# DESCRIPTION OF THE COURSE OF STUDY

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|---|---|---|
| **Course code** | **0719-2ID-F62-BM** | |
| **Name of the course in** | Polish | ***Budowa materii*** |
| | English | ***Structure of matter*** |

## 1. LOCATION OF THE COURSE OF STUDY within the system of studies

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| **1.1. Field of study** | **Data Engineering** |
| **1.2. Mode of study** | Full-time |
| **1.3. Level of study** | First-cycle engineering studies |
| **1.4. Profile of study*** | General academic |
| **1.5. Person/s preparing the course description** | dr inż. Milena Piotrowska |
| **1.6. Contact** | milena.piotrowska@ujk.edu.pl |

## 2. GENERAL CHARACTERISTICS OF THE course of study

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| **2.1. Language of instruction** | English |
| **2.2. Prerequisites*** | Knowledge of the fundamentals of mathematics and physics at the level of the courses Mathematics 1, Mathematics 2, and Physics 1, Physics 2, in particular:<br>• basic concepts of classical mechanics and electromagnetism,<br>• fundamentals of differential and integral calculus. |

## 3. DETAILED CHARACTERISTICS OF THE COURSE OF STUDY

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| **3.1. Form of classes** | | Lecture (30 h), conversatory (30 h), project (15 h) |
| **3.2. Place of classes** | | Classes conducted in a teaching room of the Jan Kochanowski University |
| **3.3. Form of assessment** | | Graded credit. |
| **3.4. Teaching methods** | | Informative lecture with elements of multimedia presentation and discussion, problem-based conversatory classes (problem solving and case analysis), individual project including elements of teamwork and independent data analysis. |
| **3.5. Bibliography** | **Required reading** | D. Halliday, R. Resnick, J. Walker, *Fundamentals of Physics*, Wiley, Vols. 1–5, New York, 2005/2006. |
| | **Further reading** | R. P. Feynman, *Six Easy Pieces: Essentials of Physics Explained by Its Most Brilliant Teacher*, Basic Books, 2011.<br>P. W. Atkins, *Physical Chemistry*, Oxford University Press. |

## 4. OBJECTIVES, SYLLABUS CONTENT AND INTENDED LEARNING OUTCOMES

**4.1. Course objectives** ***(including form of classes)***

***Lecture:***

*C1. To provide knowledge about the hierarchical structure of matter — from elementary particles, through atoms and molecules, to condensed matter.*
*C2. To familiarize students with the basic concepts and laws of modern physics describing the structure of matter, including elements of quantum mechanics.*
*C3. To present methods of studying matter and the importance of micro-scale phenomena for modern technologies and engineering sciences.*

***Conversatory:***

*C1. To develop skills in quantitative description and analysis of physical phenomena related to the structure of matter.*
*C2. To improve skills in solving numerical and problem-based tasks based on the laws of atomic, nuclear, and solid-state physics.*
*C3. To develop the ability to interpret the results of calculations and physical data and relate them to theory.*

***Project:***

*C1. To acquire skills in preparing and presenting a simple project related to the structure of matter or the analysis*

*of experimental data.*
*C2. To develop the ability to work independently or in a team on a physical problem of analytical or conceptual nature.*
*C3. To develop competences in presenting and interpreting results in the form of a report or presentation.*

**4.2. Detailed syllabus** ***(including form of classes)***

**Lecture:**

1. Hierarchical structure of matter
   • Levels of organization of matter: elementary particles, nuclei, atoms, molecules.
   • Overview of methods of studying matter (microscopy, spectroscopy, accelerators).
2. Elementary particles and atomic nuclei
   • Introduction to the Standard Model – particles and interactions.
   • Structure of the nucleus, binding energy, radioactivity and nuclear reactions.
   • Applications of radioactivity (energy production, medicine, dating).
3. Atoms and quantum phenomena
   • Wave–particle duality, uncertainty principle.
   • Bohr model, introduction to quantum mechanics: wave function, Schrödinger equation.
   • Atomic spectra and their interpretation.
4. Molecules and bonding
   • Ionic, covalent and van der Waals bonds.
   • Rotational and vibrational spectra (conceptually).
   • Influence of bonding on macroscopic properties of materials.
5. Condensed matter
   • Crystal lattices and basics of band theory.
   • Metals, semiconductors, insulators – conductivity and applications.
   • Matter under extreme conditions: superconductivity, plasma.

**Conversatory:**

1. Hierarchical structure of matter – orders of magnitude and units
   • Conversion of binding energy between different units (eV, J, MeV).
   • Estimation of the sizes of particles, atoms and atomic nuclei.
   • Calculation of nuclear binding energy based on isotope mass data.
2. Elementary particles and atomic nuclei
   • Exercises on radioactivity: half-life, sample activity, decay equations.
   • Energy balance in nuclear reactions (fission, fusion).
   • Nucleon binding energy, mass defect.
   • Example calculations related to radiation detection (e.g. energy range of alpha particles, absorption coefficient).
3. Quantum phenomena and atomic structure
   • Application of Bohr's formula for calculating energy and wavelength for the hydrogen atom.
   • Calculations related to the photoelectric and Compton effects.
   • Example exercises involving de Broglie waves: wavelength of the electron and proton.
   • Calculations of energy differences between atomic levels, interpretation of line spectra.
4. Bonding and molecules
   • Bond energy and comparison of stability between different types of bonds.
   • Harmonic oscillator model for molecular vibrations (simple approximations).
   • Calculations of energy differences between rotational and vibrational levels.
   • Application of the model to the interpretation of molecular spectra.
5. Condensed matter
   • Calculation of electron energy in a simple free-electron model.
   • Estimation of electrical conductivity and temperature dependence.
   • Exercises involving the calculation of carrier concentration in doped semiconductors.
   • Equations describing quantum effects in semiconductors (conceptual level).

**Project:**

A project consisting in the preparation and analysis of data describing the structure and properties of matter using IT tools and data analysis methods.
Example topics: analysis of material data, prediction of physical properties, visualization of relationships between atomic features and macroscopic properties.

### 4.3 Intended learning outcomes

| Code | A student, who passed the course | Relation to learning outcomes |
|---|---|---|
| | within the scope of **KNOWLEDGE:** | |
| W01 | Knows and understands the hierarchical structure of matter — from elementary particles to condensed matter. | ID1A_W03<br>ID1A_W04 |
| W02 | Knows the basic physical laws and models describing the structure of the atom, the nucleus, and quantum phenomena. | ID1A_W03<br>ID1A_W04 |
| W03 | Understands the relationships between the structure of matter and its physical properties and technical applications. | ID1A_W03<br>ID1A_W06 |
| | within the scope of **ABILITIES:** | |
| U01 | Can solve basic numerical problems in the field of atomic, nuclear, and solid-state physics. | ID1A_U01<br>ID1A_U02<br>ID1A_U05 |
| U02 | Can analyse and interpret physical data and draw conclusions based on calculations or observations. | ID1A_U02<br>ID1A_U05<br>ID1A_U06 |
| U03 | Can prepare a simple project or study including the analysis of a physical phenomenon or data concerning the structure of matter. | ID1A_U03<br>ID1A_U11<br>ID1A_U14 |
| | within the scope of **SOCIAL COMPETENCE:** | |
| K01 | Can cooperate within a team while carrying out a project and present the results of work in written and oral form. | ID1A_K01<br>ID1A_K03<br>ID1A_K04 |

### 4.4. Methods of assessment of the intended learning outcomes

| **Teaching outcomes** *(code)* | **Method of assessment (+/-)** | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Exam oral/written*** | | | **Colloquium*** | | | **Raport*** | | | **Effort in class*** | | | **Self-study*** | | | **Group work*** | | | **Others* e.g. standardized test used in e-learning** | | |
| | ***Form of classes*** | | | ***Form of classes*** | | | ***Form of classes*** | | | ***Form of classes*** | | | ***Form of classes*** | | | ***Form of classes*** | | | ***Form of classes*** | | |
| | *L* | *C* | *P* | *L* | *C* | *P* | *L* | *C* | *P* | *L* | *C* | *P* | *L* | *C* | *P* | *L* | *C* | *P* | *L* | *C* | *P* |
| W01 | | | | + | + | | | | | | + | | | | | | | | | | |
| W02 | | | | + | + | | | | | | + | | | | | | | | | | |
| W03 | | | | + | + | | | | | | + | | | | | | | | | | |
| U01 | | | | + | + | | | | | | + | | | | | | | | | | |
| U02 | | | | + | + | | | | + | | + | | | | | | | | | | |
| U03 | | | | | | | | | + | | | | | | + | | | + | | | |
| K01 | | | | | | | | | + | | | | | | + | | | + | | | |

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### 4.5. Criteria of assessment of the intended learning outcomes

| Form of classes | Grade | Criterion of assessment |
|---|---|---|
| lecture (L) | 3 | achievement of <**50 - 60) %** of the assessment requirements |
| | 3,5 | achievement of <**60 -70) %** of the assessment requirements |
| | 4 | achievement of <**70 - 80) %** of the assessment requirements |
| | 4,5 | achievement of <**80 - 90) %** of the assessment requirements |
| | 5 | achievement of <**90 -100> %** of the assessment requirements |
| Conversatory (C) | 3 | achievement of <**50 - 60) %** of the assessment requirements |
| | 3,5 | achievement of <**60 -70) %** of the assessment requirements |
| | 4 | achievement of <**70 - 80) %** of the assessment requirements |
| | 4,5 | achievement of <**80 - 90) %** of the assessment requirements |
| | 5 | achievement of <**90 -100> %** of the assessment requirements |
| | 3 | achievement of <**50 - 60) %** of the assessment requirements |

| | | |
|---|---|---|
| **Project (P)** | **3,5** | achievement of <**60 -70) %** of the assessment requirements |
| | **4** | achievement of <**70 - 80) %** of the assessment requirements |
| | **4,5** | achievement of <**80 - 90) %** of the assessment requirements |
| | **5** | achievement of <**90 -100**> **%** of the assessment requirements |

## 5. BALANCE OF ECTS CREDITS – STUDENT'S WORK INPUT

| **Category** | **Student's workload** | |
|---|---|---|
| | **Full-time studies** | **Extramural studies** |
| *NUMBER OF HOURS WITH THE DIRECT PARTICIPATION OF THE TEACHER /CONTACT HOURS/* | ***75*** | |
| *Participation in lectures* | 30 | |
| *Participation in conversatory classes* | 30 | |
| *project work* | 15 | |
| *INDEPENDENT WORK OF THE STUDENT/NON-CONTACT HOURS/* | **50** | |
| ***Preparation for the conversatory classes*** | 20 | |
| *Preparation of the project report* | 10 | |
| *Preparation for the lecture* **colloquium** | 10 | |
| *Preparation for the conversatory* **colloquium** | 10 | |
| *TOTAL NUMBER OF HOURS* | **125** | |
| ECTS credits for the course of study | **5** | |

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***Accepted for execution*** *(date and legible signatures of the teachers running the course in the given academic year)*

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