COURSE DESCRIPTION CARD - SYLLABUS

Course name
Canons of Contemporary Physics [S2FT2>KFW]

Course

Field of study
Technical Physics

Year/Semester
1/1

Area of study (specialization)
–

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
0

Other
0

Tutorials
30

Projects/seminars
0

Number of credit points

5,00

Coordinators

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Lecturers

Prerequisites

Knowledge and skills consistent with the field-specific learning outcomes of engineering studies in the field of technical physics or related fields of study, in particular in the field of: classical physics (mechanics and electromagnetism), non-relativistic quantum physics, higher mathematics. The ability to analytically solve problems in the field of classical physics and non-relativistic quantum physics, atomic physics, molecular physics and condensed phase physics. The ability to think critically and engage in substantive discussion, and an openness to expanding basic competences.

Course objective

- Providing knowledge and developing skills covering various levels of description, construction of models and theories of modern physics. - Developing an open attitude towards the effectiveness of the contemporary physics paradigm, based on the synergy of observations, experiences, physical facts and mathematical models.

Course-related learning outcomes

Knowledge:
1. The student identifies the appropriate level of description of a physical problem (discrete, statistical,

field) depending on the complexity of the physical system and indicates adequate mathematical models for solving a specific problem within the framework of issues included in the program content of the module.
2. The student indicates the scope of applicability and limitations of theories and formalisms within which models of analyzed physical systems and processes are constructed, according to classical-quantum, non-relativistic-relativistic schemes.

Skills:
1. The student is able to formulate a hypothesis for solving a physical problem in the form of a mathematical model within the framework of issues included in the program content.
2. The student is able to propose a solution strategy and solve selected, specific problems of modern physics analytically using the appropriate formalism and mathematical apparatus.
3. The student is able to use analogy in the analysis of physical systems and phenomena from various areas of modern physics, expressed by similar mathematical models.

Social competences:
1. The student is able to formulate hypotheses regarding the solution of a complex physical problem, independently and as part of a team discussion.
2. The student actively seeks new ideas, problems and their solutions in the area of modern physics.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

When assessing learning outcomes, the following assignment of grades to percentage ranges applies:
<50-60)% - 3,0,
<60-70)% - 3,5,
<70-80)% - 4,0,
<80-90) %-4,5,
<90-100>%- 5,0.
The grade for the exercises is based on individual current written tests.
The grade for the lecture is based on an exam conducted in a three-stage form: written test part (with a weight of 40%), written problem part (with a weight of 40%), oral part (with a weight of 20%).
The grade obtained for the exercises is counted equally towards the problem part of the exam.

Programme content

1) Lagrange and Hamilton formalism in the presence of an electromagnetic field.
2) Selected topics of statistical physics - statistical ensembles.
3) Selected topics of quantum physics, including elements of quantum physics in phase space.
4) Selected topics of classical and quantum relativistic physics.
5) Elements of quantum field theory.

Course topics

1)Selected problems of dynamics of complex systems.
a) Principle of least action and Lagrange and Hamilton formalism.
b) Lagrange and Hamilton formalism in the presence of electromagnetic fields with examples describing the motion of charged particles in Penning and Paul traps.
c) Applications of relativistic Hamiltonian formalism.
2) Selected problems of statistical physics
a) Microcanonical ensemble.
b) Canonical ensemble.
c) Grand canonical ensemble.
3) Quantum physics in phase space.
a) Formulation of quantum mechanics in position representation and formulation using Wigner function.
b) Strategy of tomography of quantum state (wave function)
c) Discussion of the boundary between classical and quantum domain of physical phenomena using the Wigner function.
4) Relativistic quantum physics.

a) Justification of the Dirac equation. Solution of the Dirac equation for simple quantum systems. Discussion of Klein's paradox.
b) Dirac equation in the presence of non-zero electromagnetic potentials.
c) Dirac equation in applications to the analysis of one- and two-dimensional structures.
5) Elements of quantum field theory - second quantization.
a) Second quantization for bosons
b) Second quantization for fermions.

Teaching methods

Lecture: presentation illustrated with examples given on the board.
Classes: individual and team problem-solving; guided and independent analysis of cases of contemporary physics issues.

Bibliography

Basic:
1. Albrecht Lindner, Dieter Strauch, A Complete Course on Theoretical Physics. From Classical Mechanics to Advanced Quantum Statistics, Springer 2018
2. Luca Salasnich, Modern Physics. Introduction to Statistical Mechanics, Relativity, and Quantum Physics, Springer 2022

Additional:
1. Michele Cini, Elements of Classical and Quantum Physics, Springer 2024
2. Wybrane artykuły w czasopismach naukowych:
- Contemporary Physics http://www.tandfonline.com/toc/tcph20/current
- European Journal of Physics http://iopscience.iop.org/journal/0143-0807
- American Journalof Physics http://aapt.scitation.org/journal/ajp
- Reviews of Modern Physics http://journals.aps.org/rmp/

Breakdown of average student's workload

	Hours	ECTS
Total workload	125	5,00
Classes requiring direct contact with the teacher	62	2,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	63	2,50