Department of Physics

Chairperson: Touma, Jihad R.

Professor Emeritus: Mavromatis, Harry A.

Professors: Antar, Ghassan Y.; Bitar, Khalil M.; Chamseddine, Ali H.; El Eid, Mounib F.; Isber, Samih T.; Klushin, Leonid I.; Sabra, Wafic A.; Tabbal, Malek D.; Touma, Jihad R.

Associate Professors: Christidis, Theodore C.; Kazan, Michel J.

Lecturers: Al-Sayegh, Amara A.; Bodakian, Berjouhi H.; El-Daif, Ounsi R.; Roumieh, Mohammad A

The department provides courses and facilities for graduate work leading to the MS and PhD degrees. The research activities of the department include material science, condensed and soft matter physics, plasma physics, paramagnetic resonance, nonlinear dynamics, astrophysics, high-energy physics, superstring theory and quantum gravity.

MS in Physics

Admission Requirements
Refer to the Faculty of Arts and Sciences section.

Course Work
The MS program requires the completion of 21 credits of courses and a research thesis. The courses consist of four core courses: PHYS 301, PHYS 302, PHYS 303 and PHYS 305, and 9 credits of physics graduate electives. After completion of the four core courses, the student must pass the GRE subject test, considered by the Physics Department as the Master’s Comprehensive Exam.

Master Thesis Proposal and Thesis Defense

Residence Requirements
See Residence Requirements section under General University Academic Information.

(P) Part-time
Doctor of Philosophy in Theoretical Physics

Mission Statement
The PhD program in the Department of Physics is intended to produce competent, independent researchers who are able to make original contributions to physical sciences. The program prepares students for careers in research, teaching or industry and thus provides qualified scientists for Lebanon and the region. It serves the AUB mission of promoting research and participating in the advancement of knowledge.

Admission
Admission to the PhD program is done on a competitive basis. To be eligible for admission, applicants must have an excellent academic record and must demonstrate exceptional motivation and ability to pursue research in physics. The following items are required for an application:

- **Degrees:**
  - For the Regular Track\(^1\), a Master in Science (MS) degree in Physics or related fields from an institution recognized by AUB is required.
  - For the Accelerated Track\(^2\), a Bachelor of Science (BS) degree in Physics or related fields from an institution recognized by AUB is required.

- Three letters of recommendation
- GRE General Test as per AUB requirements. Subject GRE is required as per Physics Department requirements (No GRE is required for applicants to the MS program.)
- For English, refer to the English Language Proficiency Requirements (ELPR) section in the catalogue.
- A statement of purpose
- A recommendation for admission by the AUB Department of Physics. A departmental committee may require an interview with the applicant before giving a recommendation.

Governance
Refer to the section on the Supervision of Doctoral Thesis under General University Academic Information.

Supervision of PhD Thesis
Refer to the section on the Supervision of Doctoral Thesis under General University Academic Information.

PhD Publication Requirements
Refer to PhD Publication Requirements under General University Academic Information.

---

1) Refer to the Study Section under General University Academic Information.
Course Work
The PhD program requires the completion of at least 39 credit hours of course work for students admitted on the accelerated track (BS holders) and a minimum of 18 credit hours of course work for students admitted on the regular track (MS holders).

The required courses for students admitted on the regular track are PHYS 306 and 307 (6 credits) and at least 12 credits beyond the core program, out of which one course must be in the concentration area, while the others can be taken as electives. Students may take relevant courses outside the department provided they secure departmental approval.

The required courses for students admitted on the accelerated track are PHYS 301, PHYS 302, PHYS 303, PHYS 305, PHYS 306 and PHYS 307 (18 credits) and at least 21 credits beyond the core program, out of which one course must be in the concentration area, while the others can be taken as electives. Students may take relevant courses outside the department provided they secure departmental approval.

PhD Qualification Exam Part I and Part II
Upon completion of a minimum of 15 credits of graduate courses with a cumulative average of 85 or above in the four core courses, the student should sit for PhD Qualification Exam Part I (written comprehensive examination) to determine whether s/he has acquired the background necessary to continue in the PhD program.

After choosing a thesis advisor, the student should pass the PhD Qualification Exam Part II; the student must formulate, submit and defend a thesis research proposal to demonstrate a capacity to pursue and complete a doctoral research project.

For more information, refer to the section on PhD Qualifying Exam under General University Academic Information.

Candidacy
Refer to the section on Admission to Candidacy under General University Academic Information.

PhD Thesis and Thesis Defense

Residence Requirements
Refer to Residence Requirements section under General University Academic Information.

Graduation Requirements
A student is granted the PhD degree upon approval of the PhD thesis committee in a public session. In addition to the general graduation guidelines specified by the university, the Physics Department also requires that part of the PhD thesis work be published or accepted for publication in a refereed journal by the time of graduation.
Timetable
A student is expected to abide by the following timetable:

• Finish the graduate course work (a minimum of 39 credits after the BS) within 8 semesters of starting the graduate study program
• Pass the qualifying exam upon completion of 15 credits, within 3 semesters of starting the graduate study program
• Students in the accelerated track should choose a thesis advisor within four semesters of starting the graduate study program
• Defend the PhD thesis proposal within 6 semesters and advance to candidacy within 7 semesters of starting the graduate study program
• Present research work by submitting her/his thesis to the thesis committee and defending it in a public session. The total length of the PhD should not exceed 7 years.

Financial Support
The Physics Department offers, on a competitive basis, substantial financial support. For full-time students, it covers tuition and includes a monthly stipend. There are also some funds available to support participation in two international conferences during PhD study. In return, students help in teaching undergraduate labs and recitations of introductory courses. Their duties may also include help in proctoring and correcting exams.

Course Descriptions

PHYS 301 Classical Mechanics 3.0; 3 cr.
D'Alembert's principle, variational principles and Euler Lagrange's equations, rigid bodies and small oscillations, Hamilton's mechanics, canonical transformations and Hamilton-Jacobi theory, stability, integrable systems and chaotic motion. *Annually.*

PHYS 302 Statistical Mechanics 3.0; 3 cr.
Statistical ensembles, Boltzmann distribution, density matrix, Fermi-Dirac and Bose-Einstein statistics and applications, phase transitions, mean-field theory and applications. *Annually.*

PHYS 303 Electromagnetic Theory 3.0; 3 cr.
Boundary-value problems in electrostatics, multipoles, dielectrics, magnetostatics, time-varying fields and Maxwell's equations, electromagnetic waves. *Annually.*

PHYS 305 Quantum Mechanics 3.0; 3 cr.
Hilbert space formulation of quantum mechanics; theory of angular momentum; Euler rotation; addition of angular momenta; symmetries and conservation laws: time reversal, parity, discrete symmetry, path-integral formulation of quantum mechanics, approximation methods, identical particles, elementary scattering theory. *Annually.*

PHYS 306 Introduction to Quantum Field Theory 3.0; 3 cr.
Unifying quantum theory and relativity; relativistic quantum mechanics: Klein-Gordon equation, scalar field, second quantization, Dirac's equation and Dirac's field. Interaction fields and Feynman diagrams, quantization of the electromagnetic field. *Prerequisite: PHYS 305.*
PHYS 307 Mathematical Methods of Physics 3.0; 3 cr.
Complex analysis: contour integration, conformal representation, tensor analysis; partial differential equations: heat equation, hypergeometric functions.

PHYS 310 Special Topics 3.0; 3 cr. (each)
May be repeated for credit.

PHYS 311 Astrophysics I 3.0; 3 cr.
Stars: observational properties, population, spectra analysis; stellar matter: atomic processes, equation of state including degeneracy effects; stellar structure: differential equations of stellar structure, radiative and convective energy transport, thermonuclear reactions nuclear fusion processes; stellar evolution: discussion of the evolutionary phases of stars, stellar stability and pulsations; final stages of stars: supernovae, white dwarfs, neutron stars and black holes; star formation.

PHYS 312 Astrophysics II 3.0; 3 cr.

PHYS 313 Differential Geometry and General Relativity 3.0; 3 cr.

PHYS 314 Non-Equilibrium Statistical Mechanics 3.0; 3 cr.

PHYS 315 Particle Cosmology 3.0; 3 cr.
Relativistic cosmology: Friedmann equations and their solutions, Hubble diagram. Hot Big Bang model: statistical mechanics of the expanding universe, microwave background, primordial nucleosynthesis, GUT model for baryon asymmetry. Structure formation: Newtonian perturbation theory, gauge invariant relativistic perturbation theory, the large-scale structure of the universe. Inflation theory. Prerequisite: PHYS 313.
PHYS 316  Physics of Soft Matter  3.0; 3 cr.

PHYS 317  Group Theory and Symmetry in Physics  3.0; 3 cr.

PHYS 318  Standard Model of Particle Physics  3.0; 3 cr.

PHYS 319  String Theory  3.0; 3 cr.

PHYS 322  Thin Films Physics  3.0; 3 cr.
Introduction to surface and thin films physics: definitions, importance in basic research, impact on technology and society. Ultra high vacuum techniques and processes: kinetic theory concepts, surface preparation procedures; surface chemical composition: XPS, AES, SIMS, GIXRD. Thin film deposition: evaporation, plasma, laser and ion beam processing; physical and chemical vapor deposition techniques. Surface morphology and physical structure: surface energy, reconstruction, 2-D lattices, nucleation and growth of thin films, microscopy techniques. Theory of surface scattering; inelastic scattering and dielectric theory; electron-based techniques: LEED and RHEED, RBS. Epitaxy: atomistic models and rate equations; steps, ripening and interdiffusion; HRXRD. Conduction and magnetism in thin films; superconductivity; optical and mechanical properties. Pre- or corequisite: PHYS 302.

PHYS 323  Plasma Physics  3.0; 3 cr.
The motion of a single particle (electron or ion) subject to electromagnetic forces; fluid equations for electrons and ions; guiding center description; collisional phenomena occurring in plasmas and the resultant diffusion; propagation of high and low frequency electromagnetic waves in plasmas; description of the plasma as a single fluid; the magneto-hydromagnetic (MHD) equations; MHD instabilities and their effects on the plasma; applications of plasma physics. Pre- or corequisite: PHYS 303.
**PHYS 324**  
**Electron Paramagnetic Resonance**  
3.0; 3 cr.  
The electronic Zeeman interaction and the resonance phenomenon, group theory: the rotation group, the spin-Hamiltonian and the spectrum, the lanthanide 4f group, the actinide 5f, ions of the 3d group in intermediate ligand fields and some experimental aspects of EPR. **Pre- or corequisite: PHYS 305.**

**PHYS 330**  
**Principles of Environmental Physics**  
3.0; 3 cr.  
Scope of environmental physics, review of gas laws, transport laws, radiation environment, microclimatology of radiation, momentum transfer, heat transfer, mass transfer, steady state heat balance, crop meteorology, energy for human use and environmental spectroscopy. **Not open to physics graduate students. Prerequisites: PHYS 204 and PHYS 205 or equivalent, and some knowledge of calculus.**

**PHYS 391**  
**Graduate Tutorial**  
1-3 cr. (each)  
**May not be repeated for credit.**

**PHYS 395A/B**  
**Comprehensive Exam**  
0 cr.  
**Prerequisite: Consent of advisor.**

**PHYS 399**  
**MS Thesis**  
9 cr.

**PHYS 480**  
**Qualifying Exam Part I: Comprehensive Exam**  
0 cr.  
**Every semester.**

**PHYS 481**  
**Qualifying Exam Part II: Defense of Thesis Proposal**  
0 cr.  
**Every semester.**

**PHYS 484**  
**PhD Thesis**  
30 cr.  
**Every semester. To be taken only by regular track PhD students. Taken at first thesis registration, then registered for every subsequent semester with sequential letter annotations (A-L; 0 credits) until completion of thesis work.**

**PHYS 488**  
**PhD Thesis**  
42 cr.  
**Every semester. To be taken only by accelerated track PhD students. Taken at first thesis registration, then registered for every subsequent semester with sequential letter annotations (A-L; 0 credits) until completion of thesis work.**

---

1) The choice to register for PHYS 484 or PHYS 488 should be done in consultation with the thesis advisor to ensure that the total number of PhD thesis credits and PhD course credits are met as per AUB rules and regulations.