University of Gdańsk

Subject card

Subject name and code	Calculus on Manifolds, PG_00206847		
Field of study	Mathematics		
Date of commencement of studies	October 2026	Academic year of realisation of subject	2027/2028
Education level	Master's studies	Subject group	Obligatory subject group in the field of study Optional subject group 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	3	ECTS credits	5.0
Learning profile	academic	Assessment form	exam
Conducting unit	Institute of Mathematics -> Faculty of Mathematics, Physics and Informatics -> Rector		
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. Andreas Zastrow	
	Teachers		

Lesson types

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	3.0	62.0	125

Subject objectives

To familiarize students with the main foundations of the theory of differential manifolds, essential concepts and tools, main theorems and proofs of some of them.

Developing students' ability to understand problems abstractly and use the theory of differential manifolds in mathematical scientific work

Learning outcomes

Course outcome	Subject outcome	Method of verification
[MATMU2_U01] is able to construct mathematical reasoning: prove theorems, formulate, test and refute hypotheses by constructing and selecting counterexamples, choosing, if necessary, methods and tools from various areas of mathematics	In the field of analysis on manifolds, the student is able to construct mathematical arguments: prove theorems and refute hypotheses through construction and selection of counterexamples.	[SU2] presentation/project/paper/ report [SU8] observation of student's independent or team work
[MATMU2_W03] knows and understands to a deep degree a selected field of theoretical or applied mathematics and is able to understand the formulations of issues in this field that are still at the research stage and knows the connections between issues in this field and other areas of mathematics	The student knows and understands analysis on manifolds in-depth and is able to understand the formulations of issues remaining at the research stage and knows the connections of issues with other areas of mathematics, in particular mathematical analysis, algebra or topology.	[SW4] test/exam - oral or written
[MATMU2_W02] knows and understands in depth the role and importance of the construction of mathematical reasoning	The student knows and understands well the role and importance of constructions of mathematical reasoning in the field of analysis on manifolds.	[SW1] oral statement/ conversation/discussion
[MATMU2_W01] knows and understands in depth the theory of selected areas of mathematics or related fields, the complex relationships between them and their development trends	In the field of analysis on manifold, the student knows and understands in-depth the relevant theory. Especially in this field he/she can communicate about essential definitions and formulae, knows examples and counterexamples of defined objects, and correctly formulates and proves selected theorems.	[SW4] test/exam - oral or written

Subject contents

1. Topological and differentiable manifolds, atlas and differentiable structure.

2. Mappings between manifolds, the rank of a mapping.
3. Definition of submanifolds.
4. Properties of immersions, submersions and embeddings.
5. Tangent spaces and -bundles, the derivative of mappings.
6. Approximation theorem.
7. Transversality.
8. The orientation of manifolds.
9. Manifolds with boundary.
10. The degree of a mappings.
11. Differential forms, integrals with respect to them, and Stokes' Theorem.

Prerequisites and co-requisites

the standard lectures on Analysis, Linear Algebra and metric Topology
from the prior years of mathematical studies

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
observation of the student's attitude	51.0%	0.0%
exam	51.0%	50.0%
activity during the example classes including the presentation of homework	51.0%	50.0%

Recommended reading

Basic literature	1. John M. Lee, "Introduction to Smooth Manifolds", Springer 2. John M. Lee, "Introduction to Topological Manifolds", Springer 3. Morris W. Hirsch, "Differential Topology", Springer 4. Martin Golubitsky, Victor Guillemin, "Stable Mappings and their Singularities", Springer 5. John Milnor, "Topologia z różniczkowego punktu widzenia", PWN 6. Michael Spivak, Analiza na rozmaitościach, PWN, 20
Supplementary literature	1. M. P. do Carmo, "Differential Forms and Applications", Springer-Verlag, Berlin, Heidelberg, 1994. 2. Victor Guillemin, Alan Pollack, "Differential topology", Prentice-Hall, Englewood Cliffs, New Jersey, 1974.
eResources addresses	

Example issues/ example questions/ tasks being completed	Credit for the lecture on the basis of the results of the oral exam in the range desrcribed in the required learning outcomes. Credit for the auditorium class on the basis of the results of the presented solutions in the range desrcribed in the required learning outcomes
Work placement	Not applicable

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