**COURSE SYLLABUS**

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| 1. | Course:<br>Selected Tools of Modern Theoretical Physics 2A | |
| 2. | Scientific discipline:<br>physical sciences | |
| 3. | Teaching language:<br>English | |
| 4. | University department:<br>Faculty of Physics and Astronomy | |
| 5. | Course/module type – mandatory (compulsory) or elective (optional):<br>mandatory | |
| 6. | University subject (programme/major):<br>Physics, specialty Master's Study of Theoretical Physics | |
| 7. | Study level (I or II):<br>II | |
| 8. | Year:<br>1 | |
| 9. | Semester (autumn/spring)<br>spring | |
| 10. | Form of tuition and number of hours:<br>lectures – 15, classes - 15 | |
| 11. | Initial requirements (knowledge, skills, social competences) regarding the course/module:<br>Linear algebra, analysis. | |
| 12. | Learning objectives for the subject:<br>The course objective is to gain a basic knowledge of the tools of modern differential geometry needed for the fundamentals of general relativity and gauge theories. | |
| 13. | Course content:<br>Introduction to modern mathematical tools of theoretical physics. The basis of topology. Diffeomorphisms, charts and atlases. The notion of manifold. Tangent vectors as velocities and as derivations. Vector fields and flows. Tensor fields. Metric tensor. Pull-back and push-forward. Lie derivative. Differential calculus of forms, exterior derivative. Covariant derivatives. Elements of Riemannian geometry. | |
| 14. | Learning outcomes:<br><br>Knows the advanced mathematical methods of differential geometry and their application to different objects used in theoretical physics, like vector and tensor fields on a manifold. Understands how these mathematical tools are at the basis of the description of physical spaces, like in general relativity.<br><br>Knows in-depth computational techniques based on differential geometry used in physical frameworks; knows and understands their theoretical foundations.<br><br>Can use advanced mathematical methods of differential geometry to analyze and solve problems specific to | Learning outcomes for the course:<br><br>F2_W02,<br><br>F2_W03,<br><br>F2_U01, |

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| | theoretical physics; can justify assumptions and simplifications as well as the scope of applicability of the adopted models.<br><br>Is able to develop the results of geometrical calculations, analyze them correctly, critically evaluate them and properly interpret them.<br><br>Is able to plan and implement the process of his own education, properly defining priorities to achieve the intended goal; has the ability to transfer knowledge and learn from others.<br><br>Can use the English language in accordance with the requirements specified for level B2+ of the Common European Framework of Reference for Languages, taking into account the specificity of the academic language and professional vocabulary in the field of physical sciences.<br><br>Is aware of the limitations of his competences; recognizes one's strengths and weaknesses and adequately assesses one's capabilities; understands the need to constantly expand knowledge and improve skills, in particular through skillful use of the achievements of other people.<br><br>Represents and promotes a scientific approach to solving cognitive and practical problems; shows a critical attitude towards the presented opinions, in particular pseudoscientific views. | F2_U03,<br><br>F2_U10,<br><br>F2_U11,<br><br>F2_K01,<br><br>F2_K03 |
| 15. | Obligatory literature:<br>M. Fecko, „Differential Geometry and Lie Groups for Physicists<br><br>Recommended literature:<br>C. Isham, "Modern differential geometry for physicist"<br>M. Nakahara, "Geometry, Topology and Physics"<br>Th. Frankel, "Geometry of Physics. An introduction" | |
| 16. | Methods for verifying the assumed learning outcomes:<br>- written test | |
| 17. | Conditions and form of passing individual components of the subject:<br>- constant monitoring of attendance and progress in the scope of classes<br>- control work (final written test) | |
| 18. | Student's workload | |
| | The form of carrying out classes by the student (leave appropriate) | Number of hours allocated to carry out a given type of classes |
| | classes (according to the study plan) with the instructor:<br>- lecture:<br>- classes: | <br><br>15<br>15 |
| | student's own work (including participation in group work):<br>- preparation for classes:<br>- reading the indicated literature:<br>- preparation for tests: | <br><br>20<br>20<br>20 |

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| | Total number of hours | 90 |
| | Number of ECTS | 3 |