GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Mathematical Analysis, PG_00021503		
Field of study	Mathematics		
Date of commencement of studies	October 2025	Academic year of realisation of subject	2026/2027
Education level	first-cycle studies	Subject group	Obligatory subject group in the field of study 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 polish
Semester of study	3	ECTS credits	10.0
Learning profile	general academic profile	Assessment form	exam
Conducting unit	Department of Nonlinear Analysis and Statistics -> Faculty of Applied Physics and Mathematics -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Marcin Styborski	
	Teachers	dr inż. Marcin Styborski dr inż. Robert Krawczyk	

Lesson types

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	60.0	60.0	0.0	0.0	0.0	120

E-learning hours included: 0.0

eNauczanie source address: https://enauczanie.pg.edu.pl/2025/course/view.php?id=5986

Moodle ID: 5986 Analiza matematyczna 3, 2026/27
https://enauczanie.pg.edu.pl/2025/course/view.php?id=5986

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	120	5.0	125.0	250

Subject objectives

The aim of the course is to familiarize students with the basics (definitions, theorems, methods of calculation and problem-solving methods) of integral calculus of functions of several variables and its applications.

Learning outcomes

Course outcome	Subject outcome	Method of verification
K6_U06	The student is able to define the integral of a function of several variables, convert such an integral into an iterated integral, and perform calculations for appropriately chosen examples. The student also defines line and surface integrals and is able to apply Green's, Gauss's, and Stokes's theorems.	[SU3] Assessment of ability to use knowledge gained from the subject
K6_W04	Upon completion of the course, the student will be familiar with classical theorems that generalize the Newton-Leibniz formula to higher dimensions—namely, Green's, Gauss's, and Stokes's theorems—and will be able to apply them.	[SW1] Assessment of factual knowledge
K6_U02	The student is able to carry out formal reasoning that leads to the justification of Fubini's, Green's, and Stokes's theorems.	[SU2] Assessment of ability to analyse information [SU1] Assessment of task fulfilment
K6_W07	The student is able to explain the significance of the Jacobian of a multivariable function and the role it plays in the theorem on the change of variables in a multiple integral.	[SW3] Assessment of knowledge contained in written work and projects [SW1] Assessment of factual knowledge
K6_U04	The student knows the definitions and examples of curves and surfaces. They are able to calculate their lengths and areas, respectively. They are familiar with the concept of multidimensional volume.	[SU4] Assessment of ability to use methods and tools [SU2] Assessment of ability to analyse information

Subject contents

Course content – lecture

- Implicit functions: the implicit function theorem, geometric interpretation, applications.
- Local and global inverse function theorem, diffeomorphisms.
- Constrained extrema, the method of Lagrange multipliers, connection with the geometry of the tangent space T_pM.
- Elements of Morse theory: nondegenerate critical points, the Hessian, classification of extrema.
- The Riemann integral in R^n: sets of measure zero, Lebesgue's criterion for integrability.
- Fubini's theorem and Cavalieri's principle, computation of volumes, the volume of the n-dimensional ball.
- The change of variables theorem for multiple integrals: polar, cylindrical and spherical coordinates, the Gaussian integral.
- Line integrals (scalar and vector), conservative fields.
- Surface integrals, orientation of surfaces.
- Differential forms, the exterior derivative, integration of forms.
- Stokes' theorem and its classical special cases (Green's theorem, the divergence theorem, the classical Stokes theorem in R^3).

Course content – exercises

- Differentiating implicitly defined functions, testing local invertibility of maps.
- Finding constrained extrema with Lagrange multipliers, optimization problems.
- Classifying critical points using the Hessian.
- Double and triple integrals over normal domains, changing the order of integration.
- Computing volumes and areas with multiple integrals, including via Cavalieri's principle.
- Change of variables in integrals (linear maps, polar, cylindrical and spherical coordinates), Gaussian-type integrals.
- Computing line integrals, testing whether vector fields are conservative.
- Computing surface integrals, parametrizing surfaces.
- Calculus with differential forms.
- Applications of Green's theorem, the divergence theorem and Stokes' theorem.

Prerequisites and co-requisites

Knowledge of previous courses of mathematical analysis (analysis I and analysis II: calculus of functions of several variables, integral calculus of functions of one variable)

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
a completion of the exercises	50.0%	50.0%
an exam	50.0%	50.0%

Recommended reading

Basic literature

- T. M. Apostol, *Mathematical Analysis*.
- W. Rudin, *Principles of Mathematical Analysis*.
- K. Maurin, *Analiza, cz. 1* (in Polish).
- F. J. Olmsted, *Advanced Calculus* (Appleton-Century-Crofts, 1961)

	Supplementary literature	• M. Spivak, *Calculus on Manifolds* (differential forms and Stokes' theorem). • J. R. Munkres, *Analysis on Manifolds*. • V. A. Zorich, *Mathematical Analysis II*. • G. M. Fichtenholz, *Rachunek różniczkowy i całkowy* (in Polish). • W. Krysicki, L. Włodarski, *Analiza matematyczna w zadaniach*, part 2 (problem collection, in Polish). • M. Gewert, Z. Skoczylas, *Analiza matematyczna 2* (textbook and problem collection, in Polish).
	eResources addresses	
Example issues/ example questions/ tasks being completed	• State and prove the implicit function theorem. What is its geometric interpretation? • When is a C^1 map locally invertible? Give an example of a locally invertible map that is not globally injective. • Explain why, at a constrained extremum, the gradient of the function is a linear combination of the gradients of the constraints. • State Lebesgue's criterion for Riemann integrability and apply it to a given function. • Prove Fubini's theorem for step functions and describe the passage to general integrable functions. • State the change of variables theorem and explain the role of the absolute value of the Jacobian. • When is a vector field conservative? How does this relate to closed and exact forms? • State Stokes' theorem for differential forms and derive Green's theorem and the divergence theorem from it.	
Practical activites within the subject	Not applicable	

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