University of Gdańsk

Subject card

<table>
<tr><td>Subject name and code</td><td colspan="6">Physics Laboratory, PG_00182330</td></tr>
<tr><td>Field of study</td><td colspan="6">Physics</td></tr>
<tr><td>Date of commencement of studies</td><td colspan="2">October 2026</td><td colspan="2">Academic year of realisation of subject</td><td colspan="2">2027/2028</td></tr>
<tr><td>Education level</td><td colspan="2">Master’s studies</td><td colspan="2">Subject group</td><td colspan="2">Obligatory subject group in the field of study
Optional subject group
Subject group related to scientific research in the field of study</td></tr>
<tr><td>Mode of study</td><td colspan="2">full-time studies</td><td colspan="2">Mode of delivery</td><td colspan="2">at the university</td></tr>
<tr><td>Year of study</td><td colspan="2">2</td><td colspan="2">Language of instruction</td><td colspan="2">Polish</td></tr>
<tr><td>Semester of study</td><td colspan="2">4</td><td colspan="2">ECTS credits</td><td colspan="2">6.0</td></tr>
<tr><td>Learning profile</td><td colspan="2">academic</td><td colspan="2">Assessment form</td><td colspan="2">credit</td></tr>
<tr><td>Conducting unit</td><td colspan="6">Division of Condensed Matter Spectroscopy -> Institute of Experimental Physics -> Faculty of Mathematics, Physics and Informatics -> Rector</td></tr>
<tr><td rowspan="2">Name and surname of lecturer (lecturers)</td><td colspan="2">Subject supervisor</td><td colspan="4">dr inż. Tadeusz Leśniewski</td></tr>
<tr><td colspan="2">Teachers</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Lesson types</td><td>Lesson type</td><td>Lecture</td><td>Tutorial</td><td>Laboratory</td><td>Project</td><td>Seminar</td><td>SUM</td></tr>
<tr><td>Number of study hours</td><td>0.0</td><td>0.0</td><td>75.0</td><td>0.0</td><td>0.0</td><td>75</td></tr>
<tr><td colspan="7">E-learning hours included: 0.0</td></tr>
<tr><td rowspan="2">Learning activity and number of study hours</td><td>Learning activity</td><td colspan="2">Participation in didactic classes included in study plan</td><td>Participation in consultation hours</td><td>Self-study</td><td>SUM</td></tr>
<tr><td>Number of study hours</td><td colspan="2">75</td><td>0.0</td><td>75.0</td><td>150</td></tr>
<tr><td>Subject objectives</td><td colspan="6">Experimental verification of physical phenomena discussed in lectures on basic physics, quantum mechanics and electrodynamics, solid state physics, atomic and particle physics, laser physics, quantum information. Deepening the understanding of basic physical phenomena occurring in nature and the nature of quantum phenomena. Learning to perform computer-aided experiments, using the latest software including Lab View. Learning to perform physical experiments, analyse the results obtained and the measurement uncertainties and interpretation of the results obtained.</td></tr>
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Learning outcomes	Course outcome	Subject outcome	Method of verification
	[FIZMU2_K07] is ready to perform professional roles responsibly, requiring compliance with and development of professional ethics and working to ensure their compliance	The student has developed: – the culture of both individual and teamwork in a laboratory; – responsibility for collective results; – the ability to conduct substantive discussion and formulate precise statements.	[SK1] oral statement/conversation/ discussion [SK2] presentation/project/paper/ report
	[FIZMU2_U04] can find the necessary information in professional literature, both in databases and in other sources; can reconstruct the reasoning or the course of an experiment described in the literature, taking into account the assumptions and approximations made	The student is able to: – search for and analyse descriptions of experiments and research methods; – reproduce reasoning and experimental procedures, considering assumptions and approximations; – compare obtained results with literature data.	[SU1] oral statement/conversation/ discussion [SU2] presentation/project/paper/ report
	[FIZMU2_U02] can plan and conduct basic and advanced experiments or observations in specific areas of physics or its applications	The student is able to: – design experimental setups and methods of measuring physical quantities; – select and prepare appropriate apparatus; – use computer-controlled measurements; – apply the SI system of units.	[SU1] oral statement/conversation/ discussion [SU2] presentation/project/paper/ report
	[FIZMU2_U03] can perform a critical analysis of the results of measurements, observations, or theoretical calculations along with the assessment of the accuracy of the results	The student is able to: – estimate measurement uncertainties; – analyse and explain physical processes and phenomena based on empirical evidence; – critically select information using existing knowledge; – present conclusions precisely.	[SU1] oral statement/conversation/ discussion [SU2] presentation/project/paper/ report
	[FIZMU2_U07] can present the results of research (experimental, theoretical, or numerical) in written, oral, multimedia presentation or poster	The student is able to: – prepare written reports of research; – prepare and deliver a multimedia presentation; – present methods, results and conclusions clearly and logically.	[SU1] oral statement/conversation/ discussion [SU2] presentation/project/paper/ report
	[FIZMU2_W01] has in-depth knowledge of various areas of physics; knows the history of the development of physics and its importance for the progress of exact and natural sciences, knowledge of the world and social development; has in-depth knowledge of the current directions of physics development and the fundamental dilemmas of modern civilization	The student knows/understands: – the laws of physical phenomena (electromagnetism, wave optics, structure of matter, atomic and molecular spectroscopy, laser physics, solid state physics, quantum mechanics and quantum information); – examples of their experimental verification; – the principles of operation of selected measuring instruments.	[SW1] oral statement/ conversation/discussion [SW2] presentation/project/paper/ report
	[FIZMU2_W03] knows to an in-depth degree experimental, observational, and numerical techniques allowing to plan and execute a complex physical experiment or computer simulation	The student knows/understands: – modern research techniques and methods of computer-controlled measurements; – the graphical environment LabVIEW and the functionalities of Excel and Origin; – methods of data analysis and evaluation of uncertainties.	[SW1] oral statement/ conversation/discussion [SW2] presentation/project/paper/ report
	[FIZMU2_W04] knows to an in-depth degree the principle of operation of measuring systems and research equipment specific to the area of physics related to the chosen specialization or knows advanced methods of theoretical and mathematical physics	The student knows/understands: – the structure and principles of operation of modern apparatus (light sources, detectors, measuring instruments); – the principle of operation of specific experimental setups.	[SW1] oral statement/ conversation/discussion [SW2] presentation/project/paper/ report
	[FIZMU2_U09] can work independently or in a team, and lead a team	The student is able to: – independently complete an assigned stage of research; – cooperate effectively in a group (division of roles, communication); – follow agreed procedures.	[SU1] oral statement/conversation/ discussion [SU2] presentation/project/paper/ report
	[FIZMU2_W07] knows the principles of occupational health and safety to the extent that allows them to work independently in the area corresponding to the discipline	The student knows/understands: – health and safety rules in physics laboratories equipped with modern measuring equipment; – procedures to follow in hazardous situations; – requirements concerning protective equipment and ergonomics of the workplace.	[SW1] oral statement/ conversation/discussion [SW2] presentation/project/paper/ report

	Course outcome	Subject outcome	Method of verification
	[FIZMU2_W09] knows and understands the concepts and principles of industrial property and copyright protection, as well as the need to manage intellectual property resources; knows the principles of using patent information resources	The student knows/understands: – how to use patent databases; – the basics of intellectual property protection in the context of laboratory work; – the rules of using external materials in reports and presentations.	[SW1] oral statement/ conversation/discussion [SW2] presentation/project/paper/ report

Subject contents	• Experimental verification of physical phenomena from those discussed in quantum mechanics, electrodynamics, solid state, atomic and particle physics, laser physics, quantum information. • Deepening the understanding of classical physical phenomena and the nature of quantum phenomena. • Learning to apply the learned models of phenomena, physical processes, mathematical formalisms, research methodology to specific experimental tasks performed in the physics laboratory. • To learn about modern equipment, apparatus, measuring devices: construction, principle of operation, handling. • Learning to perform computer-aided/computer-controlled experiments, learning the latest computer software including Lab View. • Learning to analyse and interpret the results obtained in experiments and their measurement uncertainties. List of laboratory exercises 1. Diffraction of laser light on a slit and a circular aperture 2. Study of the physical properties of optical fibers 3. Analysis of diffraction patterns of laser light on an ultrasonic wave 4. Study of the properties of a silicon photovoltaic module 5. Determination of the efficiency coefficient of a solar collector under various operating conditions 6. Study of the properties of a heat pump 7. Study of the properties of hydrogen fuel cells (PEM) 8. Determination of the technical parameters of a Stirling engine 9. Optical simulation of a β-DNA X-ray diffraction pattern 10. Determination of particle flow velocity using laser Doppler anemometry 11. Study of heart function using ECG and FCG methods 12. Diffraction of an electron beam on a polycrystalline graphite layer 13. Determination of the excitation potential of Hg and Ne atoms in the FranckHertz experiment 14. Determination of the specific charge e/m of the electron 15. Photoelectric effect and determination of Plancks constant 16. Measurement of relative intensities of spectral lines with doublet and triplet structure 17. Determination of the dissociation energy of iodine from the absorption spectrum 18. Determination of dipole moments of polar molecules in the ground state 19. Study of light absorption of polyatomic molecules 20. Study of the optical properties of materials doped with transition metal ions; study of the fluorescence of organic dyes

	21. Measurement of Raman spectra of silicon (Si) and diamond (C) single crystals 22. Study of the properties of solid-state lasers 23. Study of spectral properties of optical filters; recording of emission line spectra using a grating spectrograph 24. Hall effect in p-type and n-type doped germanium 25. Study of the properties of ferromagnets based on hysteresis loops 26. Identification of phase transitions in ferroelectric crystals 27. Determination of thermistor characteristics 28. Magneto-optical Faraday effect 29. Normal and anomalous Zeeman effect 30. Determination of the Landé g-factor using electron paramagnetic resonance (EPR) 31. Kerr effect in PLZT electro-optic ceramics 32. Study of the intensity of characteristic X-ray radiation of copper (Cu) and molybdenum (Mo) 33. Fine structure of X-ray radiation splitting of the Kα doublet of molybdenum 34. Determination of the lattice constant by the DebyeScherrer method 35. Study of the structure of a sodium chloride single crystal using X-ray radiation 36. Determination of the position and dimensions of a metallic object from a radiogram 37. Surface topography of materials using a scanning electron microscope 38. Determination of the polarization entanglement quality factor of photon pairs 39. Violation of Bells inequalities (CHSH) for polarization-entangled photon pairs 40. Interference of two correlated photons 41. Identification of the polarization-entangled state of two photons and determination of the entanglement quality factor 42. Determination of the electron charge e in the Millikan experiment
Prerequisites and co-requisites	• A. Formal Requirements: none • B. Prerequisites: knowledge of basic physics, mathematics, programming, electrodynamics, solid state physics, quantum mechanics at undergraduate level, ability to analyse and process measurement results at the level of Physical Laboratory II.

Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	oral examinations	51.0%	50.0%
	reports	51.0%	50.0%

Recommended reading	Basic literature	• Literatura studiowana samodzielnie przez studenta: • 1. A. Barbacki Mikroskopia elektronowa, Wydawnictwo Politechniki Poznańskiej , 2007. • 2. A. Chełkowski Fizyka dielektryków, PWN, Warszawa 1993. • 3. A. K. Wróblewski, J. A. Zakrzewski Wstęp do fizyki. T. 1. i 2. , PWN, Warszawa 1990. • 4. A. Kawski Fotoluminescencja roztworów, PWN, 1992. • 5. A. Kopystyńska Wykłady z fizyki atomu, PWN, Warszawa 1989. • 6. A. Kujawski, P. Szczepański Lasery. Podstawy fizyczne, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 1999. • 7. A. Peres Quantum Theory: Concepts and Methods, Kluwer Academic Publishers, 1993. • 8. A. Śliwiński Ultradźwięki i ich zastosowanie, Wydawnictwo Naukowo Techniczne, Warszawa 1993. • 9. A.N. Matwiejew Fizyka cząsteczkowa, PWN, Warszawa, 1989. • 10. B. Ziętek Lasery, Wydawnictwo Naukowe Uniwersytetu Mikołaja Kopernika, Toruń 2009. • 11. B. Ziętek Optoelektronika, Wydawnictwo Naukowe UMK, Toruń 2005. • 12. C. Kittel Wstęp do fizyki ciała stałego PWN, Warszawa 1999. • 13. Cz. Bobrowski Fizyka krótki kurs, Wydawnictwo Naukowo Techniczne, Warszawa 1998. • 14. D. Dehlinger, M.W. Mitchell Entangled photon apparatus for the undergraduate laboratory, Am. J. Phys. 70, 989 901 (2002). • 15. D. Halliday, R. Resnick, J. Walker Podstawy fizyki, PWN, Warszawa 2003. • 16. E. Klugman, E. Klugmann Radziemska Ogniwa i moduły fotowoltaiczne oraz inne niekonwencjonalne źródła energii, Wydawnictwo Ekonomia i Środowisko, Białystok 2005. • 17. F. Kaczmarek Ćwiczenia laboratoryjne z fizyki dla zaawansowanych, PWN, Warszawa 1986. • 18. F. Wolańczyk Termodynamika, Oficyna Wydawnicza Politechniki Rzeszowskiej, 2007. • 19. G. Barrow Chemia fizyczna, PWN, Warszawa 1978. • 20. G. Johnson A Shortcut Through Time: the Path to the Quantum Computer, Knopf, N.Y. 2003. • 21. H. A. Enge, M. R. Wehr, J. A. Richards Wstęp do fizyki atomowej, PWN, Warszawa 1983. • 22. H. Abramczyk Introduction to Laser Spectroscopy, Elsevier Science, Amsterdam 2005. • 23. H. Haken, H. C. Wolf Fizyka molekularna z elementami chemii kwantowej, PWN, Warszawa 2010. • 24. H. Haken, H. Chr. Wolf Atomy i kwanty. Wprowadzenie do współczesnej spektroskopii atomowej, PWN, Warszawa 1998. • 25. H. Ibach, H. Luth Fizyka ciała stałego, PWN, Warszawa 1996. • 26. H. Paul Introduction Quantum Optics from Light Quanta to Teleportation, Cambridge University Press, Cambridge 2004. • 27. H. Szydłowski Pracownia fizyczna wspomagana komputerem, PWN, Warszawa 2003. • 28. Handbook Laboratory Experiments Physics, Phywe System GmbH & Co. K.G. • 29. I. W. Sawieliew Wykłady z fizyki, T.1.- 3., PWN, Warszawa 2002. • 30. J. A. Buck Fundamentals of Optical Fibres, NJ: Wiley Interscience, Hoboken, 2004. • 31. J. A. Weil, J.R. Bolton Electron Paramagnetic Resonance: Elementary Theory and Practical Applications, Wiley, New York 2001. • 32. J. Ginter Fizyka fal, Tom Fale w ośrodkach jednorodnych, PWN, Warszawa 1993. • 33. J. Ginter Wstęp do fizyki atomu , cząsteczki i ciała stałego, PWN, Warszawa 1986. • 34. J. H. Moore, Ch. C. Davies, M.A. Coplan Building Scientific Apparatus, Westview Press, 2003. • 35. J. Kączkowski Podstawy biochemii, Wydawnictwo Naukowo Techniczne, Warszawa 1999. • 36. J. Laminie, A. Dicks Fuel Cell Systems Explained, Wiley, 2003. • 37. J. Młochowski Podstawy chemii, Oficyna Wydawnicza Politechniki Wrocławskiej, 1999. • 38. J. Orear Fizyka, T.1. i 2., Wydawnictwo Naukowo Techniczne, Warszawa 1998. • 39. J. P. Simons Fotochemia i spektroskopia, PWN, Warszawa 1982. • 40. J. R. Ferraro, K. Nakamoto, C. W. Brown Introductory Raman Spectroscopy, Elsevier, 2003. • 41. J. Stankowski Wstęp do spektroskopii rezonansów magnetycznych, PWN, Warszawa 2005. • 42. K. Booth, M. Kathryn Optoelektronika, Wyd. Komun. i Łączności, Warszawa 2001. • 43. K. Joon Fuel Cells a 21stCentury Power System, Journal of Power Sources, 1998, 71. • 44. K. Pigoń, Z. Ruziewicz Chemia fizyczna, PWN, Warszawa 2005. • 45. K. Shimoda Wstęp do fizyki laserów, PWN, Warszawa 1993. • 46. K. W. SzalimowaFizyka półprzewodników, PWN, Warszawa 1974.

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- 48. L. Mandel, E. Wolf Optical Coherence and Quantum Optics, Cambridge 1995.
- 49. M. Alicka, R. Alicki Pracownia Informacji Kwantowej / Quantum Information Laboratory, skrypt Uniwersytetu Gdańskiego, 2011.
- 50. M. Born, E. Wolf Principles of Optics, Cambridge University Press, Cambridge 1999.
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- 53. M. Nielsen, I. Chuang Quantum Computation and Quantum Communication, Cambridge, London 2000.
- 54. N. W. Ashcroft, N.D. Mermin Fizyka ciała stałego, PWN, Warszawa 1986.
- 55. P. Kowalczyk Fizyka cząsteczek, PWN, Warszawa 2000.
- 56. P. Suppan Chemia i światło, PWN, Warszawa 1997.
- 57. P. W. Atkins Molekularna mechanika kwantowa, PWN, Warszawa 1974.
- 58. PHYWE Laboratory Experiments Physics, 2010.
- 59. R. Eisberg, R. Resnick Fizyka kwantowa atomów, cząsteczek, ciał stałych, jąder i cząstek elementarnych, PWN, Warszawa 1983.
- 60. R. P. Feynman, R. B. Leighton, M. Sands Feynmana wykłady z fizyki, PWN, 2004.
- 61. R. T. Morrison, R.N. BoydChemia organiczna, Tom 2, PWN, Warszawa 1999.
- 62. T. Penkala Zarys krystalografii, PWN Warszawa 1983.
- 63. W. Ashcroft Fizyka ciała stałego, PWN, Warszawa 1986.
- 64. W. Demtröder Spektroskopia laserowa, PWN, Warszawa 1993.
- 65. W. J. Croft Under the Microscope. A Brief History of Microscopy, Hackensack & London: World Scientific, 2006.
- 66. W. Kołos, J. Sadlej Atom i cząsteczka, WNT, Warszawa 1998.
- 67. W. S.C. Chang Principles of Lasers and Optics, Cambridge University Press, 2005.
- 68. W. Świątkowski Doświadczenie Francka i Hertza: 85 lat później, Postępy Fizyki, Tom 49, zeszyt 4, 1998.
- 69. Z. Bojarski, M. Gigla, K. Stróć , M. Surowiec Krystalografia, PWN, Warszawa 2007.
- 70. Z. Kęcki Podstawy spektroskopii molekularnej, PWN, Warszawa 1982.
- 71. Z. Kleszczewski Podstawy fizyczne elektroniki ciała stałego, Wydawnictwo Politechniki Śląskiej, Gliwice 2000. 72. Z. Kleszczewski Wybrane zagadnienia z optyki falowej, Wydawnictwo Politechniki Śląskiej, Gliwice 2003.

	Supplementary literature	• 1. Renewable Energy Sources for Fuels and Electricity, Island Press, Washington 1993. • 2. Solid State Physics. Pt. B, Electrical, Magnetic, and Optical Properties ed. by K. Lark-Horovitz and Vivian A. Johnson, London : Academic Press, New York 1959. • 3. A. A. Lucas, PH. Lambin, R. Mairesse and M. Mathot Revealing the Backbone Structure of DNA from Laser Optical Simulations of its X Ray Diffraction Diagram, 1997. • 4. A. Dąbrowski Elektrokardiogramy, opisy i komentarze, Medycyna Praktyczna, Kraków 2003. • 5. A. Dobrowolski Technika wielkich częstotliwości, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2001. • 6. A. Dubik Zastosowania laserów, WNT, 1991. • 7. A. Feldzensztajn, L. Pacuła, J. Pusz Wodór paliwem przyszłości, Instytut Wdrożeń Technicznych, Gdańsk, 2003. • 8. A. Hrynkiewicz, E. Rokita Fizyczne metody diagnostyki medycznej i terapii, PWN, Warszawa 2000. • 9. A. J. Camm Dynamic Electrocardiography, Eimsford: Blac well/ Futura, 2004. • 10. A. Lipson, S.G. Lipson, H. Lipson Optical Physics, Cambridge University Press, 2011. • 11. A. Małek, M. Wendeker Ogniwa paliwowe typu PEM teoria i praktyka, Wydawnictwo Politechniki Lubelskiej, Lublin 2010. • 12. A. Zeilinger ŚWIAT NAUKI, Lipiec 2000. • 13. A. Łoziński Światłowody telekomunikacyjne, Akademia Morska, Gdynia 2009. • 14. D. A. Rand Clean Energy, Springer, 2005. • 15. D. M. Pozar Microwave Engineering, John Willey & Sons Inc., NY 1998. • 16. E. Klugman, E. Klugmann Radziemska Ogniwa i moduły fotowoltaiczne oraz inne niekonwencjonalne źródła energii, Wydawnictwo Ekonomia i Środowisko, Białystok 2005. • 17. J. Laminie, A. Dicks Fuel Cell Systems Explained, Wiley, 2003. • 18. K. Joon Fuel Cells a 21stCentury Power System, Journal of Power Sources, 1998, 71. • 19. L. Andrèn Solar Installations. Practical Applications for the Built Environment, James& James Science Publishers, London 2003. • 20. M. A.Green Solar Cells Operating Principles, Technology and System Applications, Ed. Univ. of New South Wales, 1992. • 21. S. Zator Laserowe przepływomierze dopplerowskie, Politechnika Opolska, 2007. • 22. W. Świątkowski Doświadczenie Francka i Hertza: 85 lat później, Postępy Fizyki, Tom 49, zeszyt 4, 1998.
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