BACHELOR 'S PROGRAMME
3rd YEAR OF STUDY, 1st SEMESTER

COURSE TITLE	PHYSICS OF ATOMS AND MOLECULES
COURSE CODE	
COURSE TYPE	full attendance
COURSE LEVEL	1st cycle (bachelor's degree)
YEAR OF STUDY, SEMESTER	3rd year of study, 1st semester
NUMBER OF ECTS CREDITS	6
NUMBER OF HOURS PER WEEK	7 (3 lecture hours + 4 seminar hours)
NAME OF LECTURE HOLDER	Conf. dr. habil. Gabriela BORCIA
NAME OF SEMINAR HOLDER	Lect. dr. Ionuţ TOPALĂ
PREREQUISITES	Advanced level of English

A — GENERAL AND COURSE-SPECIFIC COMPETENCES

General competences:

- → Achievement of professional tasks efficiently and responsibly, in compliance with the field-specific deontology legislation, with qualified assistance.
- → Application of efficient work techniques in a multi-disciplinary team, on various hierarchical levels.
- → Effective use of information sources and communication resources and assisted professional training, both in Romanian and in a foreign language.

Course-specific competences:

- → Description of physical systems, using specific theories and tools (experimental and theoretical models, algorithms, schemes, etc.). Application of the principles and laws of Physics in solving theoretical or practical problems, under qualified assistance conditions. Correct application of methods of analysis and of criteria for choosing the appropriate solutions to achieve the specified performances. Comparative assessment of the theoretical results offered by literature and of an experiment conducted in the framework of a professional project.
- → Use of computers to control experiments or processes and data acquisition. Comparison of the results given by numerical models or simulations of physical phenomena with data provided by literature and/ or experimental measurements.
- → Proper use of numerical methods and mathematical statistics in the analysis and processing of specific physical data. Elaboration of graphs and reports for explaining and interpreting physical results obtained by statistical methods. Assessing the reliability of the results and comparing them with bibliographical data or calculated theoretical values, using statistical validation methods and/ or numerical methods.
- → Application of Physics knowledge both in given situations in related fields and in experiments, using standard laboratory equipment. Explanation and interpretation of physical phenomena by formulating assumptions and operationalizing key concepts and proper use of laboratory equipment. Critical assessment of the results obtained by employing a physical model, including the degree of uncertainty of the obtained experimental results.
- → C5. Proper use in professional communication of the terminology specific to Physics but also to related domains (especially Mathematics). Critical assessment of a scientific communication, a paper/specialty report with a reduced degree of difficulty. Drafting and presenting scientific reports in the field of Physics by using of new media technologies for communication.
- → C6. Make of necessary connections to use physical phenomena, using basic knowledge from close domains (Chemistry, Biology, etc.). Making connections between knowledge of Physics and of other domains (Chemistry, Biology, Informatics, etc.).

B — LEARNING OUTCOMES

On successful completion of this course, the students will be able to:

- Identify and use adequately the principal laws and physical principles in a given context
- Solve Physics problems in given conditions, using numerical and statistical methods
- Apply the Physics knowledge both in concrete situations in related fields and in experiments using standard laboratory equipment
- Analyze and explain data obtained from numerical measurements or simulations
- Efficiently use information sources and communication resources and assisted training, both in Romanian and in an international language

C — LECTURE CONTENT

Chap. I. The discontinuous nature of matter The discrete nature of substance and electricity (Structure of atoms, Electron, Quantization of electric charge, Determination of electron charge, Mass of atoms, Isotopes)

	Chap. I. The discontinuous nature of matter □ The corpuscular character of radiation (Thermal radiation, Black body laws, Quantum hypothesis, Planck's distribution law) Chap. I. The discontinuous nature of matter □ Experimental evidence on the corpuscular nature of radiation (Photoelectric effect, Interpretation of photoelectric effect laws, Continuous X-ray spectrum, Compton effect) Chap. II. Classical and semiclassic atomic models □ Classical atomic models (Thomson, Rutherford), Bohr atomic model Chap. II. Classical and semiclassic atomic models □ The Bohr model. Generalizations (Energy level diagram for Hydrogen-like atoms, Bohr-Sommerfeld model, Orbital magnetic moment of the atom, Atomic space model of the atom, Bohr model deficiencies) Chap. III. The quantum-wave model of the atom □ Wavelike properties of particles (de Broglie's hypothesis, Experimental confirmation of de Broglie's hypothesis, Statistical interpretation of the wave function, Uncertainty relations, Schrödinger equation) Chap. III. The quantum-wave model of the atom □ Quantum-wave model for one-electron atoms (Eigenfunctions and eigenvalues, Radial and angular probability distribution for one-electron atoms) Chap. IV. Angular and magnetic momenta of atoms □ Electron spin, Vector model of atoms (one-electron atoms, multi-electron atoms), Fine structure of energy levels and spectral lines of atoms Chap. IV. Angular and magnetic momentum of atoms □ Atoms in magnetic and electric field (Atoms in magnetic field, Zeeman effect, Magnetic resonance transitions, Atoms in electric field, Stark effect) Chap. V. Multi-electron atoms □ The model of multi-electron atoms (Hartree theory, Self-consistent field theory, results of the Hartree theory, Periodic table, X-ray spectra) Chap. VI. Chemical bond. Molecule structure □ General properties of chemical bonds, Valence in electron-pair method, □ and □ bonds, Hybridization Chap. VI. Chemical bond. Molecule structure □ Chemical combinations of carbon, Space structure of molecules Chap. VII. Molecular spectra □ Rotational spectra, Vibration-rotation spectra, Electronic spectra, Electromagnetic radiation spectrum and applications Chap. V. Electric and magnetic properties of molecules □ Electric properties (Electric dipole momentum and polarization, Displacement polarization, Orientation polarization, Electric dipole and molecule spatial structure) Chap. V. Electric and magnetic properties of molecules □ Magnetic properties (magnetic momentum and magnetic susceptibility, Diamagnetic molecules, Paramagnetic molecules)
D	RECOMMENDED READING FOR LECTURES
	1. G. Borcia, Fizica atomului şi moleculei, Editura Sedcom Libris, Iaşi, 2014. 2. G. Borcia, Introducere în teoria cuantică a atomului şi moleculei, Editura Sedcom Libris, Iaşi, 2006. 3. G. Borcia, Fizica atomului şi moleculei: note de curs şi aplicaţii, Editura Sedcom Libris, Iaşi, 2006. 4. M. Ţibu, Fizica atomului şi moleculei, P. I, fasc. I şi fasc. II, P. a II-a, Univ. Al. I. Cuza Iaşi, 1985. 5. B. H. Brandsen, C. J. Joachain, Physics of Atoms and Molecules, Longman Group Limited, London and New York, 1983. 6. R. Eisberg, R. Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, John Wiley and Sons, New York, 1985. 7. P. A. Cox, Introduction to Quantum Theory and Atomic Structure, Oxford University Press, Inc., New York, 1996. 8. W. G. Richards, P. R. Scott, Energy Levels in Atoms and Molecules, Oxford University Press Inc., New York, 1994. 9. R. T. Weidner, R. L. Sells, Elementary Modern Physics, Allyn and Bacon, Inc., Boston, 1980.
E	SEMINAR CONTENT
	Movement of charged particles in electric field and magnetic fields. Electromagnetic radiation spectrum and applications Thermal radiation, black body laws Photoelectric effect, X-ray spectra, Compton effect Bohr's atomic model and generalizations De Broglie wavelength, uncertainty relations, wave functions, quantum numbers, energy, angular momentum Vector model, fine structure of energy levels, atoms in magnetic field, Zeeman effect, magnetic resonance transitions Model of multi-electron atoms. Periodic table Chemical bond, valence, □ and □ bonds, hybridization, spatial structure of molecules Electric dipole momentum, electric properties of molecules
F	RECOMMENDED READING FOR SEMINARS
	1. E. Lozneanu, E. Tereja, A. Vlahovici, Culegere de probleme de fizică atomică, Editura Universităţii Alexandru Ioan Cuza, 1980 2. N. Avram, N. Damsescu, S. Floruta, S. Goian, Probleme de fizică atomică şi nucleara, Editura Universităţii din Timisoara, 1986 3. V. Chis, V. Simon, N. Leopold, Probleme de fizica moleculei, Editura Universităţii din Cluj Napoca, 2001 4. W. Demtröder – Atoms, Molecules and Photons. An Introduction to Atomic-, Molecular- and Quantum Physics, Springer-Verlag Berlin Heidelberg, 2010 5. B. H. Brandsen, C. J. Joachain, Physics of Atoms and Molecules, Longman Group Limited, London and New York, 1983

	6. R. Eisberg, R. Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, John Wiley and Sons, 1985.
G	EDUCATION STYLE
LEARNING AND TEACHING METHODS	Lecture, thematic debates, application, discussion, explanation, demonstration, problem solving
ASSESSMENT METHODS	• Exam • Evaluation during the semester • Tests during the semester, laboratory reports, final colloquium
LANGUAGE OF INSTRUCTION	English