SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	**Babeş-Bolyai University Cluj-Napoca**
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 / Qualification	**Advanced Mathematics (Matematici avansate)**

2. Information regarding the discipline

2.1 Name of the discipline	**Complex analysis in one and higher dimensions (Analizã complexã uni şi multi dimensionalã)**						
2.2 Course coordinator	**Professor Gabriela KOHR**						
2.3 Seminar coordinator	**Professor Gabriela KOHR**						
2.4. Year of study	**2**	2.5 Semester	**3**	2.6. Type of evaluation	**E**	2.7 Type of discipline	**DF**

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

3.1 Hours per week	**3**	Of which: 3.2 course	**2**	3.3 seminar/laboratory	**1 sem**
3.4 Total hours in the curriculum	**42**	Of which: 3.5 course	**28**	3.6 seminar/laboratory	**14**

Time allotment:	hours
Learning using manual, course support, bibliography, course notes	42
Additional documentation (in libraries, on electronic platforms, field documentation)	32
Preparation for seminars/labs, homework, papers, portfolios and essays	42
Tutorship	9
Evaluations	8
Other activities:	-

3.7 Total individual study hours	133
3.8 Total hours per semester	175
3.9 Number of ECTS credits	7

4. Prerequisites (if necessary)

4.1. curriculum	• Complex analysis; Real functions; Functional analysis.
4.2. competencies	• The are useful logical thinking and mathematical notions and results from the above mentioned fields

5. Conditions (if necessary)

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

6. Specific competencies acquired

Professional competencies	• Ability to understand and manipulate concepts, individual results and advanced mathematical theories. • Ability to use scientific language and to write scientific reports and papers.
Transversal competencies	• Ability to inform themselves, to work independently or in a team in order to carry out studies and to solve complex problems. • 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. • Ability for continuous self-perfecting and study.

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

7.1 General objective of the discipline	• Knowledge, understanding and use of main concepts and results of complex analysis in one and higher dimensions. • Knowledge, understanding and use of methods of complex analysis in the study of special problems in pure and applied mathemnatics. • Ability to use and apply concepts and fundamental results of advanced mathematics in the study of specific problems of complex analysis.
7.2 Specific objective of the discipline	• Acquiring basic and advanced knowledge in complex analysis. • Understanding of main concepts and results in the theory of holomorphic functions in one and higher dimensions. • Knowledge, understanding and use of advanced topics in mathematics in the study of special problems in complex analysis. • Ability student involvement in scientific research.

8. Content

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

Hurwitz’s theorem. Applications.	conversation. Presentation of alternative explanations.	
4. The Fréchet space H(Ω). Families of holomorphic functions. Montel and Vitali’s theorems. Extremal problems on compact subsets of H(Ω).	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
5. Conformal mappings. The automorphisms of the unit disc and the upper half-plane. The automorphisms of the complex plane.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
6. The Riemann mapping theorem. Extension to the boundary.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
7. Harmonic and subharmonic mappings. Conformal equivalence of annuli.		
Part II		
8. Holomorphic functions of several complex variables. The generalized Cauchy-Riemann equations. Integral representation of holomorphic functions on the polyidsc. Sequences and series of holomorphic functions in $\mathbf{C}^n$.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
9. Sets of uniqueness for the holomorphic functions in $\mathbf{C}^n$. The Montel and Vitali theorems. Holomorphic mappings.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
10. Biholomorphic mappings in $\mathbf{C}^n$. Fatou-Bieberbach domains. Poincaré’s theorem. An n-dimensional version of Hurwitz’s theorem for biholomorphic mappings.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
11. Cartan’s uniqueness theorems. Applications.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
12. The automorphisms of the Euclidean unit ball and the unit polydisc in $\mathbf{C}^n$. Applications.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
13. Holomorphic extension. Hartogs’ theorem. Domains of holomorphy. Holomorphic convexity.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
14. Introduction to the theory of pseudoconvexity.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	

Bibliography

1. I. Graham, G. Kohr, *Geometric Function Theory in One and Higher Dimensions*, Marcel Dekker Inc., New York, 2003.

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).

4. P. Hamburg, P.T. Mocanu, N. Negoescu, *Mathmatical Analysis* (*Complex Functions*), Editura Didacticã şi Pedagogicã, Bucureşti, 1982 (in Romanian).

5. C.A. Berenstein, R. Gay, *Complex Variables: An Introduction*, Springer-Verlag New York Inc., 1991.
6. J.B. Conway, *Functions of One Complex Variable*, Graduate Texts in Mathematics, 159, Springer Verlag, New York, 1996.
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.
9. S.G. Krantz, *Function Theory of Several Complex Variables*, Reprint of the 1992 Edition, AMS Chelsea Publishing, Providence, Rhode Island, 2001.
10. R. Narasimhan, R., *Several Complex Variables*, The University of Chicago Press, Chicago, 1971.
11. M. Range, *Holomorphic Functions and Integral Representations in Several Complex Variables* Springer-Verlag, New York, 1986.
12. W. Rudin, *Function Theory in the Unit Ball of* $\mathbf{C}^n$, Springer-Verlag, New York, 1980.

8.2 **Seminar**	Teaching methods	Remarks
Part I		
1. Applications of residues to the computation of some special real integrals.	Applications of course concepts. Description of arguments and proofs for solving problems. Homework assignments. Direct answers to students.	1 hour/week
2. 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(Ω).	Applications of course concepts. Description of arguments and proofs for solving problems. Homework assignments. Direct answers to students.	1 hour/week
4. Sufficient conditions of univalence for 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 $\mathbf{C}^n$.	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 $\mathbf{C}^n$. Examples of locally biholomorphic mappings and biholomorphic 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 $\mathbf{C}^n$. Examples of locally biholomorphic mappings and biholomorphic 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 $\mathbf{C}^n$.	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 $\mathbf{C}^n$. Fatou-Bieberbach domains.	Applications of course concepts. Description of arguments and proofs for solving problems. Homework assignments. Direct answers to students.	1 hour/week

Bibliography

1. I. Graham, G. Kohr, *Geometric Function Theory in One and Higher Dimensions*, Marcel Dekker Inc., New York, 2003.
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).
4. P. Hamburg, P.T. Mocanu, N. Negoescu, *Mathmatical Analysis* (*Complex Functions*), Editura Didacticã şi Pedagogicã, Bucureşti, 1982 (in Romanian).
5. C.A. Berenstein, R. Gay, *Complex Variables: An Introduction*, Springer-Verlag New York Inc., 1991.
6. J.B. Conway, *Functions of One Complex Variable*, Graduate Texts in Mathematics, 159, Springer Verlag, New York, 1996.
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.
9. S.G. Krantz, *Function Theory of Several Complex Variables*, Reprint of the 1992 Edition, AMS Chelsea

Publishing, Providence, Rhode Island, 2001.

10. R. Narasimhan, R., *Several Complex Variables*, The University of Chicago Press, Chicago, 1971.
11. R. Narasimhan, Y. Nievergelt, *Complex Analysis in One Variable*, Birkhäser, 2001.
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 preparing future researchers in pure and applied mathematics, as well as 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 fluid mechanics	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			
➢ At least grade 5 (from a scale of 1 to 10) at both written exam and seminar activity during the semester.			

Date	Signature of course coordinator	Signature of seminar coordinator
2.05.2016	Professor PhD Gabriela KOHR	Professor PhD Gabriela KOHR

Date of approval

Signature of the head of department

Professor Octavian AGRATINI