Nuclear Track:

Master of Physics by Thesis

Table of Contents

Common Course

Course Title**: Research methodology**

Course Code: **403643-3**

(C-0)

1. Topics to be Covered		
List of Topics	**No. of Weeks**	**Contact hours**
Course overview and introduction to the Study: Introduction (why the study was selected, background and setting), Statement of Problem, Purpose of the Study, Importance of the Study, Definition of Terms (if needed)	1	3
Review of Related Literature: This chapter should contain a concise presentation of literature and research (periodicals, dissertation abstracts, books, etc.) relevant to the problem.	2	6
Developing a bibliography and properly citing sources within text Online Reading: Citing Sources	2	6
SCIENCE GRAPHICS: Discussion and illustration of the importance of clear graphical presentation of data. Review basic guidelines and critically examine good and bad examples from the literature. Producing effective and publishable figures using a suitable software	2	6
WRITING AN IMRaD MANUSCRIPT: INTRODUCTION & METHODS. Review the functions, writing style, and content of Introduction and Methods sections.	2	6
Research Presentations: - Making scientific posters; Detailed instructions will be given on the design and development of a poster in class. - Making scientific papers; Detailed instructions will be given on the design and development of a paper in class. - students will present material to the class.	2	6
Library Research & Resources Practice (class in the library): Organization of Knowledge: Metadata and searching for information Online Reading: Library Catalog, Keyword Searching, and Subject Searching.	2	6
Evaluating Web Sites Online Reading: Evaluate Web Sites (reliable website with information related to your research topic.). Information ethics: Copyright, plagiarism Online Reading: Plagiarism	2	6
Total number	15 hrs	45 hrs

	Assessment task (i.e., essay, test, quizzes, group project, examination, speech, oral presentation, etc.)	Week Due	Proportion of Total Assessment
1	Oral presentation (1)	6th week	10%
2	First Report (1)	6th week	15%
3	Oral presentation (2)	10th week	10%
4	Second Report (2)	10th week	15%
5	Scientific project report related to thesis	14th Week	50 %
	Total		100%

E Learning Resources

1. List Required Textbooks

1- John W. Creswell , J. David Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, SAGE Publications, Inc; Fifth Edition (2018) ISBN-13: 978-1506386706
2- Ron Iphofen, Martin Tolich Handbook of Qualitative Research. Sage, (2018) ISBN-13: 978-1473970977
3- Contemporary Field Research: Perspectives and Formulations. Prospect Heights, IL: Waveland Press (2001) ISBN-13: 978-1577661856
4- William Strunk Jr., Virginia Campbell , "The Elements of Style: Simplified and Illustrated for Busy People" (2018) ISBN-13: 978-1980205197.
5- William Badke, Research Strategies:6th edition (2018) ISBN-13: 978-1532018039

Elective Courses

Course Title: **Advanced programming**

Course Code: **403647-3**

(E-1)

1. Topics to be Covered		
List of Topics	**No. of Weeks**	**Contact hours**
Basics- Program construction, Output using "cout", Header files, when to use comments, Integer variables, variable names, integer constants the "endl" manipulator, exercises.	1	3
Basics- Character variables, character constants, escape sequence, input with "cin", floating point type, type bool, "setw" manipulator, the "iomanip" header file, arithmetic operation, library functions, exercises.	1	3
Loops and decisions – Relational operators, Loops, the "for" loop, the "while" loop, the "do" loop, Decisions, the "if" statement, the "if else" statement, the "switch" statement, the conditional operator	1	3
Loops and decisions- Logical operators, logical "AND" operator, logical "OR" operator, logical "Not" operator, the "break" statement, the "continue" statement, exercises	1	3
Structures- A simple structure, Defining the structure, accessing structure members, Structure within Structures, Structures and Classes, Enumeration, examples, exercises	1	3
Functions- Simple functions, the function declaration, calling the function, the function definition, passing arguments to functions, passing constants, passing variables, passing by value, Returning values from functions, the return statement, Returning structure variables	1	3
Functions- Reference arguments, Passing Data types by reference, Passing more complex pass by Reference, Passing Structures by Reference, Overloaded functions, inline functions, Returning by References.	1	3
Objects and Classes- A simple class, classes and objects, defining the class, using the class, calling member functions	1	3
Objects and Classes- Constructors, Destructors, objects as function arguments, overloaded constructors, Member functions defined outside the class, Static class data, const and classes.	1	3
Arrays- Array fundamentals, arrays as class member data, arrays of objects and exercises	1	3
Pointers– Addresses and pointers, Pointers and arrays, examples	1	3

Pointers- Pointers and functions, the "new" and "delete" operators examples.	1	3
Inheritance- Derived class and base class, Derived class constructors, class inheritance, Public and private inheritance.	1	3
Virtual functions- Normal member functions accessed with pointers, virtual member functions accesses with pointers, friend functions, static functions, examples	2	6
Total number	15	45

5. Assessment Task Schedule for Students During the Semester

	Assessment task (i.e., essay, test, quizzes, group project, examination, speech, oral presentation, etc.)	Week Due	Proportion of Total Assessment
1	Exercises & Home works	All weeks	5%
2	Online quizzes	All weeks	5%
3	Oral exam	5th Week	5%
4	Participation in activities lectures and labs	All weeks	5%
5	Test (1)	6th week	10%
6	Test (2)	13th week	10%
7	Scientific project	14th Week	10 %
8	Final Exam	15th week	50%
	Total		100%

E Learning Resources

1. List Required Textbooks

1- Object oriented programming in C++, Robert Lafore, fourth edition, Pearson and Sam Publishing (2002), ISBN 0-672-32308-7.
2- Object oriented programming using C++, Joyce Farrel, fourth edition, 2009, ISBN-13: 978-1-4239-0257-7.
3- Bjarne Stroustrup, The C++ Programming Language, 4th Edition (2013), ISBN-13: 978-0321563842.
4- -"Applied Computational Physics 1st Edition" Joseph F. Boudreau, Eric S. Swanson ISBN-13: 978-0198708643 (2018).

2. List Essential References Materials (Journals, Reports, etc.)

-Siddhartha Rao, "C++ in One Hour a Day, Sams Teach Yourself (8th Edition)", (2016) ISBN-13: 978-0789757746.

-Bjarne Stroustrup, "A Tour of C++ (C++ In-Depth Series)" , (2018), ISBN-13: 978-0134997834.

Course Title: **Advanced Research lab.**

Course Code: **403651-3**.

(E-2)

1. Topics to be Covered		
List of Topics	**No. of Weeks**	**Contact hours**
Introduction of material science laboratory.	1	3
Preparation of nanomaterial by chemical method and Preparation of nanomaterial by ball milling method and measurement it by UV-visible spectroscopy.	3	9
Preparation of thin films by spin coating and study their electrical conductivity by temperature-four probe method	2	6
Preparation of biopolymer material and study the morphology and crystal growth rate by polarized optical microscopy (POM).	2	6
Determination of the elongation at break and Young's modulus of polymer film by Tensile test.	1	3
Determination of dielectric constant, dielectric loss and Electrical conductivity of some material by impedance analyzers.	2	6
Preparation of thin film by vacuum thermal evaporation of and study the morphology by SEM.	1	3
Study of crystal size by using XRD and the cell Scherrer formula for some crystalline material.	1	3
Study the Surface morphology for some material by atomic force microscopy (AFM).	1	3
Study the I-V characteristics for solar cell temperature-two probe method	1	3
	15 weeks	**45 hrs.**

5. Assessment Task Schedule for Students During the Semester

	Assessment task (i.e., essay, test, quizzes, group project, examination, speech, oral presentation, etc.)	**Week Due**	**Proportion of Total Assessment**
1	During the examination period following the module, an oral exam (duration: 30 min.) on "certain experimental" is held.	14th week	20 %
2	Experimental reports	Each week	40 %

3	Final exam	15th week	40%

E Learning Resources

1. List Required Textbooks During the lab course, a set of references is given for each experiment. Manuals are available for all experiments; they contain individual literature references for all experiments.

Course Title: **Semiconductor device modeling**

Course Code: **403649-**3

(E-3)

1. Topics to be Covered		
List of Topics	**No. of Weeks**	**Contact hours**
❖ **Semiconductor Carrier Transport Equations:** Semiconductor bandstructure, Simplified bandstructure models, Carrier dynamics, Semiconductor effective mass, Semiclassical transport theory, Boltzmann transport equation, Maxwell's equations, Drift-Diffusion Transport Model, equations, Boundary conditions, Generation-recombination, Scattering processes, Relaxation time approximation, Thermal Conductivity and Heat flow.	**3**	**9**
❖ **Analytical modeling and analysis of semiconductor Devices:** Techniques for solving Semiconductor equations, closed – form analysis, Mobility modeling, Analysis of pn Junction Diode, Analysis of Field Effect Transistor operation, , Analysis of MOSFET operation, limitation of the closed – form analysis.	**2**	**6**
❖ **Numerical solution of the Semiconductor equations:** Finite-Difference Schemes: Discretization of Semiconductor equations, methods for solving finite difference equations, Boundary Conditions, Simulation examples. Finite Element Method: Galerkin Method, Derivation of the Finite Element equations, Simulation examples. Modeling Heterojunction Devices: Semiconductor equations for Heterojunction, High Electron Mobility Transistors, Analytical solutions, Numerical Models, Heterojunction Bipolar Transistors, and Monte Carlo Simulations.	**4**	**12**
❖ **Monte Carlo Method:** Modeling carrier transport in Semiconductors, Equations of motion, Energy band structure, Application Monte Carlo Method for transport Characteristics and device modeling.	**2**	**6**
❖ **Introduction to Quantum transport theory:** Quantum theoretical foundations, state vectors, Schroedinger and Heisenberg picture, Band structure, Bloch theorem, one dimensional periodic potential, density of states, Pseudopotential theory, crystal symmetries, reciprocal lattice, Brillouin zone, Semiclassical transport theory, Quantum Transport Theory, limits of semiclassical transport theory, quantum mechanical derivation Boltzmann transport equation, Markov-Limes.	**4**	**12**
	15 weeks	**45 hrs**

E Learning Resources

1. List Required Textbooks

- D. Vasileska, S. M. Goodnick, G. Klimeck, “Computational Electronics: Semiclassical and Quantum Device Modeling and Simulation 1st Edition”, CRC Press, 2010.
- C. Snowden, “Introduction to Semiconductor Device Modeling”, World Scientific, 1998.
- Fundamentals of Carrier Transport 2nd Edition, Cambridge University Press (2000).
- Carlo Jacoboni and Paolo Lugli, "The Monte Carlo Method for Semiconductor Device Simulation", Springer, 2002.

Nuclear Track

Course Title:

Introduction to Nuclear and High Energy Physics

Course Code: **403638**-3

(N-1)

Course Description:		
1. Topics to be Covered		
List of Topics	**No. of Weeks**	**Contact hours**
1- Properties of Nuclei	2	6
1- Masses, Sizes		
2- Nuclear Spins		
3- dipole moments.		
4- Stability and instability.		
5- Nuclear Force		
2- Nuclear Models	3	9
1- Liquid Drop Model		
2- Shell Model		
3- Collective model		
3- Strong, Weak and Electromagnetic interactions at work	4	12
1- Alpha Decay		
2- Beta Decay		
3- Gamma Decay		
4-Intoduction to Elementary Particles	3	9
1- Historical introduction to elementary particles		
2- How do we produce elementary particles		
3- How do we detect elementary particles		
4- The eight fold way		
5- The Quark model		
6- The Standard model		
5- Elementary Particle Dynamics	3	9
1- The four forces		
2- Quantum Electrodynamics		
3- Decays and conservation laws		
4- Unification schemes		

5. Assessment Task Schedule for Students During the Semester			
	Assessment task (i.e., essay, test, quizzes, group project, examination, speech, oral presentation, etc.)	**Week Due**	**Proportion of Total Assessment**
1	Midterm 1	5th week	15 %
2	Midterm 2	10th week	15 %
3	Online quizzes	every week	10 %
4	Homework	Every week	5 %
5	Oral exam	Every week	5 %
6	Final exam	End of semester	50 %

E Learning Resources

1. List Required Textbooks

1) A. Das and T. Ferbel, Introduction to nuclear and particle physics (second edition) World Scientific (2003) ISBN 981-238-744-7.
2) R.C. Verma & S.C. Gupta, V.K. Mittal, Introduction to nuclear and particle physics 4th Edition, Kindle Edition (2018) ISBN-13: 978-9387472617
3) Books Wagon, Basic Ideas And Concepts In Nuclear Physics: An Introductory Approach 3Rd Edition (Series In Fundamental And Applied Nuclear Physics) (2017). ISBN 0 7503-0534 7 hbk, 07503 0535 pbk.
4) Burcham, Nuclear and Particle Physics: An Introduction 2nd Edition (2009) ISBN-13: 978-0470742754.
5) Kenneth S. Krane , Introductory nuclear Physics, first edition, Jone Wily & Sons Inc. (2008) ISBN 0 - 471-80553-X .
6) Saverio D'Auria, Introduction to Nuclear and Particle Physics, Springer; 1st ed (2018) **ISBN-13:** 978-3319938547.

7) Alessandro De Angelis, Mário Pimenta, Introduction to Particle and Astroparticle Physics: Multimessenger Astronomy and its Particle Physics Foundations (2018) ISBN-13: 978-3319781808.

8) Irving Kaplan, Nuclear Physics, Narosa Publishing House (2002). **ISBN-13:** 978-8185015897

9) K. Langanke, J. A. Maruhn, Steven E. Koonin, Computational Nuclear Physics 1: Nuclear Structure (1991) ISBN-13: 978-0387535715.

Course Title: **Nuclear Reactions**

Course Code: **403640-3**

(N-2)

1. Topics to be Covered

1- Chapters 11-14 of K. S. Krane, Introductory nuclear physics (see references below)

List of Topics	No. of Weeks	Contact hours
1. Kinematics in Nuclear Reactions: 1- Types of reactions and conservation laws 2- Energetics of nuclear reactions 3- Reaction cross sections 4- Coulomb scattering 5- Nuclear scattering 6- The Optical model 7- Direct and compound nuclear reactions **8-** Resonance and Heavy-ion reactions	**5**	**15**
2- Neutron Physics 1- Neutron sources 2- Absorption and moderation of neutrons 3- Neutron reactions and cross sections 4- Neutron capture 5- Interference and diffraction with neutrons	**4**	**12**
3-Nuclear fission 1- Characteristics of fission 2- Energy in fission 3- Fission and nuclear structure 4- Controlled Fission reactions **5-** Fission reactors	**3**	**9**
4-Nuclear fusion 1- Basic Fusion processes 2- Characteristics of fusion 3- Solar Fusion 4- Controlled Fusion reactors	**3**	**9**
Total	**15**	**45**

Lecture : 45 hrs	**Tutorial:**	**Lab:**	**Total:** 45 hrs

5. Assessment Task Schedule for Students During the Semester

	Assessment task (i.e., essay, test, quizzes, group project, examination, speech, oral presentation, etc.)	Week Due	Proportion of Total Assessment
1	Exercises & Home works	All weeks	5 %
2	Participation	All weeks	5 %
3	In-Class Problem Solving	7th,13th week	10%

4	Midterm 1	6th week	15%
5	Midterm 2	10th week	15%
6	Final Exam	16th week	50%
	The Total		100%

E Learning Resources

1. List Required Textbooks

1. Kenneth S. Krane , Introductory nuclear Physics, first edition, Jone Wily & Sons Inc. (2008) ISBN 0 - 471-80553-X .
2. Hans Paetz gen. Schieck, "Nuclear Reactions: An Introduction (Lecture Notes in Physics) 2014th Edition" ISBN-13: 978-3642539855.
3. C.A. Bertulani , P. Danielewicz , "Introduction to Nuclear Reactions (Graduate Student Series in Physics) 1st Edition" (2004) ISBN-13: 978-0750309325.
4. Karlheinz Langanke, J.A. Maruhn , S.E. Koonin , "Computational Nuclear Physics 2: Nuclear Reactions " (1993) ISBN-13: 978-0387979540.

1. List Essential References Materials (Journals, Reports, etc.)

- Edmund Storms, The Explanation of Low Energy Nuclear Reaction: An Examination of the Relationship Between Observation and Explanation (2014) ISBN 978-1-892925-10-7 .
-Ian J. Thompson, Filomena M. Nunes , "Nuclear Reactions for Astrophysics: Principles, Calculation and Applications of Low-Energy Reactions", ISBN-13: 978-0849385483 (2009)

Course Title: **Quantum Field Theory**

Course Code: **403642-3**

(N-3)

1. Topics to be Covered		
List of Topics	**No. of Weeks**	**Contact hours**
1. Electromagnetic Field • Particles and fields • Electromagnetic field in the absence of charges • Electric dipole interaction • Electromagnetic field in the presence of charges	**1**	**3**
2. Lagrangian Field theory • Relativistic notation • Classical Lagrangian and Hamiltonian equations. • Quantized Lagrangian field theory • Symmetries and conservation laws	**2**	**6**
3. Spin-0 Fields: The Klein Gordon Equation • The neutral Klein Gordon Field • The Charged Klein Gordon Field • The invariant commutation relation	**2**	**6**
4. Spin-1/2 Fields: The Dirac Equation • The Dirac equation • Canonical quantization of the Dirac Field • The Fermion propagator	**3**	**9**
5. Photons: Covariant theory • The classical fields • Covariant quantization • The photon propagator	**2**	**6**
6. The S-matrix expansion • Natural dimensions and units • The S-matrix expansion • Wick's theorem	**2**	**6**
7. Feynman diagrams and rules in QED • Feynman Diagrams in configuration space • Feynman Diagrams in momentum space • Feynman rules for the S-Matrix • Feynman rules for QED	**3**	**9**

5. Assessment Task Schedule for Students During the Semester			
	Assessment task (i.e., essay, test, quizzes, group project, examination, speech, oral presentation, etc.)	**Week Due**	**Proportion of Total Assessment**
1	Exercises & Home works	All weeks	5 %
2	Participation	All weeks	5 %

3	In-Class Problem Solving	7th,13th week	10%
4	Midterm 1	6th week	15%
5	Midterm 2	10th week	15%
6	Final Exam	16th week	50%

E Learning Resources

1. List Required Textbooks
   - Graham Shaw and Franz Mandl, Quantum Field theory, John Wiley and Sons (2016), **ISBN-13:** 978-8126565061

2. List Essential References Materials (Journals, Reports, etc.)
   - Bipin R. Desai, Quantum Mechanics with basic field theory (2010) Cambridge university press, ISBN 978-0-521-87760-2
   - Andrei Smilga, Quantum Field Theory for the Gifted Amateur (2015) ISBN-13: 978-0199699339.
   - Andrei Smilga Digestible Quantum Field Theory 1st ed. (2017) Edition" ISBN-13: 978-3319599205.
   - Hagen Kleinert, "Particles and Quantum Fields ", (2016) ISBN-13: 978-9814740906 .
   - Eberhard Zeidler , Quantum Field Theory I: Basics in Mathematics and Physics: A Bridge between Mathematicians and Physicists 2nd printing 2009. ISBN-13: 978-3540347620.

Course Title: **High Energy Physics**

Course Code: **403639-3**

(N-4)

1. Topics to be Covered		
List of Topics	**No. of Weeks**	**Contact hours**
1. Relativistic Kinematics • Lorentz transformation • Four vectors • Energy and momentum • Collisions • Examples and applications	2	6
2. Symmetries and invariance principles • Conservation laws • Spin and angular momentum • Flavor symmetries • Parity • Charge conjugation, CP violation, TCP theorem.	4	12
3. Feynman calculus • Life times and cross sections • The Golden rule • Toy theory • Scattering • Higher order diagrams	4	12
4. Quantum Electrodynamics • Dirac Equation • Solutions to Dirac Equation • Bilinear Covariant • The Photon • Feynman rules for QED • Cross sections and lifetimes	5	15

5. Assessment Task Schedule for Students During the Semester			
	Assessment task (i.e., essay, test, quizzes, group project, examination, speech, oral presentation, etc.)	**Week Due**	**Proportion of Total Assessment**
1	Online quizzes	every week	5 %
2	Homework	Every week	10 %
3	Midterm 1	7th week	15 %
4	Midterm 2	14th week	15 %
5	Interactive discussions	Every week	5 %

6	Final exam	End of semester	50 %

E Learning Resources

1. List Required Textbooks

1. David Griffiths, Introduction to elementary particles (2008) Wiley-VCH Verlag GmbH and Co. K GaA, Weinheim, ISBN-13: 978-3527406012.
2. Robert Purdy, "Particle Physics: An Introduction (Essentials of Physics Series)", (2018) ISBN-13: 978-1683921424.
3. Brian R. Martin and Graham Shaw, "Particle Physics (Manchester Physics Series) 4th Edition" (2017) ISBN-13: 978-1118912164.
4. Francis Halzen and Alan D. Martin, Quarks and Leptons: an introductory course in modern particle physics (2008) John Wiley and Sons, Inc. **ISBN-13:** 978-8126516568

Course Title: **Detector Physics**

Course Code: **403641-3**

(N-5)

2. Topics to be Covered		
List of Topics	**No. of Weeks**	**Contact hours**
1- Interactions of electrons and charged heavy particles in matter - Cross section, mean free path, surface density units. - Bohr's calculations - The Bethe-Bloch formulae - Energy dependence -Scaling law for dE/dx -Mass stopping power -Limitations on the Bethe-Bloch Formula and other effects. - Channeling -Range	**3**	**9**
2- Counting statistics and error prediction -Characterization of data -Statistical models -Applications of statistical models -Error propagation -Optimization of counting experiments -Limits of detectability -Distribution of time intervals	**3**	**9**
3- Radiation detectors -Simplified detector model -Modes of detector operation -Pulse Height spectra -Counting curves and plateaus -Energy resolution -Detection efficiency -Dead time	**2.5**	**7.5**
4- Ionization Detectors		

-Gaseous ionization detectors -Ionization and transport phenomena in Gases -Transport of electrons and ion in Gases -Proportional counter -Drift chamber -Liquid ionization detectors	**2.5**	**7.5**
5-Gamma ray detectors		
-The Photon-cathode -Photomultiplier tube characteristics -Scintillation pulse shape analysis - Germanium detector configurations	**2**	**6**
6-Neutron detection		
-Nuclear reactions of interest in neutron detection - Detectors based on boron reaction - counters based on neutron moderation - Detectors based on fast neutron induced reactions	**2**	**6**
Total	**15**	**45**

Lecture : 45 hrs	**Tutorial:**	**Lab:**	**Total: 45 hrs**

5. Assessment Task Schedule for Students During the Semester

	Assessment task (i.e., essay, test, quizzes, group project, examination, speech, oral presentation, etc.)	Week Due	Proportion of Total Assessment
1	Exercises & Home works+ quizzes	All weeks	5%
1	Assay	15th week	5%
3	Report	All weeks	20 %
4	Written Test (1)	6th week	10%
5	Written Test (1)	11th week	10%
6	Final examination	16th week	50%
	The Total		100%

E Learning Resources

1. List Required Textbooks

1. William R. Leo, Techniques for nuclear and particle physics, Springer Verlag (1987) ISBN 3-540-17386-2 Springer Verlag Berlin Heidelbergy New York
2. Glenn F. Knoll, Radiation Detection and Measurement, John Wiley & Sons, Inc. (1999) ISBN 0-471-07338-5.
3. Stefaan Tavernier, Experimental Techniques in Nuclear and Particle Physics 2010th Edition, ISBN-13: 978-3642008283.
4. Lucio Cerrito , Radiation and Detectors: Introduction to the Physics of Radiation and Detection Devices (Graduate Texts in Physics) 1st ed. (2017) Edition, ISBN-13: 978-3319531793.
5. Claus Grupen and Boris Shwartz , Particle Detectors (Cambridge Monographs on Particle Physics, Nuclear Physics and Cosmology) 2nd Edition (2011) ISBN-13: 978-0521187954.
6. Olaf Behnke , Kevin Kroninger, Gregory Schott, Thomas Schorner-Sadenius , Data Analysis in High Energy Physics: A Practical Guide to Statistical Methods (2013) ISBN-13: 978-3527410583.

2. List Essential References Materials (Journals, Reports, etc.)

1. Journal :Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment.
2. Geoffrey G Eichholz and John W.Poston, Principles of Nuclear Radiation Detection, Ann Arbor Science Publishers (April 1, 1980) ISBN-13: 978-0250402632