**BAYERO UNIVERSITY, KANO (BUK)**

**Faculty of Physical Sciences**

**Department of Mathematical Sciences**

**BS.c Mathematics**

**Proposed 30% additional courses to the CCMAS course structure**

**100 Level**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Course Code** | **Course Tittle** | **Units** | **Status** | **LH** | **PH** |
| BUK-STA 111 | Descriptive Statistics | 3 | C | 45 | - |
| BUK-PHY 101 | General Physics I | 2 | C | 30 | - |
| BUK-PHY 102 | General Physics II | 2 | C | 30 | - |
| BUK-PHY 103 | General Physics III | 2 | C | 30 | - |
| BUK-PHY 104 | General Physics IV | 2 | C | 30 | - |
| BUK-CHM 101 | General Chemistry I | 2 | E | 30 | - |
| BUK-CHM 102 | General Chemistry II | 2 | E | 30 | - |
| BUK-BIO 101 | General Biology I | 2 | E | 30 | - |
| BUK-BIO 102 | General Biology II | 2 | E | 30 | - |
|  | **Total** | **19 (to register 15 units maximum** |  |  |  |

**200 Level**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Course Code** | **Course Title** | **Units** | **Status** | **LH** | **PH** |
| BUK-STA 211 | Probability II | 3 | C | 45 | - |
| BUK-COS 202 | Computer Programming II | 3 | C | 30 | 45 |
| BUK-MTH 201 | Sets, Logic, and Algebra II | 2 | C | 30 | - |
| BUK-MTH 202 | History and Philosophy of  Mathematics | 2 | C | 30 | - |
|  | **Total** | **10** |  |  |  |

**300 Level**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Course Code** | **Course Title** | **Units** | **Status** | **LH** | **PH** |
| BUK-MTH 301 | Introduction to Mathematical  Computing | 3 | C | 30 | 45 |
|  | **Total** | **3** |  |  |  |

**400 Level**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Course Code** | **Course Tittle** | **Unit(s)** | **Status** | **LH** | **PH** |
| BUK-MTH 401 | Research Methodology | 1 | C | 15 | - |
| BUK-MTH 402 | Discrete Mathematics | 3 | E | 45 | - |
| BUK-MTH 403 | Operations Research | 3 | E | 45 | - |
| BUK-MTH 404 | Dynamical Systems | 3 | E | 45 | - |
| BUK-MTH 405 | Group Theory | 3 | E | 45 | - |
| BUK-MTH 406 | Classical Theory of Numbers | 3 | E | 45 | - |
| BUK-MTH 407 | Numerical Linear Algebra | 3 | E | 30 | 45 |
| BUK-MTH 408 | Unconstrained Optimization Theory | 3 | E | 45 | - |
| BUK-MTH 409 | Fluid Dynamics | 3 | E | 45 | - |
| BUK-MTH 410 | Biomathematics | 3 | E | 45 | - |
| BUK-MTH 411 | Introduction to Data Science | 3 | E | 45 | - |
|  | **Total** | **31** |  |  |  |
|  | **Grand Total** | **38** |  |  |  |

**BUK-STA 111:Descriptive Statistics (2 Units C: LH=30)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

Training graduates (of Mathematics) of top-notch quality with a firm grasp of Descriptive Statistics is well-aligned with BUK’s mission of producing competent Mathematical Scientists and Mathematics teachers needed to propel scientific and technological innovations and developments in the Country and African, in general. This has equipped the graduates (of the BSc Mathematics programme) with tremendous mathematical capabilities and skills which make them take leading roles in both innovative research and teaching. It has made their presence felt in both national and international mathematical community.

**Overview**

The course *Descriptive Statistics* covers general introduction to statistical data and related concepts. It treats data collection and presentation. Tables, charts and graphs are all covered in the course. The course exposes the students to errors and approximations, measures of location, dispersion, partition, skewness and Kurtosis.

**Objectives**

1. To introduce the students to the general concepts of data collection and representation.

2. To make the students able to present data in various forms: chart, tables and graphs.

3. To make the students able to explain the distinction between measures of location, dispersion and partition.

4. To bring about a good comprehension of the concepts of Skewness and Kurtosis as well as their utility function in a given data set.

5. To make the students appreciate the difference between rates and ratios and how to use them.

6. To make the students conversant with the different types of index number from a given data set and interpret the output.

**Learning Outcomes**

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

1. explain the basic concepts of descriptive statistics;

2. present data in graphs and charts;

3. differentiate between measures of location, dispersion and partition;

4. describe the basic concepts of Skewness and Kurtosis as well as their utility function in a

given data set;

5. differentiate rates from ratio and how they are used; and

6. compute the different types of index number from a given data set and interpret the output.

**Contents**

Statistical data. Types, sources and methods of collection. Presentation of data. Tables chart and

graph. Errors and approximations. Frequency and cumulative distributions. Measures of location,

partition, dispersion, skewness and Kurtosis. Rates, ratios and index numbers.

**BUK-PHY 101: General Physics I (2 Units C: LH=30)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

Training top-quality graduates (of Mathematics) with substantial grasp of Mechanics is in line with BUK’s mission of producing first-rate Mathematical Scientists and Mathematics teachers needed to bring about the much-desired scientific and technological innovations and developments in the Country in particular, and the African continent in general. This has brought about great mathematical capabilities and skills in the graduates of the B.Sc. Mathematics programme such as to make them play leading roles in research and teaching. It has also made them the first choices of universities across the globe in postgraduate mathematics programmes and related disciplines.

**Overview**

The course *Mechanics* treats motion in a way that covers covers the notions of space, time, units and dimension. The course takes the students through the concepts of differentiation of vectors and the various operations on vectors. It offers to the students a study of Conservation principles in physics.

In the course, the students are made to solve problems that relate to motion in general and see applications of Newtonian mechanics.

**Objectives**

1. To introduce students to the basics of mechanics.

2. To make the students knowledgeable in such concepts of motion as: Newton’s law of motion, relative motion, rotational motion, circular motion, etc.

3. To develop skills of solving different simple motion-related problems.

4. To get the students to be able to apply Newtonian mechanics.

5. To gain familiarity with various coordinate systems in relation to mechanics.

6. To make the students learn how to formulate and interpret different motion related problems.

**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 Newton’s laws to describe and solve simple problems 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

**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, 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.

**BUK-PHY 102: General Physics II (2 Units C: LH=30)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

It is in line with BUK’s mission to train high-quality graduates (of Mathematics) with sound comprehension of Electricity and Magnetism to tackle the problem of dearth of Mathematical Scientists for teaching mathematics and conducting innovative researches for the development of the Nation, and more generally, the African continent. This approach has proved effective as BUK graduates of the programme (BSc Mathematics) have kept on performing excellently both nationally and internationally.

**Overview**

The course *Electricity and Magnetism* introduces the students to electromagnetism. It encompasses the notions of electric field and potential, magnetic field and related concepts. It exposes the students to such fundamentals as: Coulomb’s law, Gauss’s law, Ohm’s law, Lorentz force, Biot-Savart and Ampère’s laws, Faraday’s and Lenz’s laws. It treats the concepts of capacitance, conductors and insulators, magnetic dipoles, dielectrics, electromotive force, electromagnetic induction and other related concepts.

In the course, the students are made to learn how to calculate electrostatic properties using Coulomb’s law, Gauss’s law, and electric potential, analyse DC circuits and describe electromagnetic induction and related concepts. They are also made to perform calculations using Faraday’s and Lenz’s laws.

**Objectives**

1. To introduce the students to the basics of electromagnetism.

2. To make the students familiar with calculations involving electrostatic properties of simple charge distributions using Coulomb’s law, Gauss’s law, and electric potential.

3. To make the students knowledgeable in electric field and potential, and related concepts.

4. To make the students able to describe electromagnetic induction and related concepts and perform calculations using Faraday’s and Lenz’s laws.

5. To make the students conversant with the basic physical significance of Maxwell’s equations in integral form.

6. To effect a firm grasp of DC circuits enough to enable the students determine the electrical parameters.

7. To make the students able to determine the characteristics of AC voltages and currents in resistors, capacitors, and inductors.

**Learning Outcomes**

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

1. describe the electric field and potential, and related concepts, for stationary charges;

2. calculate electrostatic properties of simple charge distributions using Coulomb’s law, Gauss’s

law and electric potential;

3. describe and determine the magnetic field for steady and moving charges;

4. determine the magnetic properties of simple current distributions using Biot-Savart and

Ampere’s law;

5. describe electromagnetic induction and related concepts, and make calculations using Faraday

and Lenz’s laws;

6. explain the basic physical representation of Maxwell’s equations in integral form;

7. evaluate DC circuits to determine the electrical parameters; and

8. determine the characteristics of AC voltages and currents in resistors, capacitors, and

Inductors.

**Contents**

Forces in nature. Electrostatics, electric charge and its properties. methods of charging. Coulomb’s law and superposition. electric field and potential. Gauss’s law. Capacitance. Electric dipoles. Energy in electric fields; Conductors and insulators, current, voltage and resistance, Ohm’s law and analysis of DC circuits. Magnetic fields. Lorentz force. Biot-Savartand Ampère’s laws. magnetic dipoles, Dielectrics, Energy in magnetic fields, Electromotive force. Electromagnetic induction, Self and mutual inductances. Faraday and Lenz’s laws, Step up and step-down transformers: Maxwell's equations; Electromagnetic oscillations and waves. AC voltages and currents applied to inductors, capacitors, resistance, and combinations.

**BUK-PHY 103: General Physics III (2 Units C: LH=30)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

By training high-quality graduates with a solid background in trying to study the general behavior of matter, BUK is fulfilling its mission to address the scarcity of mathematical scientists and teachers in the country. This has led to notable improvements in the abilities of BUK mathematics graduates, who are now ready to represent the nation in the global mathematics community.

**Overview**

It is important to understand the properties of matter because everything is made up of matter. The course provides the states of matter with their chemical and physical properties which can be calculated. The course covers the gas laws and its equations thermodynamics processes and some of its laws. Furthermore, the course provides special topics, such as elasticity, hydrostatics and surface tension.

**Objectives**

1. To recognize matter as anything that has mass and takes up space;
2. To identify matter in the states of solid, liquid, and gas;
3. To recognize the basic properties of matter;
4. To realize that gas law is a simple mathematical formula that allows one to predict the physical properties of a gas;
5. To present the concept of thermal conductivity of a material and its applications; and
6. To present the theory of elasticity and its applications.

**Learning Outcomes**

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

1. explain the concepts of heat and temperature and relate the temperature scales;
2. define, derive, and apply the fundamental thermodynamic relations to thermal systems;
3. describe and explain the first and second laws of thermodynamics, and the concept of  
   entropy;
4. state the assumptions of the kinetic theory and apply techniques of describing macroscopicbehavior;
5. deduce the formalism of thermodynamics and apply it to simple systems in thermal  
   equilibrium; and
6. describe and determine the effect of forces and deformation of materials and surfaces

**Contents**

Heat and temperature (temperature scales). Gas laws. General gas equation. Thermal  
conductivity. First Law of thermodynamics (heat, work and internal energy, reversibility).  
Thermodynamic processes (adiabatic, isothermal, isobaric). Second law of thermodynamics (heat  
engines and entropy). Zeroth law of thermodynamics. Kinetic theory of gases. Molecular collisions  
and mean free path. Elasticity (Hooke's law, Young's, shear and bulk moduli). Hydrostatics  
(Pressure, buoyancy, Archimedes' principles). Bernoulli’s equation and incompressible fluid flow.  
Surface tension (adhesion, cohesion, viscosity, capillarity, drops and bubbles).

**BUK-PHY104: General Physics IV (2 Units C: LH=30)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

By training high-quality graduates with a solid background in general physicss, BUK is fulfilling its mission to address the scarcity of mathematical scientists and teachers in the country. This has led to notable improvements in the abilities of BUK mathematics students, who are now ready to represent the nation in the global mathematics community.

**Overview**

This course introduces the physics of waves and optics. The course provides the general behavior, types and properties of waves. Also, the course avails the students with the optical properties of matter, general wave equations, phase and group velocity. Applications of mirror, waves and scanning, frequency, optical instrument.

**Objectives**

1. To acquire the general idea about waves and optics;
2. To understand the general properties of waves and optics;
3. To comprehend the properties of waves: reflection, refraction, diffraction, interference;
4. To comprehend the simple application of reflection;
5. To comprehend the general application of waves and optics;
6. To drive the general wave equations; and
7. To comprehend the concept of spherical mirror and its application.

**Learning Outcomes**

On completion, the students should be able to:

1. describe and quantitatively analyze the behaviour of wave energy;
2. present the properties of waves and optics
3. express the types of waves and optics
4. explain the propagation and properties of waves in sound and light;
5. identify and apply the wave equations; and
6. explain geometrical optics and principles of optical instruments.

**Contents**

Simple harmonic motion (SHM): energy in a vibrating system, Damped SHM, Q values and power  
response curves, forced SHM, resonance and transients, coupled SHM. Normal modes. Waves:  
types and properties of waves as applied to sound; Transverse and Longitudinal waves;  
Superposition, interference, diffraction, dispersion, polarisation. Waves at interfaces, Energy and  
power of waves, the 1-D wave equation, 2-D and 3-D wave equations, wave energy and power,  
phase and group velocities, echo, beats, the doppler effect, propagation of sound in gases, solids  
and liquids and their properties. Optics: Nature and propagation of light; reflection, refraction,  
and internal reflection, dispersion, scattering of light, reflection and refraction at plane and  
spherical surfaces, thin lenses and optical instruments, wave nature of light; Huygens’s principle,  
interference and diffraction.

**BUK-CHM101: General Chemistry I (2 Units E: LH=30)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

By training high-quality graduates with a solid background in trying to study the concept physical chemistry and, also study the chemical and physical properties of elements as influenced by their position in the periodic table, BUK is fulfilling its mission to address the scarcity of mathematical scientists and teachers in the country. This has led to notable improvements in the abilities of BUK mathematics students, who are now ready to represent the nation in the global mathematics community.

**Overview**

This course is necessary as an introductory Inorganic and Physical chemistry. It opens up and introduces the students into the wider knowledge of chemistry of all the elements as classified in the periodic table and the historical development of the periodic table. Chemical and physical properties of elements as influenced by their position in the periodic table. Furthermore, the course provides a basis for understanding the thermodynamic influences that drive chemical reactions forward. Other aspect of the course is chemical kinetics which concern with rate of reaction, introduction to electrochemistry and radioactivity.

**Objectives**

1. To understand the scope and the fundamental principles of introductory inorganic and physical chemistry
2. To comprehend the elemental arrangement in the periodic table, electronic configuration of element and periodic law.
3. To comprehend the scientific effort that development the periodic table, properties and reactions of the elements in relation to their positions in the periodic table.
4. To understand chemical equations and stoichiometry, also the students will be introduced to elementary thermochemistry and electrochemistry.

**Learning Outcomes**

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

1. define atom, molecules and chemical reactions;
2. discuss the Modern electronic theory of atoms;
3. write electronic configurations of elements on the periodic table;
4. justify the trends of atomic radii, ionization energies, electronegativity of the elements based on their position in the periodic table;
5. identify and balance oxidation – reduction equation and solve redox titration problems;
6. illustrate shapes of simple molecules and hybridized orbitals;
7. identify the characteristics of acids, bases and salts, and solve problems based on their  
   quantitative relationship;
8. apply the principles of equilibrium to aqueous systems using LeChatelier’s principle to predict the effect of concentration, pressure and temperaturechanges on equilibrium mixtures;
9. analyze and perform calculations with the thermodynamic functions, enthalpy, entropy andfree energy; and
10. determine rates of reactions and its dependence on concentration, time and  
     temperature.

**Contents**

Atoms, molecules, elements and compounds and chemical reactions. Modern electronic theory of  
atoms. Electronic configuration, periodicity and building up of the periodic table. Hybridization  
and shapes of simple molecules. Valence Forces and structure of solids. Chemical equations and  
stoichiometry, chemical bonding and intermolecular forces, kinetic theory of matter. Elementary  
thermochemistry; rates of reaction, equilibrium and thermodynamics. Acids, bases and salts.  
Properties of gases. Redox reactions and introduction to electrochemistry. Radioactivity.

**BUK-CHM102: General Chemistry II (2 Units E: LH=30)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

Training high-quality graduates with a strong foundation in physical sciences is in line with BUK's mission to produce Mathematical Scientists and teachers needed for research in both Mathematics and Chemistry related fields that will propel the much-needed Science and Technological developments in the country. Top-notch performance has been observed in graduates of Mathematics from BUK who can represent the nation in the international communityin terms of Mathematics-Chemistry collaborative researches.

**Overview**

This course introduces the historical survey of the development and importance of organic chemistry, fullerenes as fourth allotrope of carbon, uses as nanotubules, nanostructures and nanochemistry. It also explores on electronic theory in organic chemistry, isolation and purification of organic compounds. Determination of structures of organic compounds including qualitative and quantitative analysis in organic chemistry are discussed.

It gives highlight on the nomenclature and functional group classes of organic compounds, introductory reaction, mechanism and kinetics and Stereochemistry. The chemistry of alkanes, alkenes, alkynes, alcohols, ethers, amines, alkyl halides, nitriles, aldehydes, ketones, carboxylic acids and derivatives are all covered by this course. The Chemistry of selected metals and non-metals. Comparative chemistry of group IA, IIA and IVA elements and Introduction to transition metal chemistry are also discussed.

**Objectives**

1. To explain the importance of organic Chemistry and its application
2. To use the application of fullerenes
3. To acquire the basics of electronic theory
4. To use the qualitative and quantitative of structures in organic Chemistry
5. To identify the comparative chemistry of group 1A, IIA and IVA elements

**Learning Outcomes**

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

1. state the importance and development of organic chemistry;

2. define fullerenes and their applications;

3. discuss electronic theory;

4. determine the qualitative and quantitative of structures in organic chemistry;

5. describe rules guiding nomenclature and functional group classes of organic chemistry;

6. determine rate of reaction to predict mechanisms of reaction;

7. identify classes of organic functional group with brief description of their chemistry;

8. discuss comparative chemistry of group 1A, IIA and IVA elements and

9. describe basic properties of Transition metals.

**Contents**

Historical survey of the development and importance of organic chemistry, fullerenes as fourth

allotrope of carbon, uses as nanotubules, nanostructures and nanochemistry. Electronic theory in

organic chemistry. Isolation and purification of organic compounds. Determination of structures

of organic compounds including qualitative and quantitative analysis in organic chemistry.

Nomenclature and functional group classes of organic compounds. Introductory reaction

mechanism and kinetics. Stereochemistry. The chemistry of alkanes, alkenes, alkynes, alcohols,

ethers, amines, alkyl halides, nitriles, aldehydes, ketones, carboxylic acids and derivatives. The

Chemistry of selected metals and non-metals. Comparative chemistry of group IA, IIA and IVA

elements. Introduction to transition metal chemistry.

**BUK-BIO 101: General Biology I (2 Units E: LH=30)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

Training high-quality graduates with a strong foundation in biological sciences is in line with BUK's mission to produce biomathematical Scientists needed for research in both Mathematics and Biology related fields that will propel the much-needed Science and Technological developments in the country. Top-notch performance has been observed in Biology and Mathematics students from BUK who can represent the nation in the international Biomathematics community.

**Overview**

The course begins by exploring cell structure and organisation, functions of cellular organelles. Chromosomes, genes; their relationships and importance. General reproduction. It also covers the concept of Heredity and evolution (introduction to Darwinism and Lamarkism, Mendelian laws, explanation of key genetic terms) as well as elements of ecology and types of habitats.

It equips students with skills to distinguish the characteristics and classification of living things as well as the inter-relationships that exist between organisms.

**Objectives**

1. To acquire the concept of cells structures and organizations
2. To explain the habitat types and their characteristics
3. To distinguish the inter-relationship that exists between organisms
4. To grasp the functions of cellular organelles
5. To explain living organisms and state their general reproduction

**Learning Outcomes**

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

1. explain cells structures and organizations;

2. summarize functions of cellular organelles;

3. characterize living organisms and state their general reproduction;

4. describe the inter-relationship that exists between organisms;

5. discuss the concept of heredity and evolution; and

6. enumerate habitat types and their characteristics.

**Contents**

Cell structure and organisation, functions of cellular organelles. Characteristics and classification of living things. Chromosomes, genes; their relationships and importance. General reproduction. interrelationships of organisms (competitions, parasitism, predation, symbiosis, commensalisms, mutualism, saprophytism). Heredity and evolution (introduction to Darwinism and Lamarkism, Mendelian laws, explanation of key genetic terms). Elements of ecology and types of habitat.

**BUK-BIO 102: General Biology II (2 Units E: LH=30)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

Training high-quality graduates with a strong foundation in biological sciences is in line with BUK's mission to produce biomathematical Scientists needed for research in both Mathematics and Biology related fields that will propel the much-needed Science and Technological developments in the country. Top-notch performance has been observed in Biology and Mathematics students from BUK who can represent the nation in the international Biomathematics community.

**Overview**

This course offers background knowledge needed to recognize the basic characteristics, identification and classification of viruses, bacteria and fungi. It explores on the generalized survey of the plant and animal kingdoms based mainly on the study of similarities and differences in the external features.

The course also introduces ecological adaptations andbriefs on physiology including nutrition, respiration, circulatory systems, excretion, reproduction, growth and development.

**Objectives**

1. To distinguish the unique characteristics of plant and animal kingdoms
2. To explain the characteristics, methods of identification and classification of viruses, bacteria and fungi
3. To grasp ecological adaptations in the plant and animal kingdoms
4. To acquire the concept of growth and development in plants and animals
5. To describe nutrition, respiration, excretion and reproduction in plants and animals

**Learning Outcomes**

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

1. List the characteristics, methods of identification and classification of viruses, bacteria and fungi;

2. state the unique characteristics of plant and animal kingdoms;

3. describe ecological adaptations in the plant and animal kingdoms;

4. explain nutrition, respiration, excretion and reproduction in plants and animals; and

5. describe growth and development in plants and animals.

**Contents**

Basic characteristics, identification and classification of viruses, bacteria and fungi. A generalized survey of the plant and animal kingdoms based mainly on the study of similarities and differences in the external features. Ecological adaptations. Briefs on physiology to include nutrition, respiration, circulatory systems, excretion, reproduction, growth and development.

**BUK-STA 211: Probability II (3 Units, LH=45)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

Training high-quality graduates with a strong foundation in probability is in line with BUK's mission to produce Mathematical Scientists needed for research in both Mathematics and Mathematics related fields that will propel the much-needed Science and Technological developments in the country. Top-notch performance has been observed in Mathematics students from BUK who can represent the nation in the international Mathematics community.

**Overview**

The course begins by exploring permutations and combinations, followed by an in-depth examination of the laws of probability. This includes an analysis of conditional probability, independence, and Bayes' Theorem, which are fundamental concepts in probability theory.

The course also delves into the probability distribution of discrete and continuous random variables. These distributions include binomial, Poisson, geometric, hypergeometric, rectangular (uniform), and negative exponential. Expectations and moments of random variables, along with Chebyshev's inequality, are also discussed in detail. The course concludes with a thorough exploration of joint, marginal, and conditional distributions, and moments. Finally, the course introduces limiting distributions, discrete and continuous random variables, standard distributions, moments, and moment-generating functions, along with the laws of large numbers and the central limit theorem.

**Objectives**

1. To apply permutation and combination techniques to solve complex problems involving arrangements and selections.

2. To identify and differentiate between various probability laws, such as the law of total probability and the law of conditional probability and use them to solve probability problems.

3. To apply Bayes' theorem to calculate conditional probabilities and understand the basic probability distribution for discrete and continuous random variables, including the binomial, Poisson, and geometric distributions.

4. To calculate expectations and moments of random variables and understand their significance in probability theory.

5. To explain Chebyshev's inequality and apply it to real-life situations to estimate the likelihood of an event occurring.

6. To explain joint, marginal, and conditional distributions and moments and understand limiting distributions.

7. To describe standard distributions, such as the normal distribution, and understand the significance of moments and moment-generating functions in probability theory.

8. To explain the laws of large numbers and the central limit theorem and understand their applications in statistics and probability theory.

**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. explain Chebyshev’s inequality and apply it to real life situations;

6. explain joint marginal and conditional distributions and moments as well as Limiting distributions;

7. describe standard distributions, moments and moment-generating functions; and

8. explain laws of large numbers and the central limit theorem.

**Course Contents**

Further permutation and combination. probability laws. conditional probability, 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.

**BUK-COS 202: Computer Programming II (3 Units C: LH=30, LP=45)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

BUK's mission to address the dearth of computer programmers in the country is being fulfilled through the training of high-quality graduates who possess a strong foundation in computer programming. This has resulted in marked improvement among BUK Mathematics graduates with skillful computational capabilities, who are now poised to make their mark in the global Mathematics/Computing community.

**Overview**

The course begins with a review of polymorphism, abstract classes, and interfaces, which are fundamental concepts in object-oriented programming. Class hierarchies and program organization using packages and namespaces are also covered, allowing students to develop more complex programs. The course also covers the use of APIs, including iterators, enumerators, lists, stacks, and queues. Searching, sorting, and recursive algorithms are explored in depth, along with event-driven programming and exception handling. The applications of these concepts in graphical user interface (GUI) programming are also discussed.

**Lab work**:The lab work for this course includes programming assignments that allow students to practice problem-solving and program development with an emphasis on object-orientation. Students will learn to solve basic problems using both static and dynamic data structures, and various searching and sorting algorithms using iterative and recursive approaches. The course also provides an introduction to GUI programming, allowing students to develop practical skills in creating graphical user interfaces. Overall, this course provides a solid foundation in advanced object-oriented programming, preparing students for a range of programming challenges in the real world.

**Objectives**

1. To apply object-oriented programming principles to solve a range of programming problems, such as data processing, algorithm development, and application development.

2. To use modules, packages, and namespaces to organize their programs effectively and make them more maintainable and reusable.

3. To use APIs (Application Programming Interfaces) to leverage existing libraries and frameworks and write more efficient and effective applications.

4. To apply divide and conquer strategies to searching and sorting problems using iterative and/or recursive solutions, enabling them to write more efficient and scalable programs.

5. To explain the concept of exceptions in programming and understand how to handle exceptions in programs effectively, reducing the likelihood of runtime errors and improving the reliability of their applications.

6. To write simple multithreaded applications, enabling them to take advantage of multi-core processors and write programs that can perform multiple tasks simultaneously.

7. To design and implement simple GUI applications, giving them the skills, they need to create user-friendly programs that can interact with users in intuitive ways.

**Learning Outcomes**

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

1. develop solutions for a range of problems using object-oriented programming;

2. use modules/packages/namespaces for programmeorganisation;

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; and

7. design and implement simple GUI applications.

**Course Contents**

This course is a continuation of CSC201. Review and coverage of advanced object-oriented programming - polymorphism, abstract classes and interfaces. Class hierarchies and programmeorganisation 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.

**BUK-MTH 201: Sets, Logic, and Algebra II(2 Units C: LH=30)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

Training high-quality graduates with a strong foundation in set theory, logic, and algebra is in line with BUK's mission to address the problem of inadequate manpower among Mathematics teachers and to produce Mathematical Scientists needed for research in both Mathematics and Mathematics related fields that will propel the much-needed Science and Technological developments in the country. Top-notch performance has been observed in Mathematics students from BUK who can represent the nation in the international Mathematics community.

**Overview**

Sets, Logic and Algebra II covers the fundamental concepts of set theory, logic and algebra. It offers background knowledge needed to recognize and interpret concepts in analysis, algebra, topology, and various other aspects of Mathematics.

Throughout the course, students are trained in problem-solving and Mathematical reasoning, as well as acquiringa solid foundation in the language and concepts of Mathematics.

**Objectives**

1. To introduce students to the basics of sets theory, logic and algebra.
2. To develop problem-solving skills and Mathematical reasoning abilities in students.
3. To make students versed in reading, writing and presenting Mathematical arguments.
4. To effect familiarity with set notions, notations and terminologies.
5. To introduce student to the application of propositional logic such as circuit design and automated reasoning.
6. To prepare students for more advanced Mathematics courses.

**Learning Outcomes**

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

1. have a firm grasp on techniques of problem solving in set theory and be able to use them solve real life problems;
2. solve problems involving countability of sets, cardinal numbers, Bernstein Theorem and divisibility of integers;
3. solve mathematical problems using set theory, propositional logic, and algebra;
4. have a deeper understanding of methods of mathematical proofs;
5. acquire basics of divisibility and factorization of integers.

**Course Contents**

Further Set Theory, Logic and Algebra: Cardinal numbers, Bernstein Theorem, infinite sets, countability; Propositional logic: Truth tables and logical equivalences, Normal Forms and Simplification of Propositional Formulas, Logical Connectives (conjunction, disjunction, negation, implication, equivalence), validity, satisfiability, and tautologies, logical consequence and deduction rules, applications of propositional logic (circuit design, automated reasoning). Quantification theory; universal and existential quantifiers. Divisibility and unique factorization of integers.

**BUK-MTH 202: History and Philosophy of Mathematics (2 Units C: LH=30)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

BUK's goal of training high-quality graduates with a good knowledge and appreciation of History and Philosophy of Mathematics aligns with its mission to address the shortage of Mathematics teachers in the country. As a result, Mathematics students from BUK have shown improvement and are equipped to represent the nations in the global Mathematics community.

**Overview**

History and Philosophy of Mathematics is a course that explores the historical developments and Philosophical foundations of Mathematics. It examines the chronological development of Mathematical ideas, the role of Mathematics in society, and the Philosophical issues related to Mathematical knowledge and practice.

This course is designed to expose students to the historical developments of various aspects of Mathematics.

**Objectives**

* + - 1. To makestudents recognize the historical development of Mathematics and its impact on society.
      2. To give students a deeper insight into the origin of Mathematics.
      3. To make students identify the contributions of some great founding fathers of Mathematics.
      4. To develop critical thinking skills by analyzing and evaluating historical and Philosophical arguments.
      5. To apply historical and Philosophical insights to contemporary Mathematical problems.

**Learning Outcomes**

On successful completion of this course, students will be able to:

1. explain the origin of Mathematics;

2. appraise the contributions of some great founding fathers of Mathematics;

3. appreciateMathematics as a tool for development of humanity;

4. distinguish between Mathematics and other science disciplines;

5. explain the history of modern mathematicians and their contributions in the development of Mathematics;

6. acquire how to learn and excel in Mathematics.

**Course contents**

Mathematics: Definition of Mathematics based on some founding fathers of Mathematics. Fantastic facts about some founding fathers of Mathematics. Philosophy of Mathematics: The different Philosophies of Mathematics. The contributions of Arabs, Babylonians, Chinese, Egyptians, French and Greeks to Mathematics. The importance of critical thinking in Mathematics. The beauty of Mathematics. Mathematics as a discipline. Branches of Mathematics. The integration of Mathematics with computer as an electronic machine. Mathematics as a tool for human development. Mathematics of the 20th century; Hilbert problems, Poincare conjuncture, Fermat's last theorem, mathematical theory of dynamical systems.

**BUK-MTH 301: Introduction to Mathematical Computing (3 Units C: LH=30, PH=45)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

The training of high-quality graduates with a strong foundation in Mathematical Computing is in accordance with BUK's mission to combat the shortage of Mathematics teachers and scientists related researchers in the country. This approach has yielded results, as BUK Mathematics students are now capable of representing the nation on the global stage.

**Overview**

This course introduces basic computer programming concepts and techniques useful to Mathematicians. The course exposes students to practical applications of computing and commonly used tools. It introduces techniques for problem-solving design and algorithm development.

**Objectives**

1. To introduce students to the basic principles of programming in MATLAB for solving mathematical problems.

2. To recognize how to design and implement simple algorithms using MATLAB.

3. To develop students' skills in writing simple programs in MATLAB.

4. To enable students to use MATLAB effectively for analyzing and visualizing data.

5. To demonstrate how to implement loops, branching, control instruction, and functions in MATLAB.

6. To prepare students to create and control simple plots and user-interface graphic objects in MATLAB.

7. To provide students with the skills to perform basic simulation using MATLAB.

**Learning Outcomes**

On successful completion of this course students will be able to:

1. describe the basic principles of writing MATLAB programs to solve mathematical problems;

2. design and implement simple algorithms using MATLAB;

3. write simple programs using the MATLAB;

4. use the MATLAB effectively to analyze and visualize data;

5. implement loops, branching, control instruction and functions in MATLAB;

6. create and control simple plots and user-interface graphic objects in MATLAB;

7. perform basic simulation using MATLAB.

**Course Contents**

**MATLAB (15 hours)** Basic MATLAB programming: introduction MATLAB environment and help system, basics of MATLAB interface and syntax, data types and scalar variables, arithmetic and mathematical functions, input and output, selection and iteration statements. Control structures. Functions: user defined functions, function files, passing information to and from functions, function design and program decomposition, recursion. Arrays: vectors, arrays and matrices, array addressing, vector, matrix and element-by element operations. Graphics: 2-D and 3-D plotting. Numerical methods in MATLAB such as root-finding, optimization and differential equations.

**PRACTICALS (45 hours)** MATLAB exercises; working with matrices, mathematical expressions (variables, numbers, operators, functions), vectorization, relational and logical operators, plotting functions, complex and statistical functions, input/output of variables (numbers and strings), flow control, MATLAB Simulink basic.

**BUK-MTH 401: Research Methodology (1 Unit C: LH=15)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

By prioritizing the training of high-quality graduates with a solid grounding in Mathematics research, BUK is addressing the dearth of qualified Mathematics teachers and Mathematical Scientists in the country. The outcome has been an improvement in the abilities of BUK Mathematics students, who are now well-suited to represent the nation in the international Mathematics community.

**Overview**

Research Methodology is a course that teaches students the skills and techniques necessary to conduct and present research in Mathematics effectively. It covers the entire research process, from formulating research questions to analysis, evaluating results and communicating findings.

**Objectives**

1. To equip students with basic skills for reading and understanding Mathematics research articles and technical reports.
2. To enable students to discover, verify and test new facts related to Mathematics.
3. To acquire skills on how toanalyze given facts or concepts and how to reach conclusions.
4. To enable students keep up with most recent trends in Mathematics by reading and studyingMathematical literature.
5. To provide students with skills for effective use of open sourcesoftware for writing mathematical research findings.
6. To recognize students how to propose and write novel research proposals.
7. To enable students to present research talks with clarity and precision.

**Learning Outcomes**

On successful completion of this course, students will be able to:

1. readMathematics articles/technical reports;

2. discover, verify and test new facts;

3. analyze a given fact(s), or concept(s) and how to reach a conclusion;

4. read and understand most recent trends in Mathematics;

5. effectively use open-source software to write mathematical research findings;

6. propose and write novel research proposal;

7. present a research talk.

**Course Contents**

Scientific research and literature survey. Finding and solving research problems, role of a supervisor, survey of a research topic, research proposal; basic component of research; introduction to scientific reading and writing, copyright issues, ethics, and plagiarism. major parts of project writing; research tools. Searching google (query modifiers), MathSciNet, ZMATH, Scopus, ISI Web of Science, impact factor, h-index, Google Scholar, ORCID, JStor, online and open access journals, virtual library of various countries, article review and research talk.

**BUK-MTH 402: Discrete Mathematics (3 Units E, LH=45)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

BUK's mission to address the dearth of Mathematics teachers in the country is being fulfilled through the training of high-quality graduates who possess a strong foundation in Discrete Mathematics. This has resulted in marked improvement among BUK Mathematicsgraduates, who are now poised to make their mark in the global Mathematics community.

**Overview**

Discrete Mathematics focuses on the study of Discrete Mathematical structures such as sets, graphs, and algorithms. The course covers various topics including combinatorics, graph theory, and algorithms.

Through this course, students will learn to apply Mathematical tools, such as counting techniques, graph algorithms, and logical reasoning to solve problems in Discrete Mathematics. They will also learn to analyze the properties of discrete Mathematical structures and use them to prove theorems and solve problems.

**Objectives**

1. To explain the basic concepts of discrete Mathematics, including combinatorics, graph theory, and algorithms.
2. To enable students to apply mathematical tools, such as counting techniques, graph algorithms, and logical reasoning, to solve problems in discrete Mathematics.
3. To equip students with the ability to analyze the properties of discrete mathematical structures, such as graphs and sets, and use them to prove theorems and solve problems.
4. To enable students to design and analyze algorithms to solve problems in discrete Mathematics, and to evaluate their efficiency using asymptotic notation.
5. To appreciate applications of Mathematics in real life.

**Learning Outcomes**

On successful completion of this course, students will be able to:

1. distinguish the basic concepts of discrete Mathematics, including combinatorics, graph theory and algorithms;

2. apply mathematical tools, such as counting techniques, graph algorithms, and logical reasoning, to solve problems in discrete Mathematics;

3. analyze the properties of discrete mathematical structures, such as graphs and sets, and use them to prove theorems and solve problems;

4.design and analyze algorithms to solve problems, and evaluate their efficiency using asymptotic notation.

5. practice the use of discrete Mathematics in real life.

**Course Contents**

Combinatorics; Permutations and combinations, the pigeonhole principle, inclusion-exclusion principle, and generating functions. Graphs; Directed and un-directed graphs, subgraphs, cycles, connectivity, Eulerian and Hamiltonian graphs, planar graphs, and colouring. Application (flow Charts) and state transition graphs; lattices and Boolean Algebra, Finite fields: Mini polynomials. Irreducible polynomials, polynomial roots, Application (error-correcting codes, sequences generators). Algorithms and Complexity: Algorithm design, analysis of algorithms, asymptotic notation, and NP-completeness.

**BUK-MTH 403: Operation Research (3 Units E: LH=45)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

To tackle the shortage of Mathematicsspecialists for both teaching and research in the country, BUK is focusing on training high-quality graduates with a sound understanding of Operations Research. The success of this approach is evident in the performance observed among BUK Mathematics students, who are now capable of representing the nation internationally.

**Overview**

This course introduces students to the field of Operations Research (OR) and its role in decision-making. It covers various techniques and methods used in OR, including Linear Programming, Network Analysis, Integer Programming, Decision Analysis, and Simulation.

**Objectives**

1. To identify the different OR methods and techniques, their strengths and weaknesses, and their applications in decision-making.
2. To enable students to formulate OR problems, apply appropriate OR techniques to solve the problems, and interpret the results.
3. To equip students with the ability to analyze the complexity and feasibility of OR models and methods and evaluate their limitations and assumptions.
4. To enable students to evaluate the ethical and social implications of OR models and methods and make informed decisions based on the results.
5. To equip students with the relevant effective communication skills to communicate the use of OR models and methods in written and oral forms and explain their results to a non-technical audience.

**Learning Outcomes**

On successful completion of this course students will be able to:

1. explain the different OR methods and techniques, their strengths and weaknesses, and their applications in decision-making;

2. formulate OR problems, apply appropriate OR techniques to solve the problems, and interpret the results;

3. analyze the complexity and feasibility of OR models and methods, and evaluate their limitations and assumptions;

4. evaluate the ethical and social implications of OR models and methods, and make informed decisions based on the results;

5. communicate the use of OR models and methods in written and oral form and explain their results to a non-technical audience.

**Course Contents**

Introduction to Operations Research (OR): Overview, scope and applications, and the role of OR in decision-making. Linear Programming: Formulation of linear programming problems, graphical method, simplex method, duality theory, and sensitivity analysis. Network Analysis: Shortest path problems, maximal flow problems, and minimum cost flow problems. Integer Programming: Formulation of integer programming problems, branch and bound method, cutting plane method, and applications. Decision Analysis: Decision-making under uncertainty, decision trees, expected value of perfect information, and risk analysis. Simulation: Simulation modeling, Monte Carlo simulation, and applications.

**BUK-MTH 404: Dynamical Systems (3 Units E: LH=45)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

By training high-quality graduates with a solid background in Dynamical Systems, BUK is fulfilling its mission to address the paucity of Mathematics teachers and Mathematical Scientists to conduct cutting-edge research in Mathematics and Mathematical-related fields for national developments. This has led to notable improvements in the abilities of BUK Mathematicsgraduates, who are now ready to represent the nation in the global Mathematics community and to help in national development.

**Overview**

The course Dynamical Systems is designed to introduce undergraduate students to the principles and applications of dynamical systems, which are mathematical models used to describe the behavior of complex systems over time. Students will develop a clear understanding of the basic concepts of dynamical systems and the different types of systems. They will learn to analyze the behavior of these systems using mathematical tools such as linear algebra, differential equations, and bifurcation theory, as well as computational tools such as MATLAB, Python and Maple.

Students will also learn how to apply their knowledge of dynamical systems to solve real-world problems, evaluate the limitations and assumptions of the models, and communicate their findings clearly and effectively. This course will prepare students for further studies in areas such as physics, engineering, and Mathematics, as well as careers in fields such as data analysis, systems modeling, and scientific research.

**Objectives**

1. To explain the basic concepts of dynamical systems, including the different types of dynamical systems.
2. To analyze the behavior of dynamical systems using mathematical tools such as linear algebra, differential equations, and bifurcation theory.
3. To develop proficiency in the use of computational tools such as MATLAB, Python and Maple to simulate and visualize the behavior of dynamical systems.
4. To apply knowledge of dynamical systems to solve real-world problems and evaluate the limitations and assumptions of the models.
5. To develop effective communication skills in written and oral form to clearly articulate their understanding of dynamical systems.

**Learning Outcomes**

On successful completion of this course, students will be able to:

1. distinguish between the basic concepts of dynamical systems and the different types of dynamical systems;

2. analyze the behavior of dynamical systems using mathematical tools such as linear algebra, differential equations, and bifurcation theory;

3. use computational tools such as MATLAB or Python to simulate and visualize the behavior of dynamical systems;

4. apply their knowledge of dynamical systems to solve real-world problems and evaluate the limitations and assumptions of the models;

5. communicate the use of dynamical systems in written and oral form.

**Course Contents**

Introduction to Dynamical Systems: Definition of dynamical systems, examples of dynamical systems, and classification of dynamical systems based on their properties. One-dimensional Dynamical Systems: Iterated functions and periodic points. Linear Systems: Linear algebra review, eigenvalues and eigenvectors, matrix exponentials, and stability analysis of linear systems. Nonlinear Systems: Nonlinear algebra review, fixed points, limit cycles, bifurcations, and chaos. Applications of Dynamical Systems: Examples from Physics, Engineering, Biology, and Economics.

**BUK-MTH 405: Group Theory (3 Units E: LH=45)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

BUK's mission to address the shortage of Mathematics teachers and Mathematical Scientists with requisite Mathematical knowledge to engage in research in Mathematics and Mathematics related fields in the country is being achieved through the training of high-quality graduates with a strong foundation in Group Theory. As a result, BUK Mathematics students have exhibited great abilities and are now well-prepared to help in national development and represent the nation in the international Mathematics community.

**Overview**

The course Group Theory is designed to introduce undergraduate students to the principles and applications of group theory in Mathematics. The course will cover the basic concepts of group theory, including group structures, subgroup structures, and homomorphisms. The course will explore the various properties and characteristics of groups and the ways in which they can be used to solve problems in different areas of Mathematics.

**Objectives**

On successful completion of this course, students will be able to:

1. develop the ability to solve problems using the orbit-stabilizer theorem and Burnside's lemma.
2. apply Sylow's theorems to solve problems.
3. gain familiarity with solvable and nilpotent groups, simple groups, and their classification.
4. recognize of representation theory, free groups and presentations, and finitely generated abelian groups.
5. apply group theory to solve problems in Physics, Chemistry, Cryptography, and combinatorics.

**Learning Outcomes**

On successful completion of this course, students will be able to:

1. explain group actions, use orbit-stabilizer theorem and Burnside's lemma to solve problems;

2. apply Sylow's theorems, and ability to apply them to problems;

3. identify solvable and nilpotent groups, simple groups and their classifications;

4. explain representation theory, free groups and presentations, and finitely generated abelian groups;

5. apply group theory to problems in Physics, Chemistry, Cryptography, and combinatorics.

**Course Contents**

Group Actions: Definition and examples of group actions, orbit-stabilizer theorem, Burnside's lemma, Sylow's theorems, applications. Direct product of groups: Definition, examples and properties. Groups of small order. Solvable and nilpotent groups, simple groups, classification of finite simple groups, representation theory, free groups and presentations, finitely generated abelian groups. Group Theory Applications: Symmetry groups, group theory in Physics, Cryptography, coding theory, and combinatorics.

**BUK-MTH 406: Classical Theory of Numbers (3 Units E: LH=45)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

In order to address the lack of qualified Mathematics teachers and Mathematical Scientists with requisite Mathematical knowledge to engage in research in Mathematics related fields in the country, BUK is focusing on training high-quality graduates with a solid understanding in Theory of Numbers. This approach has yielded positive results, as BUK Mathematics students have demonstrated excellent grasp of Mathematics and are now capable of playing leading role in national developments and representing the nation in the global Mathematics community.

**Overview**

This course covers a range of number theory topics, including congruences and residues, linear congruences in one variable, methods of solving systems of linear congruences, and Diophantine problems such as linear Diophantine equations and the Pell equation.

Students will also learn about quadratic residues for prime and composite moduli, continued fractions and real numbers, and number-theoretic functions like Euler's totient function and divisor functions. The course will also cover Waring's Problems, integer partitions, and cryptography topics like the RSA cryptosystem and elliptic curve cryptography.

**Objectives**

1. To develop a clear understanding of the fundamental concepts of classical number theory, such as congruences and modular arithmetic.
2. To apply appropriate techniques and methods, such as Euclid's algorithm, the Chinese Remainder Theorem, and quadratic reciprocity, in solving problems in number theory.
3. To be able to analyze the properties of number-theoretic functions and their applications to cryptography, including primality testing and factorization algorithms.
4. To be able to evaluate the validity of number-theoretic conjectures and theorems, and understand the implications of their proofs, including Fermat's Last Theorem and the ABC conjecture.
5. To communicate number theory concepts and methods in written and oral form and explain their solutions to a non-technical audience.

**Learning Outcomes**

On successful completion of this course, students will be able to:

1. explain the fundamental concepts of classical number theory, such as congruences;

2. solve problems in number theory using appropriate techniques and methods, such as Euclid's algorithm, the Chinese Remainder Theorem, and quadratic reciprocity;

3. analyze the properties of number-theoretic functions and their applications to cryptography;

4. evaluate the validity of number-theoretic conjectures and theorems, and the implications of their proofs;

5. communicateproblem solving using number theory concepts and methods in written and oral form and explain their solutions to a non-technical audience.

**Course Contents**

Congruences and residues; linear congruences in one variable (definition, examples, existence of solution and methods of finding solutions). Methods of solving system of linear congruences in one variable. The Chinese Remainder Theorem, and Wilson's Theorem. Diophantine problems (linear Diophantine equation and system of linear Diophantine equations) Pythagorean triples, Fermat's Last Theorem, and the Pell equation. Quadratic residues for prime and composite moduli (Legendre’s symbol, quadratic reciprocity, Gauss’ lemma and Jacobi’s symbol), quadratic reciprocity, and applications. Continued fractions and real numbers. Number-theoretic Functions: Euler's totient function, divisor functions, and Mobius inversion formula. Arithmetic Functions (Multiplicative and Additive functions with their examples). Waring’s Problems; Integer partitions. Cryptography: RSA cryptosystem and its security, discrete logarithm problem, and elliptic curve cryptography.

**BUK-MTH 407: Numerical Linear Algebra(3 Units E: LH=30, PH=45)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

BUK's goal of addressing the shortage of Mathematics teachers and Mathematical Scientists with relevant competencies in computational Mathematics in the country is being realized through the training of high-quality graduates with a sound understanding of Numerical Linear Algebra. This has led to outstanding performance by BUK Mathematics students, who are now poised to make a name for themselves in the international Mathematics community and steady to help with national development.

**Overview**

Driven by the needs of applications, this course studies reliable and computationally efficient numerical techniques for practical linear algebra problems,as well as traditional theoretical assessment of the algorithms studied, a suitable programming language is used to perform practical experiments to complement students’ insight into the subject.

At level 200, students are taught standard techniques for basic linear algebra tasks including finding the solution of linear systems, finding eigenvalues/eigenvectors and orthogonalization of bases. However, these techniques are usually computationally too intensive to be used for the large matrices encountered in practical applications. This course will introduce students to these practical issues, and will present, analyze, and apply algorithms for these tasks which are reliable and computationally efficient. The course includes significant lab work using a suitable programming language.

**Objectives**

1. To recognize the fundamental concepts of matrix factorization and their applications, including solving linear systems and data analysis.
2. To apply iterative methods to solve linear systems and evaluate their efficiency in terms of computational cost.
3. To use numerical methods to compute eigenvalues and eigenvectors of matrices and apply them to solve problems in various fields.
4. Apply least squares methods to solve real-world problems in data analysis.
5. To analyze the computational cost and efficiency of algorithms used in numerical linear algebra.
6. To implement matrix factorization and numerical methods using a programming language and develop proficiency in programming and numerical computation.
7. To apply numerical linear algebra methods to real-world problems in different fields, and communicate the results effectively in written and oral form.

**Learning outcomes**

On successful completion of this course, students will be able to:

1. explain matrix factorization methods and their applications;

2. apply iterative methods for solving systems of linear equations;

3. apply numerical methods for computing eigenvalues and eigenvectors of matrices and apply them to various problems.

4. solve basic least squares problems and apply to data analysis;

5. analyze the computational cost of an algorithm and discuss its computational efficiency;

6. implement the numerical methods with the programming language used in the course;

7. apply numerical linear algebra to real-world problems in different fields.

**Course Contents**

**Lectures (30 Hours)** Vector and Matrix norms; singular value decomposition; Gram-Schmidt Orthonormalization; Conditioning and stability; least squares problems; LU decomposition; Cholesky decomposition; Jacobi method; Gauss-Seidel method; SOR iteration; convergence of basic iterative methods; Generalized eigenvalue problems; Krylov subspace methods; QR method; power method; Arnoldi, Lanczos Eigenvalue algorithms.

**Practical (45 hours)**

Focused on matrix computations, LU decomposition implementation. **Application 1** - Least squares for polynomial fitting, **Application 2** - Scattered-Data Interpolation (RBF). The power method. QR decomposition. **Application 3** - Principal component analysis (PCA), **Application 4** - PCA-based feature selection, **Application 5**- eigenfaces for face image recognition with PCA.  **Application 6-** Image and Signal processing.

**BUK-MTH 408: Unconstrained Optimization Methods (3 Units E: LH=45)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

By prioritizing the training of high-quality graduates with a strong background in Optimization methods, BUK is fulfilling its mission to combat the shortage of Mathematical Scientists needed for both research and teaching in the country. As a result, BUK Mathematics students have shown excellent understanding and are now well-equipped to contribute to nation building and represent the nation in the global Mathematics community.

**Overview**

Unconstrained Optimization Methods is a course that introduces students to the fundamental concepts, techniques, and applications of optimization theory. In this course, students will learn about various optimization algorithms that are used to solve unconstrained optimization problems. They will learn about the basic concepts of optimization theory, including optimality conditions among others.

Students will also learn about optimization applications in machine learning, data science, and engineering. By the end of this course, students will have a solid understanding of unconstrained optimization methods and be able to apply them to solve real-world problems.

**Objectives**

1. Gaining a clear grasp of the principles of unconstrained optimization and the types of problems encountered.

2. Developing skills in applying one-dimensional search methods to solve optimization problems.

3. Acquiring the ability to apply gradient-based methods such as steepest descent methods, Newton's method, and quasi-Newton methods, conjugate gradient methods to optimize unconstrained objective functions.

4. Recognizing the principles of stochastic gradient descent method and applying it to optimize unconstrained objective functions in machine learning and deep learning.

5. Being able to apply unconstrained optimization methods to real-world problems such as least squares regression and maximum likelihood estimation.

**Learning Outcomes**

On successful completion of this course students will be able to:

1. distinguish between the basic principles of unconstrained optimization and the types of unconstrained optimization problems;

2. apply one-dimensional search methods such as bracketing and interpolation methods to solve unconstrained optimization problems;

3. apply gradient-based methods such as steepest descent, Newton's method, and quasi-Newton methods, conjugate gradient methods to optimize unconstrained objective functions;

4. describe the principles of stochastic gradient descent and apply it to optimize unconstrained objective functions in machine learning and deep learning;

5. apply unconstrained optimization methods to real-world problems such as least squares regression and maximum likelihood estimation.

**Course Contents**

Definition of unconstrained optimization, examples of unconstrained optimization problems. One-dimensional search methods; Bisection method, Golden section search, Newton's, Secant method. Gradient based methods: Steepest descent, Newton’s method, quasi-Newton methods, conjugate gradient methods. Line search methods; Wolfe condition, Armijo rule, backtracking line search. Stochastic gradient descent; introduction to machine learning and neural networks, stochastic gradient descent for deep learning. Applications of unconstrained optimization; Least squares regression, Maximum likelihood estimation.

**BUK-MTH 409: Fluid Dynamics (3 Units E: LH=45)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

By prioritizing the training of high-quality graduates with a strong background to assess the engineering value of various approximation procedures, BUK is fulfilling its mission to combat the shortage of Mathematical Scientists needed for both research and teaching in the country. As a result, BUK Mathematics students have shown excellent understanding and are now well-equipped to contribute to nation building and represent the nation in the global Mathematics community.

**Overview**

This course provides an introduction to fluid dynamics and covers a range of topics related to fluid behavior, including the kinematics of the flow field, dimensional analysis, equations of motion, and continuity for incompressible inviscid fluids.

Students will also explore the concepts of velocity potentials and Stoke's Stream functions, as well as Bernoulli's equation and Cauchy-Bernoulli integral for unsteady flows. In addition, the course will cover two-dimensional flows, including complex potential limiting streamlines, images and rigid planes, Lagrangian and Eulerian variables, streamlines and path lines, vorticity and circulation, and the continuity equation. Students will also learn about the stream function and how to calculate the mass flux in 2D flows.

**Objectives**

1. To comprehend the fundamental concepts of fluid dynamics and the behavior of fluid particles.
2. To learn the kinematics of the flow field and apply dimensional analysis to fluid problems.
3. To learn how to derive and analyze the equations of motion and continuity for incompressible inviscid fluids.
4. To apply the concepts of velocity potentials, Stoke's Stream functions, and Bernoulli's equation to fluid problems.
5. To analyze two-dimensional flows, including complex potential limiting streamlines, images and rigid planes, and Lagrangian and Eulerian variables.

**Learning Outcomes**

On successful completion of this course, students will be able to:

1. explain the fundamentals of fluid flow and its properties;

2. explain the fundamentals of fluid flow application;

3. apply basic laws and equations that are used in the analysis of fluid flow;

4. use dimensional analysis to determine the correctness of equations used in describing fluid flow.

5. analyze various types of two-dimensional flows.

**Course Contents**

Real and Ideal fluids.The notion of fluid particle. Kinematics of the flow field. Dimensional analysis. Equations of motion and continuity for incompressible inviscid fluids. Velocity potentials and Stoke's Stream functions. Bernoulli’s equation, Cauchy-Bernoulli integral for unsteady flows. Two-dimensional flows. Complex potential limiting streamlines. Images and rigid planes. Lagrangian and Eulerian variables. Streamlines and path lines. Vorticity and circulation. The continuity equation. Stream function and calculation of the mass flux in 2D flows.

**BUK-MTH 410: Biomathematics(3 Units E: LH=45)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

To address the lack of qualified Mathematical Biology teachers and Mathematical Scientists with requisite Mathematical knowledge to engage in research in Mathematical Biology and related fields in the country, BUK is focusing on training high-quality graduates with a solid acquaintance in Theory of Numbers. This approach has yielded positive results, as BUK Mathematics students have demonstrated excellent grasp of Mathematics and are now capable of playing leading role in national developments and representing the nation in the global Mathematics community.

**Overview**

This course introduces role of Mathematics in Biology and Medicine covers a range of topics related to Biological Sciences, Population dynamics, Modeling Concept of agent-based modeling and mathematical Genetics among others.

This course will provide to the student the knowledge of essential modeling skills and methodology for the study of infectious diseases through.

**Objectives**

1. To introduce to the students to the application of Mathematical modeling in the analysis of biological systems/phenomena.

2. To show how Mathematics can be used to analyze biological systems.

3. To equip students with skills in algebraic manipulation of linear and non-linear differential equations.

4. To learn how to analyze and interpret the results of mathematical models of biological systems.

5. To introduce students to the use of simulation software for the analysis of biological processes through simple computer programming.

**Learning Outcomes**

At the end of the course, the students will be able to

1. appraise the significance of Mathematics in real life;

2. construct mathematical models for biological systems;

3. use mathematical techniques in the analysis of mathematical models in Biology;

4. apply critical thinking to address problems in an interdisciplinary group;

5. apply mathematical modeling in the analysis of biological systems including populations of molecules, cells and organisms.

**Course Contents**

The role of Mathematics in Biology and Medicine with some examples. Mathematical models in ecology: Population dynamics (continuous and discrete time), Interactions of species; competition, predation, mutualism and symbiosis. Mathematical Genetics: Hardy-Weinberg law, Genetics matrices. Bayers theorem and its applications to Genetics.Mathematical theory of epidemics: SI, SIS and SIR epidemic models, fitting data to epidemic models. Introduction to enzyme-Kinetics. An introduction to Agent Based Modeling Concept of agent-based modeling, the modeling environment, building simple models for biological systems/phenomenon.

**BUK-MTH 411: Introduction to Data Science (3 Units E: LH=45)**

**Senate-approved relevance to vision, mission, strategic goals, uniqueness and contextual peculiarities of the university**

To address the lack of qualified Mathematical Scientists with requisite Mathematical knowledge to engage in research in data science and related fields in the country, BUK is focusing on training high-quality graduates with a solid understanding in Theory of Numbers. This approach has yielded positive results, as BUK Mathematics students have demonstrated excellent grasp of Mathematics and are now capable of playing leading role in national developments and representing the nation in the global Mathematics community.

**Overview**

Data Science is a multidisciplinary field that utilizes scientific inference and mathematical algorithms to extricate important insights from a lot of structured and unstructured data. These algorithms are actualized by means of computer programs which are generally run on amazing hardware since it requires a lot of processing. Data Science is a blend of statistical mathematics, machine learning, data analysis and visualization, domain knowledge and computer science. As it is evident from the name, the most significant segment of Data Science is “Data” itself. No amount of algorithmic computation can draw important bits of knowledge from inappropriate information. Data science includes different sorts of information, for instance, image data, text data, video data, time-dependent data, etc. Efficient data scientists can recognize significant inquiries, gather information from a large number of data sources, sort out the data, translate results into solutions, and communicate their findings in a way that emphatically influences business choices. These abilities are required in practically all industries, making talented data scientists be progressively valuable to organizations.

**Objectives**

1. To learn how to identify the key components of Data Science and its application in various industries.
2. To perform Exploratory Data Analysis (EDA) using appropriate techniques and tools.
3. Demonstrate proficiency in the Supervised Learning algorithm, Support Vector Machine (SVM).
4. To implement Linear Regression using appropriate machine learning tools and libraries.
5. To analyze and interpret data to extract meaningful insights and make informed decisions.
6. To grasp/evaluate the performance of machine learning models using appropriate metrics.
7. To communicate with findings and results effectively to technical and non-technical audiences.
8. To develop a strong foundation in statistics and programming languages commonly used in data science.
9. To apply ethical considerations and best practices in data science, such as data privacy and bias detection.
10. To equip on how to collaborate effectively with cross-functional teams to deliver data-driven solutions.

**Learning Outcomes**

1. describe what Data Science is and the skill sets needed to be a data scientist;

2. explain the significance of exploratory data analysis (EDA) in data science;

3. acquire the ability to learn the supervised learning, SVM;

4. apply basic machine learning algorithms (Linear Regression);

5. learn how to use Python/R for data manipulation and visualization.

**Course Contents**

Supervised Learning: First step, learning curves, training-validation and test. Learning models generalities, support vector machines, random forest. Examples. Modeling: Regression analysis, Regression: linear regression simple linear regression, multiple & Polynomial regression, Sparse model. Unsupervised learning, clustering, similarity and distances, quality measures of clustering, case study. Programming: Introduction, Toolboxes: Python/R, fundamental libraries for data Scientists. Integrated development environment (IDE). Data operations: Reading, selecting, filtering, manipulating, sorting, grouping, rearranging, ranking, and plotting.