Yarmouk University

Faculty of Science

Physics Department

Study Plan for the Master of Science Degree

in Nuclear Physics

(Comprehensive Exam Track)

2018

Study Plan for the Master of Science Degree in Nuclear Physics

(Comprehensive Exam Track)

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

1. Holds a bachelor's degree in one of the following: physics, medical physics, biomedical physics, mathematics, chemistry or nuclear engineering.
2. Passing the foreign 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 Nuclear 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**: (15 credit hours) as follows:

No.	Course No. and code	Course Title	Credit Hours
1.	PHYS 601	Mathematical Physics	3
2.	PHYS 605	Physics of Plasmas	3
3.	PHYS 641	Nuclear Physics	3
4.	PHYS 647	Radiation Physics	3
5.	PHYS 649	Nuclear Measurements	3
6.	PHYS 651	Quantum Mechanics	3
7.	PHYS 661	Statistical Mechanics	3
8.	PHYS 695	Project	3

b) **Elective Courses** (9 credit hours) chosen from the following:

No.	Course No. and code	Course Title	Credit Hours
1.	PHYS 611	Classical Mechanics	3
2.	PHYS 621	Advanced Lab	3
3.	PHYS 631	Classical Electrodynamics	3
4.	PHYS 633	Computational Physics	3
5.	PHYS 640	Physics of Radioactive Waste and Management	3
6.	PHYS 642	Nuclear Physics 2	3
7.	PHYS 643	Elementary Particle Physics	3
8.	PHYS 644	Atomic and Molecular Physics	3
9.	PHYS 646	Physics of Nuclear Reactors	3
10.	PHYS 648	Health Physics and Radiation Protection	3
11.	PHYS 665	Accelerator Physics	3
12.	PHYS 691	Special Topics	3

4. P Passing the Comprehensive Exam (PHYS 698) according to the valid regulations and is allocated zero credit for the registration purposes

Graduate Courses Description

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 605	Physics of Plasmas	(3 credit hours)
Course Description		
"Plasma Oscillations, Plasma Shielding, Interaction of Electromagnetic Waves With a Plasma Medium, Propagation of Waves in a Magneto-ionic Medium, Radiation From Electric Sources in Magnetized and Unmagnetized Plasmas, Electro-acoustic Waves, Vlasov Equation for Warm Plasmas Magnetohydrodynamics		
Course Objectives		
1- To learn the possible natural modes of plasma oscillations 2- To learn the phenomena of electrostatic Debye shielding 3- To study plasma radiation 4- To solve Vlasov equation for warm plasmas 5- To study the different types of plasma waves in Vlasov plasmas 6- To study the variety of Magneto-hdrodynamic waves existing in a plasma medium		
Course Outcomes		
1- Learning how to treat shielding in charged media 2- Learning the techniques of treating the Vlasov kinetic equation, 3- Learning the basic characteristics of a plasma as a charged particle medium,		

4- Learning the treatment of the plasma as a charged fluid 5- Learning how to describe plasma waves and oscillations

PHYS 611	**Classical Mechanics**	**(3 credit hours)**
Course Description		
The basic principles of mechanics, Variation principle and Lagrange's equations and their derivation from the variation principle, the central force problem, The Kinematics of Rigid Body Motion, The rigid body equations of motion, Small Vibrations, The Hamilton equations of motion, Canonical transformations		
Course Objectives		
1- To know the Variation priniciple 2- To apply Lagrange equations in solving problems 3- To know the central force problem and its applications 4- To know the kinematics and dynamics of rigid bodies 5- To know and apply Hamilton equations in solving physical problems 6- To know the importance of Canonical transformations and its applications 7- To know the theory of small vubrations 8- To apply the methods of mechanics in physics and engineering problems		
Course Outcomes		
1- Learn the basic principles of mechanics 2- know how to derive Lagrange equations form the variation principle and their appllications 3- Solve the central force problem for two objects 4- Apply the methods of kinematic and dynamics of rigid bodies in solving problems 5- Use Hamilton equations in solving physics problems 6- Apply the theory of small variations in solving problems 7- To have the ability to develop the skills to apply the machanics principles in physics and engineering problems		

PHYS 621	**Advanced Lab**	**(3 credit hours)**
Course Description		
Application of the principles of modern physics and quantum physics using spectroscopic methods and techniques, including: theory and experiments in gamma ray spectroscopy, theory and experiments in x-ray diffraction spectroscopy, theory and experiments in visible and ultraviolet light spectrometry, theory and experiments in infrared spectroscopy , Theory and experiments in Mössbauer spectroscopy		
Course Objectives		
1 - to acquire the skills of the scientific researcher and learn a range of topics in experimental physics.		

2 -To develop a sense of the nature of independent research.according to the highest professional levels. 3 - To teach the student modern methods used in measurements and advanced software o draw data and analysis results models to interpret the results of scientific experiments. 4 - To train the student to write the aduqate scientific reports. 5 - To get familiar with the use of modern technology and scientific instruments and tools necessary in the conduct advanced experiments
Course Outcomes
1 – To get familiar using laboratory notebook and to conduct literature review 2 - To use modern devices and software necessary to conduct calculations and analysis of results 3 – To use statistical methods in the analysis of data and the calculation of error. 4 – To Write scientific reports 5 – To be able to conduct advanced experiments in physics independently. 6. To be able to conduct a thorough literature review on the subject of the experiment in his hands. 7 – To Know how to stay up to date with developments in the field of physics

PHYS 631	**Classical Electrodynamics**	**(3 credit hours)**
Course Description		
Electrostatic, Poisson's equations, Method of images, Boundary- value problem, Spherical Harmonics, Bessel's functions, Multipoles expansion, Dielectrics, Green's function, Magnetostatics, Vector potential, Magnetic moment, Maxwell's equations of Time- varying fields, conservation laws, Electromagnetic waves.		
Course Objectives		
To develop student's conceptual knowledge and analytical skills in solving electrostatic ,magnetostatics and electromagnetic problems.		
Course Outcomes		
1- Demonstrate analytical skills in solving electrostatics problems. 2- Demonstrate good conceptual knowledge and analytical skills in solving magnetostatics problems. 3- Show good conceptual knowledge and analytical skills in solving problems involving time- dependant Maxwell's equations and EM conservation laws. 4- Show good conceptual knowledge and analytical skills in solving problems involving EM waves and their propagation.		

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 640	**Physics of Radioactive Waste and Management**	**(3 credit hours)**
Course Description		
An overview of the various aspects involved in radioactive waste management and how to deal with radioactive waste management during collection, characterization, adaptation, transport and storage. This course includes the basics of radioactive materials in the environment, the processes of treatment of these materials, methods of storage and disposal, and the impact of radioactive materials on humans and the environment. The course will include best practices and international regulations in this field.		
Course Objectives		
1. Identify techniques for adapting nuclear waste. 2. Identification of storage and transfer of nuclear waste. 3. Recognition of the criteria for acceptance of nuclear waste and the process of international accreditation. 4. Identify waste management during shutdown. 5. Identify the process of handling radioactive materials and methods of storage and disposal. 6. Knowledge of the impact of radioactive materials on humans and the environment. 7. Identify international laws and regulations in the field of nuclear waste management.		
Course Outcomes		
1. Advanced knowledge of the general classification of nuclear waste and the basic principles of radioactive waste management. 2. Translate these basic principles of radioactive waste management into good practice.		

3. Identify the interrelationship between the various parties involved in the nuclear field related to waste management (nuclear regulator, waste management organization). 4. Knowledge on radioactive waste characterization techniques and their adaptation. 5. Identify the accreditation and acceptance system of the IAEA. 6. Develop the student's skills in critical thinking, self-learning and hard work within the team.

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 642	**Nuclear Physics (2)**	**(3 credit hours)**
Course Description		
Nuclear reactions, non-flexible absorption and particle exchange, multiple methods		

Objects in Nuclear Physics, Betty and Goldstone Equations, Effective Interactions, Nuclear Models, Quark Model, Structure of protons and neutrons, relativistic quantum mechanics, QED, symmetry measurement and electrode dissociation: Higgs mechanics
Course Objectives
1. Identify the nature of nuclear reactions. 2. Identification of quark models of elementary particles 3. Explore the energy measures being investigated by the LHC. 4. Identify string theory and how to combine gravity with other forces. 5. Understand what happens when protons collide in the LHC as well as drops of plasma Quark-gluon made in heavy cores collisions. 6. Understand the nature of strong interactions. 7. Understanding the pattern of electrode dissociation: Higgs mechanism, Higgs boson identification and measurement method.
Course Outcomes
1. Identify the nature of strong and weak nuclear reactions. 2. The theory of strings and the unification of forces. 3. Understanding the origin of the LHC and its role in the discovery of the Higgs boson particle. 4. Understanding the Higgs theory. 5. Identify the equations of Betty and Goldstone and how to solve them.

PHYS 643	**Elementary Particle Physics**	**(3 credit hours)**
Course Description		
An introduction to the standard model of particle physics - the strong and electroweak interactions between the basic constituents of the world, quarks and leptons, via the exchange of gluons, photons and W and Z particles. Recent results on CP violation and neutrino mixing. The search for the Higgs particle. Beyond the standard model - Grand unified theories and supersymmetry.		
Course Objectives		
1- Adress what is the Standard Model, i.e. what are the particles and how do they interact? 2-Know the shortcomings of the Standard Model 3- Address how are scientists trying to figure out what the real “beyond-Standard Model” theory is.		
Course Outcomes		
1- To describe the basic constituents of the Standard Model, the quarks and leptons and the interactions between them 2- To use Feynman diagrams to classify and illustrate these interactions 3- To demonstrate the conservation rules, quantum numbers and basic quark parton model upon which the Standard Model is built		

4- To describe the basics of electroweak interactions, the Higgs mechanism and CP violation 5- To describe the experimental observation of neutrino mixing and explain its implications for neutrino masses 6- To appreciate the limitations of the Standard Model 7- To describe how some of these limitations are overcome in other models.

PHYS 644	**Atomic and Molecular Physics**	**(3 credit hours)**
Course Description		
"Recall of the Hydrogen atom spectrum. Fine structure of H atom spectrum: spin orbit interaction and relativistic corrections. Many electron atoms: Hartree- Fock approximation, Interaction of atoms with electromagnetic radiation., Fermi golden rule. Hyperfine structure, Zeeman effect, angular momentum algebra.E-lectron paramagnetic resonance and nuclear magnetic resonance. Atom-atom and electron atom collisions. Born Oppenheimer approximation, electron states in Hydrogen molecule ion and hydrogen molecule. Other diatomic molecules. Rotational vibrational spectra of diatomic molecules, Polyatomic molecules, symmetry classification of vibrational states, Rotational states and Raman spectroscopy.		
Course Objectives		
1- To provide theoretical and practical knowledge on modern atomic and molecular physics. 2- To give basic knowledge about the molecular structure and molecular spectroscopy 3- To give the basic structure of atoms starting from hydrogen atom to many electron atoms, and beside studying the fine and hyperfine structure of atoms, knowing the behavior of atoms in outer fields. 4- To provide hands-on practice in the calculation of atomic and molecule wave functions and energies.		
Course Outcomes		
1- Learn how atoms and molecules absorb and emit light and how this process can be affected by magnetic and electric fields 2- Describe the electronic state of atoms in terms of quantum numbers, 3- Learn the complexity of atomic spectra due to spin-orbit coupling and the interpretation of term symbols 4- Calculate the contributions of transitions between rotational, vibrational and electronic states to the spectra of diatomic molecules, vibrations and electronic structure of polyatomic molecules, 5- Understand basic spectroscopic techniques (absorption, fluorescence, Raman, EPR, NMR).		

PHYS 646	Physics of Nuclear Reactors	(3 credit hours)
Course Description		
Engineering principles for nuclear reactors, focusing on energy reactors. Topics include thermodynamics for power generation, reactor heat generation and removal (single phase flow as well as heat flow in two phases), structural mechanics and engineering considerations in reactor design.		
Course Objectives		
1. Recognition of nuclear reactor technology. 2. Understanding the physical foundations and mathematical modeling of nuclear reactors. 3. Identify the different types of nuclear reactors and their respective working principles. 4. Identify the nuclear fuel cycle. 5. Identify the design of nuclear reactors and their components. 6. Understand and model the hydraulic and mechanical thermal phenomena that are key to the design and operation of efficient, reliable and safe nuclear systems. 7. Identify the applications and uses of nuclear reactors in the fields of power generation, radioisotopes and others.		
Course Outcomes		
1. Understand the basic principles of the work of nuclear reactors. 2. Understand how to design nuclear reactors and identify different species and generations and their respective working principles. 3. Understand the nuclear fuel cycle and its importance in reactors. 4. Learn how to use reactors to generate energy. 5. Realize some applications for nuclear reactors. 6. Develop skills in critical thinking, self-learning and hard work within the team.		

PHYS 647	Radiation Physics	(3 credit hours)
Course Description		
The study of the composition of the matter, sources of radiation, its characteristics, radioactivity, nuclear transformations, interaction of ionizing radiation with matter, measurement statistics and error calculations, radiation detectors, radiation dose calculations and radiation protection.		
Course Objectives		
1- Study the basic mathematical and physical principles necessary to understand the interaction of radiation with matter 2- Study the basic quantities and units used in radiation physics 3- Study applications in the field of radiation protection and calculation of radiation doses		
Course Outcomes		
1- Know the composition of matter sources of radiation, characteristics, knowledge of radioactivity and nuclear transformations 2- Apply counting methods and statistics in radiation detection		

3- Understand the use of radioactive detectors, calculation of radiation doses and radiation protection

PHYS 648	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.		

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.

PHYS 651	**Quantum Mechanics**	**(3 credit hours)**
Course Description		
Introduction to the linear vector spaces, the theory of Operators, the spin of the electron, the two-level quantum system, the position and momentum space, Heisenberg equations of quantum systems, Schrodinger equations, the addition of angular momenta, time-independent and time-dependent perturbation theories, atomic transitions and selection rules, approximation used in quantum mechanics.		
Course Objectives		
1- Know the limits of classical mechanics, the necessity of quantum mechanics, and the main postulates of quantum mechanics. 2- Represent the operators and the eigen functions using matrices 3- Using Heisenberg equations to solve quantum systems 4- Understand the spin magnetic moment and its relation with the electron spin. 5- Use approximation methods (time independent perturbation theory and variational methods) to solve different systems.		
Course Outcomes		
1- Understant the mathematical basis of modern quantum theory 2- Be able to represent physical operators using matrices 3- Be able to solve dynamical quantum systems 4- Solve Schrodinger equations in 3D for the hysdeogen atom 5- Solve various quantum systems using the approximation methods (perturbation theories)		

PHYS 661	**Statistical Mechanics**	**(3 credit hours)**
Course Description		
The statistical foundations of thermodynamics, elements of the theory of ensemble, micro canonical ensemble, canonical ensemble, grand canonical ensemble, the formulation of quantum statistics, simple gas theory, ideal Bose systems, ideal Fermi systems, statistical mechanics of interacting systems.		
Course Objectives		
1- Recognition of the basic statistical foundations of thermodynamics.		

2- Knowledge of the elements of the ensemble theory, phase space, Liouville theory, the micro canonical ensemble and its applications. 3- Knowledge of the canonical ensemble and its applications on various systems 4- knowledge of the grand canonical ensemble and its applications 5- Knowledge of the formalisms of quantum statistics and its applications 6- Knowledge of the ideal gas theory and its applications 7- Knowledge of the ideal Bose systems 8- Knowledge of the ideal fermi systems 9- Knowledge of the statistics of interacting systems
Course Outcomes
1- Use the basic principles of statistical thermodynamics 2- Understand the ensemble theory, phase space, Liouville`s theorem, the micro canonical ensemble and its applications 3- Apply canonical ensemble in solving problems 4- Apply grand canonical ensemble in solving problems 5- Use quantum statistics formulism in solving problems 6- Use the simple gas theory to solve problems 7- Use the Fermi theory to solve problems 8- Use the Bose theory to solve problems

PHYS 691	**Special Topics**	**(3 credit hours)**
Course Description		
One of the specialized topics that serve as a good background for the subject of the Master's thesis. This course is an opportunity to train the student to write his thesis		
Course Objectives		
Provide the student with the opportunity for in-depth study of a specialized field in physics with direct interaction with a faculty member in preparation for selecting the topic of research in the thesis		
Course Outcomes		
1- Choose the topic of thesis research easily and confidently. 2- Writing reports in preparation for writing his thesis to facilitate his work when conducting an advanced physical experiment		

PHYS 698	**Comprehensive Exam**	**(0 credit hours)**
PHYS 699A	**Thesis**	**(0 credit hours)**
PHYS 699B	**Thesis**	**(3 credit hours)**
PHYS 699C	**Thesis**	**(6 credit hours)**
PHYS 699D	**Thesis**	**(9credit hours)**