Complex variable and transforms

Academic Year: (2024 / 2025) **Review date: 05-09-2024**

Department assigned to the subject: Mathematics Department

Coordinating teacher: LOPEZ BONILLA, LUIS FRANCISCO

Type: Compulsory ECTS Credits : 6.0

Year : 2 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Calculus II
Differential Equations

SKILLS AND LEARNING OUTCOMES

CB1. Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.
CB2. Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.
CB3. Students have the ability to gather and interpret relevant data (usually within their field of study) in order to make judgements which include reflection on relevant social, scientific or ethical issues.
CB4. Students should be able to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
CB5. Students will have developed the learning skills necessary to undertake further study with a high degree of autonomy.
CG2. Learn new methods and technologies from basic scientific and technical knowledge, and being able to adapt to new situations.
CG3. Solve problems with initiative, decision making, creativity, and communicate and transmit knowledge, skills and abilities, understanding the ethical, social and professional responsibility of the engineering activity. Capacity for leadership, innovation and entrepreneurial spirit.
CG4. Solve mathematical, physical, chemical, biological and technological problems that may arise within the framework of the applications of quantum technologies, nanotechnology, biology, micro- and nano-electronics and photonics in various fields of engineering.
CG5. Use the theoretical and practical knowledge acquired in the definition, approach and resolution of problems in the framework of the exercise of their profession.
CE1. Solve mathematical problems that may arise in engineering and apply knowledge of linear algebra, differential and integral calculus, numerical methods, numerical algorithms, statistics, differential equations and in partial derivatives, complex and transformed variables.
CE4. Analyze and manipulate analog and digital signals in the temporal and frequency domains, and understand and master the basic concepts of linear systems and related functions and transforms, as well as apply them to circuit design.
CE22. Design, plan and estimate the costs of an engineering project.
CT1. Work in multidisciplinary and international teams as well as organize and plan work making the right decisions based on available information, gathering and interpreting relevant data to make judgments and critical thinking within the area of study.

RA1. To have acquired sufficient knowledge and proved a sufficiently deep comprehension of the basic principles, both theoretical and practical, and methodology of the more important fields in science and technology as to be able to work successfully in them.
RA2. To be able, using arguments, strategies and procedures developed by themselves, to apply their knowledge and abilities to the successful solution of complex technological problems that require creating and innovative thinking.
RA3. To be able to search for, collect and interpret relevant information and data to back up their

conclusions including, whenever needed, the consideration of any social, scientific and ethical aspects relevant in their field of study.
RA6. To be aware of their own shortcomings and formative needs in their field of specialty, and to be able to plan and organize their own training with a high degree of independence.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Complex functions
Complex numbers. Complex functions. Limits. Continuous functions. Elementary functions: Polynomials. Exponential function. Trigonometric functions. Hyperbolic functions. Multivalued functions, branch points and branch cuts, Riemann surfaces. Logarithm. Complex exponents. Inverses of trigonometric and hyperbolic functions.
2. Differentiation.
Derivatives and Cauchy-Riemann equations. Harmonic functions. Analytic (holomorphic) functions and singular points. Laurent series.
3. Integrals in the complex domain.
Contour integrales. Cauchy-Goursat theorem. Independence of path, coutour deformation, indefinite integrals.
4. Residues and poles
Zeros of a function. Singularities. Poles. Residue formula. Residue theorem. Jordan's lemma. Contour indentation. Real integrals of trigonometric functions. Real improper integrals. Integrals on branch cuts. Summations of series by using residue theorem.
5. Cauchy integral formula. Series
Sequences and convergence criteria. Power series. radius of convergence. Taylor series. Cauchy integral formula. Laurent series. Analyticity and analytic continuation. Liouville theorem. Morera theorem. Bounds for analytic functions. The fundamental theorem of algebra. Power series and differential equations. Frobenius theory. Special functions of Mathematical Physics.
6. Fourier series
Fourier series and their application to periodic signals. Square integrable functions. Pointwise convergence. Uniform convergence. Application to differential and partial differential equations.
7. Fourier transform.
Definition and properties. Inverse Fourier transform. Convolution. Application to partial differential equations. Representation of aperiodic signals. Discrete time Fourier transform.
8. Laplace transform
Definition, properties and convergence. Inverse Laplace transform. Derivatives, integrals, and convolution. Applications to systems of linear differential equations. Transfer function.
9. z-Transform
Convergence region and other properties. Inverse z-transform. Transforms between continuous and discrete time signals. Applications to linear difference equations. Linear time-invariant (LTI) systems. Analysis of LTI systems with transforms.

LEARNING ACTIVITIES AND METHODOLOGY

AF1. THEORETICAL-PRACTICAL CLASSES. Knowledge and concepts students mustacquire. Receive course notes and will have basic reference texts.Students partake in exercises to resolve practical problems. It entails 44 hours with an 100% on-site.
AF2. TUTORING SESSIONS. Individualized attendance (individual tutoring) or in-group (group tutoring) for students with a teacher.Subjects with 6 credits have 4 hours of tutoring/ 100% on- site attendance.
AF3. STUDENT INDIVIDUAL WORK OR GROUP WORK.Subjects with 6 credits have 98 hours/0% on-site.
AF9. FINAL EXAM. Global assessment of knowledge, skills and capacities acquired throughout the course. It entails 4 hours/100% on-site
MD1. THEORY CLASS. Classroom presentations by the teacher with IT and audiovisual support in which the subject`s main concepts are developed, while providing material and bibliography to complement student learning
MD2. PRACTICAL CLASS. Resolution of practical cases and problem, posed by the teacher, and carried out individually or in a group
MD3. TUTORING SESSIONS. Individualized attendance (individual tutoring sessions) or in-group (group tutoring sessions) for students with teacher as tutor. Subjects with 6 credits have 4 hours of tutoring/100% on-site.
MD6. LABORATORY PRACTICAL SESSIONS. Applied/experimental learning/teaching in workshops and laboratories under the tutor's supervision.

ASSESSMENT SYSTEM

% end-of-term-examination:	40
% of continuous assessment (assigments, laboratory, practicals…):	60

SE1. FINAL EXAM. Global assessment of knowledge, skills and capacities acquired throughout the course.The percentage of the evaluation will be 60% .
SE2. CONTINUOUS EVALUATION. Assesses papers, projects, class presentations, debates, exercises, internships and workshops throughout the course.The percentage of the evaluation will be 40% of the final grade.
This methodology will me implemented if the lectures are either the synchronous and interactive online modality through Blackboard Collaborate or presential. It will depend on the decision of the university in the framework of the response to COVID pandemia.

BASIC BIBLIOGRAPHY

- A. Papoulis, Signal Analysis. , McGraw Hill International Editions,, 1984
- B. Fornberg, C. Piret Complex Variables and Analytic Functions: An Illustrated Introduction, SIAM, 2019
- D. Pestana, J. M. Rodríguez, F. Marcellán, Curso práctico de variable compleja y teoría de transformadas. , Pearson, , 2014
- J.W. Brown, R. V. Churchill, Complex Variables and Applications., McGrawHill,, 2009
- M. J. Ablowitz, A.S. Fokas Complex variables: Introduction and applications. , Cambridge University Press, 2003
- M. R. Spiegel, S. Lipschutz, J.J. Schiller, D. Spellman, Schaum's outline of complex variables. 2nd ed., McGraw Hill, 2009
- N. Levinson, R. M. Redheffer, Complex Variables., McGraw Hill,, 1989

ADDITIONAL BIBLIOGRAPHY

- A. V. Oppenheim, A. S. Willsky, I. T. Young, Signals and Systems. , Prentice Hall International Editions. , 1983
- I. Volkovyski, G. Lunts, I. Aramanovich Problemas sobre la teoría de funciones de variable compleja, Mir, 1972
- J. Bruna, J. Cufí, Complex Analysis, , EMS Textbooks in Mathematics. European Mathematical Society , 2013
- J. G. Proakis, D. G. Manolakis Introduction to Digital Signal Processing. , Macmillan Publishing Company, 1988
- P. Henrici, Applied and Computational Complex Analysis (3 volúmenes). , Wiley Classics Library. Wiley Interscience. , 1993