Physics - course description

General information

Course name	Physics
Course ID	13.2-WK-MATP-F-S18
Faculty	Faculty of Mathematics, Computer Science and Econometrics
Field of study	Mathematics
Education profile	academic
Level of studies	First-cycle studies leading to Bachelor's degree
Beginning semester	winter term 2020/2021

Course information

Semester	3
ECTS credits to win	5
Course type	optional
Teaching language	polish
Author of syllabus	• dr hab. Maria Przybylska, prof. UZ

Classes forms

The class form	Hours per semester (full-time)	Hours per week (full-time)	Hours per semester (part-time)	Hours per week (part-time)	Form of assignment
Lecture	30	2	-	-	Credit with grade
Class	30	2	-	-	Credit with grade

Aim of the course

The aim of the lecture is to introduce students to the main branches of physics (classical mechanics, electrodynamics with elements of optics, quantum mechanics and theory of relativity) with special attention on mathematical apparatus used: differential geometry, variational calculus and algebra with elements of functional analysis. Students will be acquainted with the formalisms of varoius branches of physics. An additional goal is to educate students in the ability to formulate physical problems in the language of mathematics and to apply the mathematical formalisms to the description of selected physical and astronomical phenomena.

Prerequisites

Foundations of mathematical analysis and linear algebra.

Scope

1. Galilean space-time and Newton's law of dynamics
2. Conservation laws
3. Central forces and two body problem. Kepler's laws
4. Constraints and generalized coordinates. The D'Alembert principle and the Lagrange equations. Tangential space and tangent bundle.
5. Variation calculus and Hamilton's variational principle
6. Noether theorem and conservation laws
7. Phase space, cotangent bundle and Hamilton equations
8. The symplectic structure of the phase space, the Poisson structure
9. Maxwell equations, integral and differential formulations, special cases: electrostatics and magnetostatics, scalar potentials, Gauss's law
10. Electromagnetic waves: derivation of the wave equation from Maxwell's equations
11 Fermat's principle, the law of reflection and refraction, Huygens principle
12. The energy of the electromagnetic field, the problem with the description of blackbody radiation and the birth of quantum mechanics
13 Observables and states of classical and quantum systems, structure of C * -algebras observables, observables and operators
14. Probabilistic interpretation of the wave function
15. Schrödinger's equation time-dependent and time-independent
16 Spectra of operators and measurement results, Hermitian operators, expected operators' values.
17. Commutative observables and simultaneous observability
18. Non-commutative observables and uncertainty relations
19. General properties of the wave function and its examples
20. Representations of quantum states. Hilbert spaces. Representation of operators
21 Galilean spacetime. The principle of Galileo's relativity. Einstein's postulates, Einstein's principle of relativity. Minkowski's spacetime
22 Lorentz transformation and its consequences: velocity addition, constancy of the speed of light in various inertial systems, dilation of time, relativity of simultaneity, contraction of distance, paradoxes of twins and parking. The Lorentz and Poincaré groups
23. The principles of general relativity: equivalence, relativity, minimal gravitational coupling and correspondence.
24 Description of curved space-time: local coordinates, metrics, local inertial systems, light cones. Relations between spacetimes of special and general relativity.
25. Curved spaces, Gaussian curvature of two-dimensional space, Egregium Gauss theorem, parallel transport of tangent vectors to curved two-dimensional spaces, curvature of higher-dimensional spaces.
26. Einstein's equations, mathematical formulation, interpretation and properties, physical and astronomical phenomena confirming the validity of the general theory of relativity.

Teaching methods

Traditional lecture, conversational and with discussion of certain problems

Class during which students, leaded by the teacher, solve exercises and discuss problems

Learning outcomes and methods of theirs verification

Outcome description	Outcome symbols	Methods of verification	The class form
The student can explain the basic relativistic effects using the Lorentz transformation		•	• Lecture • Class
The student knows and understands the basic differences between the different spacetime models used in physical theories: Galileo, Minkowski and general relativity spacetimes		•	• Lecture • Class
The student can calculate the electrical potential for the simplest charge distributions using Gauss's law		•	• Lecture • Class
The student can isingle-handedly find necessary information in the professional literature		•	• Lecture • Class
The student knows the basic physical concepts used in particular branches of physics, physical laws expressed with their help and their mathematical formulations		•	• Lecture • Class
The student knows and understands postulates of the general theory of relativity. He knows and understands the theoretical and experimental circumstances that led Einstein to his postulates		•	• Lecture • Class
The student can write and solve the Schrödinger equation for the simplest systems, eg a particle bounded by infinite potential barriers		•	• Lecture • Class
The student knows physical and astronomical phenomena confirming the validity of the general theory of relativity		•	• Lecture • Class
The student can calculate the Lagrange and Hamilton functions and write in the explicit form the Lagrange equation of the second kind and the Hamilton equations for simple physical problems		•	• Lecture • Class

Assignment conditions

Class

The final grade of the class is issued on the basis of points obtained from two written tests (with tasks of varying degrees of difficulty, allowing to check whether the student has achieved the effects of learning) and for active participation in classes.

Lecture.
The necessary condition of accede to the final test of the lecture is a positive evaluation of the class. The test consists of theoretical questions and short exercises to be solved and verifies the effects of learning in the areas of knowledge and skills. Obtaining 50% of points guarantees a positive grade.
he final grade is the arithmetic mean of those of the class and the lecture test.

Recommended reading

1. R. Faynman, Physics VS Math , https://www.wykop.pl/link/4255483/fizyka-a-matematyka/
2. L. Susskind, *Teoretyczne minimum*, Prószyński i S-ka, Warszawa, 2015
3. L. Susskind, G. Hrabovsky, Classical mechanics. The theoretical minimum, Penguin Books, 2013
4. R.S. Ingarden, A. Jamiołkowski, *Mechanika klasyczna*, Państwowe Wydawnictwo Naukowe, 1980
5. L. Susskind, *Mechanika kwantowa. Teoretyczne minimum*, Prószyński i S-ka, Warszawa, 2016
6. P.J. Shepherd, *A course in Theoretical Physics*, Wiley, 2013
7. 5. F. Strocchi, An introduction to the mathematical structure of quantum mechanics, World Scientific, 2005
8. J. Griffiths*, Podstawy elektrodynamiki,* Wydawnictwo Naukowe PWN, dowolne wydanie.
9. W. Kopczyński i A. Trautman, Czasoprzestrzeń i grawitacja, PWN, Warszawa, 1981.
10. L. Susskind, A. Friedman, Special relativity and classical field theory. The theoretical minimum, Penguin Books, 2017
11. R. D'Inverno, Introducing Einstein's relativity, Claredon Press, Oxford, 1998
12. Materials provided by a lecturer.

Further reading

1. R. Penrose, The road to reality. A complete guide to the laws of the Universe, Jonathan Cape, 2004

Notes

Also in semester 5.

Modified by dr Alina Szelecka (last modification: 18-09-2020 13:45)