Know the importance of nuclear physics applications in different fields.

Course Outcomes

1- Identify basic nuclear properties and outline their theoretical descriptions
2- Understand different decay modes, their state selection rules
3- Calculate the Q-value for different decays and nuclear reactions
4- Calculate the cross section and the angle of scattered particles in scattering process.
5- Summaries and account for the main aspect of at least one application of nuclear physics.
6- Develop critical thinking and independent learning, work effectively within a team.

PHYS 649 Nuclear Measurements (3 credit hours)

Course Description

This course introduces the principles and applications of nuclear detector systems, including detector theory, electronic signal processing, measurement techniques and data analysis in various reagents. The course also includes a detailed description of the various detector systems such as gas-filled ionization chambers, proportional meters, Geiger Muller counters and high-purity germanium detectors to detect alpha, beta, gamma and neutron detectors. This course also covers measurement limits for each detector and Dead Detector time.

Course Objectives

1. Classification of different detectors
2. Explain the physical principles of the operation of different detectors.
3. Learn how to use nuclear detectors.
4. Recognition of spectral nuclear techniques and methods.
5. Differentiating between different types of modern detectors in terms of structure and performance.
6. Analysis of the results measured by different detectors.
7. Know the measurement limits for each detector.
8. Apply the principles of statistics and error analysis to solve problems related to the accuracy and efficiency of each detector

Course Outcomes

1. Identify the types of nuclear detectors and the principles of their work.
2. Distinguish between different types of nuclear detectors according to their use.
3. Identify how each detector is used in the relevant facilities and laboratories.
4. Has the ability to analyze the results and data.
5. Apply new skills using critical thinking and independent learning through group work in a research team.

MPHY 699A	**Thesis**	**(0 credit hours)**
MPHY 699B	**Thesis**	**(3 credit hours)**
MPHY 699C	**Thesis**	**(6 credit hours)**
MPHY 699D	**Thesis**	**(9 credit hours)**