Department of Physics

Chairperson: Isber, Samih T.
Professors: 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: Antar, Ghassan Y.; Christidis, Theodore C.
Assistant Professor: Kazan, Michel J.
Lecturers: Bodakian, Berjouhi H.; Ghamlouche, Hassan J.; Roumieh, Mohammad A.; Said, Aurore J.

The department provides 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, non-linear dynamics, astrophysics, high energy physics, superstring theory, and quantum gravity.

MS in Physics

The MS program requires the completion of 21 credits of courses and a thesis. The courses consist of four core courses: PHYS 301, PHYS 302, PHYS 303, and PHYS 305, and nine credits of physics graduate electives. After completion of the four core courses, the student must pass a Master's Comprehensive exam. The student must then select a thesis adviser who will present the thesis proposal to the department chair for approval. The MS degree is granted after the student defends his/her thesis successfully.

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.
Boltzmann distribution, density matrix, statistical ensembles, 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, and 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; introduction to relativistic quantum mechanics. Annually.

PHYS 309/310 Special Topics 3.0; 3 cr. (each)
May be repeated for credit. Annually.
**PHYS 330**  
**Principles of Environmental Physics**  
3.0; 3 cr.  
Scope of environmental physics, review of gas laws, transport laws, radiation environment, microclimatolgy 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 205 or equivalent and some knowledge of calculus. Annually.

**PHYS 391/392**  
Graduate Tutorial  
1–3 cr. (each)  
Physics 391 is usually given in the fall semester while PHYS 392 is given in the spring semester. For more than one student or if the same student is taking two tutorials at the same time the letters A, B, C will be attached to distinguish these tutorials. **May be repeated for credit.**

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

**PHYS 399**  
MS Thesis  
9 cr.

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

- For the Regular Track*: A Master’s (MS) degree in Physics or related fields from an institution recognized by AUB;
- For the Accelerated Track*: A bachelor’s (BS) degree in Physics or related fields from an institution recognized by AUB;
- Three letters of recommendation;
- A score on the general part of the Graduate Record Examination (GRE), and the subject part in physics. This exam is also required by both BS and MS holders. A score on a previously taken GRE will remain valid for a period of three years;
- A score on the Test of English as a Foreign Language (TOEFL) or English Entrance Examination (EEE) that meets the university requirements (250 for computer-based TOEFL, 600 for paper based TOEFL, 97 for Internet-based TOEFL and 550 for EEE);

*Refer to the Program of Study section under “General University Academic Information”
• A statement of purpose; and
• 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

The PhD program is proposed as a full-time 5 year program, with a maximum of 7 years permitted for its completion. The governance of the program commences with the application process.

Upon admission into the program, a graduate student is assigned an academic adviser who evaluates his/her academic background, designs a curriculum to meet the student’s research interests and career goals, and advises if undergraduate courses are needed to rectify deficiencies. All of the duties of the academic adviser will be transferred to the thesis adviser chosen by the student and approved by the department. The thesis adviser must be chosen within 3 semesters from the admission to the program.

Supervision of PhD Thesis

Academic Adviser guides and helps the student plan a course of study and recognize a thesis adviser. The thesis adviser must be a full-time professorial rank faculty member. The PhD thesis proposal and the committee should be formed at least two semesters before the thesis defense. The thesis committee should be conforming to the AUB policy and the requirement of the Lebanese Ministry of Higher Education as described in details under the PhD Thesis Committee section of the “General University Academic Information.”

Course Work

The PhD program requires the completion of at least 39 credits 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 accelerated track are: PHYS 301, 302, 303, 305, 306 and 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.

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.

PhD Qualification Exam Part I and Part II

Upon completion of a minimum of 15 credits of graduate course work including the four core courses: PHYS 301, 302, 303 and 305 with a cumulative average of 85 or above in the core courses, the student may sit for PhD Qualification Exam Part I (written comprehensive examination) to determine a written comprehensive examination to determine whether he/she has acquired the background necessary to continue in the PhD program.
After choosing a thesis adviser, 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.

**Candidacy**

Refer to the Admission to Candidacy section under “General University Academic Information” on page 57.

**PhD Thesis and Thesis Defense**

After qualifying as a PhD candidate, the student will focus on the doctoral research. The PhD thesis is based on independent original research. The doctoral research, once completed, will be presented publicly and defended in front of the thesis committee. The thesis committee will consist of four members, all of professorial rank, with at least one member from outside AUB.

**Residence Requirements**

See Residence Requirements section under “General University Academic Information” on page 50.

**Graduation Requirements**

A student is granted the PhD degree upon approval of his/her PhD thesis by the 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 time table:

- 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;
- Choose a thesis adviser within 3 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; and
- Present his/her research work by submitting his/her 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

Graduate assistantships covering tuition fees and stipends are awarded to PhD students as they are admitted into the program. Stipends are sufficient to cover living expenses in Beirut. PhD students in their fourth and fifth years are eligible for grants for participation in international conferences. In return, students help in teaching undergraduate labs and recitations of introductory courses. Their duties also include help in proctoring and correcting exams.

Graduate Course Program

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.

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.

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.

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.

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 311  Astrophysics I  3.0; 3 cr.

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.

PHYS 316  Physics of Soft Matter  3.0; 3 cr.

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

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 co-requisite: 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 co-requisite: 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 co-requisite: PHYS 305.

PHYS 490  Preparation for PhD Qualifying Exam Part I  0 cr.

PHYS 495  Preparation for Thesis Proposal  0 cr.
Research is conducted individually by the student leading to a Thesis proposal.

PHYS 499  PhD Thesis