**Bayero University, Kano**

**Engineering**

**Mechatronics Engineerin**

**BUK-Engineering-B-Eng-Mechatronics**

# Course Summary (30% Core)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Level** | **GST/ENT** | **Basic Science** | **Discipline/ GET** | **Programme (MCE)** | **SIWES\*** | **Total Units** |
| 100 | - |  |  | 6 | - | 6 |
| 200 |  | - | 3 | 2 |  | 5 |
| 300 |  |  | 3 | 7 |  | 10 |
| 400 | - | - | - | 11 |  | 11 |
| 500 | - | - |  | 6 | - | 6 |
| **Total** | **0** | **0** | **6** | **32** | **0** | **38** |

**100 Level**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Course Code** | **Course Title** | **Units** | **Status** | **LH** | **PH** |
| 1 | BUK-PHY103 | Elementary Mathematics III (Vectors, Geometry and Dynamics) | 2 | C | 30 |  |
| 2 | BUK-PHY 102\* | General Physics II (Elec. & Mag.) | 2 | C | 30 | - |
| 3 | BUK-MCE 104 | Introduction to Python programming | 2 | C | 30 | 45 |
|  |  | Total | 6 |  |  |  |

Notes:

1. COREN request the addition of STA 112 - Probability I in Level 100. The department recommends that it should me be merged with CCMAS GET 305: Engineering Statistics and Data Analytics
2. COREN also recommends addition of PHY-104 (General Physics III). The department recommends merging this course with BUK-MCE 501 (Mechanical Vibration).

**200 Level**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Course Code** | **Course Title** | **Units** | **Status** | **LH** | **PH** |
| 1 | BUK-MCE 201 | Introduction to MATLAB Programming | 2 | C | 30 | - |
| 2 | BUK-MCE 202 | Dynamics | 2 | C | 30 | - |
| 3 | BUK-GET 208 | Strength of Materials | 3 | C | 45 | - |
|  |  | **Total** | **7** |  |  |  |

**300 Level**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Course Code** | **Course Title** | **Units** | **Status** | **LH** | **PH** |
| 1 | BUK-GET 308 | Engineering Economics | 3 | C | 45 |  |
| 2 | BUK-MCE 301\* | Control Engineering Fundamentals | 3 | C | 45 | 45 |
| 3 | BUK-MCE 302 | Digital Electronics | 2 | C | 30 |  |
| 4 | BUK-MCE 303 | Electrical Circuits Analysis | 2 | C | 30 | 45 |
|  |  | **Total** | **10** |  |  |  |

# \*Optional course moved from Level 400 and given 1 additional credit unit

**400 Level**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Course Code** | **Course Title** | **Units** | **Status** | **LH** | **PH** |
| 1 | MCE 403 | Microcontrollers and Embedded Systems | 2 | C | 30 | - |
| 2 | MCE 407 | Industrial Automation & Control | 2 | C | 30 | - |
| 3 | MCE 409 | Sensors and Actuators for Embedded Systems | 2 | C | 30 |  |
| 4 | BUK-MCE 413 | Design of Machine Elements | 2 | C | 30 | - |
| 5 | BUK-MCE 415 | Discrete Control Systems | 2 | C | 30 | 45 |
| 6 | BUK-MCE 417 | Electromechanical Devices | 3 | C | 45 |  |
| 7 | BUK-MCE 421 | Measurements and Instrumentation | 2 | C | 30 | 45 |
| 8 | BUK-MCE 423 | Group Project | 2 | C |  | 30 |
|  |  | **Total** | **17** |  |  |  |

# 500 Level

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Course Code** | **Course Title** | **Units** | **Status** | **LH** | **PH** |
| 1 | BUK-MCE 501 | Mechanical Vibration | 2 | C | 30 |  |
| 2 | BUK-MCE 502 | Reliability and Fault Detection | 2 | C | 30 |  |
| 3 | BUK-MCE 503 | Linear Multivariable Control | 2 | C | 30 |  |
| 4 | BUK-MCE 504 | Mobile Robotics | 2 | E | 30 |  |
| 5 | BUK-MCE 505 | Autonomous Vehicle Guidance Systems | 2 | E | 30 |  |
| 6 | BUK-MCE 506 | Computer Software Engineering | 2 | E | 30 |  |
| 7 | BUK-MCE 507 | Introduction to VLSI Design Concept | 2 | E | 30 | 45 |
| 8 | BUK-MCE 508 | Micro-Electro-Mechanical Systems (MEMS) for Mechatronics | 2 | E | 30 | 45 |
| 9 | BUK-MCE 509 | Digital Signal Processing | 2 | E | 30 | 45 |
| 10 | BUK-MCE 510 | Electric Drives | 2 | E | 30 |  |
| 11 | BUK-MCE 511\* | Computer Vision and Image Processing | 2 | E | 30 | - |
|  |  | **Total (Core)** | **6** |  |  |  |

\*Moved from Level 400

**COURSE CONTENTS**

1. BUK-MCE 103: Elementary Mathematics III (2 Units C: LH=30)

## Senate-approved relevance

Training of high-quality graduates in Nigeria that are knowledgeable and having the essential mathematical skills are in line with BUK’s mission to address African developmental challenges in producing qualified graduates in mechatronics engineering.

## Overview

Mathematics is at the core of engineering and serves as the universal design language of the engineer. Thus, engineering students must be knowledgeable and skilled in mathematical sciences to carry out the task of problem solving and engineering design. Vectors are required in engineering mechanics to represent quantities having both magnitude and direction while coordinate geometry provides a link between algebra and geometry of lines and curves.

The course will cover various mechanics quantities that need to be represented as vectors such as forces, accelerations, velocities and displacement. It will also cover coordinate geometry to show how lines and curves can be represented on a plane. This has many mathematical applications in trigonometry, calculus and other engineering applications like representation of systems in the complex s-plane etc.

## Objectives

The objectives of the course are to:

1. Solve some vectors in addition and multiplication
2. Calculate force and momentum
3. Explain types of vectors, a geometrical representation of vectors, and components of vectors
4. Solve differentiation and integration of vectors
5. Illustrate the linear dependence of vectors and its simple application
6. Demonstrate dimensional coordinate systems
7. Analyze the equation of a circle.
8. Describe the properties of parabola, ellipse, hyperbola, straight lines and planes in space.
9. Describe and justify force, momentum, laws of motion under gravity, projectiles, resisted vertical motion, angular momentum and simple harmonic motion.
10. Describe elastic string, simple pendulum, and impulse.
11. Analyze the impact of two smooth spheres and of a sphere on a smooth surface.

## Learning Outcomes

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

1. Explain at least two (2) types of vectors, geometrical representation of vectors, and components of vectors.
2. Illustrate the linear dependence of vectors and their simple applications clearly.
3. Demonstrate dimensional coordinates systems.
4. Analyze the equation of a circle, tangent, and normal to a circle.
5. Describe the properties of parabola, ellipse, hyperbola, straight lines, and planes in space.
6. Describe and justify force, momentum, laws of motion under gravity, projectiles, resisted vertical motion, angular momentum, and simple harmonic motion
7. Describe elastic strings, simple pendulums and impulse.
8. Analyse the impact of two smooth spheres and of a sphere on a smooth surface.

## Course Contents

Types of vectors: points, line, and relative vectors. Geometrical representation of vectors in 1-3 dimensions. Addition of vectors and multiplication by a scalar. Components of vectors in 1-3 dimensions. Direction cosines. Linear independence of vectors. Point of division of a line. 4 Scalar and vector products of two vectors. Simple applications. Two-dimensional coordinate geometry. Straight lines. The angle between two lines, distance between points. Equation of a circle, tangent and normal to a circle. Properties of parabola ellipse. Hyperbola straight lines and planes in space. Direction cosines. The angle between lines and between lines and planes. A distance of a point from a plane. Components of velocity and acceleration of a particle moving in a plane, force, momentum. Laws of motion under gravity, projectiles, and resisted vertical motion. Angular momentum. Simple harmonic motion. Elastic string. Simple pendulum, and impulse. The impact of two smooth spheres and of a sphere on a smooth surface.

## Minimum Academic Standards

Mechatronics engineering programme’s NUC-MAS requirement facilities.

1. BUK-MCE 102: General Physics II (Electricity and Magnetism) (2 Units C: LH=30)

**Senate Approved Relevance**

Training of high-quality graduates who are highly knowledgeable in the fundamentals of physics to address the challenges of the 21st century is in line with BUK’s mission to solve African developmental challenges by producing mechatronics engineering graduates that can design, optimize and maintain systems driven by electromechanical devices.

**Overview**

This course is design to provide basic foundation of Physics that is dealing with electricity and magnetism and underlining mathematical concepts that underpin a better understanding of the course. The course is an introduction to electromagnetic fields and forces and the overall goal is to use the scientific method to come to understand the enormous variety of electromagnetic phenomena in terms of a few relatively simple laws.

**Objectives**

The objectives of the course are to:

1. Describe the ways in which various concepts in electromagnetism come into play in particular situations.
2. Represent these electromagnetic phenomena and fields mathematically in those situations.
3. Understand the physical meaning of Faraday’s laws.
4. To understand the physical meaning and application of Maxwell’s equations.
5. To understand the characteristics of AC waveforms and DC signals.

**Learning Outcomes**

At the end of the course, the student 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-Savartand Ampere’s law;
5. Describe electromagnetic induction and related concepts and make calculations using Faraday and Lenz’s laws.
6. Explain the basic physical 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.

**Course Content**

Fundamentals of Electricity: Potential difference, Electric current, Coulomb’s Law. Properties and atomic structure of metals, conductors, insulators, and semiconductors. Basic Fundamental Laws: Ohm’s law, Ampere’s Law and Kirchhoff’s Laws.Electrical Circuit Elements (RLC): Basic Properties, construction and formulas of Resistors, Inductors and Capacitors. Series and parallel combination of RLC. Electrical Energy and Power of RLC.Fundamentals of Magnetism: Basics of Magnetic theory: Magnetic Flux, Magnetic Field Intensity, and Permeability. Derivation, relationships and units of the above. Magnetic circuits: Concepts and analogies with electrical circuits, Calculations and computations. Faraday’s law of electromagnetic induction. Maxwell's equations. Electromagnetic oscillations and waves.

**Minimum Academic Standard**

General Physics III (Electricity & Magnetism) is as contained in the NUC CCMAS.

1. BUK-MCE 201: Introduction to Python Programming (2 Units C: LH=30, PH = 45)

**Senate Approved Relevance**

Training of high-quality graduates who are highly skilled and knowledgeable in Python programming will have significant impact in data analysis, machine learning and problem solving. Many employers of labour in the research industry list Python programming is as a requirement for employment. This course in thus in line with BUK’s mission of addressing African developmental challenges by producing mechatronics graduates with the skills to apply computer tools to analyse and provide solutions to engineering problems.

**Overview**

Python is arguably the most popular programming language in the world at the moment. Its relative simplicity and open source architecture makes it the ideal choice to introduce students to coding and problem solving using computer tools. It is often listed as a job requirement by employers and thus necessary for mechatronics engineers to have skills in Python programming.

The course is designed to introduce students to programming with python. It is an introductory course which covers general concepts of programming with Python. It will cover basic concepts like Python installation, Python Integrated Development Environments (IDEs), installation and importation of Python modules, variable representation, data structures, plotting etc.

**Objectives**

The objective of this course are to:

1. Understand the Python environment and syntax
2. Carry out simple calculations using Python
3. Install and Import Python modules.
4. Represent data in graphical format with Python plots.
5. Understand Python data structures

**Learning Outcomes**

Upon successful completion of this course, the student should be able to:

1. Explain the main features of the Python programming language.
2. Enumerate the steps in installing Python core, modules and dependencies using PIP.
3. Represent variables in Python.
4. Distinguish between various Python data structures and their applications.
5. Write simple Python functions to solve mathematical problems.
6. Code simple Python algorithms to solve problems.
7. Import Python modules.
8. Represent data in graphical format using Matplotlib.
9. Explain the application of commonly used Python modules.

**Course Content**

The Python programming language. Python versions and installation. Python Integrated Development Environments (IDEs). Python core and modules. Object oriented programming. Python data structures: Numeric data, string data, Boolean data. Assigning Python variables. Reserved Python keywords. String functions and methods. Mathematical operators. Mathematical functions. Conversion between string and numerical data. Python data structures: Lists, Tuples and Dictionaries. Conditional statements. Program looping. User-defined Python functions. Exception handling. Python plotting libraries.

1. BUK-MCE 202: Dynamics (2 Units; Core; L = 30; P = 45)

**Senate Approved Relevance**

Training of high-quality graduates who are highly knowledgeable/skilled the motion analysis of machines and their mechanisms. It will equip them with the requisite skills to convert one type of motion into another and conduct the kinematics and kinetic analysis of motion systems. This course will assist the BUK’s mission to address African developmental challenges by producing mechatronics engineering graduates that can analyse the kinetics of various mechanisms and optimise their performance through automation and control.

**Overview**

In this course students will be exposed to the concept of how motions are being converted from one type to the other which forms the basis for any machine. Dynamics is the branch of physics where students will learn how to analyses the forces acting over bodies and the resulted motion, the fundamental principles and properties of the bodies like mass, moment, inertia, acceleration and reactions.

**Objectives**

The objectives of this course are to:

1. Define and analyse particles in motion.
2. Understand different forms of motion.
3. Use Newton’s second law and other laws of kinetics to solve problems.
4. Analyse velocity and acceleration vectors.
5. Analyse oscillations in terms of amplitude, period, frequency and angular frequency.

**Learning Outcomes**

The students should be able to:

1. Describe a particle in motion by categorizing it into either rectilinear, plane or space curvilinear.
2. Describe motion based on the co-ordinate system i.e either rectangular, normal & tangential, polar , cylindrical or spherical
3. Apply Newton’s second law, work-energy and impulse-momentum equations for the solution to problems in particle kinetics
4. Use the approach of absolute or relative motion in the analysis of rigid bodies in motion and simple mechanisms
5. Solve the velocity and acceleration equations using either scalar geometric analysis, vector algebra or graphical construction of the vector polygon.
6. Describe the motion of rigid bodies as translation, fixed-axis rotation or general plane motion
7. Apply newton’s second law, work-energy and impulse-momentum principles for the solution to problems in rigid body kinematics
8. Describe oscillations in terms of amplitude, period, frequency and angular frequency

**Course Content**

Kinematics of particles and rigid bodies: motion in one, two and three dimensions, relative motion, and the description of motion using vectors and coordinate systems, Kinematics of particles, Rectilinear and curvilinear motion, Relative motion: Newton's laws of motion, work and energy, impulse and momentum, and the dynamics of systems of particles, Space kinematics, Velocity and acceleration analysis, Conservation laws, Dynamics of systems of particles, Conservation of momentum and energy, Central force motion, Dynamics of rigid bodies.

**Laboratory Content**

1. Linear Momentum: to observe the behaviour of two colliding inelastic bodies and verify the principle of conservation of momentum.
2. Belt drives: to determine the efficiency of drive transmission.

**Minimum Academic Standard**

Dynamics course is as contained in the NUC CCMAS Applied Mechanics course.

1. **BUK-GET 208: Strength of Materials** (3 Units C: LH=45)

**Senate Approved Relevance**

Training of high-quality graduates who are highly knowledgeable in the fundamentals of mechanics which is the science in which all design of machines is based on. It will equip them with the requisite skills for the analysis of the behaviour of machines subjected to different loadings. This course will assist the BUK’s mission to address African developmental challenges by producing mechatronics engineering graduates that have the requisite scientific background knowledge/skills to design/analyse machines to solve problems.

**Overview**

In this course students will learn how to analyse the behaviour of machine components subjected to different loading and support conditions in more than one dimension. This will form the fundamentals/applied science for the design of components later.

Students will also learn to analyse machine components subjected to loading beyond their Elastic limits (plastic deformation). They will also be able to analyse forces in statically indeterminate structures and design pressure cylinders (thick and compound cylinders).

**Objectives**

The objectives of the course are to:

1. Enable students to develop the technical knowledge and skills required to analyse the behaviour of machine components subjected to various loading and support conditions.
2. Evaluate the relationship between stress and strain in planes and thermal effects.
3. Analyse/Design Thick and Compound Cylinders
4. Analyse structural members beyond their elastic limit (Inelastic and plastic cases)
5. Use strain gauges to take accurate measurements of stresses and strains.

**Learning Outcomes**

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

1. Apply the principles of equilibrium and material constitutional relationship to determine the behaviour of machine components subjected to various loading and support conditions.
2. Apply the concept of stress and strain to analyze machine parts under axial load, shear load, bending moment and torsion.
3. Solve practical problems through evaluating the relationship between stress and strain.
4. Determine stresses in inclined planes of a loaded member
5. Determine principal stresses and strains in planes
6. Determine the thermal effects.
7. Calculate stresses due to combine stresses in machine component.
8. Analyse a structural member and machine part when loaded beyond its elastic limit (inelastic and plastic cases).
9. Apply Lame’s theorem in the structural analysis/design of pressurized cylinders
10. Analyse the forces in a statically-indeterminate beams.
11. Use strain gauges for the measurement of strains in a loaded member.

**Course Content**

Plane stress: Stresses on incline planes, Transformation equations for plane stress, Principal stresses and Maximum shear stress, Mohr’s circle, Hooke’s law for plane stress, strain energy in plane stress. Plane strain: Plane strain versus plane stress, transformation equations for plane strain, principal strain, maximum shear strain, Mohr’s circle for plane strain, strain measurements. Thermal effects and combined stresses. Thick cylinders; Lame’s theory; Force fits; compound cylinders. Beam Deflection Statically indeterminate beams.

1. **BUK-GET 308: Engineering Economics** (3 Units C: LH 45)

**Senate-approved relevance**

The philosophy is to produce mechatronics engineering graduates with high academic standards and adequate practical skills for self-employment as well as been of immediate value to industry and the community. The course will provide broad-based training and eqip the students with skills to assess the costs and benefits of engineering investments such as product and technology development programs and capital purchases. This will contribute to achieving BUK’s mission of training high-quality graduates.

**Overview**

Engineering Economy is the process of making rational and intelligent decisions associated with the allocation of scarce resources in circumstances where alternatives can be enumerated. This course will introduce students to basics of engineering economics, which is the application of economics and decision theory to the evaluation of engineering alternative in planning developing, constructing and managing engineering projects. The course will include segments of the engineering economic analysis covered in the professional engineering such as the application of different economic analysis methods utilised in evaluating the viability of a project and its alternatives, concepts of replacement decisions, capital-budgeting decisions and project risk and uncertainty. Students will be exposed to specific issues of economic analysis of the private sector versus the public sector.

**Objectives**

The course objectives are to:

1. Discuss the basic concepts of engineering economy
2. Describe the techniques for making economic decisions using present worth, annual worth, future worth and capitalised cost
3. Discuss discounted cash flow and rate of return comparisons.
4. Describe the procedure for replacement analysis, breakdown analysis and benefit-cost analysis.
5. Analyse practical examples to judge attractiveness of an investment.

**Learning Outcomes**

On the successful completion of this course, the student should be able to:

1. Recall the basic concepts of engineering economy.
2. Solve examples involving making economic decisions present worth, annual worth, future worth and capitalised cost.
3. Explain discounted cash flow and rate of return comparisons.
4. Solve examples using replacement analysis, breakdown analysis and benefit-cost analysis techniques.
5. Solve practical problems to judge the attractiveness of a proposed investment.

**Course Contents**

The nature and scope of economics. Basic concepts of engineering economy. Interest formulae, discounted cash flow, present worth, equivalent annual growth and rate of return comparisons. Replacement analysis. Breakdown analysis. Benefit cost analysis. Minimum acceptable rate of return. Judging attractiveness of proposed investments.

1. **BUK-MCE 302: Digital Electronics** (2 Units; Core; L = 30; P = 45)

**Senate-approved relevance**

Training of high-quality graduates who are highly knowledgeable in modelling and analysis of mathematical representation of real-life models. This will equip the students with the required skills for design of digital logic and automation systems. This is in agreement with BUK’s mission to be forefront in digital world and lead Africa in current technologies.

**Overview**

This course provides an introduction to the fundamental principles of digital electronics and digital circuits. Topics covered include Boolean algebra, logic gates, combinational and sequential circuits, basic digital building blocks and digital system design.

The course is designed to familiarize students with analysis and design of logic circuits that are cost efficient and reliable. It will provide the students with necessary skills in automation.

**Objectives**

In this course students will learn:

1. To introduce the fundamental concepts of digital electronics and digital circuits.
2. To develop the ability to analyse and design digital circuits.
3. To understand the operation and design of basic digital building blocks, such as gates, flip-flops, counters, and registers.
4. To learn the methods for minimizing Boolean expressions and implementing digital logic circuits.
5. To understand the behaviour of combinational and sequential circuits and their applications in digital systems

**Learning Outcomes**

On the successful completion of this course, the student should be able to:

1. Analyse and design digital circuits using Boolean algebra and logic gates.
2. Design and implement combinational and sequential circuits.
3. Minimize Boolean expressions and design logic circuits using various techniques.
4. Explain the operation basic digital building blocks such as flip-flops, counters, and registers.
5. Apply digital circuits in real-world applications such as digital signal processing, communication systems, and digital automation systems.

**Course Contents**

Digital systems and their applications, Number systems and codes, Decimal, binary, octal, and hexadecimal number systems, Binary codes (BCD, Gray code, etc.), Boolean algebra and logic gates, Boolean algebra and its laws, Logic gates and their characteristics, Boolean functions and truth tables. Minimization techniques, Karnaugh maps and Boolean algebraic manipulation. Combinational circuits: Combinational logic circuits, Adders, subtractors, multiplexers, demultiplexers, encoders, and decoders. Sequential circuits: Sequential logic circuits, Flip-flops (SR, D, JK, T), registers, and counters. Digital system design: Design of digital systems using basic building blocks, Timing diagrams and state diagrams.

**Minimum Academic Standards**

Virtual Laboratory with NUC-MAS approved facilities.

1. **BUK-MCE 303: Electrical Circuits Analysis** (2 Units C: LH=30; PH=45)

**Senate approved Relevance**

Training of high quality graduates who are highly knowledgeable and skilled in the analysis and design of electrical circuits. Students will be able to design appropriate first and second order transfer functions of filters. This course will assist the BUK’s mission to address the African Development challenges by providing Mechatronics Engineering graduates that can use hand and circuit simulation software to analyse and design circuits.

**Overview**

The course is designed to provide further topics in electrical circuit design and analysis. The course is an introduction to two port networks and the definition and application of active filters.

This course is a continuation of some parts of the course principles of Electrical Engineering with the goal of more understanding about circuit theorems, circuit analysis, transfer functions and the use of simulation software.

**Objectives**

The objectives of the course are to:

1. Design and analyse two port networks.
2. Design and approximate first and second order functions of filters.
3. Realize electrical circuits from transfer functions using various methods.
4. Design and analyse various signal filters.
5. Apply circuit simulation software to analyse and design circuits.

**Learning Outcomes**

The students should be able to:

1. Define two-port networks, design and analyse the types through different parameters.
2. Define the importance and application of first and second order transfer function of filters.
3. Realize electrical circuits from transfer function using various method such Fourier and Laplace transforms.
4. Use circuit analysis theorems to solve various types of circuits.
5. Use circuit simulation software to design and analyse circuits.

**Course Content**

Two-Port Networks: Two port network parameters: z-, y- and h- parameters. Reciprocity relations for reciprocal two-ports. Measurement of the parameters. Transmission (chain) parameters. Cascaded chain parameters. Image impedance for symmetrical two-ports. Characteristic impedance. Sensitivity Analysis. Active Filter Functions: Definition of filters, importance and applications. Basic filters terminologies; pass band, stop band, transition band, roll off, ripples, gain, Q-factor, phase shift, phase delay, group delay. First and second order Low, high, Band pass, Band reject and all pass filters. Realization of electrical circuits: Foster and Causer’s methods of synthesis. Discrete components and Op-amp realization of first and second order filters, Sallen and Key Structures. Direct Replacement of Inductances: Problems with inductor, simulated grounded and floating inductor, variation of simulated inductance with frequency. Gyrators; positive impedance inverters, negative impedance converters. Fourier Methods of Analysis: Fourier Transforms and Response of linear networks. Power (or energy) spectra, random signals. Analysis and synthesis of non-linear resistive circuits, harmonic analysis of non-linear dynamic circuits. Time and frequency domain analysis of networks. Application of Fourier series in network analysis.

**Laboratory Content**

Determination of H parameters, Y parameters, Z parameters and ABCD parameters by shorting the voltage sources and opening the current sources at the terminals. Implement active low pass, high pass and band pass filters. Determine circuit voltage, transfer function, step response transform and output waveform. Use any simulation software to determine the step response through transient analysis.

**Minimum Academic Standards**

Instrumentation Laboratory with NUC-MAS requirement facilities

1. **BUK-MCE 413: Design of Machine Elements** (2 Units C: LH=30)

**Senate Approved Relevance**

Training of high-quality graduates who are highly knowledgeable/skilled in the analysis of machines elements and their mechanisms. It will equip them with the requisite skills to design various machine elements/components, which is one of the fundamental elements of the design and fabrication of mechatronics machines. This course will assist the BUK’s mission to address African developmental challenges by producing mechatronics engineering graduates that can synthesis (produce) various types of mechatronics systems and machines alongside their efficient design and optimization analysis which is one of the requirements for the selection of machine elements in a machine

**Overview**

In this course students will be exposed to the knowledge of various machine components and their fundamental design principles, concepts, procedures and guidelines, which forms the basis for any mechatronics machine. In machines, design of forces and motion, size and shape, power and energy of different machine elements linked to one another in a machine to make a systems is necessary.

The course is more specifically targeted at teaching identification of different machine components and their various functions, dynamics. It will also focus on the design steps and procedures for various mechatronics components.

**Objectives**

The objectives of the course are to:

1. Identify various mechatronics machine members and their respective functions.
2. Design simple individual mechatronics machine components to provide desired outputs.
3. Carry out assembly and test running of simple mechatronics systems based on designed machine components.
4. Theoretically solve and resolve problems relating to design of machine components.
5. Analyse and design power transmission machine elements such as universal joints, gearing systems, friction clutch and brakes.

**Learning Outcomes**

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

1. Explain the various machine elements of a general mechatronics project.
2. Explain the processes of designing mechanical machine elements.
3. Design the basic mechanical elements of a mechatronics systems.
4. Identify different individual machine components and their various functions and usage.
5. Theoretically analyse the dynamics of various machine components
6. Enumerate the design steps and procedures for the various mechatronics machine components.
7. Select appropriate components for design of specified machine elements.

**Course Content**

Introduction to components design processes. Analysis and design of individual machine components (shafts, belts, chain drives, clutches, bearing keys, keyways, and gears).

1. **BUK-MCE 415: Discrete Control Systems** (2 Units C: LH=30; PH=45)

**Senate Approved Relevance**

Training of high-quality graduates who are highly skilled and knowledgeable in the field of computer (discrete) control systems is highly desirable in small and large scale industries. Many of such industries use propriety hardware and software requiring foreign expertise for operation and maintenance. Producing skilled graduates that can provide local solutions to these industries is in agreement with BUK’s mission of addressing African developmental challenges through knowledge transfer in engineering.

**Overview**

Implementing control solutions using digital computers requires discretisation of continuous (analog) time systems. In representing systems in discrete time and implementing control solutions, there are a number of important aspects that things that have to be well-understood and considered.

This course therefore focusses on reconstructing continuous time systems in discrete form so that they can be implemented on digital devices like microcontrollers and PLCs. It will consider aspects such as sampling time, difference equations and analysis of systems’ response and stability in discrete time. It will also show how the widely used PID controller can be represented in discrete time and implemented on a microcontroller using a common programming language.

**Learning Outcomes**

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

1. Select a suitable sampling time for discrete systems.
2. Reconstruct continuous signals is discrete form.
3. Use difference equations to examine the time response of discrete systems.
4. Analyse the stability of discrete time systems.
5. Realise discrete PID algorithms on microcontrollers.

**Course Content**

Digital computers in control loops. Discrete-time and digital control systems. Sampling process and theorem. Shannon’s sampling theorem. Data reconstruction. Z-transform. Inverse z-transform. Linear difference equations and their solutions using z-transforms. Relationship between s-plane and z-plane. Discrete system time responses and steady state error analysis. Stability in the z-plane. Discrete PID controller realisation. Microcontroller implementation of discrete control systems.

**Laboratory Content**

1. Design and simulate discrete PID controllers using MATLAB/Simulink.
2. Implement discrete PID controllers on microcontrollers.
3. Tune and analyse the performance of discrete PID controllers.
4. Implement discrete time FIR and IIR filters.

**Minimum Academic Standards**

Virtual laboratory with NUC-MAS requirement facilities.

1. **BUK-MCE 417: Electromechanical Devices** (3 Units C: LH=45; PH=45)

**Senate approved Relevance**

Training of high-quality mechatronics graduates who are highly skilled and knowledgeable in the area of electrical machines and devices is highly desirable in small and large scale industries. These machines are actuators of most systems in the industry. Producing mechatronics graduates that can select, control and maintain systems driven by electrical machines in industries is in agreement with BUK’s mission of addressing African developmental challenges through knowledge transfer in engineering.

**Overview**

Electrical machines play vital role in domestic appliances and industrial applications. Almost all actuators in the industry are electromechanical. It is thus important for students of mechatronics engineering to learn the basic concepts of electromagnetic circuits including transformers, motors and generators.

This course is designed to provide mechatronics engineering students with basic knowledge of AC and DC electrical machines and transformers. The students will learn how to analyse various electrical machines using equivalent circuits.

**Objectives**

The objectives of the course are to:

* 1. Understand the theory of magnetic circuits and transformers.
  2. Discuss fundamentals of rotating machines.
  3. Describe the theory and applications of induction motors.
  4. Comprehend the principle of synchronous machines.
  5. Analyse performance of direct-current machines.
  6. Simulate various electrical machines using software like MATLAB/Simulink

**Learning Outcomes**

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

1. Explain magnetic fields, flux and mutual inductance.
2. Analyse electrical machines using equivalent circuits.
3. Explain and analyse rotating magnetics fields in three-phase machines.
4. Explain and analyse the operation of DC machines.
5. Identify various electrical machines based on principle of operation.
6. Explain the methods of speed control for various electrical machines
7. Build models of various electrical machines in MATLAB/SIMULINK.

**Course Contents**

Magnetic Circuits: magnetic fields, flux, materials, hysteresis, dc and ac operation of magnetic circuits, self and mutual inductance, equivalent circuits. Transformers: principle of operation, equivalent circuits, three-phase connections, autotransformers. Fundamentals of Rotating Machines: basic concepts, armature mmf, rotating mmf, generated voltage, torque. DC Machines: Faraday's Law, performance equations, armature reaction, generator and motor characteristics, losses and efficiency, equivalent circuits. Synchronous Machines: magnetomotive forces and fluxes, synchronous speed, generator and motor characteristics, losses and efficiency, equivalent circuits. Induction Motors: slip, performance calculations, equivalent circuits, speed control, starting techniques.

**Minimum Academic Standards**

Virtual laboratory with NUC-MAS requirement facilities.

1. **BUK-MCE 421: Measurements and Instrumentation** (2 Units C: LH=30; PH=45)

**Senate approved Relevance**

Training of high-quality graduates who are knowledgeable and skilled in identification of electronics/electrical instruments and their design and usages. Students will be able to determine errors associated with such instruments and how to minimize these errors. This course will assist the BUK’s mission to address the African Development challenges by providing Mechatronics Engineering graduates that can utilise, calibrate and maintain both laboratory and industrial instruments.

**Overview**

The course is designed to provide topics in electrical and electronics identification, measurements, calibration and instrumentation. The course is an introduction to measurement method such as analogue, digital, scaling and matching.

The course is also targeted towards teaching the determination of accuracy of measuring instruments by using calibration methods and error analysis. This course is an introduction to analogue and digital instruments and subsequently transducers.

**Objectives**

The objectives of the course are to:

1. Identify electronics and electrical instruments.
2. Determine the accuracy of instruments through error analysis and error minimization.
3. Design instruments based on laboratory and industrial applications.
4. Learn calibration and maintenance of measurement instruments.
5. Measure and compare amplitude and phase differences of two signals.

**Learning Outcomes**

The student should be able to:

1. Identify electronics/electrical instruments, their use, peculiar errors associated with the instruments and how to minimize such errors.
2. Explain the basic design techniques of electronic instruments.
3. Explain the industrial and laboratory applications of such instruments.
4. Calibrate and maintain electronics/electrical instruments.
5. Measure and compare amplitude and phase differences of two signals.

**Course Content**

Measurement Methods: Analogue techniques, comparison techniques, substitution methods, null methods. Input Characteristics- sensitivity, scaling, and matching. Accuracy: Values and uncertainty, precision, errors, summation of errors, random errors. Specifications and standards. Calibration Procedures. Wave-forms: Sine wave, mean value, RMS value, Form Factor and crest factor, phase relationships, Bias, Harmonics, Frequency Effects, Bandwidth, Rise time. Interference: Environmental and coupled. Analogue Instruments: Moving coil instruments, electro-dynamic instrument. Other pointer instruments. Energy meters. Oscilloscope, comparison methods-DC and AC potentiometers, DC and AC Bridges. Digital Instruments: Counters. Multi-function digital voltmeters. DACs and ADCs. Sample and hold circuits. Wave analyzers. Transducers: Classification, types, and characteristics. Conversion of signals into electrical variables.

**BUK-MCE 423 Group Project** (2 Units C: PH 30)

**Senate Approved Relevance**

Training of high-quality mechatronics graduates with practical knowledge and skills in developing localized and cost-effective control and automation solutions is highly desirable in small and large scale industries. Producing mechatronics graduates that can function as part of a team on in isolation under minimal supervision to provide local solutions to industrial challenges is in agreement with BUK’s mission of addressing African developmental challenges through knowledge transfer in engineering.

**Overview**

Our local industries face problems regarding their automation and control systems, which often require foreign expertise to maintain. It is thus important for students of mechatronics engineering to gain practical skills in realization and implementation of control and automation solutions.

This practical course is designed to provide mechatronics engineering students with practical skills in implementing control and automation solutions. The course will focus on team work through collaboration to produce a working mechatronics system consisting of a sensor, actuator and some control mechanism. The course will also help to prepare the students for their final-year project.

**Objectives**

The objectives of the course are to:

1. Understand the challenges in moving from theoretical design to practical implementation.
2. Learn to function as part of a team to achieve set targets.
3. Gain practical experience in programming and interfacing microcontrollers.
4. Gain hands-on experience in implementing control and automation solutions.
5. Prepare students for a feasible and applicable final-year project.

**Learning Outcomes**

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

1. Realise control and automation systems in real time.
2. Decompose projects into smaller tasks.
3. Program and interface microcontrollers with various sensors and actuators in real time.
4. Implement control and automation solutions in real time.
5. Troubleshoot and debug control and automation systems.
6. **BUK-MCE 501: Mechanical Vibrations** (2 Units C: LH=30)

**Senate Approved Relevance**

Training of high-quality graduates who are highly knowledgeable/skilled in vibration analysis of machines and their mechanisms. It will equip them with the requisite skills to design or modify a machine free of vibration, to develop models for vibrating systems which is one of the fundamental elements of the design process of machines. This course will assist the BUK’s mission to address African developmental challenges by producing mechatronics engineering graduates that can synthesis (produce) various types of systems and mechanisms that are stable with minimal vibrations which is one of the requirements for the design of machines.

**Overview**

The course is designed to expose students to the modelling and analysis of vibration characteristics of mechanical systems with single degree and multiple degrees of freedom. Vibration control by isolation, absorption, and balancing.

Students will be able to model elements including mass/inertia, spring and damper elements and their corresponding describing equations. Furthermore, harmonically excited vibrations with many practical application problems; resonance and its physical significance are studied.

**Objectives**

The objectives of the course are to:

1. Understand and analyse vibrations in machines
2. Design and modify machines devoid of vibrations.
3. Develop models for vibrating systems.
4. Model and analyse vibration of mechanical systems with single degree and multiple degrees of freedom.
5. Derive equations describing free vibrations of undamped and damped systems.
6. Find whirling speeds for shafts and analyse torsional vibration.

**Learning Outcomes**

The student should be able to:

1. Identify various types of vibrations.
2. Determine natural frequencies, displacements, velocities and accelerations of vibrating systems by using either Equilibrium method, Energy method or Rayleih’s method.
3. Analyse Damping applied to vibrating systems.
4. Classify various ways of forcing a system to vibrate.
5. Analyse forced vibrations in systems to determine vibration parameters such as amplitude, resonance and etc.
6. Determine the whirling speeds for shafts.
7. Determine vibration parameters for a system undergoing torsional vibration.

**Course content**

Mechanical Vibration: Introduction, Degrees of Freedom.

Vibrations of Linear System with one degree of Freedom: Undamped free and forced vibration, Damping (viscous), Damped free and forced vibration, Vibration isolation and transmitted force, The centrifugal pendulum, Torsional damped vibration at critical speed. Vibration of Linear System with Two or More degrees of Freedom: Equations of motion and solution. Undamped free and forced vibrations. Dynamic vibration absorber. Transmission of force and motion. Torsional Vibration: Discrete systems. Undamped free and forced torsional vibration. Oscillation of geared systems. Transverse Vibration: Natural frequency of distributed system in transverse vibration whirling shafts. Exact and approximate method. Introduction to nonlinear Vibrations.

1. **BUK-MCE 502: Reliability and Fault Detection** (2 Units C: LH=30)

**Senate Approved Relevance**

Training of high-quality graduates who are highly knowledgeable/skilled in detecting faults in an engineering systems, diagnosing and isolating fault in systems and system recovery. This will assist the BUK’s mission to address African developmental challenges by producing mechatronics engineering graduates with problem solving-skills in the area of technological advancement which is currently a global trend.

**Overview**

Faults in systems a major cause of system down-time in the industry. Thus producing mechatronics graduates that can identify, isolate and recover systems is of major significance.

This course introduces students to the handling of faults in engineering systems. It starts from the basic definition of a fault and leads towards the design of systems so that they are tolerant of faults.  This involves detection, isolation and recovering a faulty system.

**Objectives**

In this course students will learn:

1. The methodologies involved in classifying and quantifying faults within engineering systems
2. Fault Detection Techniques for engineering systems
3. Fault Isolation Techniques in the context of engineering systems
4. Reconfiguration and Redundancy methodologies to compensate for faulty sensors and actuators
5. To appreciate the hardware implementation issues associated with these techniques.

**Learning Outcomes**

By the end of this course students will be able to:

1. Analyse reliability and failure rates of a system.
2. Calculate the influence of faults in sensors, systems and actuators.
3. Apply a range of methods for detecting faults in engineering systems.
4. Classify faults based on the symptoms detected.
5. Design fault tolerant systems.
6. Design and implement reconfiguration and redundancy approaches for engineering systems.

**Course Content**

Basic theory of reliability and faults: Introduction to reliability, maintainability, availability and safety. Elementary reliability theory. Applications to mechatronics components. Faults, failures or malfunctions. Fault tolerant systems. Fault detection: Causes of faults. Common fault types. Fault detection techniques. Fault diagnosis: Fault diagnosis elements. Fault diagnosis methods. Challenges of fault diagnosis.Fault tolerance: Common methods of fault tolerance. Redundancy. Reconfiguration

1. **BUK-MCE 503: Linear Multivariable Control** (2 Units C: LH=30)

**Senate Approved Relevance**

Training of high-quality graduates who are highly skilled and knowledgeable in the area of control of multivariable systems will have a significant impact on design of controllers for multivariable systems in the process industry. Processing and bottling companies rely on multivariable control systems to optimise performance. Production of knowledgeable mechatronics graduates will help in providing indigenous solutions to process control systems in Nigeria. This is in agreement with BUK’s mission of addressing African developmental challenges through knowledge transfer in engineering.

**Overview**

Implementing modern control solutions for multivariable systems commonly found in the process industries using digital computers requires analysis and design of control solutions using multi-input-multi-output systems. In addition, improving performance via optimisation requires simultaneous consideration of process variables.

This course therefore focusses on analysis and design of modern control solutions using multivariable analysis tools. It is an extension of control system fundamentals with a focus on multivariable systems. The course will also introduce the students to more advanced state feedback control approaches and examine the concepts of controllability and observability.

**Objectives**

The objectives of the course are to:

1. Understand the concept of ‘state’ in feedback systems
2. Create model of multivariable systems using state space.
3. Ascertain the stability of systems in state-space.
4. Apply linearization techniques to nonlinear systems and create approximate state space models.
5. Understand the relationship between state-space and transfer function models of systems.
6. Understand the concept of controllability and observability in state space models.
7. Create and analyse computer models of systems in state-space using MATLAB/Simulink.

**Learning Outcomes**

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

1. Represent and analyse systems in state space.
2. Analyse multivariable systems using state space solutions.
3. Convert from transfer functions to state space representation and vice-versa.
4. Linearize nonlinear systems.
5. Investigate the controllability and observability of multivariable systems.
6. Design and simulate state feedback controllers
7. Apply computational tools (MATLAB) to simulate and analyse systems in state space.
8. Analyse the stability of linear systems in state space.

**Course Content**

Definition of state. Importance of state space analysis. State Space description of linear systems. Canonical forms. Time domain solutions of state equations. Conversion from transfer functions to state space. Conversion from state space to transfer function representation. Linearization of nonlinear systems. Concepts of controllability and observability. Definition of the state feedback control. Pole placement controller. Pole selections. Linear Quadratic Regulator (LQR) control. Stability in the sense of Lyapunov.

1. **BUK-MCE 504: Mobile Robotics** (2 Units E: LH=30)

**Senate Approved Relevance**

Training of high-quality graduates who are highly knowledgeable in the fundamentals of mobile robotics and which will equip them with broad knowledge of mobile robotics foundation to address the challenges of the 21st century, which is in agreement with BUK’s mission to address African developmental challenges by producing mechatronics engineering graduates that can produce reliable, efficient and sustainable mobile robotic systems to address Africa’s industrial challenges.

**Overview**

Mobile Robotics introduces the student to the fundamental concepts of autonomous mobile robot platforms. The goal of this course is to provide the student with an understanding of the principles that influence mobile robot design, the sensors and actuators that facilitate the robot’s interaction with the 'real' world and the software architectures used to control such systems.

**Objectives**

The objectives of this course are to:

1. Describe the operating principles of common sensors used in mobile robotics.
2. Process and interpret raw sensor output for navigation purposes.
3. Implement software to drive the actuator/effector elements of a typical mobile robot platform.
4. Acquire the skills to develop a sensor/software solution, using a dedicated robotic platform, for a basic autonomous robot problem.
5. Understand the ethical responsibilities that should be applied during mobile robot development.

**Learning Outcomes**

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

1. Describe the principles of mobile robot intelligence.
2. Explain the theory of intelligent mobile robot techniques.
3. Select appropriate sensors for specific robotic applications
4. Synthesize frontier knowledge in sensor fusion for mobile robotics.
5. List key ethical responsibilities of mobile robot development

**Course Content**

Behaviour based Robotics: Whence behaviour, Animal behaviour, Robot behaviour, behaviour-based architectures, architectural issues in behaviour-based approaches. Intelligent Mobile Robots: Theory of Voting Technique, Mobile Robot with Dynamic Weighted Voting Technique, Goal-Directed Navigation, Intelligent Multi-Agent Robotic Systems. Sensor Fusion: Introduction to Sensor Fusion, Sensors and use of Multiple Sensors, Techniques of Sensor Fusion: Bayesian Approach, Dempster-Shafer, Histogrammic in Motion Mapping.

**Minimum Academic Standard**

Mobile Robotics is as contained in the NUC CCMAS.

1. **BUK-MCE 505: Autonomous Vehicle Guidance Systems** (2 Units E: LH=30)

**Senate Approved Relevance**

Training of high-quality graduates who are highly knowledgeable in the use of guidance and navigation approaches for autonomous systems. Students will be able to provide solutions to important issues concerning the use of AGVs in the industry. This course will assist the BUK’s mission to address African developmental challenges by producing mechatronics engineering graduates with problem solving-skills in the area of technological advancement which is currently a global trend.

**Overview**

This course introduces the concepts behind autonomous vehicle guidance and enable students to practically discuss issues involved in advanced industrial applications of AGVs.

This course will also equip the students with the knowledge of design and implementation of guidance strategies for vehicles incorporating planning, optimizing, and trajectory generation elements.

**Objectives**

In this course students will learn:

1. The concept behind autonomous vehicle guidance
2. To design and implement guidance strategies for vehicles incorporating planning, optimizing and trajectory generation elements
3. Develop the theory behind trajectory optimization
4. The use of graph theory for optimal planning

**Learning Outcomes**

By the end of this course students will be able to:

1. Develop path planning systems for autonomous vehicle guidance,
2. Design and implement obstacle avoidance methods within an autonomous guidance regime.
3. Implement trajectory optimisation and smoothing for both discrete and continuous paths.

**Course Content**

Navigation and guidance systems. Path planning for Unmanned Ground Vehicles (UGVs) and Unmanned Aerial Vehicles (UAVs). Guidance systems. Guidance approaches: Proportional Navigation. Geometric guidance. Path planning and following. Optimal guidance. Navigation approaches: Navigation systems. Global Navigation Satellite System. Terrain based navigation. SLAM (Simultaneous Localisation and Mapping). Cooperative guidance and collision avoidance.

1. **BUK-MCE 506: Computer Software Engineering** (2 Units, E: LH=30)

**Senate Approved Relevance**

Training of high-quality graduates who are highly knowledgeable in the fundamentals of computer software development and which will equip them with the requisite skills for the development, testing, and implementation of computer software which is in agreement with BUK’s mission to address African developmental challenges by producing mechatronic engineering graduates that can produce reliable, efficient and sustainable digital solutions to address Africa’s economic challenges.

**Overview**

The course is designed to develop students’ self-confidence in solving problems with computer software solutions. Students will acquire sufficient knowledge to design, develop, test, and implement computer software systems for solving significant problems. The course also provides students with the knowledge of tools and methodologies necessary to adapt to the rapidly changing software platforms. The course will also provide students with communication and interpersonal skills on how to work as members and leaders of multi-disciplinary software development teams.

**Objectives**

In this course students will learn:

1. To acquire the skills to design a software structure that realizes the solution specifications.
2. To able to translate a software model structure into an executable, reliable, and efficient software program.
3. To obtain the appropriate skills to analyse, test, and evaluate developed computer software systems.
4. To acquire skills to used tools and methodologies for the continual development of a piece of software after its initial release to address changing stakeholder and/or market requirements.
5. To utilize and exhibit strong communication and interpersonal skills, as well as professional and ethical principles when functioning as members and leaders of multi-disciplinary software development teams.
6. To apply their knowledge in software engineering to adapt to readily changing environments using the appropriate theory, principles, and processes.

**Learning Outcomes**

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

Design a computer software solution from the required specifications.

Apply the software engineering lifecycle by demonstrating competence in communication, planning, analysis, design, development, and deployment of computer software.

Develop, test, implement, and maintain software in one or more significant application domains.

1. Work as an individual and as part of a multidisciplinary team to develop and
2. Deliver quality software.
3. Apply current theories, models and techniques that provide a foundation for the software lifecycle.
4. Apply techniques and tools necessary for software engineering practice.

**Course Contents**

Introduction to computer software fundamentals. Number representation. Data structure and algorithms. Abstract, modules, inheritance, models and objects. Designing for efficiency, reliability and reusability. Object oriented software design. Object oriented programming.

Software implementation and testing. Team software specification and management. Cross-platform tools and GUI development. Advance software algorithms and architecture.

Software practice and methods.

**Minimum Academic Standard**

Virtual laboratory with NUC-MAS requirement facilities.

1. **BUK-MCE 507: Introduction VLSI Design Concept** (2 Units; E; L = 15; P = 30)

**Senate-approved relevance**

Training of high-quality graduates who are highly skilled and knowledgeable in the area of semiconductor technologies that will significantly impact on our daily lives is important especially in VLSI design. Many private companies are recently engaged in providing technical supports in form of knowledge transfer strategies that will be meeting core industry needs for manufacturing of indigenous computer systems in Nigeria. This is in agreement with BUK’s mission of addressing African developmental challenges through knowledge transfer in engineering. Even though Nigeria is not an essential contributor to the semiconductor manufacturing sector, but on the other hand, BUK can contribute significantly to the VLSI design sector across the globe by producing relevant indigenous engineers that will play essential roles in designing VLSIsystems for the semiconductor industries that likely to string up in the country sooner or later.

**Overview**

Very-large-scale integration (VLSI) process involves integration of millions of transistors on a single microchip of silicon semiconductors. The importance of the course cannot be overemphasised as it helps in building big, more complex chips and memory devices that are utilized in microprocessors and microcontrollers.

This course is designed to exposed students to basic understanding of the various design steps involved in carrying out complete digital VLSI design using silicon wafer. It is an introductory course which covers basic theories and techniques of digital VLSI design in CMOS technology. The course will cover the fundamental concepts and structures of designing digital VLSI systems including CMOS devices and circuits, standard CMOS fabrication processes, CMOS design rules, static and dynamic logic structures, interconnect analysis, CMOS chip layout, simulation and testing, low power techniques, design tools and methodologies as well as VLSI architecture. The course targeted the achievement of the following sustainable development goals (SDGs) numbers 4, 8 and 9 that addresses quality education, decent work and economic growth as well as industry, innovation and infrastructure respectively. The objectives of the course, learning outcomes, and contents are geared to address all the needs.

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**Objectives**

The objectives of the course are to:

1. Explain the use of mathematical methods and circuit analysis models in analysis of CMOS digital electronics circuits, including logic components and their interconnect.
2. Create models of moderately sized CMOS circuits that realize specified digital functions.
3. Apply CMOS technology-specific layout rules in the placement and routing of transistors and interconnect, and to verify the functionality, timing, power, and parasitic effects.
4. Explain the concepts and techniques of modern integrated circuit design and testing (CMOS VLSI).
5. Experience designing integrated circuits using Computer Aided Design (CAD) Tools.
6. Design VLSI project having a set of objective criteria and design constraints.

**Learning outcomes**

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

1. Explain at least three (3) mathematical methods and circuit analysis models in analysis of CMOS digital electronics circuits, including logic components and their interconnect.
2. Create at least three (3) different models of moderately sized CMOS circuits that realize specified digital functions.
3. Apply CMOS technology-specific layout rules in the placement and routing of transistors and interconnect.
4. Determine the functionality, timing, power, and parasitic effects various CMOS technology
5. Explain the characteristics of CMOS circuit construction and the comparison between different state-of-the-art CMOS technologies and processes.
6. Achieve two (2) VLSI design projects with defined set of objective criteria and design constraints

**Course contents**

Overview of VLSI Technology. Automatic chip layout. Analog circuit simulation for digital circuit design. Structured design methodologies. CMOS Processing Technology. Logic gate, MUX, and D flip-flop design.  VLSI Design Flow. MOS Layers Stick diagram. Design rules and Layout generation. MIPS Microprocessor example. MOS Transistor Theory and Models for Resistance and Capacitance calculation. Logical Effort. Combinational circuits and CMOS logic families. Sequential circuits and layout. Analog simulation and Adder design. Data path design and SRAM design. VLSI circuit testing. VLSI circuit built-in self-testing. Boundary scan standard and circuit reliability. Power estimation and chip packaging. Pads and scaling. Case study of Intel microprocessors.

**Minimum Academic Standards**

Virtual laboratory with NUC-MAS requirement facilities.

1. **BUK-MCE 508: Micro-Electro-Mechanical Systems (MEMS) for Mechatronics** (2 Units; E; LH = 30; PH = 45)

**Senate-approved relevance**

Training of graduate for emerging fields such as MEMS which will satisfy the needs of tomorrow in our industries and other societal requirements will surely trigger developmental changes. MEMS technology will drive the reduction in the cost, size, weight, and power consumption of modern sensors, actuators, and other associated electronics. It is a multidisciplinary engineering field that combines electrical engineering, mechanical engineering, material science and even biomedical engineering. Therefore, this course is designed to prepare the students using computer based training systems using embedded modelling and simulation tools that will try to address our industries core needs in manufacturing of indigenous micro systems in Nigeria. This is in agreement with BUK’s mission of addressing African developmental challenges through knowledge transfer in engineering. Even though Nigeria is not an essential contributor to the micro system technology manufacturing sector, but on the other hand, BUK can contribute significantly to the MEMS design sector across the globe by producing relevant indigenous engineers that will play essential roles in designing MEMS systems for the micro system industries.

**Overview**

Micro-Electro-Mechanical-Systems (MEMS) technology is used for the production of structures, devices and systems on the scale of micro-meters. It is a cutting edge technology that has potential of revolutionizing miniaturization that may create an industry that exceeds the IC industry in both size and impact on society. MEMS can function as sensors, actuators and can have some electronics built-in for process control purpose. Integrated Circuits and or precision mechanical machining are deployed in the fabrication of micro-sensors and micro-actuators.

This course is designed to exposed students to Microelectromechanical systems (MEMS) as miniaturised machines and devices that typically exploit the capabilities of microelectronic fabrication. It also gives an overview of the working principles, fabrication methods and applications encountered with the world of MEMS including scaling of forces at the microscale, Materials for MEMS devices and Microscale sensor and actuator design and integration. This course is also targeted the achievement of the following sustainable development goals (SDGs) numbers 4, 8 and 9 that addresses quality education, decent work and economic growth as well as industry, innovation and infrastructure respectively. The objectives of the course, learning outcomes, and contents are geared to address all the needs.

**Objectives**

The objectives of the course are to:

1. Explain the basics of history of MEMS developmental stages and general overview of micro fabrication of MEMS.
2. Explain the essential materials properties used for MEMS fabrications
3. Discuss various sensing and transduction techniques deployed in MEMS systems
4. Identify various fabrication and machining process of MEMS
5. Determine the best design and fabrication process based on the nature of problem
6. Identify simulation tools and their optimal usage during design of MEMS generally

**Learning Outcomes**

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

1. Distinguish the developmental stages of micro fabrication of MEMS.
2. List five (5) essential materials properties used for the fabrication of MEMS
3. Explain at least four (4) sensing and transduction techniques deployed in MEMS
4. Illustrate five (5) with block diagrams the fabrication and machining processes of MEMS
5. Select at least two (2) best design and fabrication processes for any problem assigned to solved.
6. Illustrate good usage of at least two (2) rugged simulation tools for MEMS design

**Course content**

Overview of MEMS technology. History of MEMS technology. Miniaturization. Scaling in Geometry. Scaling in Rigid-Body Dynamics. Scaling in Electro Static Forces. Scaling in Electro Magnetic Forces. Scaling in Electricity. Scaling in Fluid Mechanics. Scaling in Heat Transfer. Working Principle of MEMS. MEMS Micro Sensors and Micro Actuators. Materials used in MEMS Fabrication. Microfabrication using lithography. Ion implantation. Diffusion. Oxidation. Chemical vapour deposition. Physical vapour deposition (Sputtering). Deposition by epitaxy. Etching. Fabrication using Bulk Micro-manufacturing. Surface Micro-manufacturing. LIGA Process. Design and simulation using FEM tools. Applications.

**Minimum Academic Standards**

CAD/ CAM laboratory with NUC-MAS requirement facilities.

1. **BUK-MCE 509: Digital Signal Processing** (2 Units; E; LH = 30)

**Senate Approved Relevance**

Training of high-quality graduates who are highly knowledgeable in the fundamentals of digital signal processing which is the science on which all design of digital systems is based. It will equip them with the requisite skills for the analysis of the behaviour of digital systems subject to different input signals. This course will assist the BUK’s mission to address African developmental challenges by producing mechatronics engineering graduates that have the requisite scientific background knowledge/skills to design/analyse digital systems to solve problems.

**Overview**

The course is designed to introduce students to the theory and practice of digital signal processing (DSP). Major parts of the course will concentrate on signal analysis using Fourier and Laplace transforms, Z-transform, linear system analysis, Filter design and a few more advanced topics.

The course provides students with knowledge of the sampling theorem and the relationship between continuous and discrete time transforms will be studied in this course. Also, the course contains the study of how discrete-time systems can be characterized using linear difference equations and the input response and show how tools such as the z-transform and discrete Fourier transform can be used in the design and analysis of such systems. In Addition, the course provides students with strong skills in the design and implementation of digital filters.

**Objectives**

The objectives of this course are to:

1. Develop a good understanding of modelling and analysis of discrete-time signals and systems. Works with mathematical tools (z-Transform, difference equations) to have an in-depth understanding of discrete-time signals and systems.
2. Process and interpret raw sensor output for navigation purposes.
3. Understand and utilise spectral analysis (Fourier analysis: DTFT, DFT) to analyze signals and systems.
4. Understand and work with A/D, and D/A conversion processes.
5. Acquire skills in digital filter design techniques.

**Learning Outcomes**

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

* + 1. Analyse and process signals in continuous time and discrete time domains
    2. Convert signal from time to frequency domain and vice-versa
    3. Design, simulation and implementation of FIR and IIR digital filters
    4. Apply DSP to applications which include filtering, convolution, noise reduction and compression.

**Course Content**

Introduction to signals and systems: Continuous-Time signals, Continuous-Time Convolution, Linear Time-Invariant Systems, and Properties of LTI Systems.

Discrete-Time Signals: Sampling Theory, Linear Systems, Discrete signals (impulse, step, exponential), Discrete-Time Convolution, Fourier-Transform; DFT and FFT.

Digital Filters: Advantages and disadvantages over analogue filters. Binomial transformation, FIR and IIR digital filters design.

Applications of DSP: STFT, speech; 2D signal processing-image filtering deconvolution; communication systems.

**Laboratory Content**

* 1. Design, and analysis of digital filters using MATLAB software package.
  2. Implement a project on the application of signal processing

1. **BUK-MCE 510: Electric Drives,** (2 Units; E; LH = 30; PH = 45)

**Senate-approved relevance**

Training of high-quality graduates who are highly skilled in electric drives. This will equip the students with the skills needed to convert electrical to mechanical energy and control as applied in industries. This is in line with BUK’s mission of addressing African developmental challenges through knowledge transfer in engineering.

**Overview**

Power electronics (solid-state) devices are gained significant improvement in terms of drive capability and reduced cost. There are increasingly being employed in drive and control of electrical machines.

This course introduces the methods by which electrical energy is converted from one voltage level to another using transformers or solid-state techniques, and converted to mechanical energy, using electrical machines and appropriate control techniques.

**Objectives**

The objectives of this course are to:

1. Understand electrical drives for engineering applications.
2. Gain ability to design and analyse electrical drives.
3. Gain practical skills by building and testing electrical drives.
4. Understand DC-DC converters and AC-DC rectifiers.
5. Understand methods of speed control using solid-state devices.

**Learning Outcomes**

On the successful completion of this course, the student should be able to:

1. Describe with the aid of sketched waveforms the operation of DC-DC converters and single-phase rectifiers.
2. Formulate the equivalent circuit representations of transformers, induction, synchronous and BLDC machines.
3. Model the behaviour of transformers and machines using the per-phase equivalent circuits.
4. Analyse the waveforms of DC-DC and AC-DC converters, and calculate operating conditions, component values and switching losses.
5. Evaluate the technical and environmental impact of electrical drive and power electronic technologies.

**Course Contents**

Basis of machine speed control. Nominal speed range and smoothness of speed control. Stability of operation and economic justification. Speed control of DC Machines: Braking of DC motor. Shunt field rheostat control. Armature circuit resistance control. Armature terminal voltage control. The Ward-Leonard system. Thyristors DC Machines Control: Control of DC motors using thyristors three phase types. DC-DC or chopper control of DC motors. Microprocessor control. Control of induction Motors: pole-changing method, pole amplitude modulation. Controlling speed by frequency, line voltage control. Control of Synchronous Machines: Starting methods. Thyristors AC machines Control: Variable frequency AC motor drive systems. Control with DC-Link converters. Flip power recovery. Variable frequency synchronous motor drives.

**Minimum Academic Standards**

Power Electronics laboratory with NUC-MAS requirement facilities