University of Gdańsk

Subject card

Subject name and code	Advanced Physical Laboratory, PG_00207685		
Field of study	Nuclear safety and radiological protection		
Date of commencement of studies	October 2026	Academic year of realisation of subject	2028/2029
Education level	Bachelor’s studies	Subject group	Obligatory subject group in the field of study Subject group related to scientific research in the field of study
Mode of study	full-time studies	Mode of delivery	at the university
Year of study	3	Language of instruction	Polish
Semester of study	5	ECTS credits	3.0
Learning profile	academic	Assessment form	credit
Conducting unit	Institute of Experimental Physics -> Faculty of Mathematics, Physics and Informatics -> Rector		
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. Sebastian Mahlik, prof. UG	
	Teachers		

Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	0.0	0.0	45.0	0.0	0.0	45
	E-learning hours included: 0.0						

Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
	Number of study hours	45	0.0	45.0	90

Subject objectives	Experimental verification of physical phenomena discussed in lectures on basic physics and modern physics quantum physics. Deepening the understanding of fundamental physical phenomena occurring in nature and the essence of quantum phenomena. Learning to apply acquired descriptions of phenomena, processes, research methodology, and formalisms to specific experimental tasks performed in the physics laboratory.

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[BJORL3_K07] Is ready to think and act entrepreneurially.		
	[BJORL3_K06] Is prepared to make independent decisions, working as part of a team, and taking responsibility for the consequences of his actions.		
	[BJORL3_W02] Has an advanced understanding of the role of physical and chemical experiments, mathematical theoretical models approximating reality, and computer simulations in scientific research methodology; is aware of technological, apparatus, and methodological limitations in scientific research.	The student knows the laws of physics with particular emphasis on electromagnetism, wave optics, structure of matter, atomic and molecular spectroscopy, lasers, solid state physics, quantum mechanics, and quantum information; understands the empirical foundations of interpreting physical phenomena; knows the design and operating principles of modern measuring instruments and experimental setups, as well as advanced research techniques used in physics and related sciences, methods of computer-based measurement control, the LabView environment, and the capabilities of programs such as Excel and Origin; is familiar with methods of data analysis and uncertainty evaluation, and the principles of safe work in the physics laboratory.	[SW1] oral statement/ conversation/discussion [SW2] presentation/project/paper/ report
	[BJORL3_W03] Has advanced knowledge and understanding of the principles of planning and conducting simple physical and chemical experiments and analyzing obtained results; has knowledge and understanding of the fundamentals of measurement uncertainty as applied to experiments, the base SI units and the most important derived units, as well as other systems of units.	The student knows the laws of physics with particular emphasis on electromagnetism, wave optics, structure of matter, atomic and molecular spectroscopy, lasers, solid state physics, quantum mechanics, and quantum information; understands the empirical foundations for interpreting physical phenomena; knows the design and operating principles of modern measuring instruments and experimental setups, as well as advanced research techniques and methods of computer-based measurement control, including the LabView graphical environment and software such as Excel and Origin; is familiar with methods of data analysis and uncertainty evaluation, and applies safety principles in the physics laboratory.	[SW1] oral statement/ conversation/discussion [SW2] presentation/project/paper/ report
	[BJORL3_U02] Has the ability to perform measurements of basic quantities used in physics and chemistry; can develop, describe and present the results of simple experiments and computer simulations; can perform quantitative analyses and formulate qualitative conclusions on this basis; can estimate measurement uncertainties.	he student is able to analyze and explain physical processes and phenomena in nature based on empirical data, operate modern light sources, detectors, and measuring instruments, apply safety regulations in laboratories equipped with advanced equipment, design experimental setups and propose methods for conducting experiments, use computer-based measurement control and data analysis and visualization, estimate measurement uncertainties, work with the SI system of units, critically select information based on acquired knowledge, and present facts in a precise and rigorous manner.	[SU1] oral statement/conversation/ discussion [SU2] presentation/project/paper/ report

Subject contents	**Laboratory topics:** 1. Diffraction of laser light on a slit and a circular aperture. 2. Investigation of the physical properties of optical fibers. 3. Study of the physical properties of microwaves. Localization of telecommunication satellites. 4. Analysis of diffraction patterns of laser light on an ultrasonic wave. 5. Investigation of the properties of a silicon photovoltaic module. 6. Determination of the efficiency coefficient of a solar collector under different operating conditions. 7. Investigation of the properties of a heat pump working with a solar collector. 8. Investigation of the properties of hydrogen fuel cells (PEM). 9. Determination of the technical parameters of a Stirling engine. 9A. Determination of the electrical power of a Stirling engine. 10. Determination of particle flow velocity using laser Doppler anemometry. 11. Diffraction of an electron beam on a polycrystalline graphite layer. 12. Determination of the excitation potential of Hg and Ne atoms in the FranckHertz experiment. 13. Determination of the specific charge e/m of the electron. 14. The photoelectric effect and determination of Plancks constant. 15. Measurement of the relative intensities of spectral lines with doublet and triplet structure. 16. Determination of the dissociation energy of iodine from the absorption spectrum. 17. Determination of dipole moments of polar molecules in the ground state. 18. Investigation of the optical properties of materials doped with transition metal ions. 19. Measurement of Raman spectra of silicon (Si) and diamond (C) single crystals. 20. Study of the properties of solid-state lasers. 21. Recording of emission line spectra using a grating spectrograph. 22. The Hall effect in doped germanium of type p and type n. 23. Investigation of the properties of ferromagnets based on hysteresis loops. 24. Identification of phase transitions in ferroelectric crystals.

25. Determination of thermistor characteristics.
26. The magneto-optical Faraday effect.
27. The normal and anomalous Zeeman effect.
28. The Kerr effect in PLZT electro-optic ceramics.
29. Investigation of the intensity of characteristic X-ray radiation of copper (Cu) and molybdenum (Mo).
30. Fine structure of X-ray radiation splitting of the molybdenum K doublet.
31. Determination of the lattice constants of copper (Cu), molybdenum (Mo), and potassium chloride (KCl) using the DebyeScherrer method.
32. Study of the structure of a sodium chloride single crystal using X-ray radiation.

Prerequisites and co-requisites

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
not applicable	51.0%	40.0%
not applicable	51.0%	60.0%

Recommended reading

Basic literature

Literature used during classes

1. Exercise instructions.
2. *Encyclopedia of Modern Physics*, PWN, Warsaw, 1983.
3. *Encyclopedia of Technology. Chemistry* (collective work), WNT, Warsaw, 1993.
4. A. Baran, *Determination of the characteristics of a silicon photovoltaic module*, Masters thesis, UG, 2009.
5. A. Berendt, *The Kerr effect in PLZT electro-optic ceramics*, Masters thesis, UG, 2008.
6. B.D. Cullity, *Fundamentals of X-ray Diffraction*, PWN, Warsaw, 1964.
7. J. Sobelman, *Atomic Spectra and Radiative Transitions*, Springer, 1979.
8. K. Hermbecker, *Handbook Physics X-Ray Experiments*, Phywe Series of Publications, 2010.
9. Physicochemical handbooks.
10. Tables of physical quantities.

Supplementary literature	Literature for independent study by the student 1. A. Barbacki, *Electron Microscopy*, Poznań University of Technology Press, 2007. 2. A. Chełkowski, *Physics of Dielectrics*, PWN, Warsaw, 1993. 3. A.K. Wróblewski, J.A. Zakrzewski, *Introduction to Physics*, Vol. 1 & 2, PWN, Warsaw, 1990. 4. A. Kawski, *Photoluminescence of Solutions*, PWN, 1992. 5. A. Kopystyńska, *Lectures on Atomic Physics*, PWN, Warsaw, 1989. 6. A. Kujawski, P. Szczepański, *Lasers. Physical Fundamentals*, Warsaw University of Technology Press, 1999. 7. A. Peres, *Quantum Theory: Concepts and Methods*, Kluwer Academic Publishers, 1993. 8. A. Śliwiński, *Ultrasound and its Applications*, WNT, Warsaw, 1993. 9. A.N. Matwiejew, *Molecular Physics*, PWN, Warsaw, 1989. 10. B. Ziętek, *Lasers*, Nicolaus Copernicus University Press, Toruń, 2009. 11. B. Ziętek, *Optoelectronics*, Nicolaus Copernicus University Press, Toruń, 2005. 12. C. Kittel, *Introduction to Solid State Physics*, PWN, Warsaw, 1999. 13. Cz. Bobrowski, *Physics: A Short Course*, WNT, Warsaw, 1998. 14. D. Dehlinger, M.W. Mitchell, *Entangled photon apparatus for the undergraduate laboratory*, Am. J. Phys. 70, 989901 (2002). 15. D. Halliday, R. Resnick, J. Walker, *Fundamentals of Physics*, PWN, Warsaw, 2003. 16. E. Klugman, E. Klugmann-Radziemska, *Photovoltaic Cells and Modules and Other Non-Conventional Energy Sources*, Ekonomia i Środowisko, Białystok, 2005. 17. F. Kaczmarek, *Advanced Physics Laboratory Exercises*, PWN, Warsaw, 1986. 18. F. Wolańczyk, *Thermodynamics*, Rzeszów University of Technology Press, 2007. 19. G. Barrow, *Physical Chemistry*, PWN, Warsaw, 1978. 20. G. Johnson, *A Shortcut Through Time: The Path to the Quantum Computer*, Knopf, New York, 2003.

21. H.A. Enge, M.R. Wehr, J.A. Richards, *Introduction to Atomic Physics*, PWN, Warsaw, 1983.
22. H. Abramczyk, *Introduction to Laser Spectroscopy*, Elsevier Science, Amsterdam, 2005.
23. H. Haken, H.C. Wolf, *Molecular Physics with Elements of Quantum Chemistry*, PWN, Warsaw, 2010.
24. H. Haken, H. Chr. Wolf, *Atoms and Quanta: An Introduction to Modern Spectroscopy*, PWN, Warsaw, 1998.
25. H. Ibach, H. Lüth, *Solid State Physics*, PWN, Warsaw, 1996.
26. H. Paul, *Introduction to Quantum Optics: From Light Quanta to Teleportation*, Cambridge University Press, 2004.
27. H. Szydłowski, *Computer-Assisted Physics Laboratory*, PWN, Warsaw, 2003.
28. *Handbook of Laboratory Experiments in Physics*, Phywe System GmbH & Co. K.G.
29. I.W. Sawieliew, *Lectures on Physics*, Vol. 13, PWN, Warsaw, 2002.
30. J.A. Buck, *Fundamentals of Optical Fibres*, Wiley-Interscience, Hoboken, NJ, 2004.
31. J.A. Weil, J.R. Bolton, *Electron Paramagnetic Resonance: Elementary Theory and Practical Applications*, Wiley, New York, 2001.
32. J. Ginter, *Physics of Waves. Vol. Waves in Homogeneous Media*, PWN, Warsaw, 1993.
33. J. Ginter, *Introduction to Atomic, Molecular and Solid State Physics*, PWN, Warsaw, 1986.
34. J.H. Moore, Ch.C. Davies, M.A. Coplan, *Building Scientific Apparatus*, Westview Press, 2003.
35. J. Kączkowski, *Fundamentals of Biochemistry*, WNT, Warsaw, 1999.
36. J. Larminie, A. Dicks, *Fuel Cell Systems Explained*, Wiley, 2003.
37. J. Młochowski, *Fundamentals of Chemistry*, Wrocław University of Technology Press, 1999.
38. J. Orear, *Physics*, Vol. 1 & 2, WNT, Warsaw, 1998.
39. J.P. Simons, *Photochemistry and Spectroscopy*, PWN, Warsaw, 1982.
40. J.R. Ferraro, K. Nakamoto, C.W. Brown, *Introductory Raman Spectroscopy*, Elsevier, 2003.

		41. J. Stankowski, *Introduction to Magnetic Resonance Spectroscopy*, PWN, Warsaw, 2005. 42. K. Booth, M. Kathryn, *Optoelectronics*, WKiŁ, Warsaw, 2001. 43. K. Joon, *Fuel Cells: A 21st Century Power System*, Journal of Power Sources, 1998, 71. 44. K. Pigoń, Z. Ruziewicz, *Physical Chemistry*, PWN, Warsaw, 2005. 45. K. Shimoda, *Introduction to Laser Physics*, PWN, Warsaw, 1993. 46. K.W. Szalimowa, *Physics of Semiconductors*, PWN, Warsaw, 1974. 47. L. Andrèn, *Solar Installations: Practical Applications for the Built Environment*, James & James Science Publishers, London, 2003. 48. L. Mandel, E. Wolf, *Optical Coherence and Quantum Optics*, Cambridge University Press, 1995. 49. M. Alicka, R. Alicki, *Quantum Information Laboratory*, University of Gdańsk script, 2011. 50. M. Born, E. Wolf, *Principles of Optics*, Cambridge University Press, 1999. 51. M. Le Bellac, *Introduction to Quantum Computing*, PWN, Warsaw, 2011. 52. M.M. Kash, G.C. Shilds, *Using the FranckHertz Experiment to Illustrate Quantization*, J. Chem. Educ. 71, 466, 1994.
	eResources addresses	
Example issues/ example questions/ tasks being completed	not applicable	
Work placement	Not applicable	