SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	**Babeş-Bolyai University**
1.2 Faculty	**Faculty of Mathematics and Computer Science**
1.3 Department	**Department of Computer Science**
1.4 Field of study	**Computers and Information Technology**
1.5 Study cycle	**Bachelor**
1.6 Study programme / Qualification	**Information Engineering**

2. Information regarding the discipline

2.1 Name of the discipline (en) (ro)			Calculus 2 Analiză matematică 2				
2.2 Course coordinator			Trif Tiberiu-Vasile				
2.3 Seminar coordinator							
2.4. Year of study	1	2.5 Semester	2	2.6. Type of evaluation	E	2.7 Type of discipline	Compulsory DF
2.8 Code of the discipline		MLE0071					

3. Total estimated time (hours/semester of didactic activities)

3.1 Hours per week	5	Of which: 3.2 course	3	3.3 seminar/laboratory	2 S
3.4 Total hours in the curriculum	70	Of which: 3.5 course	42	3.6 seminar/laboratory	28
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					30
Additional documentation (in libraries, on electronic platforms, field documentation)					15
Preparation for seminars/labs, homework, papers, portfolios and essays					15
Tutorship					15
Evaluations					5
Other activities:					

3.7 Total individual study hours	80
3.8 Total hours per semester	150
3.9 Number of ECTS credits	6

4. Prerequisites (if necessary)

4.1. curriculum	• Calculus 1 (Calculus in R)
4.2. competencies	• Logical thinking abilities, problematisation

5. Conditions (if necessary)

5.1. for the course	• Classroom with adequate infrastrusture
5.2. for the seminar /lab activities	• Classroom with adequate infrastrusture

6. Specific competencies acquired

Professional competencies	• C1. Operating with the basics of Mathematical, Engineering and Computer Science • C1.2. Using specific theories and tools (algorithms, schemes, models, protocols, etc.) for explaining the structure and the functioning of hardware, software and communication systems • C1.3. Building models for various components of computing systems • C1.5. Providing theoretical background for the characteristics of the designed systems
Transversal competencies	• Honorable, responsible, ethical behavior, in the spirit of the law, to ensure the professional reputation • Demonstrating initiative and pro-active behavior for updating professional, economical and organizational culture knowledge

7. Objectives of the discipline (outcome of the acquired competencies)

7.1 General objective of the discipline	• Getting to know the topolgy of the Euclidean space $\mathbf{R}^n$, the differential calculus of functions of several variables, as well as the different types of integrals for functions of several variables (multiple integrals, line integrals, surface integrals)
7.2 Specific objective of the discipline	• Presenting the basic notions and results concerning the topology of the Euclidean space $\mathbf{R}^n$ • Presenting the basic notions and results concerning the differential calculus of functions of several variables • Presenting the different types of integrals for functions of several variables (multiple integrals, line integrals, and surface integrals)

8. Content

8.1 Course	Teaching methods	Remarks
1. Topology in $\mathbf{R}^n$: the Euclidean space $\mathbf{R}^n$ (the inner product, the Euclidean norm, the Euclidean distance), the topological structure of $\mathbf{R}^n$ (balls, neighbourhoods, interior points, adherent points, boundary points, and limit points, open and closed sets). Sequences in $\mathbf{R}^n$: convergent and Cauchy sequences, characterization of adherent points, of limit points, and of closed sets by means of sequences.	Lecture, discussion, proof, problematisation	[2], pp. 110 – 132 pp. 159 – 185 [6], pp. 269 – 275
2. Compact sets in $\mathbf{R}^n$: definition of compact sets, examples of compact sets in $\mathbf{R}^n$, characterization of	Lecture, discussion, proof,	[2], pp. 132 – 142 pp. 185 – 187

compact sets in $\mathbf{R}^n$. Limits of vector functions of vector variable: definition of the limit, characterization of the limit by means of sequences, operations with functions having a limit.	problematisation	pp. 232 – 244 [6], pp. 290 – 301
3. Continuity of vector functions of vector variable: definition of the continuity at a point, characterization of the continuity by means of sequences, operations with continuous functions, the Weierstrass theorem. Linear mappings and their norm.	Lecture, discussion, proof, problematisation	[6], pp. 348 – 353
4. Differentiability in $\mathbf{R}^n$: the derivative of a vector function of a real variable, the mean value theorem for vector functions of a real variable. Differentiability of vector functions of vector variable (definition of the Frechet differential, continuity of Frechet differentiable functions, derivative vs differential for vector functions of a real variable).	Lecture, discussion, proof, problematisation	[4], pp. 393 – 404 pp. 413 – 417
5. Differentiability in $\mathbf{R}^n$: the directional derivative of a vector function of vector variable and its relationship with the Frechet differential, partial derivatives and their relationship with the Frechet differential. The chain rule, the differentiability of the inverse function.	Lecture, discussion, proof, problematisation	[4], pp. 343 – 350 pp. 417 – 422
6. Differentiabilty in $\mathbf{R}^n$: mean value theorems for functions of several variables. Functions of class C^1. The local inversion theorem, the implicit function theorem.	Lecture, discussion, proof, problematisation	[4], pp. 422 – 441
7. Differentiability in $\mathbf{R}^n$: Lagrange multipliers, second order partial derivatives, the Schwarz and Young theorems concerning the mixed partial derivatives. Necessary and sufficient conditions for extrema. Higher order partial derivatives, Taylor's formula.	Lecture, discussion, proof, problematisation	[4], pp. 361 – 384 pp. 441 – 445
8. The Riemann integral on a compact interval in $\mathbf{R}^n$: definition of the Riemann integral on a compact interval in $\mathbf{R}^n$, Riemann integrability tests on a compact interval in $\mathbf{R}^n$ (the Heine, Cauchy, and Darboux tests). Computation of Riemann integrals on compact intervals by means of iterated integrals (the Fubini theorem).	Lecture, discussion, proof, problematisation	[5], pp. 192 – 198 [9]
9. The Riemann integral on bounded sets in $\mathbf{R}^n$: computation of Riemann integrals on bounded sets in $\mathbf{R}^n$ by means of iterated integrals (the Fubini theorem). Change of variables in multiple integrals. Applications in physics of multiple integrals: centres of gravity and moments of inertia.	Lecture, discussion, proof, problematisation	[5], pp. 224 – 234 pp. 329 – 335 [9]
10. Vector functions of bounded variation: definition, examples, properties of the total variation. Additivity of the total variation with respect to the interval, the Jordan reprezentation theorem, computation of the total variation for functions of the class C^1.	Lecture, discussion, proof, problematisation	[5], pp. 17, 21 [9], pp. 27 – 29 [10], pp. 114 – 115
11. Line integrals: paths, examples, equivalent paths, curves and oriented curves. First degree differential forms. Integration of first degree differential forms	Lecture, discussion, proof, problematisation	[5], pp. 135 – 145 [10], pp. 111 – 113 pp. 126 – 128

along a path (the line integral of the second kind), mechanical work.		[9]
12. Line integrals: the Green formula, integration of exact differential forms, the Leibniz-Newton formula, the Poincaré theorem concerning the integration of exact differential forms, mechanical work in the gravitational field.	Lecture, discussion, proof, problematisation	[5], pp. 205 – 213 [10], pp. 128 – 133 [9]
13. Surface integrals: parametrized surfaces, examples. Differential forms of the second degree and their integrals over parametrized surfaces (surface integrals of the second kind).	Lecture, discussion, proof, problematisation	[5], pp. 306 – 314 [9]
14. The Stokes and the Gauss-Ostrogradski formulae.	Lecture, discussion, proof, problematisation	[9] [5], pp. 351 – 355

Bibliografie

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2. BRECKNER W. W.: Analiza matematica. Topologia spatiului R^n. Universitatea din Cluj-Napoca, 1985.
3. BROWDER A.: Mathematical Analysis. An Introduction, Springer-Verlag, New York, 1996.
4. COBZAS ST.: Analiză matematică (Calcul diferential), Presa Universitară Clujeană, Cluj-Napoca, 1997.
5. Colectiv al catedrei de analiză matematică a Universităţii Bucureşti: Analiză matematică. Vol. 2, Editura didactică şi pedagogică, Bucureşti, 1980.
6. FITZPATRICK P.M.: Advanced Calculus: Second Edition, AMS, 2006.
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8. MARSDEN J. E., TROMBA A. J., WEINSTEIN A.: Basic Multivariable Calculus. Springer, 1993.
9. MEGAN M.: Bazele analizei matematice, Vol. I + Vol. II, Editura EUROBIT, Timisoara, 1997. Vol. III, Editura EUROBIT, Timisoara, 1998.
10. NICULESCU C. P.: Calculul integral al funcţiilor de mai multe variabile. Teorie şi aplicaţii. Editura Universitaria, Craiova, 2002.
11. RUDIN W.: Principles of Mathematical Analysis, 2nd Edition, McGraw-Hill, New York, 1964.
12. WALTER W.: Analysis, I, II, Springer-Verlag, Berlin, 1990.

8.2 Seminar / laboratory	Teaching methods	Remarks
1. The Euclidean space $\mathbf{R}^n$: problems concerning the Euclidean space $\mathbf{R}^n$.	Discussion, problematisation	The coordinator's problem set
2. Compact sets in $\mathbf{R}^n$: problems concerning compact sets in $\mathbf{R}^n$.	Discussion, problematisation	[3], pp. 57 – 60
3. Limits of vector functions of vector variable, continuity of vector functions of vector variable. Linear mappings and their norm: computation of the norm for some concrete linear mappings.	Discussion, problematisation	[3], pp. 31 – 32 [7], pp. 45 – 46
4. Computation of directional derivatives, partial derivatives, and differentials for concrete functions.	Discussion, problematisation	[7], pp. 46 – 49
5. Differentials: study of the Frechet differentiability for concrete functions. Applications to the chain rule.	Discussion, problematisation	[7], pp. 50 – 56
6. Mean value theorems for functions of several variables. Difeomorphisms and implicit functions.	Discussion, problematisation	[7], pp. 56 – 69
7. Extrema for functions of several variables, higher	Discussion,	[7], pp. 73 – 79

order partial derivatives.	problematisation	
8. Computation of double integrals over rectangles. Computation of triple integrals over parallelepipeds. Double and triple integrals over normal domains with respect to an axis.	Discussion, problematisation	[7], pp. 84 – 86 p. 91
9. Computation of double integrals by means of change of variables (polar coordinates).	Discussion, problematisation	[7], pp. 87 – 91
10. Computation of triple integrals by means of change of variables (spherical coordinates, cylindrical coordinates).	Discussion, problematisation	[7], pp. 92 – 94
11. Problems concerning functions of bounded variation. Line integrals of the first kind: definition, main theoretical results, computation of line integrals of the first kind along concrete paths.	Discussion, problematisation	[1], pp. 5 – 44 pp. 166 – 185 [2], pp. 44 – 48 [4], pp. 69 – 70 [5], pp. 10 – 15
12. Line integrals of the second kind: computation of the integrals of certaind first degree differential forms along concrete paths. Integration of some exact differential forms. Applications to the Green formula.	Discussion, problematisation	[1], pp. 185 – 228 [2], pp. 49 – 55 pp. 107 – 109 [4], pp. 70 – 73 p. 74
13. Computation of surface integrals of the first and of the second kind.	Discussion, problematisation	[2], pp. 91 – 96 pp. 101 – 104 [4], p. 87 – 88
14. Problems concerning the Stokes and the Gauss-Ostrogradski formulae.	Discussion, problematisation	[2], pp. 109 – 113

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2. CĂTINAŞ D. et al.: Calcul integral. Culegere de probleme pentru seminarii, examene şi concursuri. Editura U. T. Pres, Cluj-Napoca, 2000.
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4. DONCIU N., FLONDOR D.: Analiză matematică. Culegere de probleme. Vol. 2, Editura All, Bucureşti, 1998.
5. KACZOR W. J., NOWAK M. T.: Problems in Mathematical Analysis III: Integration. American Mathematical Society, 2003.
6. KEDLAYA K. S., POONEN B., VAKIL R.: The William Lowell Putnam Mathematical Competition 1985 – 2000. Problems, Solutions, and Commentary. The Mathematical Association of America, 2002.
7. TRIF T.: Probleme de calcul diferential si integral în R^n, Universitatea Babes-Bolyai, Cluj-Napoca, 2003.
8. WREDE R., SPIEGEL M. R.: Advanced Calculus. Schaum's Outline Series. McGraw Hill, 2010.

9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

The theme of this course (the topology of the Euclidian $\mathbf{R}^n$, the differential calculus of functions of several variables, functions of bounded variation, and various types of integrals for functions of several variables - multiple integrals, line integrals, and surface integrals) is provided in the study program of to all major

universities in Romania and the world. It is an indispensable part of preparing future math teachers, future mathematics researchers, and those working in other fields that directly apply mathematical methods.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in grade
10.4 Course	- knowing the main notions and results - knowing the proofs of the main theoretical results - applying the theoretical results in solving concrete problems	Midterm exam (mandatory) Written exam at the end of the semester	50% 50%
10.5 Seminar/lab	- solving concrete problems by using the theoretical results presented at the course		
10.6 Minimum performance standards			

- The definitions of the basic notions, the statements of the main theoretical results, and the ability to apply these results in solving simple problems
- Identifying and selecting methods to address simple concrete problems

Date | Signature of course coordinator | Signature of seminar coordinator

15.5.2022

Date of approval | Signature of the head of department

Prof. dr. Laura Dioşan

24.05.2022