***Kingdom of Saudi Arabia***

***Ministry of Higher Education***

***King Saud University***

***Deanship of Graduate studies***

**Master of Science in Physics (M. Sc)**

**(Courses & Thesis)**

**Department of Physics and Astronomy**

**College of Science**

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## **2010/2011**

***College of Science***

***Department of Physics and Astronomy***

**Introduction**

The Physics & Astronomy Department is considered to be one of the oldest departments at King Saud University. It has been established in the year of 1378 H, 1958 G just upon the establishment of the College of Science. The objective of the department is to provide the necessary courses and programs for a Bachelor degree. However, the department now has expanded its objectives to include graduate studies in addition to scientific research following the developments in the Kingdom in all sectors; educational and scientific research in particular. As a result, the department has seven research groups. These are mainly: Nuclear Physics, Materials Physics, Renewable Energy & Environment, Theoretical Physics, Laser Physics and Spectroscopy, Biomedical physics, and Astronomy Research Group.

Currently, the department offers the degree of Masters of Science (M.Sc.) in Physics which has been approved in 1980. The M.Sc. program aims at providing the Kingdom with qualified graduates to satisfy the needs of the country. The program had five main specializations: Theoretical Physics, Laser Physics and Spectroscopy, Solar Energy Physics, Materials Physics and Nuclear Physics.

In view of the King Saud University (KSU) vision to give major importance to graduate studies to develop a generation of distinguished researchers that can be an important asset toward fulfilling KSU vision, the department has taken the initiative to develop and modify the current M.Sc. program in line with the latest developments in science and global technology, and to fulfill the stakeholder needs. Consequently; Biomedical Physics and Astronomy tracks have been added to this program.

**Degree Name**

Master of Science in Physics (M. Sc)

**Program Objectives**

1. To provide qualified graduates in physics in the academic and scientific research fields.
2. To promote the standards of postgraduate studies at the M.Sc. level and studies leading to the Ph. D. program in the department.
3. To contribute to the Kingdom's need for specialists in the areas of theoretical and experimental physics.

**Admission Requirements:**

1. The admission requirements as detailed in the 15th article of the unified regulatory articles organizing the graduate studies at Saudi universities.
2. Candidates should hold a Bachelors Degree (B.Sc.) in Physics or Astronomy from Saudi universities or their equivalent.
3. The student must obtain at least 450 score in the TOEFEL test or its equivalent as long as the test is passed within the past two years. This requirement may be waived for students from countries where previous degree is offered in English
4. Candidates must pass the admission test in General Physics (in English) or pass a GRE examination in Physics with score of 600 at least.

**Degree requirements**

1. Successful completion of 24 credit hours of graduate courses distributed as follows:

i) 15 credit hours: basic core courses in physics; except the Astronomy track, where students should complete 12 credit hours of the basic core courses in Physics.

ii) 9 credit hours: courses (compulsory or elective) related to the program track. In the Astronomy track, the student should complete 12 credit hours (compulsory or elective) related to the track requirements plan.

1. Successful completion and defense of the thesis.

**Program tracks**

The program includes the following seven tracks:

1. Theoretical Physics
2. Laser Physics and Spectroscopy
3. Solar Energy Physics
4. Materials Physics
5. Nuclear Physics
6. Biomedical Physics
7. Astronomy

**Program Structure:**

Twenty-four Credit hours and a thesis are required distributed as follows:

|  |  |  |
| --- | --- | --- |
| **Courses** | **Type of Courses** | **Credit Hours** |
| PHYS xxx | Basic Core Courses | 15\* |
| PHYS xxx | Elective Courses from the track courses | 9\* |
| PHYS 600 | Thesis | 6 |
| **Total** |  | **30** |

\* **Except for Astronomy: 12 basic core courses plus 12 elective courses**

**Courses of the M. Sc. Physics Program**

1. **Core Courses (List 1)**

This group is required for all tracks except for Astronomy where Phys 506 is not required.

|  |  |  |
| --- | --- | --- |
| **Course** | **Course Title** | **Units\*\*** |
| PHYS 500 | Research Methodology | 1 (1+0) |
| PHYS 501 | Mathematical Physics | 2 (2+0) |
| PHYS 505 | Advanced Quantum Mechanics | 3 (3+0) |
| PHYS 506 \* | Statistical Physics | 3 (3+0) |
| PHYS 507 | Classical Electrodynamics | 3 (3+0) |
| PHYS 508 | Classical Mechanics | 3 (3+0) |

\* **Except for Astronomy**

**\*\*** Credits are written as: a (b + c) where (a) represents total no. of hours, (b) represents the theoretical (lecture) part; while (c) represents the experimental part.

**2-Elective/ track dependent Courses (List 2)**

The student selects a number of courses from the elective track courses of student specialization. Total of 9 credit hours are required for every track except for Astronomy track where 12 credit hours are required.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Track** | **Course** | **Course Title** | **Prerequisite Course** | **Credits** |
| **T.P.** | PHYS 510 | Relativistic Quantum Mechanics | PHYS 505 | 3(3+0) |
| **T.P.** | PHYS 515 | Quantum Theory of Many Body Physics | PHYS 505 PHYS 506 | 3(3+0) |
| **T.P.** | PHYS 516 | Special Topics in Theoretical Physics | - | 3(3+0) |
| **T.P.** | PHYS 555 | Quantum Field Theory I | PHYS 505 | 3(3+0) |
| **T.P.** | PHYS 556 | Quantum Field Theory II | PHYS 555 | 3(3+0) |
| **T.P.** | PHYS 561 | Elementary Particle Physics I | PHYS 510 | 3(3+0) |
| **L.P.** | PHYS 532 | Advanced Laser Physics | - | 3(3+0) |
| **L.P.** | PHYS 533 | Quantum Optics Laboratory | PHYS 532 | 3(0+3) |
| **L.P.** | PHYS 536 | Atomic & Molecular Spectroscopy | PHYS 505 | 3(3+0) |
| **L.P.** | PHYS 537 | Advanced Optics | - | 3(3+0) |
| **S.E.** | PHYS 541 | X-Ray Diffraction and its Applications | - | 3(2+1) |
| **S.E.** | PHYS 542 | Physics and Technology of Semiconductors | PHYS 505 | 2(2+0) |
| **S.E.** | PHYS 543 | Materials of Solar Energy | PHYS 505 | 2(2+0) |
| **S.E.** | PHYS 544 | Solar Cells | - | 2(2+0) |
| **S.E.** | PHYS 545 | Heat Transfer & its Applications in Solar Energy | PHYS 506 | 2(2+0) |
| **S.E.** | PHYS 546 | Solar Radiation: Models and Applications | - | 2(2+0) |
| **S.E.** | PHYS 547 | Renewable Energy Sources and Environment | - | 2(2+0) |
| **M.P.** | PHYS 570 | Theory of Solids | PHYS 505 | 3(3+0) |
| **M.P.** | PHYS 571 | Electron Magnetic Resonance | PHYS 570 | 3(3+0) |
| **M.P.** | PHYS 574 | Materials Science | PHYS 570 | 3(3+0) |
| **M.P.** | PHYS 576 | Theory of Magnetism | - | 3(3+0) |
| **M.P.** | PHYS 577 | Nanostructures Science and Engineering | PHYS 505 | 3(3+0) |
| **M.P.** | PHYS 578 | Materials Studies Lab | PHYS 574 | 3(0+3) |
| **M.P.** | PHYS 579 | Special Topics in Materials Physics | - | 3(3+0) |
| **N.P.** | PHYS 580 | Nuclear Structure | PHYS 505 | 3(3+0) |
| **N.P.** | PHYS 583 | Nuclear Dynamics | PHYS 506 | 3(3+0) |
| **N.P.** | PHYS 581 | Nuclear Reactor Physics | PHYS 506 | 3(3+0) |
| **N.P.** | PHYS 585 | Neutron Physics | PHYS 580 | 3(3+0) |
| **N.P.** | PHYS 587 | Nuclear Techniques | PHYS 580 | 3(2+1) |
| **B.P.** | PHYS 591 | Principles of Biophysics | - | 3(3+0) |
| **B.P.** | PHYS 592 | Biomedical Physics Lab | PHYS 591 | 2(0+2) |
| **B.P.** | PHYS 593 | Introduction to Medical Physics | PHYS 591 | 2(2+0) |
| **B.P.** | PHYS 594 | Nuclear Medicine | PHYS 591 | 2(2+0) |
| **B.P.** | PHYS 595 | Biophysics of cell communication | PHYS 591 | 2(2+0) |
| **B.P.** | PHYS 596 | Special Topics in Biomedical physics | PHYS 591 | 2(2+0) |
| **A.P.** | ASTR 550 | Fundamentals of Astrophysics | - | 2(2+0) |
| **A.P.** | ASTR 551 | Astronomical Techniques | - | 2(1+1) |
| **A.P.** | ASTR 552 | Solar Physics | - | 2(2+0) |
| **A.P.** | ASTR 553 | Stellar Structure and Evolution | ASTR 550 | 2(2+0) |
| **A.P.** | ASTR 554 | Galaxies | ASTR 550 | 2(2+0) |
| **A.P.** | ASTR 555 | Planetary Physics | ASTR 550 | 2(2+0) |
| **A.P.** | ASTR 556 | Interstellar Matter | ASTR 550 | 2(2+0) |
| **A.P.** | ASTR 557 | Space Physics | ASTR 550 | 2(2+0) |
| **A.P.** | ASTR 558 | Astrodynamics | ASTR 550 | 2(2+0) |
| **A.P.** | ASTR 559 | Advanced Astrophysics | ASTR 550 | 2(2+0) |
| **A.P.** | ASTR 560 | Astronomy Seminar | - | 2(2+0) |
| **A.P.** | ASTR 561 | Celestial Mechanics | ASTR 550 | 2(2+0) |
| **A.P.** | ASTR 562 | Cosmology | ASTR 550 | 2(2+0) |

**Table key:**

|  |  |
| --- | --- |
| **T.P.** | Theoretical Physics |
| **L.P.** | Laser Physics and Spectroscopy |
| **S.E.** | Solar Energy Physics |
| **M.P.** | Materials Physics |
| **N.P.** | Nuclear Physics |
| **B.M.** | Biomedical Physics |
| **A.P.** | Astronomy |

#### Program Schedule:

##### First Semester (All tracks)

|  |  |  |  |
| --- | --- | --- | --- |
| **Specialty** | **Course Code** | **Course title** | **Credit hours** |
| **All**  **All**  **All**  **All** | PHYS 500 PHYS 501  PHYS 505 PHYS 508 | Research Methodology  Mathematical Physics  Advanced Quantum Mechanics  Classical Mechanics | 1 (1+0)  2 (2+0)  3 (3+0)  3 (3+0) |
|  | **Total** |  | **9 (9+0)** |

**Theoretical Physics**

##### Second Semester\*

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course title** | **Prerequisite Course** | **Credit hours** |
| PHYS 506  PHYS 507  PHYS 510  PHYS 555 | Statistical Physics  Classical Electrodynamics  Relativistic Quantum Mechanics  Quantum Field Theory I | -  -  PHYS 505  PHYS 505 | 3 (3+0)  3 (3+0)  3 (3+0)  3 (3+0) |

**\*The student chooses 9 credit hours, but it must with Phys 506 and Phys 507**

##### Third Semester\*

##### 

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course title** | **Prerequisite Course** | **Credit hours** |
| PHYS 515  PHYS 516  PHYS 556  PHYS 56 | Quantum Theory of Many Body Physics  Special Topics in Theoretical Physics  Quantum Field Theory II  Elementary Particle Physics I | PHYS 505 & PHYS 506  -  PHYS 555  PHYS 510 | 3 (3+0)  3 (3+0)  3 (3+0)  3 (3+0) |

**\*The student chooses only two courses (6 credits)**

**Laser Physics and Spectroscopy**

##### Second Semester

|  |  |  |
| --- | --- | --- |
| **Course Code** | **Course title** | **Credit hours** |
| PHYS 506  PHYS 507  PHYS 532 | Statistical Physics  Classical Electrodynamics  Advanced Laser Physics | 3 (3+0)  3 (3+0)  3 (3+0) |
| **Total** |  | **9 (9+0)** |

##### Third Semester\*

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course title** | **Prerequisite Course** | **Credit hours** |
| PHYS 533  PHYS 536  PHYS 537 | Quantum Optics Laboratory  Atomic & Molecular Spectroscopy  Advanced Optics | PHYS 532  PHYS 505  - | 3 (0+3)  3 (3+0)  3 (3+0) |

**\*The student chooses only two courses (6 credits)**

**Solar Energy Physics**

##### Second Semester

##### 

|  |  |  |
| --- | --- | --- |
| **Course Code** | **Course title** | **Credit hours** |
| PHYS 506  PHYS 507  PHYS 541 | Statistical Physics  Classical Electrodynamics  X-Ray Diffraction and its Applications | 3 (3+0)  3 (3+0)  3 (2+1) |
| **Total** |  | **9 (8+1)** |

##### Third Semester\*

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course title** | **Prerequisite Course** | **Credit hours** |
| PHYS 542  PHYS 543  PHYS 544  PHYS 545  PHYS 546  PHYS 547 | Physics and Technology of Semiconductors  Materials of Solar Energy  Solar Cells  Heat transfer and its applications in solar energy  Solar radiation: Models and Applications  Renewable energy sources and the environment | PHYS 505  PHYS 505  -  PHYS 506  -  - | 2 (2+0)  2 (2+0)  2 (2+0)  2 (2+0)  2 (2+0)  2 (2+0) |

**\*The student chooses only three courses (6 credits)**

**Materials Physics**

##### Second Semester

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course title** | **Prerequisite Course** | **Credit hours** |
| PHYS 506  PHYS 507  PHYS 570 | Statistical Physics  Classical Electrodynamics  Theory of Solids | -  -  PHYS 505 | 3 (3+0)  3 (3+0)  3 (3+0) |
| **Total** |  |  | **9 (9+0)** |

##### Third Semester\*

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course title** | **Prerequisite Course** | **Credit hours** |
| PHYS 571  PHYS 574  PHYS 576  PHYS 577  PHYS 578  PHYS 579 | Electron Magnetic Resonance  Materials Science  Theory of Magnetism  Nanostructures Science and Engineering  Materials Studies Lab  Special Topics in Condensed Matter | PHYS 570  PHYS 570  -  PHYS 505  PHYS 574  - | 3 (3+0)  3 (3+0)  3 (3+0)  3 (3+0)  3 (0+3)  3 (3+0) |

**\*The student chooses only two courses (6 credits)**

**Nuclear Physics**

##### Second Semester

##### 

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course title** | **Prerequisite Course** | **Credit hours** |
| PHYS 506  PHYS 507  PHYS 580\* | Statistical Physics  Classical Electrodynamics  Nuclear Structure | -  -  PHYS 505 | 3 (3+0)  3 (3+0)  3 (3+0) |
| **Total** |  |  | **9 (9+0)** |

##### Third Semester\*

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course title** | **Prerequisite Course** | **Credit hours** |
| PHYS 581  PHYS 583  PHYS 585 PHYS 587 | Nuclear Dynamics  Nuclear Reactor Physics  Neutron Physics  Nuclear Techniques | PHYS 506  PHYS 506  PHYS 580  PHYS 580 | 3 (3+0)  3 (3+0)  3 (3+0)  3 (2+1) |

**\*The student chooses only two courses (6 credits)**

**Biomedical physics**

##### Second Semester

|  |  |  |
| --- | --- | --- |
| **Course Code** | **Course title** | **Credit hours** |
| PHYS 506  PHYS 507  PHYS 591 | Statistical Physics  Classical Electrodynamics  Principles of Biophysics | 3 (3+0)  3 (3+0)  3 (3+0) |
| **Total** |  | **9 (9+0)** |

##### Third Semester

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course title** | **Prerequisite Course** | **Credit hours** |
| PHYS 592  PHYS 593  PHYS 594  PHYS 595  PHYS 596 | Biomedical Physics Lab.  Introduction to Medical Physics  Nuclear Medicine  Biophysics of cell communication  Special Topics in Biophysics | -  PHYS 591  PHYS 591  PHYS 591  PHYS 591 | 2 (0+2)  2 (2+0)  2 (2+0)  2 (2+0)  2 (2+0) |

**\*The student chooses two courses (4 credits) plus Phys 592 (total 6 credits)**

**Astronomy**

##### Second Semester

##### 

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course title** | **Prerequisite Course** | **Credit hours** |
| PHYS 507  ASTR 550  ASTR 551  ASTR 553 | Classical Electrodynamics  Fundamentals of Astrophysics  Astronomical techniques  Stellar structure and evolution | -  -  -  ASTR 550 | 3 (3+0)  2 (2+0)  2 (1+1)  2 (2+0) |
| **Total** |  |  | **9 (8+1)** |

##### Third Semester\*

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **Course title** | **Prerequisite Course** | **Credit hours** |
| ASTR 552  ASTR 554  ASTR 555  ASTR 556  ASTR 557  ASTR 558  ASTR 559  ASTR 560  ASTR 561  ASTR 562 | Solar Physics  Galaxies  Planetary Physics  Interstellar Matter  Space Physics  Astrodynamics  Advanced Astrophysics  Astronomy Seminar  Celestial Mechanics  Cosmology | -  ASTR 550  ASTR 550  ASTR 550  ASTR 550  ASTR 550  ASTR 550  -  ASTR 550  ASTR 550 | 2 (2+0)  2 (2+0)  2 (2+0)  2 (2+0)  2 (2+0)  2 (2+0)  2 (2+0)  2 (2+0)  2 (2+0)  2 (2+0) |

**\*The student chooses only three courses (6 credits)**

**Fourth Semester for all students**

|  |  |  |
| --- | --- | --- |
| **Course Code** | **Course title** | **Credit hours** |
| PHYS 600 | **Thesis** | 6 |

**Courses Description**

**PHYS 500 Research Methodology 1(1+0)**

Master research planning- Proposal writing- Research in the library and internet- How to collect, extract and classify the voluble information from the published articles- Literature review writing - Experimental work planning- Data analysis and representation and discussion- Thesis writing – Bibliography classification, writing and arrangement- Thesis representation and defense. How to write and published a scientific paper from the thesis.

**PHYS 501 Mathematical Physics 2(2+0)**

Vector Analysis, Vector Analysis in Curved Coordinates and Tensors, Functions of Complex variable I, Functions of Complex variable II, Differential equations, Sturm-Liouville Theory-Orthogonal Functions.

**PHYS 505 Advanced Quantum Mechanics 3(3+0)**

Fundamental concepts, Introduction to group theory and Lie algebra. Theory of total angular momentum (Lie algebra of the components of angular momentum, parity and time reversal, sum of two angular momentum and Clebsch-Gordan coefficients). Applications of time- dependent and time –independent perturbation theory, Scattering theory (Born approximation for the scattering wave, scattering using phase-shift analysis).

**PHYS 506 Statistical Physics 3(3+0)**

The statistical basis for thermodynamics, Review of classical statistical mechanics, Postulates of quantum statistical mechanics, Micro canonical ensemble, Micro canonical ensemble, Ideal Bose gas, phonon gas, Ideal Fermi gas, Degeneracy pressure, interacting systems.

**PHYS 507 Classical Electrodynamics 3(3+0)**

Introduction to Electrostatics, Boundary value problems in Electrostatics I&II, Magnetostatics, Faraday’s law, quasi static fields, Maxwell’s equations and macroscopic electromagnetism, conservation laws, Plane electromagnetic waves and waves propagation.

**PHYS 508 Classical Mechanics 3(3+0)**

Variational principles and Lagrange's Equations, Central force problem, Oscillations, Classical mechanics of the special theory of relativity, Hamiltonian equations of motion, Canonical transformation, Hamilton-Jacobi theory and action-angle variables, Lagrangian and Hamiltonian formulation for continuous systems and fields.

**PHYS 510 Relativistic Quantum Mechanics** Prerequisite course Phys 505 **3(3+0)**

Relativistic wave equation for spin zero particle (Klein-Gordon equation), Wave equation for spin half particle (Dirac equation), Lorentz-Covariance of the Dirac equation, Spinors under special reflection, Bilinear covariant of the Dirac spinors, Dirac particles in external fields, The hole theory, The Weyl equation-The neutrino.

**PHYS 515 Quantum Theory of Many Body Physics** Prerequisite course Phys 505 & Phys 506

**3 (3+0)**

Second Quantization & Statistical Mechanics, Green’s Functions and Field Theory, Fermi Systems, Linear Response, Bose Systems, Field Theory at Finite Temperature, Physical Systems at Finite Temperatures. Real-Time Green’s Functions and Linear Response.

**PHYS 516 Special Topics in Theoretical Physics 3(3+0)**

This course will be given and selected by the supervisor/staff member to help the student to achieve his thesis.

**PHYS 532 Advanced Laser Physics**   **3(3+0)**

Propagation of optical beams in homogenous and guiding media; ABCD law, Optical resonators, Fabry-Perot etalon, mode stability criteria, losses in optical resonator, unstable resonator ; Theory of laser oscillation, threshold conditions, Fabry-Perot laser, line-shape function and line broadening effects, three and four level systems, mode locking and Q-switching; Non-linear phenomena; Frequency conversion; High power lasers.

**PHYS 533 Quantum Optics Laboratory** Prerequisite course Phys 532 **3(0+3)**

Measurement of spectrum and pulse duration of YAG laser pumped by a semiconductor laser, characteristics measurements of SHG and THG of YAG laser, fiber optics characteristics measurements, spatial filtering, Raman scattering, characteristics of nitrogen laser, spectral measurement of dye laser, pumped dye laser system.

**PHYS 536 Atomic and Molecular Spectroscopy** Prerequisite course Phys 505 **3(3+0)**

Bohr's atom; Vector atom models; Space, spin quantization. Fine structure of one electron, two electrons and many electrons systems; L-S and j-j coupling; Zeeman effect; Low and high magnetic fields; Stark effect; Electronic, vibrational and rotational energy levels, Electronic configuration of simple molecules; Vibrational modes; P.Q.R. branches of rotational transition; Fluorescence, phosphoresce; Frank, Candon factors; Raman effect. Tunable lasers; Spectral and temporal tuning; Raman lasers; CARS; Horses; Harmonic and parametric oscillators; Picosecond, continuum, femtosecond spectroscopy; LIBS, PAS, Rydberge states; Photogalvanic, multiphoton spectroscopy; High resolution spectroscopy; Lamb dip and saturation spectra; Laser cooling.

**PHYS 537 Advanced Optics 3(3+0)**

Coherence; coherence time and coherence length, temporal and spatial coherence. Matrix treatment of polarization, Jones vectors and Jones matrices. Fourier optics; Fourier analysis and transform. Holography. Nonlinear optics; non-linear susceptibility, second harmonic generation, wave mixing, Effects of Pockel, Kerr, faraday and acousto-optics, phase conjugation.

**PHYS 541 X-Ray Diffraction and its Applications 3 (2+1)**

Properties of X-Rays, Geometry of Crystals, Diffraction I: Geometry, Diffraction II: Intensities of diffracted beams, Diffraction III: real samples, Laue Photographs, Powder photographs, Diffractometer measurements, Determination of crystal structure, Structure of polycrystalline aggregates.

**PHYS 542 Physics and Technology of Semiconductors** Prerequisite course Phys 505 **2(2+0)**

Semiconductor Materials, Energy bands and Carrier Concentration, Carrier Transport Phenomena, p-n junctions, Metal- Semiconductor junctions (Unipolar Devices), Diffusion and Ion Implantation, Photonic Devices (Optical Absorption, Luminescence, and Carrier Lifetime and Photoconductivity) and other technical Topics: Photolithography, Etching, Bulk Crystal Growth, Thermal Oxidation, Epitaxial Growth, Metallization, MIS devices, LEDs, Semiconductor Lasers and Microwave devices.

**PHYS 543 Materials of Solar Energy** Prerequisite course Phys 505 **2(2+0)**

Glass Based and PVC Based (Flexible) Substrate Materials, Transparent Conductors, Ohmic, selective and Photovoltaic Materials (Amorphous, Polycrystalline and Crystalline Silicon), Gallium arsenide, Indium Phosphide and other III- V Materials, CdS, CdTe and other II-VI Materials, CuInSe2 Materials, Organic and polymeric semiconducting materials, New nanostructure materials for solar energy applications.

**PHYS 544 Solar Cells 2 (2+0)**

Photovoltaic Behavior of Junctions (Homo Junctions, Hetero Junctions, MS and CIS Junctions, Photovoltaic parameters), Photovoltaic Measurements (I-V Characteristics, Spectral Response, C-V Measurements), Polycrystalline Thin silicon solar cell, Amorphous Silicon Solar Cells, Emerging Solar Cells (GaAs based, CdTe, Zn3P2, InP, CuInSe2, CuInS2, CIGS), Organic Solar Cells, Photo electro Chemical Cells, Novel concepts in Design of High Efficiency Solar Cells, Nano solar cells.

**PHYS 545 Heat Transfer and its Applications in Solar Energy** Prerequisite course Phys 506 **2 (2+0)**

Heat transfer mechanisms, Forced convection heat transfer, Natural convection heat transfer, Thermal radiation, Thermal energy and instrumentation, Heat treatment and techniques, Thermovision systems, Thermal applications in solar energy.

**PHYS 546 Solar Radiation: Models and Applications 2 (2+0)**

Solar physics, Electromagnetism radiation, Universal and terrestrial solar radiation, Geometrical factors for solar radiation and atmospheric layers, Solar radiation equations, Solar radiation tables, Solar radiation measurements, Models and applications.

**PHYS 547 Renewable Energy Sources and Environment 2 (2+0)**

Basic concepts and energy conversion, Solar-thermal and photovoltaic energy, Wind energy, Hydropower, Biomass energy, Geothermal energy, Hydrogen energy, Organic and waste energy, Renewable energy storage, Global warming, The atmosphere and ozone and Environmental control.

**PHYS 555 Quantum Field Theory I** Prerequisite course Phys 505 **3(3+0)**

Photon and electromagnetic field, Lagrangian field theory, Klein-Gordon field, Dirac field, Covariant theory of photons, S-matrix expansion, Feynman Digrams in QED, Lowest order QED processes

**PHYS 556 Quantum Field Theory II** Prerequisite course Phys 555 **3(3+0)**

Basics in field quantization, Introduction to renormalization theory, Renormalization group, Radiative correction in QED, Regularization in QED.

**PHYS 561 Elementary Particle Physics I** Prerequisite course Phys 510 **3(3+0)**

Historical introduction for the elementary particles, Elementary particle dynamics, Relativistic kinematics, Symmetries, Boundstates, Feynman calculus, Quantum Electrodynamics, Electrodynamics of quarks and hadrons, Quantum chromodynamics, Weak Interactions, Gauge theories.

**PHYS 570 Theory of Solids** Prerequisite course Phys 505 **3 (3+0)**

Band theory for metals, semiconductors and insulators - Properties of metals, semiconductors and insulators – Transport theory - Magnetic properties superconducting materials – Photovoltaic and thermoelectric effects – Interaction of radiation with solids – Elementary excitations.

**PHYS 571 Electron Magnetic Resonance** Prerequisite course Phys 570 **3(3+0)**

Magnetic properties of the electron - Interaction with the proton - Zeeman splitting phenomena - Quantum mechanics of electron spin resonance - Absorption, Saturation and relaxation - Multi-spin systems - Magnetic resonance of crystals and anisotropic systems - Free radicals - Iron group - Magnetic resonance spectrometers at medium and high frequencies.

**PHYS 574 Materials Science** Prerequisite course Phys 570 **3(3+0)**

Crystalline and amorphous solids – Metallic, semiconducting and insulating materials – Crystal growth – Thin films – Nanoproperties – Phase change in solids and phase diagrams – X-ray diffraction – Elemental analysis – Preparation of alloys and ceramics – Types of defects – Elasticity and hardness – Polymers and plastics - Ultraviolet and infrared properties of materials.

**PHYS 576 Theory of Magnetism 3(3+0)**

Electronic and atomic magnetism – Types of magnetism – Paramagnetism – Ferromagnetism and Antiferromagnetism – Heisenberg and Ising models – Impurity magnetism – Kando effect – Transition element magnetism – Effective field theories – Amorphous and magnetic glasses – Magnetic energy – Magnetic phenomena in superconducting materials.

**PHYS 577 Nanostructures Science and Engineering** Prerequisite course Phys 505 **3(3+0)**

Introduction to nanostructure, Nanoparticles, Nanowires, Superlattices , Fullerenes, Nanotubes, Graphene , Interfaces, Silicon Technology, Solar Cells , Magnetic Data Storage, Spin Valves, Self-Assembly, Supermolecular Chemistry, Single Electron Devices, Molecular Electronics, Bio-Interfaces, Bio-Sensors, Molecular Motors, Quantum dots; Nano-scale probes; Fabrication of nanostructures; Transport in low-D systems; Optoelectronics of nanostructures

**PHYS 578 Materials Studies Lab** Prerequisite course Phys 574 **3 (0+3)**

Experiments are to be undertaken by each student out of the following:

Superconductivity - Thin films - Magnetic properties – Ferroelectrics - Semiconductors and metals.

A detailed report on: background, methods and analysis of data, conclusions and full references should be given in a publication style.

Some of these experiments can be replaced with other experiments according to the available experiments and students number

**PHYS 579 Special Topics in Materials Physics 3(3+0)**

This wide and opened course is exceptional, since it will be given and selected by the supervisor/staff member to help the student in research work.

**PHYS 580 Nuclear Structure** Prerequisite course Phy s 505 **3(3+0)**

Alpha Decay: theory of barrier penetration, role of angular momentum,

Beta Decay: Role of neutrino, Fermi theory, shape of energy spectrum, Decay rate, selection rules, mass of neutrino, double Beta decay.

Gamma decay in nuclei: Excited states in nuclei, gamma decay, decay rates, selection rules, spectroscopic information from gamma decays, internal conversion, isomers, resonance absorption, Mossbauer Effect.

Nuclear moments: Multi-pole expansion of nuclear charge and current density, magnetic dipole moment, electric quadruple moment, hyperfine structure, nuclear magnetic resonance.

Nuclear forces: properties of nuclear force, the deuteron, nucleon, scattering.

Nuclear models: shell model, collective properties, Rotation, Vibrations, Single particle states in deformed nuclei, Multi-particle configurations, Back pending, and Super deformation.

**PHYS 581 Nuclear Reactor Physics** Prerequisite course Phy s 506 **3 (3+0)**

Neutron Physics: properties of neutrons, Neutron sources, nuclear reactions, BF3 detectors.

Nuclear Fission by thermal neutron in homogenous reactors: Scattering Cross Section, Energy release from fission, Neutron yield, Reactor Criticality, Neutron cycle

Neutron diffusion: Diffusion equation and its solutions.

The Critical equation in steady homogenous reactors: Diffusion equation applied to thermal for infinite and finite reactors, Fast neutron diffusion and Fermi age equation.

Heterogeneous Reactors: Effect of fuel distribution on the parameters of the multiplication factor, Non-steady nuclear reactors.

**PHYS 583 Nuclear Dynamics** Prerequisite course Phy s 506 **3(3+0)**

Scattering, particle transfer, resonance reactions, fission. Time-dependent. Hartree-Fock, Vlasov equation. Nuclear transport equations, particle production, nuclear liquid-gas phase transition, quark-gluon plasma.

**PHYS 585 Neutron Physics** Prerequisite course Phy s 580 **3(3+0)**

Production of monoenergetic neutrons, Integral and Differential cross sections, Measurement of thermal, epithermal and fast neutron fluxes, Neutron source strength measurement, Neutron spectrometry using semiconductor, proportional and scintillation counters, Scattering of neutrons, Debye Waller Factor, Incoherent and Coherent scattering, Neutron diffraction and its applications in studies of magnetic and non magnetic materials and amorphous solids, Polarization of neutrons and its applications,

Neutrons activation analysis, Neutron radiography.

**PHYS 587 Nuclear Techniques** Prerequisite course Phy s 580 **3(2+1)**

Course (2h): Passage of radiation through matter, Statistics and treatment of experimental data, General Characteristics of detectors, Ionization detectors, Scintillation Detectors, Semiconductor Detectors

Lab (1h): Linux environment, C/C++ programming, data analysis tools, simulation codes.

**PHYS 591 Principles of Biophysics 3(3+0)**

Biological cell and membrane structures. Membrane permeability. Permeability barrier. Active transport. Nernst Potential. Different models of membrane system. Liposomes and its applications. Functional organization of the human body and the control of internal environment. Hemostasis. Blood composition and coagulation; rheology of blood. Structure of heart & heart muscles. The electrocardiogram (ECG). The regulation of circulation. Hemodynamics of blood (blood flow and pressure). Macro-circulation and microcirculation. physiological biophysics techniques.

**PHYS 592 Biomedical Physics Lab.** Prerequisite course Phys 591 **2(0+2)**

Spectroscopy - Models membrane preparation and measurements –AC & DC Dielectric relaxation of biological molecules- Viscosity and Dynamics of Biological Fluids – Radiation Dosimeters. Radiation diagnosis and treatments (Hospital training).

**PHYS 593 Introduction to Medical Physics** Prerequisite course Phys 591 **2(2+0)**

Ultrasound waves and its production , the interaction of ultrasound with tissues , Ultrasonic scanning , A-scan and B-scan method, Doppler Effect. X-rays and their Production , X-ray spectra, Attenuation of X-rays, The radiographic image, Diagnostic applications of X-rays, Advantages and Disadvantages of X-rays. Magnetic resonance imaging: Nuclear Magnetic resonance, Localization of the signal, Factors influencing of signal intensity, Instrumentation and equipment.

**PHYS 594 Nuclear Medicine** Prerequisite course Phys 591 **2(2+0)**

Nuclear radiation, Interaction of radiation with biological materials. Production of artificial radionuclide's, Radio-pharmaceuticals, Radionuclide imaging, radioisotopes diagnostic.

**PHYS 595 Biophysics of Cell Communication** Prerequisite course Phys 591 **2(2+0)**

Overview of cell signaling; Communication and distance; Receptor locations; Cell Membrane surface receptor classes; Signal Transduction Pathways; Signals Amplification; Specificity of cell signaling; Cellular response; .

**PHYS 596 Special Topics in Biophysics** Prerequisite course Phys 591 **2(2+0)**

This course will be given and selected by the supervisor/staff member to help the student to achieve his thesis.

**ASTR 550 Fundamentals of Astrophysics 2(2+0)**

Applications of fundamental physics to astrophysical phenomena – Elements of general relativity – Basics of hydrodynamics – Radiative processes – High energy astrophysics–Stellar physics – Introduction to the physics of galaxies.

**ASTR 551 Astronomical Techniques 2(1+1)**

Space and terrestrial telescopes – Optical and UV detection – X-ray detection – Gamma ray detection – Image processing and data reduction for Solar and Stellar observations.

**ASTR 552 Solar Physics 2(2+0)**

Solar structure, atmosphere, activities, nuclear reactions and heat transfer – Solar terrestrial physics.

**ASTR 553 Stellar Structure and Evolution** Prerequisite course Astr 550 **2(2+0)**

The inner structure of stars, the hydrostatic equilibrium, mass radius relation, solar model, main sequence, age of stars, the convection zone, optical depth, sun’s atmosphere, formation of the spectra lines and classification, lines of growth, evolution of stars, white dwarfs, neutron stars and black holes.

**ASTR 554 Galaxies** Prerequisite course Astr 550 **2(2+0)**

The Milky Way – Galaxies, classification, dynamics and distribution – Active galaxies– Clusters of galaxies – Evolution of galaxies – Quasars – Universe expansion – Big bang theory.

**ASTR 555 Planetary Physics** Prerequisite course Astr 550 **2(2+0)**

Atmosphere, internal structure, magnetosphere, ionosphere, satellites, rings, comets, asteroids, interplanetary matter.

**ASTR 556 Interstellar Matter** Prerequisite course Astr 550 **2(2+0)**

Interstellar medium: distribution, chemistry and chemical evolution, physics of interstellar medium, star formation.

**ASTR 557 Space Physics** Prerequisite course Astr 550 **2(2+0)**

Earth: Neutral atmosphere – Ionosphere – Magnetosphere ,Solar wind, activity – Solar terrestrial physics – Space environment.

**ASTR 558 Astrodynamics** Prerequisite course Astr 550 **2(2+0)**

The spherical triangle, the celestial coordinates, the sidereal time, seasons, position of the celestial objects, setting and rising times, the refraction, parallax, aberration, motion of the planet around the sun, motion of the planet in sky, the galactic coordinates, the changing in the celestial coordinates, orbital theory.

**ASTR 559 Advanced Astrophysics** Prerequisite course Astr 550 **2(2+0)**

Radiation in astrophysics – High energy astrophysics – Magneto hydrodynamics – Space plasma physics.

**ASTR 560 Astronomy Seminar 2(2+0)**

Selected advanced topics in Astronomy and Astrophysics. Topics change every semester.

**ASTR 561 Celestial Mechanics** Prerequisite course Astr 550 **2(2+0)**

Orbit theory, two body problem, three body problem, relativistic movement equations, movements in the polar coordinates, elliptical orbits, Kepler laws and Kepler Equations, Lambert Theory, secular and general perturbation, lunar theory.

**ASTR 562 Cosmology** Prerequisite course Astr 550 **2(2+0)**

Geometry of the universe – Simple cosmological models – Observational parameters – Cosmological Constant – CMB – SNe – Inflation, Early Nucleosynthesis, relativity.