GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

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| Subject name and code | Fundamentals of modern physics, PG_00049441 | | |
| Field of study | Technical Physics | | |
| Date of commencement of studies | October 2024 | Academic year of realisation of subject | 2025/2026 |
| Education level | first-cycle studies | Subject group | Obligatory subject group in the field of study<br>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 | 2 | Language of instruction | Polish |
| Semester of study | 4 | ECTS credits | 5.0 |
| Learning profile | general academic profile | Assessment form | exam |
| Conducting unit | Zakład Fizyki Organicznych i Perowskitowych Struktur Fotowoltaicznych -> Instytut Fizyki i Informatyki Stosowanej -> Faculty of Applied Physics and Mathematics | | |
| Name and surname of lecturer (lecturers) | Subject supervisor | | |
| | Teachers | dr inż. Ireneusz Linert<br>dr hab. inż. Grażyna Jarosz | |

| Lesson types and methods of instruction | Lesson type | Lecture | Tutorial | Laboratory | Project | Seminar | SUM |
|---|---|---|---|---|---|---|---|
| | Number of study hours | 30.0 | 30.0 | 0.0 | 0.0 | 0.0 | 60 |
| | 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 | 60 | 5.0 | 60.0 | 125 |

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| Subject objectives | The student knows and understands fundamentals of moder physics. |
| Learning outcomes | Course outcome \| Subject outcome \| Method of verification |

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| Subject contents | 1. Atomic structure of matter (4 h). Statistical physics. Boltzmann factor. Maxwell's statistics. Atom, atomic size, determination of atomic parameters based on the kinetic theory of gases, barometric formula, transport phenomena in gases, X-ray diffraction, atomic nucleus, measurement of atomic mass, passage of alpha particles through matter, Rutheford formula, cross section, electron, determination of the e/m ratio.<br><br>2. Emission and absorption of optical radiation (4 h). Black body, spontaneous emission, absorption and stimulated emission, lasers, black body emission, Planck distribution, Stefan-Boltzmann law, Wien's displacement law.<br><br>3. Theory of relativity (4 h) Michelson-Morley experiment. Einstein's postulates. Lorentz transformations. Time dilation and length contraction. Doppler effect. The twin paradox. Relativistic momentum. Relativistic energy. Conversion of mass into energy and binding energy. General theory of relativity.<br><br>4. Basic properties of matter (2 h). Matter waves, de Broglie hypothesis, Davisson and Germer experiment, properties of matter waves, wave-particle duality, photon, photoelectric effect, Compton effect, Heisenberg uncertainty principle, statistical description of particles, distribution functions, Fermi-Dirac statistics, Bose - Einstein and Boltzmann statistics.<br><br>5. Bohr's model of the hydrogen atom (2 h). Bohr's model and theory of the atom, Bohr's postulates, energy levels of the hydrogen atom, photon absorption and emission, ionization, hydrogen-like atoms, muon atoms, criticism of Bohr's theory.<br><br>6. Quantum mechanics (5 h). Postulates of quantum mechanics, wave function, energy and momentum operators, Schrödinger equation, particle in a potential well, eigenfunctions and eigenvalues, flux, passage of a particle through a potential battery, tunneling, examples, quantum harmonic oscillator. The hydrogen atom in quantum mechanics. Schrödinger equation in spherical coordinates, atomic magnetic moments, experimental confirmation of spatial quantization, electron spin, total angular momentum, fine and hyperfine structure, nuclear resonance.<br><br>7. Multi-electron atoms (2 h). Periodic table of elements, quantum numbers, Pauli exclusion principle, Zeeman effect.<br><br>8. Atomic spectra (2 h). X-rays, emission and absorption of X-rays, characteristic radiation, formation of electron-positron pairs, total mass absorption coefficient of electromagnetic radiation.<br><br>9. Atomic nucleus (2 h). Size and density of nuclear matter, nucleons, nuclear mass, nuclear models, droplet, shell and collective models.<br><br>10. Nuclear decays and nuclear reactions (4 h). Alpha, beta and gamma decay, average lifetime, radioactive equilibrium, Mössbauer phenomenon, nuclear reactions, cross section, excited states of nuclei, fusion reactions, thermonuclear reactions, natural and artificial radioactivity, uses of isotopes in medicine, geology, archeology and other fields. Nuclear radiation detection.<br><br>11. Classification of elementary particles and elements of astrophysics (1 h) |
| Prerequisites and co-requisites | |
| Assessment methods and criteria | see table below |

| Subject passing criteria | Passing threshold | Percentage of the final grade |
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| | 0.0% | 15.0% |
| Tests during the semester | 50.0% | 45.0% |
| Written exam | 50.0% | 40.0% |

| Recommended reading | Basic literature | |
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| | | 1. P. A. Tripler, R. A. LLewellyn, Fizyka Współczesna, PWN, Warszawa 2011.<br>2. R. Eisberg, R. Resnick, Fizyka kwantowa atomów, cząsteczek, ciał stałych, jąder i cząsteczek elementarnych, PWN, W-wa 1983<br>3. H. A. Enge, M.R. Wehr, J. A. Richards, Wstęp do fizykiatomowej, PWN, W-wa 1983<br>4. H. H. Haken, H. C. Wolf, Atomy i kwanty, PWN, W-wa 1997<br>5. V. Acosta, C. L. Cowan, B. J. Graham, Podstawy fizyki współczesnej, PWN, W-wa 1987<br>6. Halliday, Resnick, Walker, Podstawy Fizyki PWN, W-wa 2014. |

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| | Supplementary literature | 1. A. A. Czerwiński, Energia jądrowa i promieniotwórczość, Oficyna edukacyjna, W-wa 1998<br>2. Sz. Szczeniowski, Fizyka doświadczalna, tom V (fizyka atomu); tom VI (fizyka jądra i cząstek elementarnych), PWN, W-wa 1974<br>3. K.Wróblewski, J. A. Zakrzewski, Wstęp do fizyki, t. 1, Wydawnictwo Naukowe PWN, Warszawa 1984.<br>4. J. Massalski, Fizyka dla inżynierów. Część II. Fizyka współczesna, WNT, Warszawa 2018.<br>5. E. Skrzypczak, Z. Szafliński, Wstęp do fizyki jądra atomowego i cząstek elementarnych, PWN, W-wa 2002<br>6. H. H. Haken, H. C. Wolf, Atomy i kwanty, PWN, W-wa 1997<br>7. Matwiejew, Fizyka cząsteczkowa, W-wa 1989, PWN. |
| | eResources addresses | Adresy na platformie eNauczanie: |
| Example issues/ example questions/ tasks being completed | The problems for tutorials:<br><br>1. Using the energy distribution of molecules in an ideal gas, derive formulas for the energy corresponding to the mean energy of gas molecule. Calculate the value for the ideal gas in room temperature T=300 K. 2. What is the frequency of the photon absorbed when the hydrogen atom makes the transition from the ground state (n=1) to the n=4 state?<br><br>The exam questions:<br><br>Draw and explain the Maxwell-Boltzmann speed distribution function. Show in the graph the shape of that function for a given temperature and present how the graph is changing when the gas temperature increases. Present the method of determining the specific e/m of electron in the Thomson experiment. | |
| Work placement | Not applicable | |

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