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	**Bachelor**
1.6 Study programme / Qualification	**Mathematics and Computer Science**

2. Information regarding the discipline

2.1 Name of the discipline	**Complex Analysis**						
2.2 Course coordinator	**Lecturer PhD Mihai IANCU**						
2.3 Seminar coordinator	**Lecturer PhD Mihai IANCU**						
2.4. Year of study	2	2.5 Semester	3	2.6. Type of evaluation	**E**	2.7 Type of discipline	**DF/Compulsory**

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

3.1 Hours per week	4	Of which: 3.2 course	**2**	3.3 seminar/laboratory	**2 sem**
3.4 Total hours in the curriculum	56	Of which: 3.5 course	28	3.6 seminar/laboratory	28

Time allotment:	hours
Learning using manual, course support, bibliography, course notes	22
Additional documentation (in libraries, on electronic platforms, field documentation)	12
Preparation for seminars/labs, homework, papers, portfolios and essays	20
Tutorship	7
Evaluations	8
Other activities:	-

3.7 Total individual study hours	69
3.8 Total hours per semester	125
3.9 Number of ECTS credits	5

4. Prerequisites (if necessary)

4.1. curriculum	• Calculus 1 (Analysis on **R**); Calculus 2 (Differential and integral calculus in $\mathbf{R}^n$); Analytical geometry
4.2. competencies	• There 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	• Classroom with blackboard/video projector

activities	

6. Specific competencies acquired

Professional competencies	• C1.1 Identification the notions, describing theories and using the specific language. • C1.4 Recognition of main classes/types of mathematical problems and selecting the adequate methods and techniques for their solving. • C5.2 Using mathematical arguments to prove mathematical results. • Ability to formulate and communicate orally and in writing ideas and concepts from complex analysis. • Ability to use various specific methods of complex analysis to approach problems in other fields of mathematics.
Transversal competencies	• CT1 Applying rigorous and effective work rules, manifest responsible attitude to science and teaching, and creative order to maximize their potential in specific situations, the principles and rules of professional ethics. • The student must have the ability to apply the studied notions and to formulate mathematical models of concrete problems which appear in various fields of mathematics.

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

7.1 General objective of the discipline	• Knowledge, understanding and use of fundamental concepts and results of complex analysis.
7.2 Specific objective of the discipline	• Acquiring basic knowledge of complex analysis. • Knowledge of fundamental topological notions in the complex plane. • Understanding and studying fundamental results in the theory of holomorphic functions of one complex variable. • Acquiring basic knowledge of various elementary functions in the complex plane. • Understanding and studying fundamental results related to the complex integral. • Ability to compute complex integrals. • Advanced knowledge on Taylor and Laurent series expansions. • Ability to compute various types of real integrals by using methods of complex analysis. • Ability to use specific methods of complex analysis to study some problems from other fields of mathematics and physiscs.

8. Content

8.1 **Course**	Teaching methods	Remarks
Part I		
1. Complex numbers. The complex plane. The stereographic projection. The extended complex plane.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
2. The derivative of complex functions of one complex variable. Paths in **C**. Fundamental	Lectures, modeling, didactical demonstration,	

notions and results.	conversation. Presentation of alternative explanations.	
3. The Cauchy-Riemann theorem. Holomorphic functions. General properties. Applications.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
4. Elementary functions. Harmonic functions. Examples. Linear fractional transformations (Möbius transformations). General properties. Applications.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
5. Integration of complex functions. General properties of the complex integral.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
6. Primitives (anti-derivatives) of complex functions of one complex variable. Fundamental results.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
7. Cauchy's theorem. Applications.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
8. Cauchy's formulas. Cauchy's inequalities. Morera's and Liouville's theorems. Applications.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
9. Sequences of holomorphic functions. Weierstrass' theorem. Series of holomorphic functions. Fundamental results.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
10. Power series. The Cauchy-Hadamard theorem. The equivalence between analyticity and holomorphy.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
11. Zeros of holomorphic functions. The identity theorem of holomorphic functions. The maximum modulus theorem. Schwarz's lemma.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
12. Laurent series. Singular points. Classification of isolated singularities. Meromorphic functions.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
13. The residue theorem. Applications to calculus of complex integrals.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
14. Applications of residue theorem to the evaluation of real integrals.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	

Bibliography

1. Hamburg, P., Mocanu, P.T., Negoescu, N., *Mathematical Analysis* (*Complex Functions*), Editura Didacticã şi Pedagogică, Bucureşti, 1982 (in Romanian).
2. Kohr, G., *Complex Analysis*, lecture notes (in Romanian), 2020.
3. Kohr, G., Mocanu, P.T., *Special Topics of Complex Analysis*, Cluj University Press, Cluj-Napoca, 2005 (in Romanian).

4. Ahlfors, L.V., *Complex Analysis*, 3rd ed., McGraw-Hill Book Co., New York, 1979.
5. Bulboacă, T., Joshi, S.B., Goswami, P., *Complex Analysis. Theory and Applications*, de Gruyter, Berlin, Boston, 2019.
6. Conway, J.B., *Functions of One Complex Variable,* vol. I, Graduate Texts in Mathematics, Springer Verlag, New York, 1978 (Second Edition).
7. Gaşpar, D., Suciu, N., *Complex Analysis*, Publishing House of the Romanian Academy, Bucharest, 1999 (in Romanian).
8. Krantz, S., *Handbook of Complex Variables*, Birkhäuser Verlag, Boston, Basel, Berlin, 1999.
9. Narasimhan, R., Nievergelt, Y., *Complex Analysis in One Variable*, Second Edition, Birkhäuser, 1985.
10. Popa, E., *Introduction in the Theory of Functions of One Complex Variable*, A.I. Cuza Univ. Press , Iaşi, 2001 (in Romanian)
11. Rudin, W., *Real and Complex Analysis*, 3rd ed., Mc. Graw-Hill, 1987.
12. Stein, E.M., Shakarchi, R., *Complex Analysis,* Princeton University Press, 2003.

8.2 **Seminar**	Teaching methods	Remarks
Part I		
1. Properties of complex numbers. Applications.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
2. The stereographic projection. The extended complex plane. Sequences of complex numbers.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
3. Complex functions of one complex variable. Examples and applications.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
4. The derivative of functions of one complex variable. Applications of the Cauchy-Riemann theorem. The geometric interpretation of the complex derivative.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
5. Linear fractional transformations (Möbius transformations). Applications (I).	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
6. Linear fractional transformations (Möbius transformations). Applications (II).	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
7. Entire functions. Harmonic functions. Examples and applications.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
8. The complex integral. Computation of elementary complex integrals. Applications of Cauchy's theorem.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
9. Cauchy's formulas. Applications.	Description of arguments and proofs for solving problems. Direct answers to students.	

	Homework assignments.	
10. Taylor series expansions.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
11. Applications of Liouville's and maximum modulus theorems for holomorphic functions.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
12. Laurent series expansions. Isolated singular points. Examples and applications.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
13. Applications of Residue theorem to calculus of complex integrals.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
14. Applications of Residue theorem to calculus of real integrals.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	

Bibliography

1. Hamburg, P., Mocanu, P.T., Negoescu, N., *Mathematical Analysis* (*Complex Functions*), Editura Didacticã şi Pedagogicã, Bucureşti, 1982 (in Romanian).
2. Kohr, G., *Complex Analysis*, seminar notes (in Romanian), 2020.
3. Kohr, G., Mocanu, P.T., *Special Topics of Complex Analysis*, Cluj University Press, Cluj-Napoca, 2005 (in Romanian).
4. Berenstein, C.A., Gay, R., *Complex Variables: An Introduction*, Springer-Verlag New York Inc., 1991.
5. Bulboacă, T., Joshi, S.B., Goswami, P., *Complex Analysis. Theory and Applications*, de Gruyter, Berlin, Boston, 2019.
6. Conway, J.B., *Functions of One Complex Variable,* vol. I, Graduate Texts in Mathematics, Springer Verlag, New York, 1978 (Second Edition).
7. Popa, E., *Introduction in the Theory of Functions of One Complex Variable*, A.I. Cuza Univ. Press , Iaşi, 2001 (in Romanian)
8. Volkovysky, L., Lunts, G., Aramanovich, I., *Problems in the Theory of Functions of a Complex Variable*, Moscow: MIR Publishers, 1972.
9. Evgrafov, M., Bejanov, K., Sidorov, Y., Fedoruk, M., Chabounine, M., *Recueil de Problèmes sur la Théorie des Fonctions Analytiques*, Moscou: Editions Mir, 1974.
10. Mocanu, G., Stoian, G., Vişinescu, E., *Function Theory of One Complex Variable* (*Textbook of Problems*), Editura Didacticã şi Pedagogicã, Bucureşti, 1970 (in Romanian).
11. Sălăgean, G.S., *Geometria Planului Complex*, Promedia-Plus, Cluj-Napoca, 1997.

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 course is in accordance with the curricula of the most important universities in Romania and abroad. This discipline is useful in preparing future teachers and researchers in mathematics,

as well as those who use various mathematical methods and techniques of study in other areas (physics, chemistry, engineering).

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 at the course in solving concrete problems of complex analysis.	Evaluation of student activity during the semester, and active participation in the seminar activity. A midterm written test.	10% 30%
	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
21.04.2022	Lecturer PhD Mihai IANCU	Lecturer PhD Mihai IANCU

Date of approval

Signature of the head of department

Professor Octavian AGRATINI