# GODFREY OKOYE UNIVERSITY ENUGU, ENUGU STATE, NIGERIA

www.gouni.edu.ng

## B.SC. MATHEMATICS

## Student Handbook

## 2023 – 2028

**Course Contents**

## Overview

Mathematics programme develops in students' self-confidence in handling problems with minimal or no supervision. Graduates of the programme will acquire sufficient knowledge to develop confidence in appreciating and solving problems in general.

## Philosophy

The philosophy of the mathematics programme is to train students to acquire academic excellence and competence in Mathematical reasoning and problem–solving through the use of logic and computational skills with main purpose of meeting our national needs in the area of technological advancement which is currently a global trend.

## Objectives

1. To instil in students a sense of enthusiasm for mathematics, an appreciation of its application in different areas and to involve them in an intellectually stimulating and satisfying experience of learning and studying.
2. To provide students a broad and balanced foundation in mathematics knowledge and practical skills in statistics and computer science.
3. To develop in students the ability to apply their mathematics knowledge and skills to the solution of theoretical and practical problems in mathematics.
4. To develop in students, through an education in mathematics, a range of transferable skills of value in mathematical related and non-mathematical related employment.
5. To provide students with knowledge and skills base from which they can proceed to further studies in specialised areas of mathematics or multi-disciplinary areas involving mathematics.
6. To generate in students an appreciation of the importance of mathematics in an industrial, economic, environmental and social context.

## Employability Skills

Mathematics is embodiment of employability skills and the graduates will be equipped with skills that include the following: 1. Learning and innovation skills

2. Life and career skills
3. Information, media and technology skills
4. quantitative reasoning;
5. ability to manipulate precise and intricate ideas; 6. numeracy.

## 21st Century Skills

1. creative and critical thinking;
2. problem solving;
3. analytical thinking;
4. logical thinking;
5. communication;
6. time management;
7. teamwork;
8. independence;

## Unique Features of the Programme

The unique features of the programme include

1. graduates will certainly possess the needed skills to bring to bear the applications of mathematics to address industrial and societal problems towards improvement of quality of life in both the developed and developing worlds taking advantage of current innovations in technology;
2. they will be well equipped to pursue careers in several other emerging areas that encompasses all the mathematics disciplines as well as many other areas of science, social science, business, etc. Examples include finance and cryptography, artificial intelligence, machine learning, actuarial science, climate change, energy and sustainable development, mathematical modelling, biomathematics; and
3. graduates will be equipped to demonstrate anywhere they find themselves that mathematical skills propel a better world and enable one to excel in every other field

## Admission and Graduation Requirements

### Admission Requirements

The entry requirements shall be at least credit level passes in five subjects including English Language, Mathematics, and Physics to form the core subjects with credit in any other two relevant science subjects at the Senior Secondary Certificate (SSC) or its equivalent. In addition, an acceptable pass in the Unified Tertiary Matriculation Examination (UTME), with appropriate subject combination is required for admission into 100 Level.

Candidates with two A level passes (graded A-E) at the GCE/IJMB Advanced Level in relevant subjects (Mathematics, Further Mathematics, Physics and Chemistry) may be admitted into 200level.

### Graduation Requirements

Students are required to pass a minimum of 120 credits and 90 credits for UTME and Direct entry students respectively.

## Global Structure

### 100 Level

| Course Code | Course Title | Units | Status | LH | PH |
|---|---|---|---|---|---|
| GST 111 | Communication in English I | 2 | C | 15 | 45 |
| GST 112 | Nigerian Peoples and Culture | 2 | C | 30 | - |
| MTH 101 | Elementary Mathematics I | 2 | C | 30 | - |
| MTH 102 | Elementary Mathematics II | 2 | C | 30 | - |
| CSC 101 | Introduction to Computer Science | 3 | C | 30 | 45 |
| MTH 103 | Elementary Mathematics III | 2 | C | 30 | - |
| STA 112 | Probability I | 3 | C | 45 | - |

**Course Contents**

| | | | | | |
|---|---|---|---|---|---|
| GOU-PHY 101 | General Physics I for Mathematics | 2 | Compulsory | 30 | 0 |
| GOU-CSC 102 | Problem Solving | 3 | Compulsory | 30 | 45 |
| GOU-PHY 107 | General Practical Physics I | 1 | Compulsory | 0 | 30 |
| | TOTAL | 22 | | | |

**200 Level**

| Course Code | Course Title | Unit(s) | Status | LH | PH |
|---|---|---|---|---|---|
| GST 212 | Philosophy, Logic and Human Existence | 2 | C | 30 | - |
| ENT 211 | Entrepreneurship and Innovation | 2 | C | 30 | - |
| COS 201 | Computer Programming I | 3 | C | 30 | 45 |
| MTH 201 | Mathematical Methods I | 2 | C | 30 | - |
| MTH 202 | Elementary Differential Equations | 2 | C | 30 | - |
| MTH 203 | Sets Logic and Algebra I | 2 | C | 30 | - |
| MTH 204 | Linear Algebra I | 2 | C | 30 | - |
| MTH 205 | Linear Algebra II | 1 | C | 15 | - |
| MTH 207 | Real Analysis I | 2 | C | 30 | - |
| MTH 209 | Introduction to Numerical Analysis | 2 | C | 30 | |
| MTH 210 | Vector Analysis | 1 | C | 15 | - |
| GOU-CYB 201 | Introduction to Cybersecurity and Strategy | 2 | Compulsory | 30 | - |
| GOU-CSC 202 | Computer Programming II | 3 | Compulsory | 30 | 45 |
| GOU-CSC 204 | Introduction to Computational Finance | 3 | Compulsory | 30 | 45 |
| GOU-STA 211 | Probability II | 2 | Compulsory | 30 | - |
| | TOTAL | 31 | | | |

**300 Level**

| Course Code | Course Title | Units | Status | LH | PH |
|---|---|---|---|---|---|
| GST 312 | Peace and Conflicts Resolutions | 2 | C | 30 | - |
| ENT 311 | Enterprise Appreciation | 2 | C | 30 | - |
| MTH 300 | Abstract Algebra I | 2 | C | 30 | - |
| MTH 301 | Metric Space Topology | 2 | C | 30 | - |

**Course Contents**

| | | | | | |
|---|---|---|---|---|---|
| MTH 302 | Ordinary Differential Equations | 2 | C | 30 | - |
| MTH 303 | Vector and Tensor Analysis | 2 | C | 30 | - |
| MTH 304 | Complex Analysis I | 2 | C | 30 | - |
| MTH 305 | Complex Analysis II | 2 | C | 30 | - |
| MTH 306 | Abstract Algebra II | 2 | C | 30 | - |
| MTH 307 | Real Analysis II | 2 | C | 30 | - |
| MTH 308 | Introduction to Mathematical Modelling | 2 | C | 30 | - |
| MTH 310 | Mathematical Methods II | 2 | C | 30 | - |
| MTH 399 | Industrial Attachment II (12 Weeks) | 3 | C | | - |
| GOU-MTH 313 | Numerical Analysis I | 2 | Compulsory | 30 | - |
| GOU-MTH 314 | Numerical Analysis II | 3 | Compulsory | 45 | - |
| GOU-MTH 315 | Operation Research | 2 | Compulsory | 30 | - |
| GOU-MTH 316 | Optimization Theory I | 2 | Compulsory | 30 | - |
| GOU-MTH 317 | Discreet Mathematics | 3 | Compulsory | 45 | 0 |
| | TOTAL | 39 | | | |

**400 Level**

| Course Code | Course Title | Units | Status | LH | PH |
|---|---|---|---|---|---|
| MTH 401 | Theory of Ordinary Differential Equations | 2 | C | 30 | 45 |
| MTH 402 | Theory Of Partial Differential Equations | 2 | C | 30 | - |
| MTH 403 | Functional Analysis | 2 | C | 30 | - |
| MTH 404 | Project | 6 | C | - | - |
| MTH 405 | General Topology | 2 | C | 15 | 45 |
| MTH 406 | Lebesgue Measure and Integrals | 2 | C | 30 | - |
| MTH 407 | Mathematical Methods | 2 | C | 30 | - |
| MTH 408 | Entrepreneurship in Mathematics | 2 | C | 30 | - |
| GOU-MTH 411 | Quantum Mechanics | 2 | Elective | 30 | - |
| GOU-MTH 412 | Systems Theory | 2 | Elective | 30 | - |

**Course Contents**

| | | | | | |
|---|---|---|---|---|---|
| GOU-MTH 413 | Optimization Theory II | 2 | Compulsory | 30 | - |
| GOU-MTH 414 | Measure Theory | 2 | Compulsory | 30 | - |
| | TOTAL | 28 | | | |

## Course Contents and Learning Outcomes

### 100 Level

**GST 111: Communication in English** **(2 Units C: LH 30; PH 45)**

**Learning Outcomes**

At the end of this course, students should be able to

1. identify possible sound patterns in English language;
2. list notable Language skills; classify word formation processes; construct simple and fairly complex sentences in English;
3. apply logical and critical reasoning skills for meaningful presentations;
4. demonstrate an appreciable level of the art of public speaking and listening; and 5. write simple and technical reports.

**Course Contents**

Sound patterns in English language (vowels and consonants, phonetics and phonology). English word classes (lexical and grammatical words, definitions, forms, functions, usages, collocations). Sentence in English (types: structural and functional, simple and complex). Grammar and Usage (tense, mood, modality and concord, aspects of language use in everyday life). Logical and Critical Thinking and Reasoning Methods (Logic and Syllogism, Inductive and Deductive Argument and Reasoning Methods, Analogy, Generalisation and Explanations). Ethical considerations, Copyright Rules and Infringements. Writing Activities: (pre-writing, writing, post writing, editing and proofreading; brainstorming, outlining, paragraphing, types of writing, summary, essays, letter, curriculum vitae, report writing, note making etc. mechanics of writing). Comprehension Strategies: (reading and types of reading, comprehension skills, 3RsQ). Information and communication technology in modern language learning. Language skills for effective communication. Major word formation processes. Writing and reading comprehension strategies. Logical and critical reasoning for meaningful presentations. Art of public speaking and listening. Report writing.

**GST 112: Nigerian Peoples and Culture** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. analyse the historical foundation of the Nigerian culture and arts in pre-colonial times;
2. list and identify the major linguistic groups in Nigeria;
3. explain the gradual evolution of Nigeria as a political unit;

**Course Contents**

4. analyse the concepts of trade, economic and self-reliance status of the Nigerian peoples towards national development;
5. enumerate the challenges of the Nigerian State towards Nation building analyse the role of the Judiciary in upholding people's fundamental rights identify acceptable norms and values of the major ethnic groups in Nigeria; and
6. list and suggest possible solutions to identifiable Nigerian environmental, moral and value problems.

**Course Contents**

Nigerian history; culture and art up to 1800 (yoruba, hausa and igbo peoples and culture, peoples and culture of the ethnic minority groups). Nigeria under colonial rule (advent of colonial rule in Nigeria, colonial administration of Nigeria). Evolution of Nigeria as a political unit (amalgamation of Nigeria in 1914, formation of political parties in Nigeria. Nationalist movement and struggle for independence). Nigeria and challenges of nation building (military intervention in Nigerian politics, Nigerian Civil War). concept of trade and economics of self-reliance (indigenous trade and market system; indigenous apprenticeship system among Nigeria people; trade, skill acquisition and selfreliance). Social justices and national development (law definition and classification). Judiciary and fundamental rights. Individual, norms and values (basic Nigeria norms and values. Patterns of citizenship acquisition. Citizenship and civic responsibilities. Indigenous languages, usage and development. Negative attitudes and conducts. Cultism, kidnapping and other related social vices). Re-orientation, moral and national values (The 3R's – reconstruction, rehabilitation and re-orientation). Re-orientation strategies. Operation feed the nation (OFN). Green revolution and austerity measures. War against indiscipline (WAI). War against indiscipline and corruption (WAIC). Mass mobilization for self-reliance, social justice and economic recovery (MAMSER). National orientation agency (NOA). Current socio-political and cultural developments in Nigeria.

**COS 101: Introduction to Computing Sciences (3 Units C: LH 30; PH 45)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. explain basic components of computers and other computing devices;
2. describe the various applications of computers;
3. explain information processing and its roles in the society;
4. describe the Internet, its various applications and its impact;
5. explain the different areas of the computing discipline and its specializations; and
6. demonstrate practical skills on using computers and the internet.

**Course Contents**

Brief history of computing. Description of the basic components of a computer/computing device. Input/Output devices and peripherals. Hardware, software and human ware. Diverse and growing computer/digital applications. Information processing and its roles in society. The Internet, its applications and its impact on the world today. The different areas/programs of the computing discipline. The job specializations for computing professionals. The future of computing.

**Course Contents**

**Lab Work:** Practical demonstration of the basic parts of a computer. Illustration of different operating systems of different computing devices including desktops, laptops, tablets, smart boards and smart phones. Demonstration of commonly used applications such as word processors, spreadsheets, presentation software and graphics. Illustration of input and output devices including printers, scanners, projectors and smartboards. Practical demonstration of the Internet and its various applications. Illustration of browsers and search engines. How to access online resources.

**MTH 101: Elementary Mathematics I (Algebra and Trigonometry) (2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. explain basic definition of set, subsets, union, intersection, complements and use of Venn diagrams;
2. solve quadratic equations;
3. solve trigonometric functions;
4. identify various types of numbers; and
5. solve some problems using binomial theorem.

**Course Contents**

Elementary set theory, subsets, union, intersection, complements, Venn diagrams. Real numbers, integers, rational and irrational numbers, mathematical induction, real sequences and series, theory of quadratic equations, binomial theorem. Complex numbers, algebra of complex numbers, the Argand diagram. De-Moivre's theorem, nth roots of unity. Circular measure, trigonometric functions of angles of any magnitude, addition and factor formulae.

**MTH 102: Elementary Mathematics II (Calculus) (2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. identify the types of rules in differentiation and integration;
2. describe the meaning of function of a real variable, graphs, limits and continuity; and
3. solve some applications of definite integrals in areas and volumes.

**Course Contents**

Function of a real variable, graphs, limits and idea of continuity. The derivative as limit of rate of change. Techniques of differentiation. Extreme curve sketching. Integration as an inverse of differentiation. Methods of integration. Definite integrals. Application to areas, volumes.

**Course Contents**

**MTH 103: Elementary Mathematics III (Vectors, Geometry and Dynamics) (2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. solve some vectors in addition and multiplication;
2. calculate force and momentum; and
3. solve differentiation and integration of vectors.

**Course Contents**

Geometric representation of vectors in 1-3 dimensions, components, direction cosines. Addition, scalar, multiplication of vectors, linear independence. Scalar and vector products of two vectors. Differentiation and integration of vectors with respect to a scalar variable. Two-dimensional coordinate geometry. Straight lines, circles, parabola, ellipse, hyperbola. Tangents, normals. Kinematics of a particle. Components of velocity and acceleration of a particle moving in a plane. Force, momentum, laws of motion under gravity, projectiles and resisted vertical motion. Elastic string and simple pendulum. Impulse, impact of two smooth spheres and a sphere on a smooth surface.

**STA 112: Probability I (3 Units C: LH 45)**

**Learning Outcomes**

At the end of the course students should be able to

1. explain the differences between permutation and combination;
2. explain the concept of random variables and relate it to probability and distribution functions;
3. describe the basic distribution functions; and 4. explain the concept of exploratory data analysis.

**Course Contents**

Permutation and combination. Concepts and principles of probability. Random variables. Probability and distribution functions. Basic distributions: Binomial, geometric, Poisson, normal and sampling distributions; exploratory data analysis.

**GOU-PHY 101: General Physics I for Mathematics (2 Units; Compulsory; LH = 30; PH = 0)**

**Senate-Approved Relevance**

Indeed this course will be very important for students who have interest in Mathematics, Physics and other related fields in Natural Sciences. The course will create the enabling background for students to understand the basic principles of Physics in relation to solving mathematical problems. The goal of this course is in agreement with the mission of Godfrey

**Course Contents**

Okoye University to produce graduates who excel in academics and who are equipped to contribute to societal growth.

**Overview**

General Physics deals with the concept of vector space, time, kinematics, application of Newtonian mechanics and moments of inertia. The course emphasizes the connection between General Physics and other branches of Mathematics and modelling.

The skills acquired in this course can be beneficial for students' career in research, academics and industry, where Linear Algebra is widely used for analyzing physical problems.

**Objectives**

The objectives of the course are to:

1. Explain the broad meaning of vector and scalars.
2. State Newton's law of motion.
3. Apply Newtonian mechanics in solving physical problems.
4. Explain moment of inertia.
5. Explain the concept of gravitational potential energy, escape, velocity.
6. Explain work, energy, velocity, momentum and acceleration.
7. Apply the principle of conservation of energy.

**Learning Outcomes**

At the end of the course, students should be able to:

1. Identify and deduce the physical quantities and their units.
2. Differentiate between vectors and scalars.
3. Describe and evaluate motion of systems on the basis of the fundamental laws of mechanics.
4. Apply one Newton's law to describe and solve a simple problem of motion.
5. Evaluate work, energy, velocity, momentum, acceleration, and torque of moving or rotating objects.
6. Explain and apply the principles of conservation of energy, linear and angular momentum;
7. Describe the laws governing motion under gravity; and

8. Explain motion under gravity and quantitatively determine behaviour of objects moving under gravity.

**Course Contents**

Space and time. Units and dimension. Vectors and scalars. Differentiation of vectors (displacement, velocity and acceleration). Kinematics. Newton laws of motion (Inertial frames, impulse, force and action at a distance, momentum conservation). Relative motion. Application of Newtonian mechanics. Equations of motion. Conservation principles in physics (conservative forces, conservation of linear momentum, kinetic energy and work, potential energy). System of particles. Centre of mass. Rotational motion (torque, vector product, moment, rotation of coordinate axes and angular momentum). Coordinate systems. Polar coordinates. Conservation of angular momentum. Circular motion. Moments of inertia (gyroscopes, and precession). Gravitation (Newton's Law of Gravitation, Kepler's laws of planetary motion, gravitational potential energy, escape velocity, satellites motion and orbits).

**Minimum Academic Standards**

Mathematics laboratory with NUC-MAS requirements and facilities.

## GOU-CSC 102: Problem Solving (3 Units; Compulsory; LH = 30; PH = 45)

### Senate-Approved Relevance

This course is relevant because it introduces students to the concepts of problem solving and approaches necessary to follow to arrive at a positive result. It plays a crucial role in preparing a student to know how to solve prospective challenges that could arise unexpectedly. There are problems that requires step by step approaches, this course offers solutions to this kind of problem and equally introduce students to algorithm development. It aligns with one of the important goals of Godfrey Okoye University to produce graduates with problem solving abilities in other to enhance their performance in research conduct and produce intelligent result.

### Overview

Problem solving is the process of identifying a problem and developing possible solution approach, and take the appropriate cause of action. This will include prioritizing, and selecting alternatives for a solution, and implement a solution. Some of the techniques relevant in problem solving is algorithm development, and it is the step by step method of solving a problem. George Polya is regarded as the father of modern problem solving, He did extensive studies and work on numerous mathematical papers and books in problem solving.

The course is designed to expose the concept of problem solving and its methods. It also show the language of algorithm, and how it is written in natural language for ease of understanding for possible solution.

### Objectives

The objective of the course are to:

1. Introduce the concept of problem solving.
2. Illustrate the step by step methods of approaching a problem.
3. Introduce the development of an algorithm while solving a problem
4. Explain the techniques to employ to arrive at a traceable solution.
5. Identify different types of problems.
6. Explain how to develop flowchats and pseudocode.

**Course Contents**

**Learning Outcomes**
At the end of this course, students should be able to:

1. Explain the problem solving processes.
2. List and explain at least four skills for problem solving.
3. Describe the concept of algorithms development and properties of algorithms.
4. Discuss the solution techniques of solving problem.
5. Solve three computer problems using algorithms, flowcharts, pseudo-code.
6. Solve two problems using the programming language of C, PYTHON.

**Course Contents**

Introduction to the core concepts of computing. Problems and problem-solving. The identification of problems and types of problems (routine problems and non-routine problems). Method of solving computing problems (introduction to algorithms and heuristics). Solvable and unsolvable problems. Solution techniques of solving problems (abstraction, analogy, brainstorming, trial and error, hypothesis testing, reduction, literal thinking, means-end analysis, method of focal object, morphological analysis, research, root cause analysis, proof, divide and conquer). General Problem-solving process. Solution formulation and design: flowchart, pseudocode, decision table, decision tree. Implementation, evaluation and refinement. Programming in C, Python etc.

**Lab Work:** Use of simple tools for algorithms and flowcharts; writing pseudocode; writing assignment statements, input-output statements and condition statements; demonstrating simple programs using any programming language (Visual Basic, Python, C)

**Minimum Academic Standards**

Mathematics laboratory with NUC-MAS requirements and facilities.

## Course Contents

### GOU-PHY 107: General Practical Physics I (1 Unit; Compulsory; LH = 0; PH = 30)

**Senate-Approved Relevance**

Indeed this course will be very important for students who have interest in Mathematics, Physics and other related fields in Natural Sciences. The course will create the enabling background for students to understand the basic principles of Physics in relation to solving mathematical problems. The goal of this course is in agreement with the mission of Godfrey Okoye University to produce graduates who excel in academics and who are equipped to contribute to societal growth.

**Overview**

General Practical Physics I is an aspect of Physics that emphasizes on quantitative measurement errors and graphical analysis. Indeed, the course emphasizes the basic physical techniques for observation, measurements, data collection analysis and deduction.

This course will equip the students with the basic knowledge and safety which are beneficial for research and industry where General Practical Physics I is widely used for solving practical problems.

**Objectives**

The objectives of the course are to:

1. Explain the basic safety measures when dealing with practical problems.
2. Apply graphical analysis and its interpretation to identify natural phenomenon.
3. Carry out experiments on meter, oscilloscope, mechanical system, electrical and mechanical resonant systems, light, heat, viscosity etc.
4. Illustrate the basic physical techniques for observation, measurement, data collection, analysis and deduction.
5. Illustrate how to draw conclusion from numerical and graphical analysis of data.

**Learning Outcomes**

At the end of the course, students should be able to:

1. Conduct measurements of some physical quantities.

2. Make observations of events, collect and tabulate data.

3. Identify and evaluate some common experimental errors.

**Course Contents**

4. Plot and analyze three graphs.

5. Draw conclusions from numerical and graphical analysis of data.

**Course Content**

This introductory course emphasizes quantitative measurements. Experimental techniques. The treatment of measurement errors. Graphical analysis. The experiments include studies of meters, the oscilloscope, mechanical systems, electrical and mechanical resonant systems, light, heat, viscosity, etc. (covered in PHY 101, 102, 103 and PHY 104). However, emphasis should be placed on the basic physical techniques for observation, measurements, data collection, analysis, and deduction.

**Minimum Academic Standards**

Mathematics laboratory with NUC-MAS requirements and facilities.

**200 Level**

**GST 212: Philosophy, Logic and Human Existence (2 Units C: LH 30)**

**Learning Outcomes**

A student who has successfully gone through this course should be able to:

1. know the basic features of philosophy as an academic discipline;
2. identify the main branches of philosophy & the centrality of logic in philosophical discourse;
3. know the elementary rules of reasoning;
4. distinguish between valid and invalid arguments;
5. think critically and assess arguments in texts, conversations and day-to-day discussions;
6. critically asses the rationality or otherwise of human conduct under different existential conditions;
7. develop the capacity to extrapolate and deploy expertise in logic to other areas of knowledge, and
8. guide his or her actions, using the knowledge and expertise acquired in philosophy and logic.

**Course Contents**

Scope of philosophy; notions, meanings, branches and problems of philosophy. Logic as an indispensable tool of philosophy. Elements of syllogism, symbolic logic— the first nine rules of inference. Informal fallacies, laws of thought, nature of arguments. Valid and invalid arguments, logic of form and logic of content — deduction, induction and inferences. Creative and critical thinking. Impact of philosophy on human existence.

**Course Contents**

Philosophy and politics, philosophy and human conduct, philosophy and religion, philosophy and human values, philosophy and character molding, etc.

**ENT 211: Entrepreneurship and Innovation** **(2 Units C: LH 15; PH 45)**

**Learning Outcomes**

At the end of this course, students should be able to

1. explain the concepts and theories of entrepreneurship, intrapreneurship, opportunity seeking, new value creation, and risk-taking state the characteristics of an entrepreneur
2. analyse the importance of micro and small businesses in wealth creation, employment, and financial independence engage in entrepreneurial thinking;
3. identify key elements in innovation; describe stages in enterprise formation, partnership and networking including business planning;
4. describe contemporary entrepreneurial issues in Nigeria, Africa and the rest of the world; and
5. state the basic principles of e-commerce.

**Course Contents**

Concept of entrepreneurship (entrepreneurship, intrapreneurship/corporate entrepreneurship,). Theories, rationale and relevance of entrepreneurship (Schumpeterian and other perspectives, risk-taking, necessity and opportunity-based entrepreneurship and creative destruction). Characteristics of entrepreneurs (opportunity seeker, risk taker, natural and nurtured, problem solver and change agent, innovator and creative thinker). Entrepreneurial thinking (critical thinking, reflective thinking, and creative thinking). innovation (concept of innovation, dimensions of innovation, change and innovation, knowledge and innovation); enterprise formation, partnership and networking (basics of business plan, forms of business ownership, business registration and forming alliances and join ventures). Contemporary entrepreneurship Issues (knowledge, skills and technology, intellectual property, virtual office, networking). Entrepreneurship in Nigeria (biography of inspirational entrepreneurs, youth and women entrepreneurship, entrepreneurship support institutions, youth enterprise networks and environmental and cultural barriers to entrepreneurship); basic principles of e-commerce.

**COS 201: Computer Programming I** **(3 Units C: LH 30; PH 45)**

**Learning Outcomes**

At the end of this course, students should be able to:

1. Explain the principles of good programming and structured programming concepts;
2. Explain the programming constructs, syntax and semantics of a higher-level language;
3. Describe the chosen programming language variables, types, expressions, statements and assignment; simple input and output;
4. Describe the programme control structures, functions and parameter passing, and structured decomposition; and
5. Develop simple programmes in the taught programming language as well as debug and test them.

**Course Contents**

**Course Contents**

Introduction to computer programming. Functional programming; Declarative programming; Logic programming; Scripting languages. Introduction to object-orientation as a technique for modelling computation. structured, and even some level of functional programming principles; Introduction of a typical object-oriented language, such as Java; Basic data types, variables, expressions, assignment statements and operators; Basic object-oriented concepts: abstraction; objects; classes; methods; parameter passing; encapsulation. Class hierarchies and programme organisation using packages/namespaces; Use of API – use of iterators/enumerators, List, Stack, Queue from API; Searching; sorting; Recursive algorithms; Event-driven programming: eventhandling methods; event propagation; exception handling. Introduction to Strings and string processing; Simple I/O; control structures; Arrays; Simple recursive algorithms; inheritance; polymorphism.

**Lab work**: Programming assignments; design and implementation of simple algorithms, e.g., average, standard deviation, searching and sorting; Developing and tracing simple recursive algorithms. Inheritance and polymorphism.

**MTH 201: Mathematical Methods 1** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. explain real-valued functions of a real variable;
2. solve some problems using mean value theorem and Taylor series expansion; and
3. evaluate line integral, surface integral and volume integrals.

**Course Contents**

Real-valued functions of a real variable. Review of differentiation and integration and their applications. Mean value theorem. Taylor series. Real-valued functions of two and three variables. Partial derivatives chain rule, extrema, lagrangian multipliers. Increments, differentials and linear approximations. Evaluation of line integrals. Multiple integrals.

**MTH 202: Elementary Differential Equations** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. define the following: order and degree of a differential equation;
2. describe some techniques for solving first and second order linear and non-linear equations; and
3. solve some problems related to geometry and physics.

**Course Contents**

Derivation of differential equations from primitive geometry, physics etc. Order and degree of differential equation. Techniques for solving first and second order linear and

**Course Contents**

non-linear equations. Solutions of systems of first order linear equations. Finite linear differential equations. Application to geometry and physics.

**MTH 203: Sets, Logic and Algebra I** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. solve various problems using the concept of set theory;
2. recognise Algebraic structures; and
3. describe the meaning of logic in Mathematics.

**Course Contents**

Introduction to the language and concepts of modern mathematics. Topics include: basic set theory: mappings, relations, equivalence and other relations, Cartesian products, binary logic, methods of proof, binary operations. Algebraic structures, semi-groups, rings, integral domains, fields. Homeomorphics. Number systems; properties of integers, rationals, real and complex numbers.

**MTH 204: Linear Algebra I** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. explain vector space;
2. describe linear transformations and their representation by matrices; and
3. calculate algebra of various matrices.

**Course Contents**

Vector space over the real field. Sub-spaces, linear independence, basis and dimension. Linear transformations and their representation by matrices – rings, null space, rank. Singular and nonsingular transformation and matrices. Algebra of matrices.

**MTH 205: Linear Algebra II** **(1 Unit C: LH 15)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. recognise systems of linear equations.
2. calculate the Eigen values and Eigen vectors.
3. describe the Cayley-Hamilton theorem and its uses.

**Course Contents**

Systems of linear equation, change of basis, equivalence and similarity. Eigen values and Eigen vectors. Minimum and characteristic polynomials of a linear transformation (matrix). CayleyHamilton theorem. Bi-linear and quadratic forms, orthogonal diagonalisation. Canonical forms.

**Course Contents**

**MTH 207: Real Analysis I** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. describe convergence of sequence of numbers;
2. discuss the monotone, cauchy sequences;
3. test for convergence of series; and 4. state roles and mean value theorem.

**Course Contents**

Bounds of real numbers, convergence of sequence of numbers. Monotone sequences, the theorem of nested intervals. Cauchy sequences, tests for convergence of series. Absolute and conditional convergence of series and re-arrangements. Completeness of reals and incompleteness of rationale. Continuity/and differentiability of functions. Rolles' mean and value theorems for differentiable functions, Taylor series.

**MTH 209: Introduction to Numerical Analysis** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. solve some numerical solution of algebraic and transcendental equations;
2. describe curve fitting;
3. discuss error analysis;
4. calculate interpolation and approximation;
5. solve some numerical differentiation and numerical integration problems; and
6. solve some numerical problems in ordinary Differential equations with initial value problems;

**Course Contents**

Solution of algebraic and transcendental equations. Curve fitting. Error analysis. Interpolation and approximation. Zeros of non-linear equations 'in one variable'. Systems of linear equations. Numerical differentiation and integration. Initial value problems in ordinary differential equation.

**MTH 210: Vector Analysis** **(1 Unit C: LH 15)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. describe vector algebra;
2. explain geometrical equation of lines and planes; and 3. outline problems in gradients, divergent and curl.

**Course Contents**

**Course Contents**

Elementary vector algebra, vector and vector triple, vector products (more application solution of vector equation, plain curves and space curves. Geometrical equation of lines and planes. Linear independence of vectors; components of vectors, direction cosines; position vector and scaler products; Frenet-Serret formulas; differential definition ofgradients, divergent and simple multiplication)

**GOU-CSC 202: Computer Programming II (3 Units; Compulsory; LH = 30; PH = 45)**

**Senate Approved Relevance**

Programming is relevant for all mathematics students because it offers the ability to write codes that can solve complex mathematical problems. It is a skill that makes a student become relevant in this present digital world of object oriented programming. Solutions on a lot of mathematical problems is now based on ones abilities to write programs in relevant programming languages like python, C++, and C#. This is in line with the mandate of Godfrey Okoye University to produce graduates that are up to date with developments in various disciplines.

**Overview**

Computer programming is the process of writing codes to facilitate specific actions in a computer application or software program, and instruct them on how to perform a particular task. It can equally be viewed as a sequence of instructions written using a programming language to handle a particular task. A computer program can equally be referred to as a computer software and can range from to lines of codes to millions of codes depending on what to writer is trying to achieve.

This course is a continuation of GOU-CSC 201. It will introduce students to the basic knowledge of computer programming and will then focus on the writing of computer codes and the use of applications.

**Objectives**

The objectives of the course are to:

1. Introduce the concepts of computer programming.
2. Discuss how to write simple computer codes in different programming languages.
3. Explain how to develop solutions using object oriented-programming skill.
4. Explain the use of API’s.
5. Describe how to implement simple GUI applications.

**Learning Outcomes**
At the end of this course, students should be able to:

1. Develop solutions to a range of problems using object-oriented programming.
2. Use modules/packages/namespaces for programme organization;
3. Use API in writing applications.
4. Apply divide and conquer strategy to searching and sorting problems using iterative and/or recursive solutions.
5. Explain the concept of exceptions in programming and how to handle exceptions in programmes.
6. Write simple multithreaded applications.
7. Design and implement simple GUI applications.

**Course Contents**
Review and coverage of advanced object-oriented programming - polymorphism, abstract classes and interfaces. Class hierarchies and programme organization using packages/namespaces. Use of API – use of iterators/enumerators, List, Stack, Queue from API; Searching; sorting; Recursive algorithms; Event-driven programming: event-handling methods; event propagation; exception handling. Applications in Graphical User Interface (GUI) programming. **Lab work**: Programming assignments leading to extensive practice in problem-solving and programme development with emphasis on object-orientation. Solving basic problems using static and dynamic data structures. Solving various searching and sorting algorithms using iterative and recursive approaches. GUI programming.

**Minimum Academic Standards**

Mathematics laboratory with NUC-MAS requirements and facilities.

**GOU-CSC 204: Introduction to Computational Finance (3 Units; Compulsory; LH=30; PH=45)**

**Senate -Approved Relevance**

Training mathematics graduates who are knowledgeable in the use of computing techniques, algorithms and mathematical models in analyzing and modeling business/financial investments for Nigerian SMEs is in line with Godfrey Okoye University's mission to foster entrepreneurial ecosystem that will facilitate the development of talents, skills and confidence needed to pursue an entrepreneurial career. Relevance is seen in Mathematics graduates of Godfrey Okoye University being able to use computational methods and techniques for modeling financial asset prices, returns, and volatility of financial instrument. The importance of this course lies in the fact that there is a growing demand for people who understand math, financial securities and technology especially in this era of digital currency.

**Overview**

Computational methods and the mathematics behind them have become an indispensable part of the finance industry especially in the emerging Nigerian digital finance product and service (Fintech) industry. This highlights the importance of preparing computer students with mathematical, programming and statistical tools used in the real world analysis and modeling of financial data.

This course involves the design and analysis of algorithms, data structures and computer programming environments needed for quantitative analysis and financial problem solving as applied to computational financial modeling and data analysis. It will expose the students to the mathematical, programming and statistical tools used in the real world analysis and modeling of financial data. Statistical tools can be applied to model asset returns, measure risk, and construct optimized portfolios using the open source R programming language and Microsoft Excel. Students will learn about a variety of financial tools as well as how to develop an approach to effectively utilize those tools. The objectives of the course, learning outcomes, and the contents are provided to address this need.

**Objectives**

The objectives of the course are to:

1. Explain different financial models, quantitative methods and computational analysis techniques.

2. Describe a range of numerical methods for option valuation, such as binomial trees, finite difference methods, finite element methods and Monte Carlo methods.

3. Conduct practical exercises with R or Python to perform numerical computations of option values using various numerical methods.

4. Describe different models for financial time series and how to select the appropriate model.

5. Demonstrate the methodologies for financial simulation and evaluation.

**Learning Outcomes**

On completion of the course, students should be able to:

1. Describe at least four (4) financial models and computational analysis techniques.

2. Describe how option values can be expressed both as conditional expectations and as functions that solve certain partial differential equations, and list numerical methods that are appropriate in each case.
3. Create computer code (in R or Python) to perform numerical computations of option values using various numerical methods.
4. Choose suitable computation model to solve problems in finance.
5. Perform financial simulation and analysis.
6. Implement computational solutions to real-world financial problems in portfolio optimization and time series analysis.

**Course Content**

Computing asset returns. Univariate random variables and distributions: Characteristics of distributions, the normal distribution, linear function of random variables, quintiles of a distribution, Value-at-Risk. Bivariate distributions: Covariance, correlation, autocorrelation, linear combinations of random variables. Time Series concepts. Matrix algebra. Descriptive statistics. The constant expected return model. Introduction to portfolio theory. Portfolio theory with matrix algebra. Statistical Analysis of Efficient Portfolios. Risk budgeting. The Single Index Model. Option Pricing and Numerical Approach. Model Calibration: brute-force search, Nelder-Mead algorithm, and BFGS algorithm. Introduction to R for Finance: essential data structures such as lists and data frames and application to real-world financial examples. Interest Rates and Interest Rate Instruments.

**Minimum Academic Standards**

Computer laboratory with NUC-MAS requirement facilities

## Course Contents

### GOU-STA 211: Probability II (3 Units; Compulsory; LH = 45; PH = 0)

**Senate-Approved Relevance**

A course on Probability for students of Mathematics will lead to the production of high quality graduates who will be knowledgeable in this area. This course will introduce students to a wide range of probability distribution in order to teach students on when and how to use the normal distribution. Relevance is seen in this area from being able to educate students on independence of events and the condition of an event occurring, depending on a previous one. This aligns with the mission of Godfrey Okoye University and the Sustainable Development Goal 4 which emphasizes quality education.

**Overview**

This course is designed as the continuation of **STA 211: Probability I,** in order to give students the opportunity to carry out experiments on the characteristics of a population. Statistics involves working with very large samples. Sampling is the process of selecting a group from a population to study and characterize the population as a whole. All possible outcomes or measurements are considered. Studying a whole sample is not always optimal, hence the introduction of events in a sample space.

The course will focus on Probability distribution of random variables and major theorems like Baye and Central Limit.

**Objectives**

The objectives of the course are to:

1. Outline the information about a population without examining each and every unit of the population.
2. Calculate representative results of small samples of a comparatively large population.
3. Construct confidence interval of the population.
4. Differentiate between combination and permutation.
5. Differentiate between Central Limit theorem and Chebyshev's inequalities.
6. Compute expectations and moment generating functions.
7. Explain Chebyshev's inequality and apply it to real life situations.
8. Explain joint marginal and conditional distributions and moments as well as Limiting distributions;

**Course Contents**

**Learning Outcomes**

At the end of the course, students should be able to:

1. Explain further permutation and combination.
2. Define probability laws, conditional probability, and independence.
3. Describe Bayes' theorem and explain some of the basic probability distribution for discrete and continuous random variables.
4. Compute expectations and moments of random variables.
5. Describe standard distributions, moments and moment-generating functions.
6. Explain laws of large numbers and the central limit theorem.

**Course Contents**

Further permutation and combination. Probability laws. Conditional probability and independence. Bayes' theorem. Probability distribution of discrete and continuous random variables: binomial, Poisson, geometric, hypergeometric, rectangular (uniform), negative exponential, binomial. Expectations and moments of random variables. Chebyshev's inequality. Joint marginal and conditional distributions and moments. Limiting distributions. Discrete and continuous random variables, standard distributions, moments and moment-generating functions. Laws of large numbers and the central limit theorem.

**Minimum Academic Standards**

Mathematics laboratory with NUC-MAS requirements and facilities.

**300 Level**

**GST 312: Peace and Conflict Resolution (2 Unit C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. analyse the concepts of peace, conflict and security;
2. list major forms, types and root causes of conflict and violence;
3. differentiate between conflict and terrorism;
4. enumerate security and peace building strategies; and
5. describe roles of international organisations, media and traditional institutions in peace building.

**Course Contents**

**Course Contents**

Concepts of peace, conflict and security in a multi-ethnic nation. Types and theories of conflicts: ethnic, religious, economic, geo-political conflicts; structural conflict theory, realist theory of conflict, frustration-aggression conflict theory. Root causes of conflict and violence in Africa: indigene and settlers phenomenon; boundaries/boarder disputes; political disputes; ethnic disputes and rivalries; economic inequalities; social disputes; nationalist movements and agitations; selected conflict case studies – Tiv-Junkun; Zangon Kataf, chieftaincy and land disputes, etc. Peace building, management of conflicts and security: peace & human development. Approaches to peace & conflict management (religious, government, community leaders, etc.). Elements of peace studies and conflict resolution: conflict dynamics assessment. Scales: constructive & destructive. Justice and Legal framework: concepts of social justice; the Nigeria legal system. Insurgency and terrorism. Peace mediation and peace keeping. Peace & security council (international, national and local levels). Agents of Conflict resolution – conventions, treaties, community policing. Evolution and imperatives. Alternative Dispute Resolution, ADR. a). dialogue b). arbitration, c). negotiation d). collaboration, etc. Roles of International Organizations in Conflict Resolution. a). The United Nations, UN and its conflict resolution organs. b). The African Union & peace security council c). ECOWAS in peace keeping. Media and traditional institutions in peace building. Managing post-conflict situations/crisis: refugees. Internally Displaced Persons, IDPs. The role of NGOs in post-conflict situations/crisis.

**ENT 312: Venture Creation (2 Units C: LH 15; PH 45)**

**Learning Outcomes**

At the end of this course, students, through case study and practical approaches, would be able to:

1. describe the key steps in venture creation;
2. spot opportunities in problems and in high potential sectors regardless of geographical location;
3. state how original products, ideas, and concepts are developed;
4. develop business concept for further incubation or pitching for funding;
5. identify key sources of entrepreneurial finance;
6. implement the requirements for establishing and managing micro and small enterprises;
7. conduct entrepreneurial marketing and e-commerce; apply a wide variety of emerging technological solutions to entrepreneurship; and
8. appreciate why ventures fail due to lack of planning and poor implementation.

**Course Contents**

Opportunity Identification (Sources of business opportunities in Nigeria, Environmental scanning, Demand and supply gap/unmet needs/market gaps/Market Research, Unutilised resources, Social and climate conditions and technology adoption gap). New business development (business planning, market research). Entrepreneurial Finance

**Course Contents**

(Venture capital, Equity finance, Micro finance, Personal savings, small business investment organisations and Business plan competition). Entrepreneurial marketing and e-commerce (Principles of marketing, customer acquisition & retention, B2B, C2C and B2C models of e-commerce, First mover advantage, Ecommerce business models and successful E-Commerce Companies,). Small business management/family business: Leadership & management, Basic book keeping, Nature of family business and family business growth model. Negotiation and business communication (Strategy and tactics of negotiation/bargaining, traditional and modern business communication methods). Opportunity discovery demonstrations (business idea generation presentations, business idea contest, brainstorming sessions, idea pitching). Technological solutions (The concept of market/customer solution, customer solution and emerging technologies, business applications of new technologies - Artificial Intelligence (AI), Virtual/Mixed Reality (VR), Internet of Things (IoTs), Blockchain, Cloud computing, Renewable energy etc. Digital business and E-Commerce strategies).

**MTH 300: Abstract Algebra I** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. state various groups, sub-groups, ring, field and Integral domain; and
2. calculate the H.C.F and L.C.M of Polynomials.

**Course Contents**

Group definition, examples including permutation groups. Sub-groups, Cosets. Lagrange's theorem and applications. Cyclic groups. Rings: definition and examples including Z, Zn, rings of polynomials and matrices. Integral domains, fields. Polynomial rings, factorisation. Euclidean algorithm for polynomials, H.C.F. and L.C.M. of polynomials.

**MTH 301: Metric Space Topology** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. describe the following: set, metric, open sphere, open set, closed sets, interior, exterior, neighbourhood, connectedness and compactness; and
2. discuss convergence in metric space.

**Course Contents**

Sets, metrics, and examples. Open spheres (or balls). Open sets and neighbourhoods. Closed sets. Interior, exterior, frontier, limit points and closure of a set. Dense sub-sets and separable space. Convergence in metric space homeomorphisms. Continuity and compactness, connectedness.

**MTH 302: Ordinary Differential Equations** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

**Course Contents**

1. describe line dependence, Wronskian, reduction order, variation of parameters, series solution about ordinary and regular points; and
2. discuss orthogonal polynomials.

**Course Contents**

Ordinary differential equations: linear dependence, Wronskian, reduction order, variation of parameters, series solution about ordinary and regular points. Special functions: Gamma, Beta, Bessel, Legendre's theorem, hyper geometric. Laplace transform and applications to initial value problems

**MTH 303: Vector and Tensor Analysis (2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. discuss vector differentiation and vector integration;
2. describe gradient, divergence and curl;
3. discuss Green's, Stoke's and divergence theorems;
4. solve some problems involving applications of vector differentiation and vector integration; and
5. Discuss tensor and Cartesian tensor.

**Course Contents**

Vector differentiation and applications. Gradient, divergence and curl. Vector integration, line, surface and volume integrals, Greens, Stoke's and divergence theorems. Tensor products of vector spaces. Tensor algebra. Symmetry. Cartesian tensors.

**MTH 304: Complex Analysis (2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. define functions of complex variable;
2. derive Cauchy-Riemann equations;
3. discuss conformal mapping;
4. solve some problems involving contour integrals, Power and Taylor series of function of a complex variable.

**Course Contents**

Functions of a complex variable. Limits and continuity of functions of a complex variable. Derivating the Cauchy-Riemann equations. Analytic functions. Bi-linear transformations, conformal mapping, contour integrals. Cauchy's theorems and its main consequences, convergence of sequences and series of functions of a complex variable. Power series. Taylor series.

**MTH 305: Complex Analysis II (2 Units C: LH 30)**

**Course Contents**

**Learning Outcomes**

At the end of the course, students should be able to:

1. discuss Laurent expansion, Isolated singularities and Residues; and
2. define Residue theorem and Rouche's theorem

**Course Contents**

Laurent expansions. Isolated singularities and residues. Residue theorem. Calculus of residue, and application to evaluation of integrals and to summation of series. Maximum modulus principle. Argument principle. Rouche's theorem. The fundamental theorem of algebra. Principle of analytic continuation. Multiple valued functions and Riemann surfaces.

**MTH 306: Abstract Algebra II** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. define normal subgroups and quotient groups;
2. state isomorphism theorem and Cayley's theorems;
3. discuss Sylow theorems; and
4. describe algebraic and transcendental extensions.

**Course Contents**

Normal subgroups and quotient groups. Monomorphism, isomorphism theorems. Cayley's theorems. Direct products. Groups of small order. Group acting on sets. Sylow theorems. Ideal and quotient rings. P.I.D. &, U.F.D's Euclides rings. Irreducibility; Field extensions, degree of an extension, and minimum polynomial. Algebraic and transcendental extensions. Straight edged and compass constructions.

**MTH 307: Real Analysis II** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. discuss Riemann integral of several functions;
2. define Riemann Stieltjes integral; and
3. describe continuous differentiable functions.

**Course Contents**

Riemann integral of functions $R^n \rightarrow R$, continuous monopositive functions. Functions of bounded variation. The Riemann Stieltjes integral. Pointwise and uniform convergence of sequences and series of functions $R^n \rightarrow R$. Effects on limits (sums) when the functions are continuous differentiable or Riemann integrable. Power series.

**MTH 308: Introduction to Mathematical Modelling** **(2 Units C: LH 30) Learning Outcomes**

**Course Contents**

At the end of the course, students should be able to:
1. develop some mathematical models in Biology, Physics, Chemistry, and Social Science;
2. describe flow Diagrams;
3. discuss method of Analysis of models formulated; and 4. describe the method of solutions to the models formulated.

**Course Contents**

Methodology of model building; identification, formulation and solution of problems, cause-effect diagrams. Equation types: algebraic, ordinary differential, partial differential, difference, integral and functional equations. Applications of mathematical models to physical, biological, social and behavioural sciences.

**MTH 310: Mathematical Methods II** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:
1. describe Sturm-Liouville problems.
2. discuss orthogonal polynomials and functions.
3. solve some problems using first and second order differential equations

**Course Contents**

Sturm – Liouville problems. Orthogonal polynomials and functions. Fourier series and integrals. Partial differential equations: general and particular solutions. Linear equations with constant coefficients, first and second order equations, solutions of the heat, wave and Laplace equations by the method of separation of variables. Eigen function expansions. Methods of variation of parameters. Fourier transforms.

**MTH 399: Industrial Attachment II (12 Weeks)** **(3 Units C: PH 135)**

Students should be attached to some industrial organizations for additional 12 weeks at their 300 Level preferably during the long vacation for more industrial experience. Students to be assessed based on seminar presentation, their reports and assessment by supervisors.

**GOU-MTH 313: Numerical Analysis I (2 Units; Compulsory; LH = 30; PH = 0)**
**Senate-Approved Relevance**

This course is designed to prepare Godfrey Okoye University mathematics students for life challenges, using essential skills and knowledge needed for an embellished career in fields like mathematical sciences, computer science, physics and engineering. The course provides the students with special skills in computation, assembly and high level languages used in Numerical Analysis. One of the visions of Godfrey Okoye University in establishing the Department of Mathematics is to produce graduates who can apply mathematical skills in solving real life problems. So aim is to produce competitive graduates with strong foundation in numerical analysis for the sake of conducting researches in institutions of higher learning and in industries.

### Overview

The father of Numerical Analysis, Rene Decartes, once said that any knowledge which cannot be transformed into numbers is of an inferior type. This gives credence to the importance of use of numbers (collecting data, presenting them, manipulating them like in calculus and analyzing them.

This Course helps the students to learn with ease concepts like algebra, interpolations, differential and integral calculus and solutions to numerical integrations. Students will learn design and analysis of algorithms for mathematics problems. More so, students learn to solve problems using some statistical/computer methods. They learn how to use FORTRAN, COBOL, ASSEMBLY, SCILAB, SPSS Computer packages.

### Objectives

The objectives of the course are to

1. Explain the concept of Numerical Computation.
2. Explain how to solve some mathematical problems of differential and integral calculus.
3. Explain the ways to simulate interest in Numerical Analysis.
4. Apply Numerical techniques like Trapezoidal in solving problems in numerical integration.
5. Constructing low and high level computer languages: FORTRAN, COBOL, BASIC languages.

### Learning Outcomes

On completing the course, students should be able to:

1. Explain in some details the concepts of Numerical Computations.
2. Explain the importance of numbers in day to day activities.
3. Apply three basic rules of differentiations and integrations.
4. Explain the ways to simulate interests in solving differentiation/integration.
5. Apply numerical techniques like Trapezoidal rules in solving numerical integration.
6. Apply numerical techniques like Simpson's rules in solving problems of numerical integration.
7. Develop computer languages like: FORTRAN, COBOL, BASIC and ASSEMBLY (Machine language)

### Course Contents

**Course Contents**

Numbers and Numerations. Introduction to Numerical Analysis. Basic rules of Differentiation. Basic rules of Integration. Integration by substitution. Rules of Integration by substitution. Substitution of definite integrals. Substitution of indefinite integrals. A Life Science Application: Probability using integrations. Integration by Parts. Guide to Integration by Parts. Integration by Parts Applied to a single factor. Finding integrals using Power rules. Integrals as anti-derivatives. Converting the linuts of integration u. Calculating present value of income. Finding the probability of a region $P(a \leq x \leq b)$. Numerical Integration using Trapezoidal rule. Numerical Integration using Simpson's rule. Approximations of Trapezoidal and Simpson's rules. Introduction to Normal Distribution. Constructions of high level languages like FORTRAN, COBOL and BASIC.

**Minimum Academic Standards**

Mathematics laboratory with NUC-MAS requirements and facilities.

## Course Contents

**GOU-MTH 314: Numerical Analysis II (2 Units; Compulsory; LH = 30; PH = 0)**

**Senate-Approved Relevance**

This course is designed to equip our students with the essential skills and knowledge necessary for a successful career in mathematics, computer science, engineering physics and other related fields. The course will also provide hands-on experience with computational tools and programming languages commonly used in numerical analysis. One of the strategic goals of GOUNI, as a University is to produce graduates with strong foundation in numerical analysis to enhance their ability to conduct research in various fields, as well as their employability in industry and academia. This course satisfies this strategic goal. This course is in line with goal 4 of the United Nations' Sustainable Development Goals. Goal 4 deals with the necessity of ensuring quality education.

**Overview**

Numerical analysis is a branch of mathematics that deals with developing algorithms and methods. It is used in approximating solutions to mathematical problems that cannot be solved analytically. Numerical analysis provides students with a foundation in the principles and methods of numerical computing. The course covers topics such as numerical linear algebra, numerical optimization, interpolation, differentiation, integration, and numerical solutions to differential equations. Students will learn how to design and analyze numerical algorithms for various mathematical problems and how to evaluate the accuracy, stability, and efficiency of these algorithms.

Additionally, the course emphasizes the implementation of these algorithms using computer programming languages such as MATLAB, Python, and C++. By the end of the course, students will be able to apply numerical methods to solve mathematical problems that arise in various fields, including engineering, physics, finance, and computer science. The skills gained in this course can be beneficial for students pursuing careers in research, academia, and industry where numerical analysis is widely used for modeling and simulating complex systems.

**Objectives**

The objectives of the course are to:

1. Explain the broad and balanced foundation of Numerical computations to students.
2. Discuss students' ability to identify and apply iterative skills to solve mathematical problems.
3. Describe ways to simulate sustained interest in Numerical Analysis among students.
4. Explain various numerical techniques that can be employed for equipping students for practical application of Mathematics.
5. Discuss linear systems.
6. Explore numerical analysis.
7. Analyze pivoting strategies.

**Learning Outcomes:**

At the end of the course, students should be able to:

1. Explain numerical analysis
2. Discuss interpolation.

3. Explore numerical differentiation.
4. Analyse numerical integration.
5. Explain linear systems.
6. Discuss pivoting strategies.
7. Analyse matrix operations,
8. Explore optimisation.
9. Identify discreet and continuous Tan Methods for solving IVPS-ODEs.
10. Explain error analysis.

**Course Contents**

Introduction to numerical analysis. Interpolation. Numerical Differentiation. Numerical integration. Linear Systems. Pivoting Strategies. Matrix Operations. Optimization. Numerical Solutions of Ordinary Differential Equations. Discrete Variable Methods for Solution of IVPS-ODEs. Discrete and Continuous Tan Methods for Solving IVPS-ODEs. Error Analysis. Numerical Solutions of Partial Differential Equations. Finite Difference and Finite Element Methods. Stability. Convergence. Computational Complexity. Applications of Numerical Analysis

**Minimum Academic Standards**

The academic standards set for B. Sc Mathematics by the National Universities Commission.

## GOU-MTH 315: Operation Research (2 Units; Compulsory; LH = 30; PH = 0)

### Senate-Approved Relevance

Operation Research is a relevant and essential course that provides students with valuable skills to solve complex problems and make informed decisions in various fields. Some of the key areas where Operations Research is applied include supply chain management, transportation, logistics, finance, healthcare, and manufacturing. This course is developed in line with the vision of the Senate of GOUNI in producing graduates who can make informed decisions in solving complex real-life problems. This course tallies with goal 9 of UN's Sustainable Development Goals. The goal targets to 'enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research', among other targets.

### Overview

Operations research is a multidisciplinary field that uses mathematical modeling, statistical analysis, and optimization techniques to solve complex problems in various fields, including business, engineering, healthcare, and social sciences. The course in operations research provides students with a fundamental understanding of mathematical modeling and optimization techniques for decision-making in real-world scenarios. Students will learn how to formulate and solve optimization problems using linear programming, integer programming, network optimization, and nonlinear programming techniques.

Additionally, the course covers other topics such as game theory, queueing theory, decision analysis, and simulation modeling. Students will also gain experience using various software packages, such as Excel Solver, MATLAB, and R, to solve optimization problems. The course emphasizes the application of these techniques to real-world problems in various domains. By the end of the course, students will be able to model and analyze complex systems, formulate optimization problems, select appropriate techniques to solve them, and interpret and communicate results effectively. The skills gained in this course can be applied to various fields and can be beneficial for students pursuing careers in analytics, management, engineering, and research.

### Objectives:

The objectives of the course are to:

1. Explain the basic principles of operations research and how they can be applied to solve problems in different fields.
2. Identify the main tools and techniques used in operations research, such as linear programming, network analysis, queuing theory, and simulation.
3. List the steps involved in the operations research process, including problem formulation, model development, and data collection and analysis, and solution implementation.
4. Describe the importance of mathematical modeling in operations research and how it can be used to optimize complex systems.
5. Distinguish between deterministic and stochastic models, and explain how uncertainty can be incorporated into models using probabilistic techniques.

6. Develop optimization models to solve practical problems in operations research, using appropriate software tools and techniques.
7. Analyse the application of operations research techniques to different domains, such as supply chain management, transportation planning, healthcare, and finance, among others.
8. Analyze the limitations and assumptions of operations research models, and evaluate their appropriateness for different problem domains and decision-making contexts.
9. Explain the role of simulation in operations research, and develop simulation models to analyze complex systems and evaluate alternative strategies.
10. Explain the concept of multi-objective optimization, and develop methods to solve problems with conflicting objectives.
11. Explain the application of operations research techniques to address ethical, social, and environmental issues, and evaluate the impact of decisions on different stakeholders.
12. Describe the use of data analytics and machine learning in operations research, and develop predictive models to support decision-making.
13. Explore the minimization and maximisation of problem.

**Learning Outcomes**

On completion of the course, students should be able to:

1. Explain two basic principles of operations research and how they can be applied to solve problems in different fields.
2. Identify the main tools and techniques used in operations research, such as linear programming, network analysis, queuing theory, and simulation.
3. Describe the importance of mathematical modelling in operations research and how it can be used to optimize complex systems.
4. Distinguish between deterministic and stochastic models, and explain how uncertainty can be incorporated into models using probabilistic techniques.
5. Develop optimization models to solve practical problems in operations research, using appropriate software tools and techniques.
6. Analyse the application of operations research techniques to different domains, such as supply chain management, transportation planning, healthcare, and finance, among others.
7. Describe the use of data analytics and machine learning in operations research.

**Course Content**

Introduction to Operations Research. Modelling Techniques. Classical Methods of Optimization. Maxima and Minima. Lagrange's Multipliers. Linear Programming. Convex Sets and Functions. Simplex. Revised Simplex Methods. Sensitivity Analysis. Duality Theory. Transportation and logistics. Games Theory. Dynamic Programming. Two Person's Zero Sum Games. Saddle Point. Dominance. Strategies.

**Minimum Academic Standards**

The academic standards set for B. Sc Mathematics by the National Universities Commission.

## Course Contents

### GOU-MTH 316: Optimization Theory I (2 Units; Compulsory; LH = 30; PH = 0)

**Senate-Approved Relevance**

Optimization Theory is a branch of mathematics that deals with finding the best possible solution to a problem by maximizing or minimizing a function under certain constraints. It is a fundamental tool for solving complex problems in Engineering, Economics, Finance, Operations research, and other fields. This course is relevant to the visions of the Senate of GOUNI in solving complex societal problems with minimal resources at the shortest time.

This course tallies with goal 9 of UN’s Sustainable Development Goals. The goal targets to ‘enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research’, among other targets.

**Overview**

Optimization theory involve optimization which include minimization and maximization of the function value. The course in Optimization Theory introduces students to the fundamental concepts and techniques of optimization, and equips them with the necessary skills to apply these techniques to real-world problems. The course covers topics such as linear programming, nonlinear programming, convex optimization, and numerical optimization algorithms.

In the first part of the course, students will learn the basics of linear programming, which involves optimizing a linear objective function subject to linear constraints. They will study the simplex method, the most widely used algorithm for solving linear programming problems, as well as its variants and extensions. In the second part of the course, students will delve into nonlinear programming, which involves optimizing a nonlinear objective function subject to nonlinear constraints. They will learn the necessary conditions for optimality, such as the Karush-Kuhn-Tucker (KKT) conditions, and optimization algorithms such as gradient-based methods, Newton's method, and quasi-Newton methods. By the end of the course, students will have a solid foundation in optimization theory and will be able to apply this knowledge to a wide range of problems in engineering, economics, finance, and other fields.

**Objectives**

The objectives of the course are to:

1. Explain the application of linear programming models to solve real-world optimization problems, such as resource allocation and production planning.
2. Explore the application of the simplex method and its variants to solve linear programming problems.
3. Discuss the application of the optimization techniques.
4. List and discuss the differences and similarities between linear and nonlinear programming.
5. Analyze the different optimality criteria used in optimization theory.
6. Explain optimality criteria.
7. Discuss simple variable optimization.
8. Identify and describe the fundamental concepts of optimization theory.
9. State and explain the difference between linear and nonlinear optimization problems.
10. Apply optimization techniques to solve real-world problems, such as resource allocation, production planning, and portfolio optimization.
11. Explain the use of optimization techniques in solving real-world problems.

12. Discuss the importance of optimization theory in various fields, including engineering, economics, finance, and operations research.
13. Explain optimization techniques to tackle complex problems in various field.
14. Describe how to manipulate mathematical equations to derive optimization models.
15. Explain how to perform optimization algorithms to obtain optimal solutions for various problems.

**Learning Outcomes**

On completion of the course, students should be able to:

1. Explain the application of linear programming models to solve real-world optimization problems.
2. Explore the application of the simplex method and its variants to solve linear programming problems.
3. Discuss the application of the optimization techniques to solve transportation problems.
4. List and discuss the differences and similarities between linear and nonlinear programming.
5. Explain optimality criteria.
6. Discuss simple variable optimization.
7. Identify and describe the fundamental concepts of optimization theory.
8. State and explain the difference between linear and nonlinear optimization problems.
9. Apply optimization techniques to solve real-world problems.
10. Explain optimization techniques to tackle complex problems in various fields, including engineering, economics, finance, and operations research, by developing the ability to identify optimization problems and apply appropriate techniques to solve them.
11. Explain how to perform optimization algorithms to obtain optimal solutions for various problems, by understanding how to select appropriate algorithms, implement them using software packages, and interpret the results obtained.

**Course Contents**

Introduction to Optimization theory. Types of optimization. Linear programming models. The simplex Method. Formulation and theory. Quality integer programming. Transportation problem. Two-person zero-sum games. Nonlinear programming. Quadratic programming. Kuhn-Tucker methods. Optimality criteria. Simple variable optimization. Multivariable techniques. Gradient methods. Stochastic Optimization Multi-objective Optimization

**Minimum Academic Standards**

The academic standards set for B. Sc Mathematics by the National Universities Commission.

**GOU-MTH 317: Discrete Mathematics (3 Units; Compulsory; LH = 45; PH = 0)**

**Senate - Approved Relevance**
We believe that this course will be of great importance to our students who are interested in choosing careers in Mathematics, Statistics, Computer Science and other related fields. It will give students the necessary background to analyze Complex systems and solve problems of Real analysis. GOUNI is an environment where quality education is acknowledged and appreciated. We acknowledge that the addition of this course will definitely enhance the quality and relevance of GOUNI's visions.

**Overview**
Discrete mathematics is an area in Mathematics that deals with the concepts of Groups and subgroups, Graphs, directed and undirected graphs, sub groups, Applications (Flow Charts), Lattices and Boolean Algebra, Finite Fields and Application (error-correcting codes).

Indeed, the skills gained in this course can be beneficial to students pursuing careers in research and industry where discrete mathematics is greatly used for analyzing mathematical and complex problems.

**Objectives**
The objectives of the course are to:
1. Explain to the students the fundamental meaning of group and subgroup.
2. Analyze permutation groups.
3. Illustrate directed and undirected graphs.
4. Apply Flow Charts in solving problems.
5. Demonstrate Lattice and Boolean Algebra.
6. Explain Finite Fields.

**Learning outcomes**
At the end of the course, students should be able to :
1. Explain the concept of group and subgroup.
2. Describe permutation group.
3. Identify directed and undirected graphs.
4. Apply two Flow Charts in solving simple problems in mathematics.
5. Solve simple problems involving Lattice and Boolean Algebra.
6. Illustrate Finite Fields.

**Course contents**
Groups and subgroups, group axioms, permutation groups, coset. Graphs; directed and undirected graphs. Sub groups, cycles, connectivity. Applications (flow charts) and state-transition graphs. Lattices and Boolean algebra. Finite fields: mini-polynomials, irreducible polynomials, polynomial roots. Applications (error-correcting codes).

**Course Contents**

**Minimum Academic Standards**

The academic standards set for B. Sc Mathematics by the National Universities Commission.

**400 Level**

**MTH 401: Theory of Ordinary Differential Equations (2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. define existence and uniqueness theorems;
2. describe Volterra and Fredholm types; and
3. solve some problems of reduction of ordinary differential equations to integral equations.

**Course Contents**

Existence and uniqueness theorems, dependence of solutions on initial data and parameters.

Properties of solutions. Sturm comparison and Sonin-Polya theorems. Linear and non-linear systems. Floquet's theory and stability theory. Integral equations: classification, Volterra and Fredholm types, Neumann series. Fredholm alternative for degenerate Hilbert – Schmidt kernels. Reduction of ordinary differential equations to integral equations. Symmetric kernels, eigenfunction expansion with application.

**MTH 402: Theory of Partial Differential Equations (2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. define first and second order linear equations;
2. describe Cauchy problems; and
3. solve some problems in parabolic, hyperbolic and elliptic equations.

**Course Contents**

Theory and solutions of first-order and second order linear equations. Classification, characteristics and canonical forms. Cauchy problems. Elliptic equations: Laplace's and Poisson's formulas, properties of harmonic functions. Hyperbolic equations; wave equations, retarded potential: transmission line equation, Riemann method. Parabolic equation: diffusion equation, singularity function, boundary and initial – value problems.

**MTH 403: Function Analysis (2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. define Hilbert spaces, Banach spaces and vector spaces;
2. describe Banach algebra.

**Course Contents**

**Course Contents**

Hilbert Spaces bounded linear functionals, operators on Banach spaces, topological vector spaces, Banach algebra.

**MTH 404: Project:** **(6 Units C: PH 270)**

A research project and dissertation to be undertaken on any topic of mathematical interest.

**MTH 405: General Topology** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. define the following: topological spaces, continuous functions and topological invariants;
2. describe pointwise and uniform convergence.

**Course Contents**

Topological spaces, definition, open and closed sets neighbourhoods. Coarser, and finer topologies. Basis and sub- basis. Separation axioms, compactness, local compactness, connectedness. Construction of new topological spaces from given ones. Sub-spaces and quotient spaces. Continuous functions, homeomorphisms and topological invariants. Spaces of continuous functions: Pointwise and uniform convergence.

**MTH 406: Lebesgue Measure and Integrals** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. define Lesbesgue measure; and
2. describe Measurable functions and Integral convergence theorems.

**Course Contents**

Lebesgue measure; measurable and non-measurable sets. Measurable functions. Lebesgue integral: Integration of non-negative functions, the general integral convergence theorems.

**MTH 407: Mathematical Methods** **(2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. define calculus of variation;
2. describe isoperimetric problems; and
3. solve some problems using integral transforms like: Laplace, Fourier, Hankel, Mellin, Z, Hilbert transforms.

**Course Contents**

**Course Contents**

Calculus of variation. Lagrange's functional and associated density. Necessary condition for a weak relative extremum. Hamilton's principles. Lagrange's equations and geodesic problems. The Du Bois-Raymond equation and corner conditions. Variable end-points and related theorems. Sufficient conditions for a minimum. Isoperimetric problems. Variational integral transforms. Laplace, Fourier and Hankel transforms. Complex variable methods, convolution theorems. Application to solution of differential equations.

**MTH 408: Entrepreneurship in Mathematics (2 Units C: LH 30)**

**Learning Outcomes**

At the end of the course, students should be able to:

1. read, write, execute, run and analyse prevailing programming languages
2. prepare documents using LaTeX
3. engage in web designing, printing technology and other related assignments

**Course Contents**

Student should be exposed to programming languages and how to write projects using latex, web designing, printing technology and mathematics improvement projects.

**GOU-MTH 411: Quantum Mechanics (2 Units; Elective; LH = 30; PH = 0)**

**Senate-Approved Relevance**

Quantum Mechanics is a highly relevant and rapidly developing field in physics that deals with the behavior of particles at the subatomic level. It has significant implications for a variety of scientific and technological fields, including materials science, electronics, cryptography, and energy production. The inclusion of Quantum Mechanics in our course catalog will help Godfrey Okoye University to stay at the forefront of scientific research and education. It will also provide students with the necessary skills and knowledge to pursue careers in a variety of fields. This course is essential to the actualization of the visions of the university in solving societal problems at a minimal cost and maximizing efficiency. This course is in line with goal 4 of the United Nations' Sustainable Development Goals. Goal 4 deals with the necessity of ensuring quality education.

**Overview**

Quantum mechanics is a branch of physics that deals with the behavior of matter and energy at the atomic and subatomic level. The course in quantum mechanics provides students with a foundational understanding of the principles and concepts that govern the behavior of particles in the quantum world.

The course covers topics such as wave-particle duality, uncertainty principle, Schrodinger equation, quantum states, and operators. Students will learn how to analyze and solve problems related to the behavior of particles in various systems, including one-dimensional and three-dimensional potentials, harmonic oscillator, and hydrogen atom. By the end of the course, students will be able to model and solve real-world problems related to the behavior of particles and systems at the quantum level. The skills gained in this course can be beneficial for students pursuing careers in research, academia, and industry, where quantum mechanics is widely used for developing new materials, designing quantum computers, and understanding the behavior of complex systems.

.

**Objectives**

The objectives of the course are to:

1. Identify and explain the basic principles of quantum mechanics, including wave-particle duality, superposition, and uncertainty.
2. Develop an understanding of the mathematical foundations of quantum mechanics, such as Hilbert spaces, operators, and states.
3. Describe the properties of quantum systems, such as energy levels, angular momentum, and spin.
4. Distinguish between different types of quantum systems, such as atoms, molecules, and solids.
5. Explain the concept of quantum entanglement and its applications in quantum information theory.
6. Describe the skills employed in solving the Schrödinger equation for simple quantum systems and calculating their wave functions and energy levels.
7. Apply quantum mechanics to solve problems in various fields, such as chemistry, physics, and materials science.
8. Solve problem associated with stationery problem
9. State and prove fundamental theorems of quantum mechanics, such as the uncertainty principle and the superposition principle.
10. Describe the concept of quantum measurement and its role in the collapse of the wave function.
11. Explain the concept of quantum computing and its potential impact on information technology.
12. Explain skills deployed in modelling and simulating quantum systems using software tools, such as MATLAB and Python.
13. Distinguish between different types of quantum interactions, such as Coulomb interaction and exchange interaction.

**Learning Outcomes**

On completion of the course, students should be able to:

1. Identify and explain the basic principles of quantum mechanics, including wave-particle duality, superposition, and uncertainty.
2. Describe the properties of quantum systems, such as energy levels, angular momentum, and spin.
3. Distinguish between different types of quantum systems, such as atoms, molecules, and solids.
4. Explain the concept of quantum entanglement and its applications in quantum information theory.
5. Apply quantum mechanics to solve problems chemistry, physics, and materials science.
6. State and prove fundamental theorems of quantum mechanics, such as the uncertainty principle and the superposition principle.
7. Describe the concept of quantum measurement and its role in the collapse of the wave function.
8. Explain the concept of quantum computing and its potential impact on information technology.
9. Explain skills deployed in modelling and simulating quantum systems using software tools, such as MATLAB and Python.

10. Describe the properties of different types of quantum particles, such as bosons and fermions.
11. Distinguish between different types of quantum interactions, such as Coulomb interaction and exchange interaction.

**Course Contents**

Introduction to Quantum Mechanics. Wave Functions and Operators. Particle wave duality. Quantum States and Observables. Quantum States and Observables. Quantum Superposition and Entanglement. Quantum Mechanics of Simple Systems. Hydrogen Atom and Atomic. Spectra. Many-Particle Systems. Schrodinger equation of motion. Potential steps and wells in 1-dim Heisenberg formulation. Classical limit of Quantum mechanics. Computer brackets. Linear harmonic oscillator. Angular momentum. 3-dim square well potential. The hydrogen atom collision in 3-dim. Approximation methods for stationary problems

**Minimum Academic Standards**

The academic standards set for B. Sc Mathematics by the National Universities Commission.

**GOU-MTH 412: System Theory (2 Units; Elective; LH = 30; PH = 0)**

**Senate Approved Relevance**
This course is relevant to the vision of Godfrey Okoye University in producing graduates with necessary skills and knowledge to analyze complex systems and design effective solutions to real-world problems. This course is designed to provide our students with a deep understanding of the principles, concepts, and applications of system theory. This course is in line with goal 4 of the United Nations' Sustainable Development Goals. Goal 4 deals with the necessity of ensuring quality education.

**Overview**
System theory is a field of study that deals with the mathematical modeling and analysis of complex systems, including physical, biological, and social systems. The course in system theory provides students with a comprehensive understanding of the principles and methods used in the analysis and design of systems. The course covers topics such as linear and nonlinear systems, state-space representation, feedback control, stability analysis, and optimization. Students will learn how to apply system theory to solve problems related to control, communication, signal processing, and robotics.

Moreover, the course emphasizes the importance of modeling and simulation in system analysis and design. By the end of the course, students will be able to model and analyze complex systems using various mathematical tools, including differential equations, linear algebra, and optimization theory. The skills gained in this course can be beneficial for students pursuing careers in engineering, computer science, and applied mathematics, where system theory is widely used for developing new technologies, designing control systems, and optimizing performance of complex systems.

**Objectives**
The objectives of the course are to:
1. Explain system theory to provide students with a broad and balanced foundation of knowledge in the subject.
2. Identify and solve problems in both linear and nonlinear systems.
3. Describe ways to simulate sustained interest in system theory among students.
4. Predict the future behavior of a given system.
5. Apply effective teaching methods to expose students to an appreciation of system theory in tertiary institutions, expanding their understanding and interest in the subject.

**Learning Outcomes**
On the completion of the course, students should be able to:
1. Identify and explain the basic concepts of system theory, such as system, input, output, and feedback.
2. Discuss the mathematical foundations of system theory, such as linear algebra, differential equations, and Laplace transforms.
3. Describe the properties of linear time-invariant systems, such as stability, controllability, and observability.
4. Distinguish between different types of systems, such as discrete-time and continuous-time systems, and deterministic and stochastic systems.

5. Explain the concept of state-space representation and its applications in system analysis and design.
6. Itemise skills in modelling and simulating linear systems using software tools, such as MATLAB and Simulink.

**Course Contents**

Introduction to System Theory: definition of a system, types of systems, feedback, and control. Mathematical Modeling of Systems: differential equations, transfer functions, block diagrams, and state space representation. Linearization of Nonlinear Systems: linearization techniques, stability analysis, and Lyapunov stability theorems. Theorem on existence of solution of linear systems of differential operations with constant coefficients. Controllability and Observability: controllability and observability of linear and nonlinear systems, Kalman decomposition, and observer design. Stability Analysis: stability criteria for linear and nonlinear systems, Routh-Hurwitz criterion, and Nyquist stability criterion. Frequency Domain Analysis: Bode plots, Nyquist plots, and gain and phase margins. Feedback Control Systems: closed-loop control, PID control, and root locus analysis. State Feedback and State Estimation: state feedback design, pole placement, and state estimator design. Robust Control: H-infinity control, mu-synthesis, and loop shaping. Adaptive Control: model reference adaptive control, self-tuning regulators, and gain scheduling. Nonlinear Control: feedback linearization, sliding mode control, and back stepping control. Optimal Control: minimum principle, linear quadratic regulator, and dynamic programming. Stochastic Control: stochastic differential equations, linear quadratic Gaussian control, and Kalman filtering. Multi-Input Multi-Output (MIMO) Systems: MIMO system analysis, decoupling, and control design. Intelligent Control: fuzzy logic control, neural network control, and genetic algorithm control. System Identification: parameter estimation, identification algorithms, and model validation. Applications of System Theory: case studies and applications of system theory in engineering, economics, and social sciences.

**Minimum Academic Standards**

The academic standards set for B. Sc Mathematics by the National Universities Commission.

**Course Contents**

**GOU-MTH 413: Optimization Theory II (2 Units; Compulsory; LH = 30; PH = 0)**

**Senate – Approved Relevance**

Optimization Theory is used to design systems and processes that maximize efficiency and minimize costs. It is used in the design of aircraft, automobiles, and other transportation systems, as well as in the development of algorithms for signal processing, control systems, and image processing, optimizing the allocation of resources, such as time, money, and labor, in order to maximize efficiency and minimize costs. This course is essential to the actualization of the visions of Godfrey Okoye University to solve societal problems at a minimal cost and maximizing efficiency. This course is in line with goal 4 of the United Nations' Sustainable Development Goals. Goal 4 deals with the necessity of ensuring quality education.

**Overview**

Optimization theory is a branch of mathematics that deals with the development and application of mathematical techniques for finding the best possible solution to a given problem. The course in optimization theory provides students with a foundation in the principles and methods of optimization. Students will learn how to formulate and solve optimization problems using various mathematical tools, such as gradient descent, Lagrange multipliers, and Karush-Kuhn-Tucker conditions. The course also emphasizes the implementation of optimization algorithms using software tools such as MATLAB, Python, and AMPL.

By the end of the course, students will be able to model and solve real-world optimization problems, such as resource allocation, production planning, portfolio optimization, and scheduling. The skills gained in this course can be beneficial for students pursuing careers in research, academia, and industry, where optimization theory is widely used for decision-making and problem-solving.

**Objectives**

The objectives of the course are to:

1. Identify and explain the basic concepts of optimization theory, such as objective functions, constraints, and feasible solutions.
2. Explain various types of optimization problems, including linear programming, nonlinear programming, and integer programming.
3. Describe the properties of optimization problems, such as convexity, duality, and optimality conditions.
4. Distinguish between different optimization algorithms, such as gradient descent, Newton's method, and simplex method.
5. Explain the concept of sensitivity analysis and its significance in optimization theory.
6. Develop skills in constructing and solving optimization problems using various optimization techniques.
7. Apply optimization theory to solve problems in various fields, such as engineering, economics, and finance.
8. State and prove fundamental theorems of optimization theory, such as the Kuhn-Tucker conditions and the Karush-Kuhn-Tucker conditions.
9. Describe the concept of game theory and its connection to optimization theory.
10. Describe the skills in modeling and solving optimization problems using software tools, such as MATLAB and GAMS.
11. Explain the concept of global optimization and its importance in solving non-convex optimization problems.

**Course Contents**

12. Explain the application of optimization theory in solving real-world problems in areas such as logistics, resource allocation, and supply chain management.

**Learning Outcomes**
On completion of the course, students should be able to:

1. Identify and explain the basic concepts of optimization theory, such as objective functions, constraints, and feasible solutions.
2. Explain various types of optimization problems, including linear programming, nonlinear programming, and integer programming.
3. Distinguish between different optimization algorithms, such as gradient descent, Newton's method, and simplex method.
4. Explain the concept of sensitivity analysis and its significance in optimization theory.
5. Develop skills in constructing and solving optimization problems using various optimization techniques.
6. State and prove fundamental theorems of optimization theory, such as the Kuhn-Tucker conditions and the Karush-Kuhn-Tucker conditions.
7. Describe the skills in modeling and solving optimization problems using software tools, such as MATLAB and GAMS.
8. Distinguish between different types of optimization models, such as linear programming models and quadratic programming models.

**Course Contents**
Introduction to Optimization theory. Definition, history, and applications. Mathematical preliminaries, including linear algebra and calculus. Linear programming models, constraints, and objective functions. The simplex method for solving linear programming problems. Duality theory and sensitivity analysis for linear programming. Integer programming and branch-and-bound algorithms. Nonlinear programming, including unconstrained optimization and constrained optimization with inequality constraints. Quadratic programming, including convexity and quadratic forms. Kuhn-Tucker conditions and optimality criteria for constrained optimization. Interior point methods for linear and nonlinear programming. Single variable optimization, including the bisection method, Newton's method, and gradient descent. Multivariable optimization techniques, including gradient methods, Newton's method, and quasi-Newton methods. Convex optimization, including convex sets, convex functions, and convex programming. Combinatorial optimization, including network flow problems and the traveling salesman problem. Stochastic optimization and simulation optimization. Metaheuristic methods, including genetic algorithms, simulated annealing, and tabu search. Applications of optimization theory in fields such as engineering, economics, finance, and management science.

**Minimum Academic Standards**
The academic standards set for B. Sc Mathematics by the National Universities Commission.

**GOU-MTH 414: Measure Theory (2 Units; Compulsory; LH = 30; PH = 0)**

**Senate-Approved Relevance**

**Course Contents**

We believe that this course will be of great value to our students who are interested in pursuing careers in mathematics, statistics, computer science, economics, and other related fields. It will provide them with the necessary mathematical tools and techniques to analyze complex systems and solve real-world problems. Godfrey Okoye University is committed to maintaining the high standards of education. We believe that the addition of this course will significantly enhance this envisaged high standard. This course is in line with goal 4 of the United Nations' Sustainable Development Goals. Goal 4 deals with the necessity of ensuring quality education.

**Overview**

Measure theory is a branch of mathematics that deals with the concepts of size, length, area, and volume in a rigorous and generalized manner. The course in measure theory provides students with a deep understanding of the foundations of integration theory and probability theory. The course covers topics such as measurable sets, sigma-algebras, measures, integration, convergence theorems, and product measures. Students will learn how to construct and analyze measures on various mathematical spaces, including real and abstract measure spaces, and how to apply integration theory to solve problems in analysis, probability, and statistics.

Additionally, the course emphasizes the connections between measure theory and other branches of mathematics, such as functional analysis and harmonic analysis. By the end of the course, students will be able to apply measure theory concepts and techniques to solve advanced mathematical problems, including those related to stochastic processes, Fourier analysis, and PDEs. The skills gained in this course can be beneficial for students pursuing careers in research, academia, and industry, where measure theory is widely used for modeling and analyzing complex systems.

**Objectives**

The objectives of the course are to:

1. Explain the broad and balanced foundation of measure theory.
2. Explore students' ability to identify key concepts and draw reasonable conclusions in measure theory.
3. Describe ways to simulate sustained interest in measure theory among students.
4. Apply the concepts of $L^P$ −space, including metric spaces, topological spaces, Banach spaces, and Hilbert spaces, to explain measure theory concepts.
5. State and differentiate between abstract spaces and other related concepts, and identify their similarities and differences in measure theory.
6. Describe the concept of integration with respect to a measure and develop skills in computing integrals using various integration techniques.
7. Explain the connections between measure theory and other areas of mathematics, including functional analysis and harmonic analysis.
8. Develop an understanding of the relationship between measure theory and probability theory.
9. Explain the concept of sigma-algebras and their significance in measure theory.
10. Develop skills in constructing and manipulating sigma-algebras.
11. Explain the concept of product measures and their significance in probability theory.
12. Apply measure theory to solve problems in probability theory and statistical inference.

**Learning Outcomes:**

**Course Contents**

1. On completion of the course, students should be able to:
2. Identify the basic concepts and principles of measure theory and explain their applications in mathematical analysis.
3. Develop an understanding of different types of measures, including Lebesgue measure, Borel measure, and Radon measure.
4. Describe the properties of measures, including additivity, monotonicity, and continuity.
5. Distinguish between measurable and non-measurable sets and explain why non-measurable sets exist.
6. Explain the concept of measure zero and its significance in mathematical analysis.
7. Develop skills in constructing and manipulating measures and measure spaces.
8. Apply measure theory to solve problems in real analysis, probability theory, and other related areas.
9. State and prove fundamental theorems of measure theory, such as the Radon-Nikodym theorem and the Hahn decomposition theorem.

**Course Contents**

Abstract $L^P$ spaces - Completeness and Approximation. Normed linear spaces. The inequalities of Young, Holder and Minkowskii. The Riesz-Fischer's theorem. Approximations. Separability. Duality and weak convergence. The Riesz-representation for the dual of $L^P$ spaces. Weak sequential convergence in $L^P$. Weak sequential compactness. The minimization of convex functionals. General properties of metric spaces. General properties of topological spaces. The fundamental theorem on metric spaces. The fundamental theorem on topological spaces. Metric spaces and topological spaces. Abstract spaces.

**Minimum Academic Standards**

The academic standards set for B. Sc Mathematics by the National Universities Commission.

## Minimum Academic Standards

### Staffing

#### Academic Staff

The guidelines on academic staff/student ratio of 1:20 for science programmes shall apply. To start any programme in science, there should be a minimum of six academic staff. There is need to have a reasonable number of staff with PhD degrees accounting for at least 70% of the total number and having adequate teaching experience for every programme in the discipline.

#### Administrative support staff

The services of the administrative support staff are indispensable in the proper administration of departments and faculty offices. It is important to recruit very competent, computer literate senior staff.

#### Technical support personnel

The services of technical support staff, which are indispensable in the proper running of laboratories and workshops, are required. It is important to recruit very competent senior technical staff to maintain teaching and research equipment. They are also to undergo regular training developments in equipment operation and maintenance.

**Classrooms, Laboratories, Workshops and Office Space** The NUC recommends the following physical space requirements:

| Description | | Size $m^2$ |
|---|---|---|
| Professor's Office | - | 18.50 |
| Head of Department's Office | - | 18.50 |
| Tutorial Teaching Staff's Office | - | 13.50 |
| Other Teaching Staff Space | - | 7.00 |
| Technical Staff Space | - | 7.00 |
| Secretarial Space | - | 7.00 |
| Research Laboratory | - | 16.50 |
| Seminar Space/per student | - | 1.85 |
| Laboratory Space per FTE | - | 7.50 |
| Conference Room | - | 37.0 |

Adequate space should be provided for all departments in the sciences. Effort must be made to provide each department with at least:

1. Four (4) large laboratories calculated according to specifications of 7.5 $m^2$ per FTE; a minimum of four (4) preparatory rooms for each laboratory at the NUC specifications of 7 $m^2$ each.
2. At least two lecture rooms capable of sitting at least sixty students at the specification of 1 $m^2$ per FTE.
3. A departmental conference room.
4. A staff common room.

**Library and Information Resources**

Universities should leverage on available technology to put in place rich databases and other electronic/digital library and information resources. In addition, well stock and current hardcopies of reference and other textual materials should be provided centrally at the level of the faculty.

A well network digital library should serve the entire university community. Availability of wireless facilities (Wifi) with adequate bandwidth should enhance access to these electronic resources.

In any case, there should be internet-ready workstations available in the library for at least 25% of the total students enrolled in each academic programme. The funding of the library should be in line with NUC guidelines.

**Equipment**

| S/N | Description | Quantity Required |
|---|---|---|
| 1 | Computers | 60 |
| 2 | Computer software | 6 |
| 3 | Flash drives | 10 |

**Course Contents**

| | | |
|---|---|---|
| 4 | Printers | 10 |
| 5 | Projectors | 10 |
| 6 | Smart board | 5 |
| 7 | Smart TV | 5 |
| 8 | Video machine | 5 |
| 9 | Screen board | 10 |
| 10 | Pen drive | 10 |
| 11 | Loud speaker with microphones | 5 |