#### **SYLLABUS**

## 1. Information regarding the programme

1.1 Higher education	Babeş-Bolyai University Cluj-Napoca
institution	
1.2 Faculty	Faculty of Mathematics and Computer Science
1.3 Department	Department of Mathematics
1.4 Field of study	Mathematics
1.5 Study cycle	Master
1.6 Study programme /	Advanced Mathematics
Qualification	

## 2. Information regarding the discipline

2.1 Name of the	dis	scipline	Complex analysis in one and higher dimensions (Analiză						
			complexă uni și multi dimensională)						
2.2 Course coor	2.2 Course coordinator Professor PhD Gabriela KOHR								
2.3 Seminar coordinator				Professor PhD Gabriela KOHR					
2.4. Year of	1	2.5	1	2.6. Type of	E	2.7 Type of	DF/Compulsory		
study		Semester		evaluation		discipline			

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

3.1 Hours per week	3	Of which: 3.2 cour	se	2	3.3	1 sem
					seminar/laboratory	
3.4 Total hours in the curriculum	42	Of which: 3.5 cour	se	28	3.6	14
					seminar/laboratory	
Time allotment:						hours
Learning using manual, course support	rt, bił	oliography, course n	otes	5		46
Additional documentation (in libraries, on electronic platforms, field documentation)					46	
Preparation for seminars/labs, homework, papers, portfolios and essays					46	
Tutorship					11	
Evaluations					9	
Other activities:					-	
3.7 Total individual study hours		158				

## **4. Prerequisites** (if necessary)

3.8 Total hours per semester

3.9 Number of ECTS credits

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4.1. curriculum	• Complex analysis; Real functions; Partial differential equations;
	Differential and integral calculus in R <sup>n</sup>
4.2. competencies	The are useful logical thinking and mathematical notions and
	results from the above mentioned fields

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## **5. Conditions** (if necessary)

5.1. for the course	Classroom with blackboard/video projector
5.2. for the seminar /lab	Classroom with blackboard/video projector
activities	

6. Specific competencies acquired

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nal	cies	•	Ability to understand and manipulate concepts, individual results and advanced mathematical theories.
Professional	competencies	•	Ability to use scientific language and to write scientific reports and papers.
	Ø	•	Ability to inform themselves, to work independently or in a team in order to carry out studies and to solve complex problems.
Transversal	competencies	•	Ability to use advanced and complementary knowledge in order to obtain a PhD in Pure Mathematics, Applied Mathematics, or in other fields that use concepts in complex analysis.
Tran	comp	•	Ability for continuous self-perfecting and study.

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

<ul> <li>Knowledge, understanding and use of main concepts and results of complex analysis in one and higher dimensions.</li> <li>Knowledge, understanding and use of methods of complex analysis in the study of special problems in pure and applied mathemnatics.</li> <li>Ability to use and apply concepts and fundamental results of advanced mathematics in the study of specific problems of complex analysis.</li> </ul>
<ul> <li>Acquiring basic and advanced knowledge in complex analysis.</li> <li>Understanding of main concepts and results in the theory of holomorphic functions in one and higher dimensions.</li> <li>Knowledge, understanding and use of advanced topics in mathematics in the study of special problems in complex analysis.</li> <li>Ability student involvement in scientific research.</li> </ul>

#### 8. Content

8.1 Course	Teaching methods	Remarks
Part I		
1. Analytic branches. Index (winding number).	Lectures, modeling,	
General properties. The Cauchy integral formulas.	didactical demonstration,	
Applications.	conversation. Presentation	
	of alternative explanations.	
2. Cauchy's theorem related to zeros and poles of	Lectures, modeling,	
meromorphic functions. The argument principle.	didactical demonstration,	
Applications.	conversation. Presentation	
	of alternative explanations.	
3. Rouché's theorem. Open mapping theorem and	Lectures, modeling,	
	didactical demonstration,	

<ul> <li>4. The Fréchet space H(Ω). Families of holomorphic functions. Montel and Vitali's theorems. Extremal problems on compact subsets of H(Ω). conversation. Presentation of alternative explanations.</li> <li>5. Conformal mappings. The automorphisms of the unit disc and the upper half-plane. The automorphisms of the complex plane.</li> <li>6. The Riemann mapping theorem. Extension to the boundary.</li> <li>7. Harmonic and subharmonic mappings. Conformal equivalence of annuli.</li> <li>8. Holomorphic functions of several complex variables. The generalized Cauchy-Riemann equations. Integral representation of holomorphic functions on the polydise. Sequences and series of holomorphic functions in C<sup>n</sup>. The Montel and Vitali theorems. Holomorphic mappings.</li> <li>10. Biholomorphic mappings in C<sup>n</sup>. Poincaré's theorem. An n-dimensional version of Hurwitz's theorem. An Integral representation of Hurwitz's theorem for biholomorphic mappings.</li> <li>11. Cartan's uniqueness theorems. Applications.</li> <li>12. The automorphisms of the Euclidean unit ball and the unit polydisc in C<sup>n</sup>. Applications.</li> <li>13. Holomorphic extension. Hartogs' theorem. Domains of holomorphy. Holomorphic convexity.</li> <li>14. Introduction to the theory of pseudoconvexity.</li> <li>15. Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.</li> <li>16. Lecture</li></ul>		
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#### Bibliography

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- 2. G. Kohr, *Basic Topics in Holomorphic Functions of Several Complex Variables*, Cluj University Press, Cluj-Napoca, 2003.
- 3. G. Kohr, P.T. Mocanu, *Special Topics of Complex Analysis*, Cluj University Press, Cluj-Napoca, 2005 (in Romanian).
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- 5. C.A. Berenstein, R. Gay, *Complex Variables: An Introduction*, Springer-Verlag New York Inc., 1991.
- 6. Conway, J.B., *Functions of One Complex Variable*, vol. I, Graduate Texts in Mathematics, Springer Verlag, New York, 1978 (Second Edition).
- 7. K. Güerlebeck, K. Habetha, W. Spröβig, *Holomorphic Functions in the Plane and n-Dimensional Space*, Birkhäuser, Basel-Boston-Berlin, 2008.
- 8. R.C. Gunning, *Introduction to Holomorphic Functions of Several Variables*, vol.I. *Function Theory*, Wadsworth & Brooks/Cole, Monterey, CA, 1990.
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- 12. W. Rudin, Function Theory in the Unit Ball of C<sup>n</sup>, Springer-Verlag, New York, 1980.

8.2 Seminar	Teaching methods	Remarks
Part I		
Applications of residues to the computation of some real integrals.	Applications of course concepts.  Description of arguments and proofs for solving problems.  Homework assignments. Direct answers to students.	1 hour/week
Applications of the argument principle and Rouché's Theorem.	Applications of course concepts. Description of arguments and proofs for solving problems. Homework assignments. Direct answers to students.	1 hour/week
3. Examples of compact families of holomorphic functions. Extremal problems on compact subsets of $H(\Omega)$ .	Applications of course concepts.  Description of arguments and proofs for solving problems.  Homework assignments. Direct answers to students.	1 hour/week
Sufficient conditions of univalence for holomorphic functions of one complex variable. Examples of univalent functions.	Applications of course concepts.  Description of arguments and proofs for solving problems.  Homework assignments. Direct answers to students.	1 hour/week
5. Applications of the Riemann mapping theorem. Conformal mappings of special simply connected domains in C (I).	Applications of course concepts. Description of arguments and proofs for solving problems. Homework assignments. Direct answers to students.	1 hour/week
6. Applications of the Riemann mapping theorem. Conformal mappings of special simply connected domains in C (II).	Applications of course concepts.  Description of arguments and proofs for solving problems.  Homework assignments. Direct answers to students.	1 hour/week
7. The automorphisms of the extended complex plane.	Applications of course concepts.  Description of arguments and proofs for solving problems.  Homework assignments. Direct answers to students.	1 hour/week
Part II		
8. Applications of the Cauchy integral representations	Applications of course concepts.	1 hour/week

on the unit polydisc in C <sup>n</sup> .	Description of arguments and proofs for solving problems. Homework assignments. Direct answers to students.	
9. Applications of the maximum modulus theorem and the Schwarz Lemma for holomorphic functions of several complex variables.	Applications of course concepts.  Description of arguments and proofs for solving problems.  Homework assignments. Direct answers to students.	1 hour/week
10. Harmonic and subharmonic mappings. Pluriharmonic and plurisubharmonic mappings. Examples.	Applications of course concepts. Description of arguments and proofs for solving problems. Homework assignments. Direct answers to students.	1 hour/week
11. Sufficient conditions of univalence for holomorphic mappings on the unit ball in C <sup>n</sup> . Examples of locally biholomorphic mappings and univalent mappings (I).	Applications of course concepts.  Description of arguments and proofs for solving problems.  Homework assignments. Direct answers to students.	1 hour/week
12. Sufficient conditions of univalence for holomorphic mappings on the unit ball in C <sup>n</sup> . Examples of locally biholomorphic mappings and univalent mappings (II).	Applications of course concepts.  Description of arguments and proofs for solving problems.  Homework assignments. Direct answers to students.	1 hour/week
13. Automorphisms of special bounded domains in C <sup>n</sup> .	Applications of course concepts. Description of arguments and proofs for solving problems. Homework assignments. Direct answers to students.	1 hour/week
14. Examples of automorphisms of the n-dimensional complex space C <sup>n</sup> . Fatou-Bieberbach domains and Runge domains in C <sup>n</sup> .	Applications of course concepts. Description of arguments and proofs for solving problems. Homework assignments. Direct answers to students.	1 hour/week

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- 12. M. Range, *Holomorphic Functions and Integral Representations in Several Complex Variables* Springer-Verlag, New York, 1986.

# 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 content of this discipline is in accordance with the curricula of the most important universities in Romania and abroad, where the advanced mathematics plays an essential role. This discipline is useful in specifical PhD research activities, in preparing future researchers in pure and applied mathematics, and for those who use mathematical models and advanced methods of study in other areas.

#### 10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)				
10.4 Course	Knowledge of concepts and basic results	Written exam.	60%				
	Ability to justify by proofs theoretical results						
10.5 Seminar/lab activities	Ability to apply concepts and results acquired in the course in mathematical modeling and analysis of problems in pure and applied mathematuics.	Evaluation of reports and homework during the semester, and active participation in the seminar activity.  A midterm written test.	15% 25%				
	There are valid the official rules of the faculty concerning the attendance of students to teaching activities.						
10.6 Minimum performance standards							

The final grade should be at least 5 (from a scale of 1 to 10).

Date Signature of course coordinator Signature of seminar coordinator

29.04.2020 Professor PhD Gabriela KOHR Professor PhD Gabriela KOHR

Date of approval Signature of the head of department

Professor PhD Octavian AGRATINI