University of Dhaka

Department of Robotics and Mechatronics Engineering

Curriculum of
Bachelor of Science in Robotics and Mechatronics Engineering
(B.Sc. in RME)

Academic Year 2024-25 and Onwards

Preface

Welcome to the Department of Robotics and Mechatronics Engineering at the University of Dhaka. We are pleased to present the curriculum for our Bachelor of Science in Robotics and Mechatronics Engineering (B.Sc. in RME) program, effective from the academic year 2024-25 and onwards.

Robotics and Mechatronics Engineering is a cutting-edge multidisciplinary field that integrates mechanical, electrical, and computer engineering. It is at the heart of the current industrial revolution, often referred to as Industry 4.0. Our program is designed to produce graduates who can design, develop, and maintain intelligent machines and systems that interact with the physical world.

For Bangladesh, a nation on the cusp of significant industrial and technological growth, expertise in these fields is crucial for driving innovation, improving manufacturing processes, and solving complex societal challenges. By fostering skilled robotics and mechatronics engineers, we are investing in our nation's future, paving the way for technological self-reliance, and positioning Bangladesh as a competitive player in the global tech landscape.

This curriculum has been meticulously crafted to provide a comprehensive and cutting-edge education. It uniquely combines elements from Computer Science and Engineering (CSE), Mechanical Engineering, and Electrical and Electronic Engineering (EEE), ensuring students gain a holistic understanding of the complex systems that comprise modern robotics and mechatronics. The program structure features foundation courses from all three disciplines in the earlier semesters, gradually progressing to more specialized subjects in later years. This carefully designed progression allows students to build a strong base before delving into advanced topics. The curriculum comprises a total of 150 credits, providing a robust educational experience.

Key features of our curriculum include:

1. A strong foundation in mathematics, physics, and core engineering concepts
2. Specialized courses reflecting the latest industry trends and research developments
3. Hands-on laboratory experiences to reinforce theoretical knowledge
4. Two specialized streams in the final year: Robotics and Mechatronics
5. A two-semester research project encouraging original thinking and innovation
6. An internship program providing real-world industry exposure

7. General education courses to develop well-rounded professionals

Our graduates will be equipped to work in diverse fields such as manufacturing, aerospace, defense, mining, cargo handling and transportation, agriculture, health care, service industries, and more. They will be prepared for careers in robotics, control systems, automation, Internet of Things (IoT), and artificial intelligence.

We believe this curriculum will produce not only technically proficient engineers but also creative problem-solvers and ethical leaders who can contribute meaningfully to society. Our goal is to inspire and empower our students to push the boundaries of what's possible, innovate, and shape the future of technology.

We look forward to guiding our students through this transformative educational experience.

1st Year 1st Semester

Course Code	Course Title	Credit Hour
	Theory Courses	
RME 1101	Electrical Circuits Analysis	3
RME 1102	Fundamentals of Mechanical Engineering	3
MATH 1103	Discrete Mathematics	3
MATH 1104	Differential and Integral Calculus	3
PHY 1105	Physics	3
	Lab Courses	
RME 1111	Electrical Circuits Analysis Lab	1.5
RME 1116	Engineering Drawing Lab	1.5
RME 1117	Engineering Workshop Lab	1.5
	Total Credits:	**19.5**

1st Year 2nd Semester

Course Code	Course Title	Credit Hour
	Theory Courses	
RME 1201	Structured Programming	3
RME 1202	Linear and Power Electronics	3
RME 1203	Statics and Dynamics	3
MATH 1204	Linear Algebra	3
MATH 1205	Multivariate and Vector Calculus	3
	Lab Courses	
RME 1211	Structured Programming Lab	1.5
RME 1212	Linear and Power Electronics Lab	1.5
ENG 1216	Functional English Lab	2
	Total Credits:	**20**

2nd Year 1st Semester

Course Code	Course Title	Credit Hour
	Theory Courses	
RME 2101	Digital Logic Circuits and Microprocessors	3
RME 2102	Fundamentals of Mechatronics Engineering	3
RME 2103	Mechanical Power Transmission	3
BUS 2104	Accounting and Business Entrepreneurship	3
MATH 2105	Differential Equations and Coordinate Geometry	3
	Lab Courses	
RME 2111	Digital Logic Circuits and Microprocessors Lab	1.5
RME 2112	Fundamentals of Mechatronics Engineering Lab	1.5
RME 2116	Object Oriented Programming Lab	2
	Total Credits:	**20**

2nd Year 2nd Semester

Course Code	Course Title	Credit Hour
	Theory Courses	
RME 2201	Data Structure and Algorithms	3
RME 2202	Electrical Machines	3
RME 2203	Instrumentation and Measurement	3
RME 2204	Robotics I	3
STAT 2205	Statistics for Data Science	3
	Lab Courses	
RME 2211	Data Structure and Algorithms Lab	1.5
RME 2212	Electrical Machines Lab	1.5
RME 2213	Instrumentation and Measurement Lab	1.5
RME 2214	Robotics I Lab	1.5
	Total Credits:	**21**

3rd Year 1st Semester

Course Code	Course Title	Credit Hour
	Theory Courses	
RME 3101	Artificial Intelligence	3
RME 3102	Digital Signal Processing	3
RME 3103	Microcontroller and Programmable Logic Controller	3
RME 3104	Machine Learning	3
MATH 3105	Mathematical Analysis for Engineers	3
	Lab Courses	
RME 3111	Artificial Intelligence Lab	1.5
RME 3112	Digital Signal Processing Lab	1.5
RME 3113	Microcontroller and Programmable Logic Controller Lab	1.5
RME 3114	Machine Learning Lab	1.5
	Total Credits:	**21**

3rd Year 2nd Semester

Course Code	Course Title	Credit Hour
	Theory Courses	
RME 3201	Digital Image Processing	3
RME 3202	Control Engineering	3
RME 3203	Mechanics of Solids	3
RME 3204	Fluidics	3
RME 3205	Neural Networks and Deep Learning	3
	Lab Courses	
RME 3211	Digital Image Processing Lab	1.5
RME 3213	Solids and Fluids Lab	1.5
RME 3215	Neural Networks and Deep Learning Lab	1.5
	Total Credits:	**19.5**

4th Year 1st Semester

Common Courses

Course Code	Course Title	Credit Hour
Theory Course		
RME 4101	Robotics II	3
RME 4102	Embedded Systems Design and Interfacing	3
Lab Course		
RME 4111	Robotics II Lab	1.5
RME 4112	Embedded Systems Design and Interfacing Lab	1.5
RME 4113	Research Methodology and Scientific Writing Lab	2
Research Project Work		
RME 4100	Research Project	2
	Total Credits:	**13**

Stream 1: Robotics[1]

Course Code	Course Title	Credit Hour
Theory Courses		
ROB 410X	Stream 1 Theory 1	3
ROB 410X	Stream 1 Theory 2	3
Lab Courses		
ROB 411X	Stream 1 Lab 1	1.5
ROB 411X	Stream 1 Lab 2	1.5
	Total Credits:	**9**

Stream 2: Mechatronics[1]

Course Code	Course Title	Credit Hour
Theory Courses		
MTE 410X	Stream 2 Theory 1	3
MTE 410X	Stream 2 Theory 2	3
Lab Courses		
MTE 411X	Stream 2 Lab 1	1.5
MTE 411X	Stream 2 Lab 2	1.5
	Total Credits:	**9**

[1] For the 4th Year 1st Semester, students need to complete a total of 22 credits. Among them, 13 credits from common courses, and the remaining 9 credits will come from a stream (a student will take two theory courses and two lab courses either from stream 1 or stream 2).

Robotics Courses

Course Code	Course Title	Credit Hour
Theory Courses		
ROB 4104	Generative Artificial Intelligence	3
ROB 4105	Human Robot Interaction	3
ROB 4106	Cloud Robotics	3
ROB 4107	Mobile Robotics	3
ROB 4108	Robot Vision	3
ROB 4109	Control Systems Design	3
Lab Courses		
ROB 4114	Generative Artificial Intelligence Lab	1.5
ROB 4115	Human Robot Interaction Lab	1.5
ROB 4116	Cloud Robotics Lab	1.5
ROB 4117	Mobile Robotics Lab	1.5
ROB 4118	Robot Vision Lab	1.5
ROB 4119	Control Systems Design Lab	1.5

Mechatronics Courses

Theory Courses		
Course Code	**Course Title**	**Credit Hour**
MTE 4104	Automobile Engineering	3
MTE 4105	Biomedical Sensors and Signals	3
MTE 4106	Networking and Internet of Things	3
MTE 4107	Finite Element Analysis	3
MTE 4108	Manufacturing Process and CNC Programming	3
MTE 4109	Smart Materials and Structures	3
Lab Courses		
MTE 4114	Automobile Engineering Lab	1.5
MTE 4115	Biomedical Sensors and Signals Lab	1.5
MTE 4116	Networking and Internet of Things Lab	1.5
MTE 4117	Finite Element Analysis Lab	1.5
MTE 4118	Manufacturing Process and CNC Programming Lab	1.5
MTE 4119	Smart Materials and Structures Lab	1.5

4th Year 2nd Semester

Course Code	Course Title	Credit Hour
Research Project Work		
RME 4200	Research Project	4
Internship		
RME 4300	Internship/ Industry-oriented Project	3
	Total Credits:	**7**

General Education Courses

Course Code	Course Title	Credit Hour
MATH 1102	Discrete Mathematics	3
MATH 1103	Differential and Integral Calculus	3
PHY 1104	Physics	3
MATH 1204	Linear Algebra	3
MATH 1205	Multivariate and Vector Calculus	3
BUS 2104	Accounting and Business Entrepreneurship	3
MATH 2105	Differential Equations and Coordinate Geometry	3
STAT 2205	Statistics for Data Science	3
MATH 3105	Mathematical Analysis for Engineers	3
ENG 1214	Functional English Lab	2
RME 4113	Research Methodology and Scientific Writing Lab	2
	Total Credits:	**31**

Summary of Eight Semesters	**Credit Hours**
Semester I (First Year First Semester)	19.5
Semester II (First Year Second Semester)	20
Semester III (Second Year First Semester)	20
Semester IV (Second Year Second Semester)	21
Semester V (Third Year First Semester)	21
Semester VI (Third Year Second Semester)	19.5
Semester VII (Fourth Year First Semester)	22
Semester VIII (Fourth Year Second Semester)	7
Total Credit in Eight Semesters	**150**

RME 1101: Electrical Circuits Analysis

Basic Information

Semester	1st Year 1st Semester
Course Code	RME 1101
Course Title	Electrical Circuits Analysis
Course Credit	3.0
Course Status	Core Course
Foundation Knowledge	Physics

Syllabus

DC Circuits

Basic Concepts: Systems of Units, Charge and Current, Voltage, Power and Energy, Circuit Elements.

Basic Laws: Ohm's Law, Nodes, Branches, and Loops, Kirchhoff's Current and Voltage Laws, Series Resistors and Voltage Division, Parallel Resistors and Current Division, Wye-Delta Transformations: Delta to Wye Conversion, Wye to Delta Conversion.

Methods of Analysis: Nodal Analysis, Nodal Analysis with Voltage Sources, Mesh Analysis, Mesh Analysis with Current Sources.

Circuit Theorems: Circuit Theorems: Superposition Theorem, Source Transformation, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem, Millman's Theorem, Tellegen's Theorem, Reciprocity Theorem, Compensation Theorem, Substitution Theorem.

Capacitors and Inductors: Capacitors, Series and Parallel Capacitors, Inductors, Series and Parallel Inductors.

First-Order and Second-order Circuits: The Source-Free RC Circuit, The Source-Free RL Circuit, The Source-Free Series RLC Circuit, The Source-Free Parallel RLC Circuit.

AC Circuits

Sinusoids and Phasors: Sinusoids, Phasors, Phasor Relationships for Circuit Elements, Impedance and Admittance.

Sinusoidal Steady-State Analysis: Nodal Analysis, Mesh Analysis, Superposition Theorem, Source Transformation, Thevenin and Norton Equivalent Circuits.

AC Power Analysis: Instantaneous and Average Power, Maximum Average Power Transfer, Effective or

RMS Value, Apparent Power and Power Factor, Complex Power.

Three-Phase Circuits: Balanced Three-Phase Voltages, Balanced Wye-Wye Connection, Balanced Wye-Delta Connection, Balanced Delta-Delta Connection, Balanced Delta-Wye Connection, Power in a Balanced System.

Magnetically Coupled Circuits: Mutual Inductance, Energy in a Coupled Circuit, Linear Transformers, Ideal Transformers, Ideal Autotransformers, Three-Phase Transformers.

Text and Reference Materials

- Textbook:
  - *Charles K. Alexander and Matthew N.O. Sadiku*, **Fundamentals of Electric Circuits**, McGraw Hill.
- References:
  - *Robert L. Boylestad*, **Introductory Circuit Analysis**, Pearson.
  - *V.K Mehta*, **Introduction to Electrical Engineering**, S. Chand.
  - *Joseph A Edminister and Mahmood Nahvi*, **Schaum's Outline of Electric Circuits**, McGraw Hill.

RME 1111: Electrical Circuits Analysis Lab

Basic Information

Semester	1st Year 1st Semester
Course Code	RME 1111
Course Title	Electrical Circuits Analysis Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 1101: Electrical Circuits Analysis**.

RME 1102: Fundamentals of Mechanical Engineering

Basic Information

Semester	1st Year 2nd Semester
Course Code	RME 1102
Course Title	Fundamentals of Mechanical Engineering
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Physics, Math

Syllabus

Introduction: Scope of Mechanical Engineering, Engineering Codes and Standards, Engineering Ethics and Occupational Safety.

Sources of Energy: Conventional and Renewable Energy Sources, Sustainability of Energy Resources, Environmental Impact of Different Energy Resources, Energy Resources in Bangladesh.

Thermodynamics: Fundamental Concepts and Definitions, Thermodynamic Properties, Thermodynamic Cycles, Laws of Thermodynamics, Properties of Pure Substances during Phase Change Processes, Use of Property Tables for Different Phases, Equation of State.

Heat Transfer: Introduction to Heat Transfer; Modes of Heat Transfer- Fundamental Concepts and Laws related to the Conduction, Convection, and Radiation Heat Transfer Processes; Steady Heat Conduction-Analysis of Thermal Resistance Network; Unsteady State Heat Conduction- Lumped Parameter Analysis; Convection Heat Transfer- Natural and Forced Convection Processes; Radiation Heat Transfer- Radiation Heat Transfer from Black, Diffuse, and Gray Surfaces, Net Radiation Heat Transfer from and to a Surface and Between Two Surfaces.

Major Mechanical Applications: Heat Engines- Types of Heat Engine, Introduction to Internal Combustion (IC) Engines, Main Components of an IC Engine, Terminologies related to an IC Engine, Working Principles and Thermodynamic Cycles of a Petrol Engine, a Diesel Engine, a Two Stroke Engine, and a Four Stroke Engine; Fluid Machinery- Fundamental Concepts and Working Principles of Fans, Blowers, Pumps, and Turbines; Boilers- Classification of Boilers, Working Principles of Commonly Used Boilers, Boiler Mountings and Accessories; Refrigeration Systems- Fundamental Concepts, Definitions, and Applications of Refrigeration systems, Working Principles of a Vapour Compression Refrigeration System and the related Thermodynamic Cycle.

Text and Reference Materials

- Textbook:
  - *Yunus A. Cengel*, **Introduction to Thermodynamics and Heat Transfer**, McGraw Hill.
  - *V.P. Vasandani and D.S. Kumar*, **Heat Engineering**, Metropolitan.
  - *Ahmedul Ameen*, **Refrigeration and Airconditioning**, Prentice Hall.
- References:
  - *Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, and Margaret B. Bailey*, **Engineering Thermodynamics**, Wiley.
  - *J.P. Holman*, **Heat Transfer**, McGraw Hill.

MATH 1103: Discrete Mathematics

Basic Information

Semester	1st Year 1st Semester
Course Code	MATH 1103
Course Title	Discrete Mathematics
Course Credit	3.0
Course Category	GED Course
Foundation Knowledge	Algebra, Geometry and Pre-calculus

Syllabus

Discrete Mathematics

Introduction: Theoretical Computer Science, Information Theory, Mathematical Thinking, Mathematical Logic, Set Theory, Combinatorics, Graph and Number Theory, Discrete Geometry.

Logic and Sets: Propositional Logic, Composite Statements, Logical Connectives, Application of Propositional Logic, Limitation of Propositional Logic, Propositional Equivalences, Predicate Logic, Quantifiers and Nested Quantifiers, Rule of Inference, Introduction of Proofs, Direct Proof, Proof by Contraposition and Contradiction, Use of Counter Examples, Basics of Set, Cardinality, Infinite Set, Power Set, Cartesian Product, Set Operation, Computer Representation of Set.

Function & Relation: Definitions and Examples, Properties of Functions, Injective Function, Subjective Function, Bijection Function, Inverse Function, Composition of Function, Sequences and Summations, Zero-One Matrices, Boolean Product, Binary Relation, Reflexive Relation, Symmetric Relation, Transitive Relation, Closure of a Relation, Composite Relation, Equivalence Relation.

Combinatorics: Fundamental Counting Principles, Inclusion, Pigeonhole Principle, Permutation, Combination, Binomial Coefficients and Identifies, Generalized Permutations and Combinations.

Mathematical Induction and Recursion: Proof Technique, Mathematical Induction, Discrete Probability, Uniform Probability Measure, Probability of Complementary Event, Probability of a Union Event, Applications of Recurrence Relations, Inclusion-Exclusion Principles.

Number Theory: Importance of Number Theory, Divisors, Prime Numbers, Fundamental Theorem of Arithmetic, GCD and Relatively Prime, Least Common Multiple, Mod Function.

Text and Reference Materials

- Textbooks:
  - *Keneth H. Rosen*, **Discrete Mathematics and Its Applications**, AMC.
  - *Pradeep K. Sinha & Priti Sinha*, **Computer Fundamentals**, BPB Publications.
- References:
  - *Ronald Tocci, N. Widmer & G. Moss* , **Digital Systems: Principles and Applications**, Prentice Hall.

MATH 1104: Differential and Integral Calculus

Basic Information

Semester	1st Year 1st Semester
Course Code	MATH 1104
Course Title	Differential and Integral Calculus
Course Credit	3.0
Course Category	GED Course
Foundation Knowledge	Pre-calculus

Syllabus

Differential Calculus

Functions: Functions and their Graphs (Polynomial, Rational, Logarithmic, Exponential, Trigonometric, Hyperbolic Functions and Combination of such Functions).

Limits, Continuity and Differentiability: Concepts and Definitions, One Sided Limits, Limit at Infinity and Infinite Limits, Limit Laws, Sandwich Theorem, Continuous and Discontinuous Functions with Properties, Intermediate Value Theorem, One Sided Derivatives, Differentiability of Functions.

Differentiation: Tangent Lines and Rates of Change, Techniques of Differentiation, Chain Rule, Derivatives of Various Functions, Successive Differentiation, Leibnitz Theorem, Related Rates, Indeterminate Forms, L'Hopital's Rule.

Applications of Differentiations: Analysis of Functions, Absolute Extrema, Applied Maximum and Minimum Problems, Intermediate Value Theorem, Rolle's Theorem, Mean-Value Theorem.

Integral Calculus

Integration: Indefinite Integral (Integration by Substitution, Integration by Parts, Standard Integrations, Integration by Successive Reduction), Definite Integrals, Fundamental Theorem of Calculus, Properties of Definite Integrals, Riemann Sum.

Applications of Integration: Area between Two Curves, Volume of Solid by Slicing, Disk and Washers, Volume by Cylindrical Shells, Arc Length, Area of a Surface of Revolution.

Improper Integrals: Different Types of Improper Integrals, Beta and Gamma Functions, Feynman Technique.

Text and Reference Materials

- Textbook:
  - *H. Anton and I. Bivens and S. Davis*, **Calculus: Early Transcendentals**, Wiley.
- References:
  - *G. B. Thomas and R. L. Finney*, **Calculus and Analytic Geometry**, Addison Wesley.
  - *J. Stewart*, **Calculus: Early Transcendentals**, Thomson Brooks.
  - *R.T. Smith and R. B. Minton*, **Calculus**, McGraw-Hill Education.

PHY 1105 : Physics

Basic Information

Semester	1st Year 1st Semester
Course Code	PHY 1105
Course Title	Physics
Course Credit	3.0
Course Category	GED Course
Foundation Knowledge	Basic physics and Mathematics

Syllabus

Measurement and Vectors: Units and Dimensions, Scalars and Vectors, Vector Addition and Subtraction.

Statics of Particles and Rigid Bodies: Forces and Equilibrium, Free-Body Diagrams, Torque and Moment of Forces, Center of Gravity and Centroid.

Force and Motion : Displacement, Velocity, and Acceleration, Kinematic Equations for Uniform and Non-uniform Acceleration, Projectile Motion, Circular Motion, Relative Motion, Newton's Laws of Motion, Applications of Newton's Laws, Friction, Drag Force, and Terminal Speed.

Energy and Work: Work Done by a Constant and Variable Force, Kinetic Energy and Work-Energy Theorem, Potential Energy, Conservation of Mechanical Energy, Power, Center of Mass, Linear Momentum, Impulse and Momentum Conservation.

Rotation and Rolling, Torque, and Angular Momentum: Rotational Kinematics and Dynamics, Moment of Inertia, Torque and Angular Momentum.

Gravitation: Newton's Law of Universal Gravitation, Gravitational Potential Energy, Orbits of Planets and Satellites.

Oscillations and Waves: Simple Harmonic Motion (SHM), Energy in SHM, Damped and Driven Oscillations, Resonance, Properties of Waves, Sound Waves and Acoustics.

Electromagnetism in Actuators and Sensors: Coulomb's Law, Electric Fields and Field Lines, Gauss' Law, Electric Potential and Potential Energy, Capacitance, Inductance, Magnetic Forces and Fields, Faraday's Law of Electromagnetic Induction, Fleming's Rule, Lenz's Law, Magnetic Hysteresis, Series & Parallel Magnetic Circuits, Leakage Flux.

Semiconductor Physics: Types of Materials, Atomic Structure and Bonding, Bohr's Atomic Model, Energy Levels, Energy Bands, Charge Carriers in Semiconductors, Carrier Transport in Semiconductors, Effect of Temperature on Semiconductors, N-type Semiconductor, P-type Semiconductor, Majority and Minority

Carriers, P-N Junction, Properties of P-N Junction.

Text and Reference Materials

- Textbook:
  - *David Halliday, Robert Resnick, and Jearl Walker*, **Fundamentals of Physics**, Wiley.
  - *J.L. Meriam and L.G. Kraige*, **Engineering Mechanics: Dynamics**, Wiley.
- References:
  - *V.K Mehta*, **Principles of Electronics**, S. Chand.
  - *Steven E. Schwarz and William G. Oldham*, **Electromagnetics for Engineers**, Oxford University Press.

RME 1116: Engineering Drawing Lab

Basic Information

Semester	1st Year 1st Semester
Course Code	RME 1116
Course Title	Engineering Drawing Lab
Course Credit	1.5
Course Category	Core course
Prerequisite Course	None

Syllabus

Introduction to Mechanical Drawing, Introduction to Lettering, Numbering and Heading, Instrument and their Uses, First and Third Angle Projections, Orthographic Drawings, Missing Lines and Views, Sectional Views and Conventional Practices, Auxiliary Views, Pictorial Drawing- Isometric Views, Surface Development, Computer Aided Drawing.

RME 1117: Engineering Workshop Lab

Basic Information

Semester	1st Year 2nd Semester
Course Code	RME 1117
Course Title	Engineering Workshop Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Foundry: Introduction to Foundry, Tools and Equipment.

Patterns: Function, Pattern Making.

Molding: Molding Materials, Types of Mold, Procedure.

Cores: Types, Core Making Materials, Metal Melting and Casting.

Tools: Hand Tools, Power Tools, Safety Rules for Workshop Practices.

Practices on Machine Tools: Lathe Machine, Drilling Machine, Shaper Machine, Milling Machine, Grinding Machine.

Metal Joints: Riveting, Grooving, Soldering.

Welding Practice: Electric Arch Welding, Spot Welding, Pressure Welding.

RME 1201: Structured Programming

Basic Information

Semester	1st Year 2nd Semester
Course Code	RME 1201
Course Title	Structured Programming
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Discrete Mathematics & Computing Concepts

Syllabus

Introduction to Computer Programming: Problem Solving Techniques, Flow Charts, Algorithm Specification and Development, Programming Style, Interpreter, Compiler, Debugging and Testing, Documentation.

Introduction to 'C': Features of C Language, Structure of C Program, Comments, Header Files, Data Types, Constants and Variables, Operators, Expressions, Evaluation of Expressions, Type Conversion, Precedence and Associativity, I/O functions.

Fundamentals of 'C': - Operators: Arithmetic, Relational, Logical and Bitwise Operators, Operator Precedence and Associativity, Arithmetic Expression Evaluation. - Conditional Logics: If, If-Else, Switch etc. - Control Structures in 'C': Simple Statements, Decision-Making Statements, Looping Statements, Nesting of Control Structures, Break and Continue Statements, Goto Statements. - Loops: Looping Basic, Necessity of Loops, While Loop, For Loop, Do While Loop, Nested Loop. - Formatted I/O: Specifying Width Using Format Specifier in Printf and Scanf in Details.

Array: Basics of Array, Accessing through Indices, Accessing using Loops, Two Dimensional Arrays.

String: Basics, I/O Operations using String, Basic Operations without using Library Functions, Basic String Operations.

Functions: Basic Functions, Different Types of Functions, Local and Global Variables, Call by Value, Call by Reference, Passing Arrays in a Function as Parameter, Recursion, Scope Visibility and Lifetime of Variable.

Pointers: Basics,Pointer Operation, Call by Reference using Pointers, Pointer for Array, Array of Pointers.

Dynamic Memory Allocation: Basics, Malloc, Free, Calloc.

Structure and Union: Basics of Structure, Structure Members, Accessing Structure Members, Nested Structures, Array of Structures, Structure and Functions, Structures and Pointers, Unions, Bit-fields.

File Operation: Basic File Handling, Text File , Binary File, Stream, File I/O.

Text and Reference Materials

- Textbook:
  - *E. Balagurusamy*, **Programming in ANSI C** , McGraw-Hill Education.
- References:
  - *Brian W. Kernighan and Dennis M. Ritchie*, **The C Programming Language** , Prentice Hall.
  - *Herbert Schieldt*, **C the Complete Reference** , McGraw-Hill Education.

RME 1211: Structured Programming Lab

Basic Information

Semester	1st Year 2nd Semester
Course Code	RME 1211
Course Title	Structured Programming Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 1201: Structured Programming**.

RME 1202: Linear and Power Electronics

Basic Information

Semester	1st Year 2nd Semester
Course Code	RME 1202
Course Title	Linear and Power Electronics
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Physics, Electrical Circuits Analysis

Syllabus

Linear Electronics

Semiconductor Diode: Crystal Diode as a Rectifier, Resistance of Crystal Diode, Equivalent Circuit of Crystal Diode, Half-Wave Rectifier, Centre-Tap Full-Wave Rectifier, Full-Wave Bridge Rectifier, Nature of Rectifier Output, Ripple Factor, Types of Filter Circuits, Zener Diode, and Zener Diode as Voltage Stabilizer.

Clipper and Clamper: Clipping Circuits, Applications of Clippers, Clamping Circuits, Basic Idea of a Clamper–Positive Clamper and Negative Clamper.

Bipolar Junction Transistor (BJT): Naming the Transistor Terminals, Transistor Action, Transistor as an Amplifier, Characteristics of Common Base, Common Emitter, and Common Collector Connection, Transistor Load Line Analysis, Cut Off, Active, and Saturation Points, Methods of Transistor Biasing–Base Resistor Method, Emitter Bias Circuit, Circuit Analysis of Emitter Bias, Biasing with Collector Feedback Resistor, Voltage Divider Bias Method.

Junction field effect transistor (JFET): Principle and Working of JFET, JFET as an Amplifier, Relation among JFET Parameters, JFET Biasing.

Metal oxide semiconductor FET (MOSFET): Types of MOSFET, Circuit Operation of D-MOSFET, D-MOSFET Biasing, Circuit Operation of E-MOSFET, E-MOSFET Biasing Circuits.

Power Electronics

Silicon Controlled rectifier (SCR): Working of SCR, Equivalent Circuit of SCR, V-I characteristics of SCR, SCR as a switch, SCR Half-wave Rectifier, SCR Full-wave Rectifier, Single Phase SCR Inverter Circuit, Applications of SCR.

TRIAC: Triac construction, SCR Equivalent Circuit of TRIAC, TRIAC Operation, TRIAC Phase Control Circuit, Applications of TRIAC.

DIAC: DIAC Construction, Applications of DIAC.

Unijunction transistor (UJT): UJT Construction, Equivalent Circuit of a UJT, Characteristics of UJT, Applications of UJT..

Power Converters and Drives: AC to DC Converter, DC to DC Converter–Buck Converter, Boost Converter, Buck-Boost Converter, DC to AC Converter–Single Phase and Three Phase Inverters, AC to AC Converter–Single Phase AC Voltage Controller (Resistive and Inductive Loads), Cycloconverter, Matrix Converter, Variable Frequency Drive (VFD), Stepper and Servo Motor Drives.

Solar PV Systems: Introduction to Solar Energy, Solar Cells and Modules, System Components, System Design and Sizing.

Text and Reference Materials

- Textbook:
  - *Muhammad Rashid*, **Power Electronics: Circuits, Devices & Applications, Pearson**.
  - *V. K. Mehta , Rohit Mehta*, **Principles of Electronics, S. Chand**.
- References:
  - *Ned Mohan*, **Power Electronics: A First Course, Wiley**.
  - *Steven E. Schwarz and William G. Oldham*, **Electromagnetics for Engineers, Oxford University Press**.

RME 1212: Linear and Power Electronics Lab

Basic Information

Semester	1st Year 2nd Semester
Course Code	RME 1212
Course Title	Linear and Power Electronics Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 1202: Linear and Power Electronics**.

RME 1203 : Statics and Dynamics

Basic Information

Semester	1st Year 2nd Semester
Course Code	RME 1203
Course Title	Statics and Dynamics
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Physics

Syllabus

Statics

Introduction: Fundamental Concepts and Principles of Mechanics.

Statics of Particles: Addition of Planar Forces, Adding Forces by Components, Forces and Equilibrium in a Plane, Adding Forces in Space, Forces and Equilibrium in Space.

Equivalent Systems of Forces: Forces and Moments, Moment of a Force about an Axis, Couples and Force-Couple Systems, Simplifying Systems of Forces.

Equilibrium of Rigid Bodies: Equilibrium in Two Dimensions, Equilibrium in Three Dimensions.
Centroids and Centres of Gravity: Planar Centres of Gravity and Centroids, Centres of Gravity and Centroids of Volumes.
Friction: The Laws of Dry Friction, Wedges and Screws, Friction on Axles, Disks, and Wheels, Belt Friction.
Moments of Inertia: Moments of Inertia of Areas, Radius of Gyration of an Area, Parallel-Axis Theorem and Composite Areas, Transformation of Moments of Inertia, Mohr's Circle for Moments of Inertia, Mass Moments of Inertia.

Dynamics

Kinematics: Kinematics of Particles- Rectilinear and Curvilinear Motion of Particles. Kinematics of Rigid Bodies- Rigid body in Translation, Rotation about a Fixed Axis, Absolute and Relative Velocity in a Plane Motion, Instantaneous Centre of Rotation in Plane Motion, Absolute and Relative Acceleration in Plane Motion.
Kinetics: Kinetics of Particles- Newton's Second Law of Motion, Principles of Work, Energy, Impulse and Momentum, System of Particles. Kinetics of Plane Motion of Rigid Bodies- Forces and Acceleration.

Text and Reference Materials

- Textbook:
  - *Russell C. Hibbeler*, **Engineering Mechanics: Statics, Pearson**.
  - *Russell C. Hibbeler*, **Engineering Mechanics: Dynamics, Pearson**.
- References:
  - *Ferdinand P. Beer, E. Russell Johnston Jr., Phillip J. Cornwell*, **Vector Mechanics for Engineers: Statics, McGraw Hill**.
  - *Ferdinand P. Beer, E. Russell Johnston Jr., Phillip J. Cornwell*, **Vector Mechanics for Engineers: Dynamics, McGraw Hill**.

MATH 1204: Linear Algebra

Basic Information

Semester	1st Year 2nd Semester
Course Code	MATH 1204
Course Title	Linear Algebra
Course Credit	3.0
Course Category	GED Course
Foundation Knowledge	None

Syllabus

Matrices and Determinants: Notion of Matrix, Types of Matrices, Matrix Operations, Laws of Matrix Algebra, Determinants and Properties of Determinants, Minors, Cofactors, Expansion and Evaluation of Determinants, Elementary Row and Column Operations and Row-reduced Echelon Matrices.

System of Linear Equations: Linear Equations, System of Linear Equations (Homogeneous and Non-homogeneous), Solutions of System of Linear Equations using Different Methods, Applications to Network Flow and Electrical Networks.

Vector Space: Vectors in $\mathbb{R}^n$ and $\mathbb{C}^n$, Vector Space, Subspace, Linear Dependence of Vectors, Basis and Dimension of Vector Spaces, Change of Bases, Row Space and Column Space of Matrix, Rank of Matrices, Solution Space of System of Linear Equations.

Linear Transformation: Linear Transformations, Example and Illustrations with Applications, Kernel and Image of a Linear Transformation and their Properties.

Eigenvalues and Eigenvectors of Matrices: Eigenvalues and Eigenvectors, Diagonalization, Cayley-Hamilton Theorem, Applications.

Least Squares Problems: Least Squares, Mathematical Modeling using Least Squares.

Text and Reference Materials

- Textbook:
  - *H. Anton and C. Rorres*, **Elementary Linear Algebra: Applications Version** , 11th Edition, John-Wiley & Sons..
- References:

- *S. Boyd and V. Lieven*, **Introduction to applied linear algebra: vectors, matrices, and least squares.**, Cambridge University Press.
- *G. Jean and Q. Jocelyn*, **Lecture note: Linear algebra for computer vision, robotics, and machine learning**, University of Pennsylvania (2023).
- *J. Solomon*, **Lecture note: Mathematical Methods for Computer Vision, Robotics, and Graphics**, Stanford University (2013).
- *S. Lipshutz*, **Linear Algebra**, Schaum's Outline Series.

MATH 1205: Multivariate and Vector Calculus

Basic Information

Semester	2nd Year 1st Semester
Course Code	MATH 1205
Course Title	Multivariate and Vector Calculus
Course Credit	3.0
Course Category	GED Course
Foundation Knowledge	Differential and Integral Calculus

Syllabus

Vectors and Geometry of Space: Three Dimensional Coordinate Systems, Dot Product and Cross Product of Vectors, Lines and Planes in 3-space, Cylindrical and Quadric Surfaces.

Vector Valued Functions: Calculus of Vector Valued Functions, Arc Length, Unit Tangent, Normal and Binormal Vectors, Curvature, Motion in Space.

Partial Derivatives: Functions of Two or More Variables, Limit and Continuity, Partial Derivatives, Chain Rule, Taylor Series, Directional Derivatives, Tangent Planes and Normal Vectors, Maxima and Minima of Functions of Two Variables, Lagrange Multipliers.

Multiple Integral: Double Integrals (Over Rectangular and Non Rectangular Regions and in Polar Coordinates), Triple Integrals in Rectangular Coordinates, Cylindrical Coordinates and Spherical Coordinates, Change of Variables in Multiple Integrals.

Vector Calculus:Vector Fields, Line Integrals, Conservative Vector Fields, Green's Theorem, Surface Integrals, Divergence Theorem, Stokes' Theorem.

Gradient, Divergence, and Curl: Gradient- Interpretation and Applications, Divergence- Definition and Physical Meaning, Curl- Definition and Applications in Fluid Dynamics.

Text and Reference Materials

- Textbook:
  - *H. Anton, I. Bivens and S. Davis*, **Calculus: Early Transcendentals**, Wiley.
- References:
  - *G. B. Thomas and R. L. Finney*, **Calculus and Analytic Geometry**, Addison Wesley.
  - *J. Stewart*, **Calculus: Early Transcendentals**, Thomson Brooks/Cole.
  - *R.T. Smith and R. B. Minton*, **Calculus**, McGraw-Hill Education.

ENG 1216: Functional English Lab

Basic Information

Semester	1st Year 2nd Semester
Course Code	ENG 1216
Course Title	Functional English Lab
Course Credit	2.0
Course Category	GED Course
Foundation Knowledge	None

Syllabus

Listening Skill: Recognizing speakers' attitude, accent and signal; Techniques for developing listening skill; Common mistakes in listening tests & how to avoid the mistakes in listening tests; Paying attention to detailed information; Responding to directed questions; Being able to follow instructions and directions.
Speaking Skill: Understanding speaking etiquettes; Demonstrating proper public speaking decorum; Using advanced vocabulary; Eliminating their inhibition of speaking in English; Performing: One-on-one basic conversation.
Reading Skill: Reading strategies; Understanding vocabulary, connotations, denotations etc.; Identifying thesis statements and topic sentences; main idea of a text; Understanding formal/informal language; Scanning, skimming, and analyzing texts of different genres and standards.
Writing Skill: Fundamentals: the tense, subject-verb agreement, sentence structures, run-ons, fragments, capitalization, punctuation marks; Brainstorming, prewriting, drafting, proofreading, editing; Structure of paragraphs; Mechanics of writing: unity, cohesion, coherence, use of context modulators; Structure of essay: thesis statement, introduction, body paragraphs, conclusion; Formal letter writing.

Text and Reference Materials

- Textbook:
  - *A.J. Thomson and A.V. Martinet*, **A Practical English Grammar**, Oxford University Press.
- References:
  - *Maurice L Imhoof and Herman Hudson*, **From Paragraph to Essay: Developing Composition Writing**, Longman.
  - *Clive Taylor*, **Advancing Language Skills**, University Grants Commission.
  - *John Arnold and Jeremy Harmer*, **Advanced Writing Skills**, Longman.
  - *Simon Greenall and Michael Swan*, **Effective Reading**, Cambridge.
  - *Thomas E. Tyner*, **Writing Voyage: A Process Approach to Basic Writing**, Harcourt College Publisher.
  - *Robert O'Neill and Reger Scott*, **View Points: Interviews for Listening**,
  - *R. Sharma and Krishna Mohan*, **Business Correspondence and Report Writing**, McGraw Hill Education.

RME 2101: Digital Logic Circuits and Microprocessors

Basic Information

Semester	2nd Year 1st Semester
Course Code	RME 2101
Course Title	Digital Logic Circuits and Microprocessors
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Computing Concepts, Electrical Circuits Analysis

Syllabus

Digital Logic Circuits

Number Systems: Binary, Decimal, Hexadecimal, Octal Number Systems, Binary Operations, Arithmetic in Number Systems.

Combinational Logic Circuit: Logic Gates and Boolean Algebra, Combinational Circuits Design using Logic Gates, Minimization of Functions, Simplifying Logic Circuits, Algebraic Simplification, Arithmetic Circuits.

Flip-Flop and Related Devices: NAND Gate Latch, NOR Gate Latch, Clock Signals and different types of Clocked Flip-Flops, Flip-Flop Timing.

Counter and Registers: Asynchronous (Ripple) Counters, Propagation Delay in Ripple, Synchronous (Parallel) Counters, Counters with MOD Numbers Less than 2^N, Synchronous Down and Up/Down Counters, Shift-Register Counters- Ring Counter, Johnson Counter.

MSI Logic Circuits: Encoders, Decoders, Multiplexers, De-Multiplexers.

Memory Devices: Semiconductor Memory Technologies, Timing and Types of ROM, EPROM, EEPROM, Static and Dynamic RAM, DRAM Structure Operation and Refreshing.

Microprocessors

Microprocessors, Microcomputers and Assembly Language: Microprocessors, Microprocessor Instruction Set and Computer Languages, Application - Microprocessor-Controlled Temperature System.

Introduction to 8085/8086 Assembly Language Programming: 8085/8086 Programming Model, Instruction Classification, Instruction, Data Format and Storage, How to Write, Assemble and Execute a Simple

Program, Overview of 8085/8086 Instruction Set, Writing and Hand Assembling a Program.

8085/8086 Microprocessor: Microprocessor Architecture and Its Operations, Addressing Modes, Data Movement Instructions, Arithmetic and Logic Instructions, Program Control Instructions, Constructing Machine Codes, Assembly Language, Programming the Microprocessor, Memory Interface, Basic I/O Interface.

Text and Reference Materials

- Textbook:
  - *Ronald J. Tocci*, **Digital Systems: Principles and Applications**, Prentice Hall.
  - *Sunil Mathur*, **Microprocessor 8086: Architecture, Programming and Interfacing**, PHI Learning Pvt.
- References:
  - *Morris Mano and M. D. Ciletti*, **Digital Design: With an Introduction to the Verilog HDL**, Pearsons.
  - *Ramesh Gaonkar*, **8085 Microprocessor**, Penram Int. Publishing.

RME 2111: Digital Logic Circuits and Microprocessors Lab

Basic Information

Semester	2nd Year 1st Semester
Course Code	RME 2111
Course Title	Digital Logic Circuits and Microprocessors Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 2101: Digital Logic Circuits and Microprocessors**.

RME 2102: Fundamentals of Mechatronics Engineering

Basic Information

Semester	2nd Year 1st Semester
Course Code	RME 2102
Course Title	Fundamentals of Mechatronics Engineering
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Electrical Circuit Analysis, Linear and Power Electronics

Syllabus

Introduction: Definition and Components of Mechatronics, Applications of Mechatronics, Traditional vs. Mechatronics Design, Examples of Mechatronic Systems.

System Models: Building Blocks of Electrical, Mechanical, Fluid and Thermal Systems, Modelling Multi-discipline Systems.

System Response: Amplitude Response, Bandwidth and Frequency Response, Phase Response, Distortion of Signals, Dynamic Characteristics of Zeroth Order, First Order, and Second Order Systems.

Sensors and Transducers: Types of Sensors- Active and Passive Sensors; Terminologies Related to Sensor Performance and Characteristics, Fundamentals of Resistive Sensors, Capacitive Sensors, Inductive Sensors, Hall-Effect Sensors, Piezoelectric Sensors, Piezoresistive Sensors, Optical Sensors, Semiconductor Sensors, MEMs Sensors, etc.

Operational Amplifiers (Op-Amps): Ideal Op-Amp, Inverting Amplifier, Non-inverting Amplifier, Summing Amplifier, Difference Amplifier, Common-mode Rejection Ratio (CMRR), Bandwidth of An OP-Amp, Slew Rate, Cascaded Op-Amp Circuits, OP-Amp Integrator, OP-Amp Differentiator, OP-Amp Comparators.

Signal Conditioning and Data Acquisition: Basics of Analog Filtering and Signal Amplification, Protection Circuit, Wheatstone Bridge Circuit, A/D and D/A Converters, Data Acquisition Systems.

Actuation Systems: Basics of Pneumatic and Hydraulic Actuation Systems, Mechanical Actuation Systems, Electrical Actuation Systems.

Control Systems and Controllers: Open and Closed Loop Systems, Analog and Digital Control Systems, Control Modes, PID and Digital Controllers, Velocity Control, Adaptive Control, Microprocessor and Microcontrollers, Programmable Logic Controllers.

Communication Protocols: UART, SPI, I2C Communication Protocols.

Case Studies: Case Studies of Mechatronics Systems, e.g. Bathroom Scale, Pick-and-Place Robot, etc.

Text and Reference Materials

- Textbook:
  - *W.Bolton*, **Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering**, Pearson.
  - *Christopher T. Kilian*, **Modern Control Technology: Components and Systems**, Second Edition, Cengage learning.
- References:
  - *David G. Alciatore*, **Introduction to Mechatronics and Measurement Systems**, McGraw-Hill.

RME 2112: Fundamentals of Mechatronics Engineering Lab

Basic Information

Semester	2nd Year 1st Semester
Course Code	RME 2112
Course Title	Fundamentals of Mechatronics Engineering Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 2102: Fundamentals of Mechatronics Engineering**.

RME 2103: Mechanical Power Transmission

Basic Information

Semester	2nd Year 1st Semester
Course Code	RME 2103
Course Title	Mechanical Power Transmission
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Statics and Dynamics

Syllabus

Power Transmission Devices: Introduction to Mechanical Drive Systems and Components.
Gear: Classification of Gear, Gear Terminologies, Law of Gearing, Cycloidal and Involute Gear Teeth
Cam: Classification and Terminologies, Displacement, Velocity and Acceleration Diagram, and the Construction of Cam Profile for Uniform and Simple Harmonic Motion of the Follower.
Bearing: Types and Terminologies, Bearing Load, Life and Reliability.
Brakes: Types and Terminologies, Single Block, Pivoted Block, and Double Block Brake.
Clutches: Single and Multiple Disc Friction Clutches.
Power Transmission Systems: Gear Trains, Belt, Rope and Chain Drives, Efficiency of Different Power Transmission Systems.
Couplings: Types and Functions of Couplings Used in Industrial Power Transmission Systems.
Converters: Fluid and Mechanical Converters.
Case Studies: Case Studies Based on the Application of Mechanical Power Transmission Systems in Robotics and Mechatronics.

Text and Reference Materials

- Textbook:
  - *R.S. Khurmi*, *J.K. Gupta*, **Theory of Machines**, Eighth Edition, Eurasia Publishing House.
  - *Richard Gordon Budynas*, *J. Keith Nisbett*, **Shigley's Mechanical Engineering Design**, McGraw Hill.
- References:

- *R Holmes*, *Pergamon*, **The Characteristics of Mechanical Engineering Systems, Elsevier**,
- *PER Mucci*, *BSI*, **Handbook for Engineering Design, Health and Safety Executive**,

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BUS 2104: Accounting and Business Entrepreneurship

Basic Information

Semester	2nd Year 1st Semester
Course Code	BUS 2104
Course Title	Accounting and Business Entrepreneurship
Course Credit	3.0
Course Category	GED Course
Foundation Knowledge	None

Syllabus

Entrepreneurship: Entrepreneur and Entrepreneurship, Emerging Dimensions of Entrepreneurship, Entrepreneurial Motivation, Business: Its Nature and Scope, Forms of Ownership, Financing of Business, Legal Framework for Business, Management and Marketing Process.

Accounting for Business: Accounting, Building Blocks of Accounting- Ethics, Standards, Principles, Assumptions, Accounting as an Information System, Accounts and their Classifications, Accounting Equation, Accounting Cycle, Steps in the Recording Process, Journal, Ledger, Trial Balance, Adjusting Entries, Preparation of Financial Statements Considering Adjusting and Closing Entries, Financial Statement Analysis and Interpretation.

Accounting for Cost Determination and Control: Cost Concepts and Classification, Cost Behavior Analysis, Preparation of Cost Sheets, Job Order Costing, Absorption Costing and Variable Costing Technique.

Accounting for Profit Planning and Budgeting: Cost-Volume-Profit Analysis, Budgeting and Budgetary Control.

Accounting for Decision Making: Relevant and Differential Cost Analysis.

Accounting for Financial Management: Capital Budgeting, Short-Term and Long-Term Investment Decisions.

Text and Reference Materials

- Textbook:

– *J. J. Weygandt, P. D. Kimmel and D. E. Kieso*, **Financial Accounting**, IFRS Edition, John Wiley & Sons, Inc,

– *Garrison, R. H., Noreen, E. and Brewer, P. C.*, **Managerial Accounting**, McGraw Hill India

– *Khanka, S.S and Gupta, C.B.*, **Entrepreneurship and Small Business Management.**, Sultan Chand and Sons

– *Datar, S. M. and Rajan, M. V.*, **Horngren's Cost Accounting: A Managerial Emphasis**, Pearson

- References:

  – *Horngren, C. T., Sundem, G. L., Burgstahler, D. and Schatzberg, J. O.*, **Introduction to Management Accounting**,Pearson.

  – *James C. Van Horne and John M. Wachowicz Jr.*, **Fundamentals of Financial Management** , Prentice Hall

  – *S. A. Ross, R. W. Westerfield and B. D. Jordan*, **Fundamentals of Corporate Finance**, Irwin and McGraw-Hill

  – *Siropolis, N.C.*, **Small Business Management: A Guide to Entrepreneurship**, Houghton Mifflin

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MATH 2105: Differential Equations and Coordinate Geometry

Basic Information

Semester	2nd Year 2nd Semester
Course Code	MATH 2105
Course Title	Differential Equations and Coordinate Geometry
Course Credit	3.0
Course Category	GED Course
Foundation Knowledge	Multivariate and Vector Calculus

Syllabus

Ordinary Differential Equations: Order and Degree of an Ordinary Differential Equation, Classification of Differential Equations, Solutions of Differential Equations, Formation of Differential Equations, Basic Existence and Uniqueness Theorem for initial value problem (IVP) (Statement and Illustration Only).
First-order Differential Equations: Separable Equations, Homogeneous Equations, Exact Differential Equations, Linear and Bernoulli Equations, Special Integrating Factors, Substitutions and Transformations, Applications of First-Order Linear Differential Equations.

Higher Order Differential Equations: Basic Theory of Linear Differential Equations, Reduction of Order, Homogeneous Linear Equations with Constant Coefficients, Non-Homogeneous Equations (Method of Undetermined Coefficients, Variation of Parameters, Cauchy-Euler Differential Equations), Boundary value problems (BVP), Applications of Second-Order Linear Equations with Constant Coefficients.
System of Two First-order Differential Equations: Stability Analysis of the Equilibrium Solutions of a System. The General Solution of a System of Two First-Order Linear Differential Equations.
Coordinate Geometry Coordinates: Coordinate Systems in Two and Three Dimensions, Translations and Rotations, and the Geometry of Linear Transformations.
Three-dimensional Geometry: Projections, Direction Cosines and Direction Ratios, Equations of Planes and Lines.

Text and Reference Materials

- Textbook:
  - *Paul Blanchard*, *Robert L. Devaney*, *Glen R. Hall*, **Differential Equations**, Thomson Brooks/Cole,
- References:
  - *Morris Hirsch*, *Robert L. Devaney*, *Stephen Smale*, **Differential Equations, Dynamical Systems, and an Introduction to Chaos**, Academic Press.
  - *D. G. Zill*, **A First Course in Differential Equations with Applications**, Thomson Brooks/Cole.
  - *Khosh Mohammad*, **Analytic Geometry and Vector Analysis**, Dhaka P.K. Bhattacharjee.

RME 2116: Object Oriented Programming Lab

Basic Information

Semester	2nd Year 1st Semester
Course Code	RME 2116
Course Title	Object Oriented Programming Lab
Course Credit	2
Course Category	Lab Course

Syllabus

Introduction: Object Oriented Programming Overview, Encapsulation, Inheritance and Polymorphism. Object Oriented vs. Procedural Programming, Basics of Object-Oriented Programming Language.

Basic Programs: Write Basic C++ Programs using Operators, Conditional Logic, Control Structures and Loops.

Objects and Classes: Attributes and Functions, Constructors and Destructors, Static Class Data, Operator Overloading, Function Overloading.

Class Declarations: Definition and Accessing Class Members, Default Constructor, Parameterized Constructor and Copy Constructors, Encapsulation and Data Hiding, Controlling Access to Attributes, Properties for Data Access, Example Cases.

Function Overloading: With Different Numbers of Arguments, With Type, Order, and Sequence of Arguments.

Operator Overloading: Overloading Operator++ and Operator—Using Friend Functions. Demonstrate Friend Function and Friend Class.

Inheritance: Derived Class and Base Class, Derived Class Constructors, Overriding Member Functions, Abstract Base Class, Public and Private Inheritance, Multilevel Inheritance, Multiple Inheritance, Ambiguity in Multiple Inheritance.

Virtual Functions: Virtual Functions, Pure Virtual Functions, Static Binding, Dynamic Binding, Friend Functions, Static Functions, Friend Class.

Stream and Files: Stream Classes, iOS Class, istream Class, ostream Class, Stream Errors. Disk File I/O with Streams, File Pointers.

Exception and Exception Handling: Exception Handling Fundamentals, Exception Types, Chained Exception, Creating Own Exception Subclasses.

RME 2201: Data Structure and Algorithms

Basic Information

Semester	2nd Year 2nd Semester
Course Code	RME 2201
Course Title	Data Structure and Algorithms
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Fundamentals of Programming

Syllabus

Introductory Concepts and Data Structure: Complexity Analysis, Beyond Experimental Analysis, Comparing Growth Rates, Best, Average, and Worst-case Analysis, Data Types– Primitive and Non-primitive, Types of Data Structures-Linear & Non-Linear Data Structures.

Searching, Recursion & Sorting: Searching: Linear Search, Binary Search, Applications of Binary Search-Finding Elements in a Sorted Array, Finding the nth Root of a Real Number, Solving Equations. Recursion: Basic Idea of Recursion, Tracing Output of a Recursive Function, Applications - Merge sort, Permutation, Combination, Memoization. Sorting: Insertion, Selection, Bubble, Merge, Quick and Distribution Sort, Lower Bounds for Sorting, External Sort.

Linear Data Structure: Array: Representation of Arrays, Applications of Arrays, Sparse Matrix and Its Representation. Linked List: Singly/Doubly/Circular Linked Lists, Basic Operations on Linked List (Insertion, Deletion, and Traverse), Dynamic Array and Its Application. Stack: Stack Operations (Push/Pop/Peek), Stack-Class Implementation using Array and Linked List, In-fix to Postfix Expressions Conversion and Evaluation, Balancing Parentheses using Stack. Queue: Basic Queue Operations (Enqueue, Dequeue), Circular Queue/ Dequeue, Queue-Class Implementation using Array and Linked List, Application - Josephus Problem, Palindrome Checker using Stack and Queue.

Non-Linear Data Structure: - Binary Tree: Binary Tree Representation using Array and Pointer, Traversal of Binary Tree (In-order, Pre-order and Post-order). Binary Search Tree: BST Representation, Basic Operations on BST (Creation, Insertion, Deletion, Querying and Traversing), Application - Searching, Sets. Self-balancing Binary Search Tree: AVL, Red Black Tree. Graph: Matrix Representation of Graphs, Elementary Graph operations, (Breadth First Search, Depth First Search, Spanning Trees, Shortest path, MST).

Heap: Min-heap, Max-heap, Binomial Heap, Fibonacci Heap, Applications-Priority Queue, Heap Sort.

Hashing and File Structures: Hashing: The Symbol Table, Hashing Functions. File Structure: Concepts of

Fields, Records and Files, Sequential, Indexed and Relative/Random File Organization, Indexing Structure for Index Files, Hashing for Direct Files.

Disjoint Set: MakeSet, Union, Find Set, Path Compression Optimization Techniques.

Huffman Coding: Method and Application in Lossless Data Compression.

Text and Reference Materials

- Textbook:
  - *T. H. Cormen, C. E. Leiserson, R. L. Rivest & C. Stein*, **Introduction to Algorithms**, MIT Press.
- References:
  - *M. T. Goodrich, R. Tamassia & M. H. Goldwasser*, **Data Structures and Algorithms in Python**, Wiley.
  - *M. A. Weiss*, **Data Structures & Algorithm Analysis in C++**, Pearson.

RME 2211: Data Structure and Algorithms Lab

Basic Information

Semester	2nd Year 2nd Semester
Course Code	RME 2211
Course Title	Data Structure and Algorithms Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 2201: Data Structure and Algorithms**.

RME 2202 : Electrical Machines

Basic Information

Semester	2nd Year 2nd Semester
Course Code	RME 2202
Course Title	Electrical Machines
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Physics, Electrical Circuits Analysis, Linear and Power Electronics, Digital Logic Circuits and Microprocessor

Syllabus

DC Generator: Generator Principle, Simple Loop Generator, Action of Commutator, Construction of D.C. Generator, General Features of D.C. Armature Windings, Armature Winding Terminology, Types of D.C. Armature Windings, E.M.F. Equation of a D.C. Generator, Torque Equation of a D.C Generator, Types of D.C. Generators, Losses in D.C, Machines, Power Stages, Condition for Maximum Efficiency, Armature Reaction, D.C. Generator Characteristics, Critical Speed, Critical Resistance for Series and Shunt Generator.

D.C. Motor: D.C. Motor Principle, Construction, Working of D.C. Motor, Back E.M.F, Voltage Equation, Power Equation, Types of D.C. Motors, Armature Torque, Shaft Torque, Brake Horse Power, Speed of D.C Motor, Speed Relations, Speed Regulation, Losses in D.C. Motor, Efficiency, Power Stages, D.C. Motor Characteristics, Applications of D.C. Motors, Speed Control of D.C. Motors, Electric Braking. Necessity of Starter for a DC Motor.

Transformer: Working Principle, Construction, E.M.F. Equation, Voltage Transformation Ratio, Ideal Transformation, Practical Transformation, Phasor Diagram of Different Types of Transformer, Impedance Ratio, Shifting Impedance, Equivalent Circuit of Transformer, Voltage Drop, Voltage Regulation, Transformer Tests, Transformer Rating, Losses in Transformer, Efficiency, Conditions for Maximum Efficiency.

Three Phase Induction Motor: Construction, Types, Rotating Magnetic Field due to 3 Phase Currents, Principle of Operation, Slip, Rotor Current, Rotor Torque, Starting Torque, Motor under Load, Torque-Slip Characteristics, Full Load, Starting and Maximum Torques, Torque-Speed Curve, Speed Regulation, Power Factor, Measurement of Slips, Power Stages, Induction Motor Torque, Rotor Output, Induction Generator, Equivalent Circuit of 3 Phase Induction Motor, Starting Methods of 3 Phase Induction Motor.

Synchronous Generator/Alternator: Alternator, Construction, Operation, Frequency, Armature Winding, Winding Factors, E.M.F equation, Alternator on Load, Synchronous Reactance, Phasor Diagram of Loaded

Alternator.

Synchronous Motor: Construction, Principle of Operation, Method of Starting, Equivalent Circuit, Motor on Load, Motor Phasor Diagram, Effect of Changing Field Excitation, V Curves for Synchronous Motor, Mechanical Power Developed by Motor, Power Factor, Synchronous Condenser, Stopping Synchronous Motors.

Special Purpose Motors: Stepper Motors, Servo Motors.

Text and Reference Materials

- Textbook:
  - *V.K Mehta and Rohit Mehta*, **Principles of Electrical Machines**, S. Chand.
- References:
  - *B.L. Theraja and A.K. Theraja*, **A Text Book of Electrical Technology**, S. Chand.
  - *Stephen J. Chapman*, **Electric Machinery Fundamentals**, McGraw Hill.

RME 2212: Electrical Machines Lab

Basic Information

Semester	2nd Year 2nd Semester
Course Code	RME 2212
Course Title	Electrical Machines Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 2202: Electrical Machines**.

RME 2203: Instrumentation and Measurement

Basic Information

Semester	2nd Year 2nd Semester
Course Code	RME 2203
Course Title	Instrumentation and Measurement
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Electrical Circuit Analysis, Linear and Power Electronics, Fundamental of Mechatronics Engineering

Syllabus

Introduction: Classification of Measuring Instruments, Methods of Measurement, Elements of a Measurement System, Block Diagram Symbols, Static and Dynamic Characteristics of a Measurement System.

Signal Conditioning: Different Types of Input Circuits used with Sensors, Signal Amplification, Filter designing- Passive, Active, First Order, and Higher Order Filter Design, Shielding and Grounding of Electrical and Electronic Circuitry.

Data Acquisition: Analog and Digital Signals, Sampling Theorem, Analong to Digital Conversion Process and Converters, Digital to Analog Conversion Process and Converters, Multiplexers, Example of a Commercial Data Acquisition Board and Related Specification.

Measurement Systems: Pressure Measurement- Fluid Pressure at a Point, Pascal's Law, Pressure Variation in a Fluid at Rest, Pressure Types, Mercury Barometer, Simple Manometers including Piezometer, U-tube Manometer, Multi-Column Manometer, Mechanical Gauges including Bourdon Tube Pressure Gauge and Bellow Pressure Gauge; Level Measurement- Dipsticks, Sight Glass Level Gauge, Float Level Gauge, Hydrostatic Level Measurement Principle, Bubble Tube Principle, Capacitive Level Sensor Principle, Ultrasonic Level Gauge; Flow Measurement- Types of Flow Meter, Venturimeter, Orifice Meter, Pitot Tube, Rectangular and V-notch Weir; Temperature Measurement- Liquid in Glass Thermometer, Thermocouple, Resistance Temperature Device, Thermistor, IC Temperature Sensor; Measurement of Translational and Rotational Motions- Measurement of Displacement Using Potentiometers and Linear Variable Differential Transformers, Measurement of Velocity, Measurement of Acceleration, Measurement of Vibration and Shock; Mass, Force, and Torque Measurement- Load Cell, Force Sensitive Resistor, Pony Brake, Torque Measurement Using Strain Gauge, Dynamometer; Stress-Strain Measurement- Strain Gauge, Strain Gauge Bridge Circuits- Quarter, Half and Full Bridge Circuits, Strain Resette, Stress Measurement Using Strain

Gauge; Measurement of Current, Voltage, and Electrical Power- Moving Coil Meter, Electrodynamometer, Induction Type Wattmeter, Power Factor Meter; .

Error in Measurement: Types and Sources of Errors in a Measurement System, Uncertainty in Measurement-Sampling, Probability Distribution, Quantification of Uncertainty using Mean, Standard Deviation, and Probability Distribution, Confidence Interval, Propagation of Error.

Text and Reference Materials

- Textbook:
  - *Thomas G. Beckwith, Roy D. Marangoni, John H. Lienhard V*, **Mechanical Measurements**, Pearson.
  - *Alan S. Morris and Reza Langari*, **Measurement and Instrumentation: Theory and Application**, Academic Press.
- References:
  - *John P Bentley*, **Principles of measurement systems**, Fourth Edition, Pearson Education.
  - *William David Cooper*, **Electronic instrumentation and measurement techniques**, Prentice-Hall.

RME 2213: Instrumentation and Measurement Lab

Basic Information

Semester	2nd Year 2nd Semester
Course Code	RME 2213
Course Title	Instrumentation and Measurement Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 2203: Instrumentation and Measurement**.

RME 2204: Robotics I

Basic Information

Semester	2nd Year 2nd Semester
Course Code	RME 2204
Course Title	Robotics I
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Linear Algebra, Statics and Dynamics

Syllabus

Introduction: Definition and Classification of Robots, Laws of Robotics, Applications of Robots, Basic Components of Robot Systems.

Mechanical Design of Robots: Links and Joints, Kinematic Chain, Mechanisms and Machines, Degrees of Freedom.

Robot End Effectors: Types and Classification of End Effectors, Remote Center Compliance Devices.

Spatial Descriptions and Transformations: Description of Position, Orientation and Frames, Changing Descriptions from Frame to Frame, Operators: Translation, Rotation and Transformations, Transform Equations, Representation of Transformations, Homogeneous Transformations.

Manipulator Kinematics: Link Parameters and Link Co-ordinate Systems, Link Description, Link Connection Description, Actuator Space, Joint Space, and Cartesian Space, D-H Homogeneous Transformation Matrices, Forward and Inverse Kinematics of Serial Manipulators.

Jacobian Analysis: Link Differential Transformation Matrix, Manipulator Jacobian Matrix, Conventional and Screw Based Jacobian of Serial Manipulator, Differential Motion and Velocities, Calculation of Jacobian, Relation between the Jacobian and Differential Motion.

Manipulator Dynamics: Recursive Newton-Euler Formulation of Serial Manipulator, Lagrangian Formulation of Serial Manipulator, Dynamic Equations for Multiple-DOF Robots, Static Force Analysis of Robots, Transformation of Forces and Moments between Coordinate Frames.

Trajectory Planning: Basics of Trajectory Planning, Joint-Space Trajectory Planning, Cartesian-Space Trajectories.

Robot Control Architecture: Interpolation Methods, Path Planning Algorithms, Collision Avoidance.

Methods of Robot Programming: Manual Programming Method, Walk Through Programming Method, Teach Pendant or Le Through Programming Method, Offline Programming Method.

Text and Reference Materials

- Textbook:
  - *Saeed Benjamin Niku*, **Introduction to Robotics: Analysis, Control, Applications**, John Wiley & Sons.
  - *Lung-Wen Tsai*, **Robot Analysis: The Mechanics of Serial and Parallel Manipulators**, Wiley-Interscience.
  - *R. K. Rajput*, **Robotics And Industrial Automation**, S. Chand.
- References:
  - *John J. Craig*, **Introduction to Robotics: Mechanics and Control**, Prentice Hall.
  - *Lung-Wen Tsai*, **Robot Analysis** , John Wiley & Sons.

RME 2214: Robotics I Lab

Basic Information

Semester	2nd Year 2nd Semester
Course Code	RME 2214
Course Title	Robotics Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 2204: Robotics I**.

STAT 2205: Statistics for Data Science

Basic Information

Semester	3rd Year 2nd Semester
Course Code	STAT 2205
Course Title	Statistics for Data Science
Course Credit	3.0
Course Category	GED Course
Foundation Knowledge	Discrete Mathematics, Linear Algebra, Calculus, Object Oriented Programming

Syllabus

Basic Statistics for Data Science: Introduction to Statistics in Data Science, Population vs. Sample in Data Analysis, Variables and Their Significance in Data Analysis, Scales of Measurement and Their Relevance in Data Interpretation, Classification and Tabulation of Data for Analysis.
Data Visualization Techniques: Understanding Frequency Distribution and constructing Them for Data Exploration, Statistical Graphs: Bar, Pie, Histogram, Stem and Leaf Plots for Visualizing Data Distributions.
Descriptive Statistics for Data Science: Measures of Central Tendency: Mean, Median, Mode, Measures of Dispersion: Range, Variance, Standard Deviation, Quartiles, Percentiles, and Their Importance in Summarizing Data Distributions, Coefficient of Variation for Comparing Variability in Different Datasets.
Probability and Probability Distributions in Data Science: Random Variables and Their Role in Modeling Uncertainty, Sample Space, Events, and Experiment in The Context of Data Analysis, Probability Concepts using Venn and Tree Diagrams, Probability Distributions: Bernoulli, Binomial, Poisson, Normal, and Exponential Distributions.
Sampling Distributions and Inference: Sampling Distributions of Sample Mean and Proportion, Central Limit Theorem and Its Implications for Inferential Statistics, Types of Estimation: Point and Interval Estimation, Confidence Interval and Margin of Error for Making Inferences about Population Parameters.
Hypothesis Testing in Data Science: Introduction to Hypothesis Testing: Null and Alternative Hypotheses, One-Tailed and Two-Tailed Tests and Their Applications, Type I and Type II Errors, Power of a Test, Tests about Single Mean and Proportion, Tests concerning Two Means and Proportions, Chi-square Test for Categorical Data Analysis and Analysis of Variance (ANOVA).
Correlation and Regression Analysis: Scatter Plot Visualization for Assessing Relationships Between Variables, Simple Linear Correlation and Karl Pearson's Correlation Coefficient, Simple and Multiple Linear Regression.

Text and Reference Materials

- Textbook:

  - *M. N. Islam*, **An Introduction to Statistics and Probability**, Book World.

- References:

  - *Ronald Walepole and Raymond H. Myers*, **Probability and Statistics for Engineers and Scientists**, Pearson.
  - *Prem S. Mann*, **Introductory Statistics**, John Wiley & Sons.

RME 3101: Artificial Intelligence

Basic Information

Semester	3rd Year 1st Semester
Course Code	RME 3101
Course Title	Artificial Intelligence
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Linear Algebra, Data Structure and Algorithms, Fundamentals of Programming

Syllabus

Introduction: What is AI? The Foundations of AI. The History of AI. The State of the Art.

Intelligent Agents: Agents and Environments. Good Behavior: The Concept of Rationality. The Nature of Environments. The Structure of Agents.

Uninformed Search Strategies: Depth-First Search, Breadth-first Search, Uniform Cost Search.

Informed Search Strategies: Heuristics, Greedy Search, A* Search, Admissibility and Consistency.

Beyond Classical Search: Local Search Algorithms and Optimization Problems. Local Search in Continuous Spaces. Searching with Nondeterministic Actions.

Adversarial Search: Games, Optimal Decisions in Games, Minimax for Zero-Sum Games. Alpha-Beta Pruning. Finite Lookahead and Evaluation. Games with Chance Elements.

Constrained Satisfaction Problems (CSPs): Defining CSPs, Constraint Graphs, Solving CSPs by Backtracking, Improving Backtracking by Filtering (Forward Checking and Arc Consistency), Variable/Value Ordering, and Structural Exploitation.

Markov Decision Processes (MDPs): Non-Deterministic Search, Defining MDPs, Finite Horizons and Discounting. Markovianess. Solving Markov Decision Processes: The Bellman Equation, Value Iteration, and Policy Iteration.

Reinforcement Learning (RL): Relationship to MDPs, Model-based and Model-free Learning. Passive RL: Direct Evaluation and Temporal Difference Learning, and Active RL: Q-learning, Generalization in RL, Policy Search.

Text and Reference Materials

- Textbook:

- *S. Russell and P. Norvig*, **Artificial Intelligence: A Modern Approach**, Pearson Education.

- References:
  - *E. Rich & K. Knight*, **Artificial Intelligence** , Mc-Graw Hill .
  - *Richard S. Sutton & Andrew G. Barto*, **Reinforcement Learning: An Introduction**, The MIT Press.

RME 3111: Artificial Intelligence Lab

Basic Information

Semester	3rd Year 1st Semester
Course Code	RME 3111
Course Title	Artificial Intelligence Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 3101: Artificial Intelligence**.

RME 3102: Digital Signal Processing

Basic Information

Semester	3rd Year 1st Semester
Course Code	RME 3102
Course Title	Digital Signal Processing
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Electrical Circuit Analysis, Linear Algebra, Multivariate & Vector Calculus

Syllabus

Introduction: Signal, System, Analog Signal Processing, Digital Signal Processing (DSP), Basic Elements of DSP, Classification of Signals.

Sampling: Nyquist Sampling Theorem, Reconstruction, Sampling Techniques, Folding Frequency.

Fundamentals of Modulation: Basic Concepts of Modulation and Demodulation, Analog and Digital Modulation Techniques, Pulse Modulation Techniques.

Discrete Time Signals and Systems: Elementary Discrete Time Signals, Classification of Discrete Time Signals and Systems, Discrete Signal Manipulation-Shifting, Scaling, Reversal, Differentiation, Integration, Discrete Time System - Representation, Classification, Linear Time Invariant (LTI) System - Impulse Response of a System.

Key DSP Operation: Convolution - Linear and Circular, Correlation-Auto and Cross.

Z-transform: Definition, Geometrical Interpretation, Region of Convergence (ROC), Poles and Zeros, ROC Properties - Finite, Infinite, Right-sided, Left-sided, Two-sided Sequence, Properties of Z-transform, Stability and Causality, Inverse Z-transform, Methods of Inverse Z-transform - Inspection, Partial Fraction, Power Series Expansion.

Discrete Fourier Transform (DFT): Definition, Properties of DFT, DFT-related Mathematical Problem, Direct DFT Computation Requirement, Circular Convolution using DFT, Inverse DFT (IDFT).

Fast Fourier Transform (FFT): Definition, Purposes, Types of FFT Algorithms, Radix-2 FFT Algorithm - Decimation in Time and Frequency FFT Algorithm.

Implementation of Discrete Time Systems: Structure for the Realization of LTI System, FIR and IIR Structure, Direct I, II, Cascaded, Parallel Form Structure.

Digital Filters: Definition, Filter Types, FIR Filter-Window Method, Window Function, Low Pass, High Pass, Band Pass and Band Stop Filter, Infinite Impulse Response (IIR)- Filter Performance Parameters, IIR Filter Design Methods, Low Pass, High pass, Bandpass and Bandstop Butterworth IIR Filter.

Text and Reference Materials

- Textbook:
  - *John G. Proakis* , *Dimitris G. Manolakis*, **Digital Signal Processing: Principles, Algorithms, and Applications**, Pearson.
- References:
  - *John G. Proakis*, **Digital Communication**, McGraw-Hill.
  - *B.P. Lathi* , *Zhi Ding*, **Modern Digital and Analog Communication Systems**, Oxford University Press.
  - *Simon Haykin*, **Communication Systems**, Wiley.

- *Richard G. Lyons*, **Understanding Digital Signal Processing**, Pearson.

RME 3112: Digital Signal Processing Lab

Basic Information

Semester	3rd Year 1st Semester
Course Code	RME 3112
Course Title	Digital Signal Processing Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 3102: Digital Signal Processing**.

RME 3103: Microcontroller and Programmable Logic Controller

Basic Information

Semester	3rd Year 1st Semester
Course Code	RME 3103
Course Title	Microcontroller and Programmable Logic Controller
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Linear Algebra, Linear and Power Electronics, Fundamentals of Programming, Digital Logics Circuit and Microprocessor

Syllabus

Microcontroller

Introduction:Basics of Microcontroller, Architecture of Microcontroller, Evolution of Microcontroller, Microcontroller Family.

PIC Microcontrollers: Features, Architecture, Block Diagrams, I/O Ports, Functions of Each Pin.

Registers and their Functions: General Purpose and Special Function Registers.

Timer and Counter: Timer Registers, Timer Control Register (TCON), Timer Mode Control Register (TMOD).

Interfacing with External Memory: Memory Capacity, Memory Organization, Speed, Interfacing External ROM, Real World Interfacing.

Instruction Set: Data Transfer Instructions, Arithmetic Instructions, Logical Instructions, Branching and Control Transfer Instructions, Arithmetic and Logical Operations, Subroutines, Addressing Modes.

Programming and Applications of Microcontrollers: Programming for Speed Control of a DC Motor and Servo Motor.

Programmable Logic Controller

Fundamentals of PLC: Basic Functional Components of PLC, Applications, Importance, Classification, Comparison of PLC with Relay Panel.

Internal Architecture of PLC: Hardware, Block Diagram and Operation of PLC, Memory, Storage Capacity, Bus System.

Communication between PC and PLC: Serial Communication, Ethernet, IOT etc.

Ladder Programming: Ladder Programming Conventions, Logic Functions, Latching, Sequencing.

Types of Instructions: Timer/Counter Instructions, Logical Instructions, Compare Instructions, Move Instructions, Program Control Instructions.

PLC Programming: Motor Control using PLC, Central Heating System, Robot Control System.

Text and Reference Materials

- Textbook:
  - *Muhammed Ali Mazidi, Rolin D McKinlay, and Danny Causey*, **PIC Microcontroller and Embedded Systems: Using Assembly and C for PIC18**, Pearson Prentice Hall.
  - *N. Senthil Kumar*, **Microprocessors and Microcontrollers**, OUP India
  - *Frank D. Petro Zella*, **Programmable Logic Controller** , McGraw Hill Publications

RME 3113: Microcontroller and Programmable Logic Controller Lab

Basic Information

Semester	3rd Year 1st Semester
Course Code	RME 3113
Course Title	Microcontroller and Programmable Logic Controller Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 3103: Microcontroller and Programmable Logic Controller**.

RME 3104: Machine Learning

Basic Information

Semester	3rd Year 2nd Semester
Course Code	RME 3104
Course Title	Machine Learning
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Linear Algebra, Statistics, Probability, Programming, Artificial Intelligence

Syllabus

Introduction: Intelligent Systems, Expert Systems, Processes, Components and Types of Expert Systems, Neural Network, Fuzzy Logic, Genetics Algorithm.

Machine Learning: Definition, General Concepts and Techniques of Machine Learning, Classification of Machine Learning, Supervised, Unsupervised, Reinforcement, Ensemble and Deep Learning, Supervised vs Unsupervised vs Reinforcement Learning, Different Machine Learning Algorithms.

Supervised Learning: Definition, General Concept, Problem Solving using Supervised Learning, Learning from a class, Hypothesis, Version Space, Margin, Vapnik-Chervonenkis Dimension, Probably Approximately Correct (PAC) Learning, Noise and Model Complexity, Generalization, Underfitting and Overfitting, Bias-Variance Tradeoff, Triple Tradeoff, Cross Validation, Curse of Dimensionality, Selection of Supervised Learning Algorithms.

Linear Regression: Linear Correlation and Regression, Covariance, Correlation Coefficients, Distribution of the Correlation Coefficient, Bivariate and Multivariate Regression Models, Applications, Access the Fit of Regression Model, Coefficient of Determination, Error Matrices, Multiple Linear Regression.

Logistic Regression: Logistic Regression, Decision Boundary, Cost Function for Logistic Regression, Gradient Descent Implementation, Multi-class Classification.

Regularization: Role of Regularization, How Does Regularization Work?, Modifying the Loss Function, L1 Regularization, L2 Regularization, Elastic Net Regularization .

Decision Tree: Definition, General Considerations, Decision Rules, Top-Down Decision Tree Generation, Trees Construction Algorithm (ID3), Information Gain, Attribute Selection, Gini Index, Overfitting and Tree Pruning.

Bayesian Decision Theory: Probability and Inference, Classification, Conditional Probability, Bayes' Theorem, Likelihood, Evidence, Prior, Posterior, Mathematical Examples, Sensitivity and Specificity, Different Losses and Reject, Discriminant Functions, Association Rules, Apriori Algorithm, Maximum Likelihood and Least Squares, Regularized Least Squares.

Dimensionality Reduction: Introduction, Subset Selection, Principal Component Analysis, Feature Embedding, Factor Analysis, Singular Value Decomposition and Matrix Factorization, Multidimensional Scaling, Linear Discriminant Analysis, Canonical Correlation Analysis, Independent Component Analysis.

Clustering: Definition, Similarity, Euclidean and Non-Euclidian Distance Measures, Partitional and Hierarchical Clustering, Aglomerative Clustering Algorithm, Divisive Clustering, Computing Distance Matrix, Partitional Clustering, K-means Clustering Algorithm, Nearest Neighbor Clustering, The Birch algorithm, Applications of Clustering.

Other Clustering Approaches: Density-Based Clustering, Distribution Model-Based Clustering, Fuzzy Clustering, Mean-shift algorithm, DBSCAN Algorithm, Expectation-Maximization Clustering, Agglomerative Hierarchical Algorithm, Affinity Propagation.

Support Vector Machine: Introductory Concept, Max-Margin Classifiers, Lagrangian Multipliers, Kernels, Complexity, Linear Classifier, Classifier Margin, Maximum Margin, Linear SVM, Constrained Optimization Problem, Quadratic Programming, Kernel Trick, Overtraining, Practical Example, Performance Measurements, Properties, Applications and Issues with SVM.

Artificial Neural Networks: Introduction, History, NN to Solve Problems, Human Biological Neurons, Artificial Neurons, Properties, ANN, Characterizations, Single Layer, Multilayer, Activation Functions, First NN, Perceptron, Training a Perceptron, Problem Domains, Applications of ANN, Practical Examples, ANN vs Expert Systems.

Text and Reference Materials

- Textbook:
  - *Tom M. Mitchel*, **Machine Learning**, McGraw-Hill Education.
  - *Christopher M. Bishop* , **Pattern Recognition and Machine Learning**, Springer.
- References:
  - *Peter Flach*, **Machine Learning: The Art and Science of Algorithms that Make Sense of Data**, Cambridge University Press.
  - *Dirk P. Kroese, Zdravko I. Botev, Thomas Taimre, and Radislav Vaisman*, **Data Science and Machine Learning: Mathematical and Statistical Methods**, CRC Press, Taylor and Francis.

RME 3114: Machine Learning Lab

Basic Information

Semester	3rd Year 2nd Semester
Course Code	RME 3114
Course Title	Machine Learning Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 3205: Machine Learning**.

MATH 3105: Mathematical Analysis for Engineers

Basic Information

Semester	3rd Year 1st Semester
Course Code	MATH 3105
Course Title	Mathematical Analysis for Engineers
Course Credit	3.0
Course Category	GED Course
Foundation Knowledge	Differential and Integral Calculus, Linear Algebra

Syllabus

Introduction: Numerical Analysis, Analytical vs Numerical Solutions, Numerical Computing Process, Errors in Numerical Computing, Significant Digits, Accuracy and Precision, Error Approximation, Patriot Failure Example.

Finding Roots: Iterative Method, Graphical Method, Bisection Method, Decision Making Process, Pros and Cons of Bisection Method, Method of False Position, Fixed Point Iteration Method, Newton-Raphson Method, Error Analysis and Drawbacks of Newton-Raphson Method, Secant Method and Analysis.

Simultaneous Linear Equations: Gauss Elimination Method, Forward Elimination and Back Substitution, Pitfalls of Gauss Elimination Method, Technique to Improve, Partial Pivoting, Matrix Operation, Elementary Row Operation, Rank of Matrix, Echelon Form, Cramer's Rule, LU Decomposition, Gauss-Jordan Elimination.

Interpolation: Interpolation, Quadratic Interpolation, Cubic Interpolation, Newton's Divided Difference Method of Interpolation, Spline Interpolation, Polynomial Interpolation, Piecewise Polynomial Interpolation, Newton's Forward and Backward Difference Interpolating Polynomials.

Numerical Differentiation and Integration: Forward Difference Approximation, Backward Difference Approximation, Derive Forward Difference from Central Divided Difference, Finite Difference Approximation of Higher Derivatives, Higher Order Accuracy of Higher Order Derivatives, Taylor Series, Trapezoidal Rule and Simpson's Rule. Initial Value Problems for ODE- Euler's and Modified Euler's Method, Runge-Kutta Method.

Laplace Transforms: Forward Transform, Inverse Transform, Examples of Transform Pairs, The Laplace Transform of a Differential Equation, The Use of Laplace Transforms for the Solution of Initial Value Problems, Existence and Uniqueness of Laplace Transforms.

Fourier Transforms: Properties of Fourier Series, Fourier Sine and Cosine Series, Fourier Transform of

Continuous and Discrete Signals, Fourier Coefficients and Orthogonally, Generally Periodic Functions, Odd and Even Functions, Fourier Transform of Continuous and Discrete Signals and the Discrete Fourier Transform and the FFT Algorithm.

Text and Reference Materials

- Textbook:
  - *R. L. Burden, J. D. Faires and A. M. Burden*, **Numerical Analysis**, Cengage Learning.
- References:
  - *S. C. Chapra and R. P. Canale*, **Numerical Methods for Engineers**, McGraw-Hill Education.
  - *S. S. Sastry*, **Introductory Methods of Numerical Analysis**, Prentice Hall India.
  - *Phil Dyke*, **An Introduction to Laplace Transforms and Fourier Series**, Springer Science & Business Media.
  - *E. Kreyszig*, **Advanced Engineering Mathematics**, Wiley.
  - *M. R. Spiegel*, **Laplace Transforms**, Schaum's Outline Series.

RME 3201: Digital Image Processing

Basic Information

Semester	3rd Year 2nd Semester
Course Code	RME 3201
Course Title	Digital Image Processing
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Data Structure and Algorithms, Artificial Intelligence, Python Programming, Linear Algebra, Calculus

Syllabus

Introduction: Definition of Image, Differences Between Image Processing, Image Analysis and Computer Vision, Introduction to Image Processing, Sources of Images, Digital Image Representations and Image Processing, Applications of Digital Image Processing (DIP), Key Stages of DIP, Light and EM Spectrum.

Image Acquisition: Human Eye vision, How Camera Works, Digital Image: RGB to Grayscale Conversion, Average Method, Weighted Method. Spatial Resolution, Image contouring, Image Sampling and Quantization, Image InterpolatIon, Image Quality, Image Storage.

Histogram and Point Operation: Histograms and Interpreting Histogram, Brightness, Contract and Dynamic Range, Detecting Image Defects Using Histogram, Histogram Binning, Color Image Histogram, PDF, CDF, Point Operation, Clamping, Image Negative, Thresholding, Image Transformation, Linear, Log, Power law and Piecewise Linear Transformation, Bit-plane Slicing, Intensity Windowing, Automatic and Modified Contrast Enhancement, Histogram Equalization, Histogram Specifications, Adjusting Linear Distribution Piecewise, Histogram Matching.

Image Enhancement and Spatial Filtering: Gamma Correction, Alpha Blending, Image Enhancements, Filters, Convolution, Spatial Filtering Operation, Smoothing Filter, Computing Filter, Weighted Smoothing Filter, Linear and Non-linear Filter, Sharpening Filter, Laplace Operator, Unsharp Masking and High Boost Filtering, Outlier Method of Filtering.

Filtering in Frequency Domain: The Fourier Series and Fourier Transform, Trigonometric Fourier Series, Exponential Fourier Series, Discrete Fourier Transform (DFT), Properties, DFT and Image Processing, Magnitude and Phase of DFT. Image Deblurring in Frequency Domain: Inverse Filter, Wiener Filter. Ideal Low and High Pass Filter, Butterworth Low and High Pass Filter, Gaussian Low and High Pass Filter, FFT.

Noise and Image Restoration: Gaussian Noise, Impulse noise, Periodic Noise. Noise Removal: Median

Filter, Mean Filter, Adaptive Median Filter. Image Degradation/Restoration Model.

Edge and Line Detection: Introduction, Types of Edges, Steps in Edge Detection, Methods of Edge Detection, First Order Derivative Methods, Second Order Derivative Methods, Optimal Edge Detectors: Canny Edge Detection, Edge Detector Performance, Line Detection, Convolution Based Technique, Hough Transform, Application Areas.

Image Segmentation: Detection of Isolated Points, Line and Edge Detection (Recap), Edge Linking and Boundary Detection, Local Processing, Regional processing, Global Processing, Region Based Segmentation, Region Splitting and Merging, Segmentation Using Morphological Watersheds, K-Means Clustering.

Image Compression: Redundancy, Types of Data Redundancy, Measuring Information, Entropy Estimation, General Image Compression and Transmission Model, Encoder and Decoder, Lossless Model, Huffman Coding, LZW Coding, Run-length Coding, Lossy Compression, FT, Discrete Cosine Transform, JPEG Coding: 2D-DCT, Quantization, Zig-Zag Scan etc.

Morphological Image Processing: Erosion and Dilation, Opening and Closing, Some Basic Morphological Algorithms: Boundary Extraction, Hit-or-Miss Transformation, Morphological Thinning, Skeletons, Thickening.

Medical Imaging: Introduction to Medical Imaging, Image Properties and Quality, General Overview of Anatomy & Physiology, Ultrasound Imaging, Planar Radiography (X-ray) Imaging, Computed Tomography (CT) Imaging, Magnetic Resonance Imaging (MRI).

Case Studies: Car Number Plate Detection, FIngerprint Detection, Template Matching, Moving Object Detection, etc.

Text and Reference Materials

- Textbook:
  - *R. C. Gonzalez & E. E. Woods*, **Digital Image Processing**, Prentice Hall.
- References:
  - *Richard Szeliski*, **Computer Vision: Algorithms and Applications**, Springer.
  - *Berthold K. P. Horn*, **Robot Vision**, MIT Press.

RME 3211: Digital Image Processing Lab

Basic Information

Semester	3rd Year 2nd Semester
Course Code	RME 3211
Course Title	Digital Image Processing Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 3201: Digital Image Processing**.

RME 3202: Control Engineering

Basic Information

Semester	3rd Year 2nd Semester
Course Code	RME 3202
Course Title	Control Systems Design
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Calculus, Linear Algebra, Electrical Circuits Analysis, Statics and Dynamics, Fundamentals of Mechatronics Engineering, Mathematical Analysis for Engineers.

Syllabus

Introduction: A History of Control Systems, System Configurations, Analysis and Design Objectives, Case Study, The Design Process, Computer-Aided Design, The Control Systems Engineer.

Modeling in the Frequency Domain: Laplace Transform Review, The Transfer Function, Electrical Network Transfer Functions, Translational Mechanical System Transfer Functions, Rotational Mechanical System Transfer Functions, Transfer Functions for Systems with Gears, Electromechanical System Transfer

Functions, Electric Circuit Analogs, Nonlinearities, Linearization.

Modeling in the Time Domain: The General State-Space Representation, Applying the State-Space Representation, Converting a Transfer Function to State Space, Converting from State Space to a Transfer Function.

Time Response: Poles, Zeros, and System Response, First-Order Systems, Second-Order Systems- Introduction, The General Second-Order System, Underdamped Second-Order Systems, System Response with Additional Poles, System Response with Zeros, Effects of Nonlinearities upon Time Response, Laplace Transform Solution of State Equations, Time Domain Solution of State Equations.

Reduction of Multiple Subsystems: Block Diagrams, Analysis and Design of Feedback Systems, Signal-Flow Graphs, Mason's Rule, Signal-Flow Graphs of State Equations.

Stability: Routh-Hurwitz Criterion, Routh-Hurwitz Criterion- Special Cases, Routh-Hurwitz Criterion-Additional Examples, Stability in State Space.

Steady-State Errors: Steady-State Error for Unity Feedback Systems, Static Error Constants and System Type, Steady-State Error Specifications, Steady-State Error for Disturbances, Steady-State Error for Unity Feedback Systems, Sensitivity, Steady-State Error for Systems in State Space.

Root Locus Techniques: Defining the Root Locus, Properties of the Root Locus, Sketching the Root Locus, Refining the Sketch, Transient Response Design via Gain Adjustment, Generalized Root Locus, Root Locus for Positive-Feedback Systems, Pole Sensitivity.

Frequency Response Techniques: Asymptotic Approximations- Bode Plots, Introduction to the Nyquist Criterion, Sketching the Nyquist Diagram, Stability via the Nyquist Diagram, Gain Margin and Phase Margin via the Nyquist Diagram, Stability, Gain Margin, and Phase Margin via Bode Plots, Relation Between Closed-Loop Transient and Closed-Loop Frequency Responses, Relation Between Closed- and Open-Loop Frequency Responses, Relation Between Closed-Loop Transient and Open-Loop Frequency Responses, Steady-State Error Characteristics from Frequency Response, Systems with Time Delay, Obtaining Transfer Functions Experimentally.

Digital Control Systems: Modeling the Digital Computer, The z-Transform, Transfer Functions, Block Diagram Reduction, Stability, Steady-State Errors, Transient Response on the z-Plane, Gain Design on the z-Plane, Cascade Compensation via the s-Plane, Implementing the Digital Compensator.

Text and Reference Materials

- Textbook:
  - *Norman S. Nise* , **Control Systems Engineering**, Wiley.
- References:
  - *Katsuhiko Ogata*, **Modern Control Engineering**, Prentice Hall.

RME 3203: Mechanics of Solids

Basic Information

Semester	3rd Year 1st Semester
Course Code	RME 3203
Course Title	Mechanics of Solids
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Multivariate and Vector Calculus, Linear Algebra, Differential and Integral Calculus, Physics, Statics and Dynamics

Syllabus

Stress: Concepts of Internal Force and Stress, Stress Analysis of Axially Loaded Bars, Shear Stress, Bearing Stress.

Strain: Concept of Strain, Stress-Strain Diagram, Working Stress and Factor of Safety, Analysis of Axially Loaded Bars, Generalized Hooke's Law - Uniaxial Loading, Poisson's Ratio, Multiaxial Loading, Shear Loading; Statically Indeterminate Problems, Thermal Stresses.

Torsion: Torsion of Circular Shafts - Simplifying Assumptions, Compatibility and Equilibrium Equations, Torsion Formulas, Power Transmission, Statically Indeterminate Problems; Stresses in Helical Springs.

Shear and Moment in Beams: Supports and Loads, Shear-Moment Equations and Shear-Moment Diagrams, Area Method for Drawing Shear-Moment Diagrams.

Stresses in Beams: Bending Stresses in Beams- Simplifying Assumptions, Compatibility and Equilibrium Equations, Flexure Formula, Procedures for Determining Bending Stresses, Economic Sections, Shear Stress in Beam.

Deflection of Beams: Double-Integration Method - Differential Equation of the Elastic Curve, Double Integration of the Differential Equation, Procedure for Double Integration; Double Integration Using Bracket Functions.

Stresses Due to Combined Loads: Thin-Walled Cylindrical Pressure Vessels, Combined Axial and Lateral Loads, State of Stress at a Point, Mohr's Circle for Plane Stress.

Columns: Definition and Types of Column, Critical Load, Euler's formula, Critical Stress and Slenderness Ratio, Design Formulas for Intermediate Columns: Tangent Modulus Theory, AISC Specifications for Steel Columns; Eccentric Loading: Secant Formula, Derivation and Application of the Secant Formula.

Theories of Failure: Failure Theory for Brittle Material, Failure Theory for Ductile Material.

Text and Reference Materials

- Textbook:
  - *Andrew Pytel*, *Jann Kiusalaas*, **Mechanics of Materials**, Global Engineering.
  - *Ferdinand P. Beer and E. Russell Johnston Jr*, **Mechanics of Materials**, McGraw Hill.
- References:
  - *Egor P. Popov*, **Engineering Mechanics of Solids**, PHI Learning Private Limited.

RME 3204: Fluidics

Basic Information

Semester	3rd Year 2nd Semester
Course Code	RME 3204
Course Title	Fluidics
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Calculus, Linear Algebra, Physics, Statics and Dynamics, Differential Equations and Coordinate Geometry

Syllabus

Basics of Fluid Mechanics: Fluid Properties, Hydrostatic Pressure, Manometry, Fluid Flow Types, Velocity and Acceleration of Fluid, Continuity Equation, Bernoulli's Equation, Flow through Circular Pipes, Losses in Pipes and Fittings, Important Dimensionless Numbers in Fluid Mechanics.

Introduction to Fluid Power: Basic Concept of Hydraulic Cylinder, Basic Concept of Hydraulic Motor, Basics of Fluid Power Circuit Analysis.

Pressure and Flow Control: Relief Valve, Unloading Valve, Sequence Valve, Pressure Reducing Valve, Fixed Displacement Pump Circuits, Variable Displacement Pump Circuits, Comparison of Pump Performance Characteristics of Different Designs, Flow Control Valves.

Rotary Actuators: Stall Torque Efficiency, Typical Performance Data for a Gear Motor, Comparison of Motor Performance Characteristics of Different Designs, Performance Characteristics of Low-Speed, High-Torque Motors.

Linear Actuators: Analysis of Cylinders in Parallel and Series, Synchronization of Cylinders, Rephasing of Cylinders, Load Analysis.

Pneumatics: Orifice Equation, Compressors, Receivers, Pipelines, Cylinders, Motors, Valves.

Microfluidics: Fundamental Concepts, Microfluidic Components, Application-oriented Microfluidic Systems, Introduction to Numerical Simulation Models to Microfluidics.

Text and Reference Materials

- Textbook:
  - *John S. Cundiff*, **Fluid Power Circuits and Controls- Fundamentals and Application**, CRC Press.
  - *Yunus A. Cengel and John M. Cimbala*, **Fluid Mechanics**, McGraw-Hill.
  - *Yujun Song, Daojian Cheng, and Liang Zhao*, **Microfluidics- Fundamentals, Devices and Applications**, Wiley-VCH.
- References:
  - *Md. Quamrul Islam, A. C. Mandal*, **Fluid Mechanics Through Worked Out Problems**, Macmillan.
  - *Jagadeesha T. and Thammaiah Gowda*, **Fluid Power: Generation, Transmission and Control**, Wiley.

RME 3213: Solids and Fluids Lab

Basic Information

Semester	3rd Year 2nd Semester
Course Code	RME 3213
Course Title	Solids and Fluids Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 3203: Mechanics of Solids** and **RME 3204: Fluidics**.

RME 3205: Neural Networks and Deep Learning

Basic Information

Semester	4th Year 1st Semester
Course Code	RME 3205
Course Title	Neural Networks and Deep Learning
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Basic Programming Knowledge (Preferably Python), Understanding of Linear Algebra, Calculus, and Probability, Introductory course in Machine Learning.

Syllabus

Introduction to Neural Networks: Historical Context - McCulloch-Pitts Neuron and Hebbian Learning. The Perceptron - Concept and Limitations. Multilayer Perceptrons (MLPs) and Feedforward Neural Networks. Activation Functions - Sigmoid, Tanh, ReLU, and Modern Variants, Loss Functions - Mean Squared Error, Cross-Entropy.

Deep Learning Fundamentals: Backpropagation - Theory and Implementation, Gradient Descent- Batch, Mini-batch, and Stochastic. Advanced Optimization Techniques- Momentum, RMSprop, Adam, Vanishing and Exploding Gradients - Causes and Solutions. Regularization Techniques - Dropout, L1/L2 Regularization.

Hyperparameter Tuning and Best Practices: Hyperparameter Optimization Strategies. Overfitting and Underfitting- Detection and Mitigation, Data Augmentation Techniques.

Convolutional Neural Networks (CNN): CNN Fundamentals - Convolutional Layers, Pooling, Batch Normalization, Classic CNN Architectures - LeNet, AlexNet, VGG, ResNet, InceptionNet, PointNet, DGCNN. Transfer Learning and Fine-tuning.

Object Detection: Object Detection Task and its Challenges, Evaluation metrics- IoU, Precision, Recall, AP, mAP. Single-Stage Detectors- YOLO (You Only Look Once)- Architecture, Core Concepts, Loss Function, and Variations, Two-Stage Detectors - R-CNN Family Overview, Region Proposal Networks (RPN). Fast R-CNN, Faster R-CNN, Single-stage vs. Two-stage Detectors - Speed-accuracy Trade-offs, Anchor Boxes-concept and Implementation, Non-Maximum Suppression (NMS).

Recurrent Neural Networks: RNN Architecture and Backpropagation Through Time, Long Short-Term Memory (LSTM) Networks, Gated Recurrent Units (GRUs), Bidirectional RNNs, Applications in NLP.

Transformers: Attention Mechanisms- Theory and Implementation, Self-Attention and Multi-Head Attention, Transformer Architecture -Encoder-Decoder Structure, Positional Encoding and Layer Normalization, BERT, GPT, and their variants, Vision Transformers (ViT).

Diffusion Models: Principles of Diffusion for Image Generation, Denoising Diffusion Probabilistic Models (DDPMs), Training Process and Loss Functions, Text-to-Image Models- DALL-E, Imagen, Stable Diffusion, Comparison with GANs and VAEs.

Zero-Shot and Few-Shot Learning: Introduction to Zero-Shot Learning (ZSL) - Concept and Motivation, Differences from Traditional Supervised Learning, Applications and Use Cases, Zero-Shot Learning Frameworks - Attribute-based ZSL, Embedding-based ZSL, Generative Approaches to ZSL, Few-Shot Learning (FSL) Fundamentals - N-way K-shot classification, Episodic Training, Support and Query Sets.

Text and Reference Materials

- Textbook:
  - *Ian Goodfellow and Yoshua Bengio and Aaron Courville*, **Deep Learning**, MIT Press.
- References:
  - *John D. Kelleher*, **Deep Learning**, MIT Press.
  - *Eli Stevens*, *Luca Antiga*, *and Thomas Viehmann*, **Deep Learning with PyTorch**, Manning.

RME 3215: Neural Networks and Deep Learning Lab

Basic Information

Semester	4th Year 1st Semester
Course Code	RME 3215
Course Title	Neural Networks and Deep Learning Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 3205: Neural Networks and Deep Learning** .

RME 4101: Robotics II

Basic Information

Semester	4th Year 1st Semester
Course Code	RME 4101
Course Title	Robotics II
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	Calculus, Linear Algebra, Differential Equations and Coordinate Geometry, Robotics-I, Physics, Mechanics of Solids, Statics and Dynamics.

Syllabus

Introduction: Robotic Systems, System Interface - The Conceptual Structure of the Interface, Conceptual Software Modeling and Analysis, The Algorithm Design, Implementation of the Interface, Mathematical Modeling of Robot- Symbolic Representation of Robots, Engineering Tools to Design Robots- Driving Robots.

Structural Robot Design: Statics Analysis of Serial Manipulators- Force and Moment Balance of a Link-Equivalent Joint Torques- Application of the Principle of Virtual Work, Stiffness Analysis of Serial Manipulator-Compliance Matrix- Stiffness Matrix, Statics Analysis of Parallel Manipulators- Free-Body Diagram Approach-Application of the Principle of Virtual Work, Stiffness Analysis of Parallel Manipulator, Wrist Mechanisms-Bevel – Gear Wrist Mechanisms- Structure Representation of Mechanisms- Structure Characteristics of Epicyclic Gear Trains, Gripper Design- Calculation of the Forces Exerted in the Gripper.

Dynamics of Serial Manipulators: Mass Properties, Momentum, Transformation of Inertia Matrix, Newton-Euler Laws.

Dynamics of Parallel Manipulators: Newton-Euler Formulation and Lagrangian Formulation of Parallel Manipulators, Principal of Virtual Work.

Jacobian Analysis of Parallel Manipulators: Singularity Conditions, Conventional and Screw Based Jacobian of Parallel Manipulators.

Soft Robotics: Soft Materials/Body Robot Modelling, Soft Actuators and Sensors, Control and Learning of Soft Robots.

Case Studies to Design a Robotic System: Manipulator Design Procedure, Motor Power Selection and Gear Ratio Design for Mobile Robots.

Text and Reference Materials

- Textbook:
  - *Ben-Zion Sandier*, **Robotics: Designing the Mechanisms for Automated Machinery**, Academic Press.
- References:
  - *Harry Henderson*, **Modern Robotics: Building Versatile Machines**, Chelsea House Publications.
  - *Albert Y. Zomaya*, **Modelling and Simulation of Robot manipulators: A Parallel Processing Approach**, World Scientific Publishing Co.
  - *Harry Henderson*, **Modern Robotics: Building Versatile Machines**, Chelsea House Publications.
  - *Lung-Wen Tsai*, **Robot Analysis**, Wiley & Sons Inc.

RME 4111: Robotics II Lab

Basic Information

Semester	4th Year 1st Semester
Course Code	RME 4111
Course Title	Robotics II Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 4101: Robotics II** and Robot Operating Systems.

Introduction to ROS: Overview of ROS Architecture and Concepts, Installation and Setup.

ROS Development: Creating ROS packages and nodes, Publishing and Subscribing to Topics.

ROS Simulation Tools: Gazebo, Webots etc.

Robot Control and Sensor Integration in ROS.

Line Following Robot using ROS with Raspberry Pi: Develop a Line Following Robot using Raspberry Pi Lidar Positioned in front of the Robot to Detect the Path. Use MATLAB's Robotics Operating System Software package to Communicate with the ROS Installed in the Raspberry pi.

Obstacle Avoidance Robot: Develop a System With the Help of 360-degree Lidar to Map the Obstacles in the Environment. Write a Program to Eeach the Desired Destination by Avoiding the Obstacle.

SLAM Robot using Raspberry Pi and ROS: Use Components Like Arduino, Raspberry pi, HC-05 Bluetooth Module, etc. for Robot Localization. Establish the Communication with ROS in Raspberry pi using ROS Network Configurations. Finally, Apply SLAM Algorithms for Mapping the Environment.

Autonomous Mobile Robot Navigation: Autonomously Navigate a Known Map with ROS Navigation.

Robotic Arm Simulation using ROS: Create a Robotic Arm Model and Perform Simulation in Gazebo. Provide Various Commands to Make the Robotic Arm to Perform Various Tasks.

ROS Vision: Investigating Object Detection and Pose Estimation Fusion in ROS-enabled Robots.

Gesture Controlled Robot using ROS: Develop a Gesture-controlled Robot that Can be Controlled Easily with Just the Hand Movements.

Project Development.

RME 4102: Embedded Systems Design and Interfacing

Basic Information

Semester	4th Year 1st Semester
Course Code	RME 4102
Course Title	Embedded Systems Design and Interfacing
Course Credit	3.0
Course Category	Core Course (Mechatronics Stream)
Foundation Knowledge	Electrical Circuits, Mechatronics Engineering, Instrumentation and Measurement, Linear and Power Electronics, Microcontroller and Programmable Logic Controller.

Syllabus

Introduction: Embedded System Speciation and Modeling, Overview of Microprocessors and Microcontrollers, Harvard Architecture, Instruction Set Architecture (ISA): CISC and RISC, ARM processor Families and their Applications.

ARM Cortex-M Series: Overview, ARM Cortex-M4 Processor- Clock Frequency, Registers, Pipelining, Floating Point Unit (FPU), Memory Protection Unit (MPU), Nested Vectored Interrupt Controller (NVIC).

ARM Cortex-M4 Assembly Language/ Embedded C Programming: Addressing Modes, Instruction Sets: Data Movement, Arithmetic, Logical and Flow Control Instructions.

STM32 Microcontrollers: Introduction to STM32 Microcontroller Family, STM32F446RE Microcontroller-Pin Diagram, Memory Organization, Exceptions and Interrupts, Interrupt Vector Table, Watchdog Timer, Timers and Counters.

Communication Protocols: Details of UART, USART, SPI, I2C Protocols used in STM32 Microcontrollers.

Introduction to PCB Design: PCB Materials, PCB Layers, PCB Design Software, Schematic Capture, Component Placement, Routing Techniques, Signal Integrity, Power Integrity, Grounding Techniques, PCB Manufacturing Process, Design for Manufacturability (DFM), Design for Testability (DFT), Thermal Management, EMI/EMC Considerations, High-Speed PCB Design Principles.

Text and Reference Materials

- Textbook:

- *Jonathan W. Valvano*, **Real-Time Interfacing to ARM® Cortex™-M Microcontrollers**, CreateSpace Independent Publishing Platform.

- References:
  - *Tim Wilmshurst Palgrave*, **An Introduction to the Design of Small-Scale Embedded Systems**, Palgrave.

RME 4112: Embedded Systems Design and Interfacing Lab

Basic Information

Semester	4th Year 1st Semester
Course Code	RME 4112
Course Title	Embedded Systems Design and Interfacing Lab
Course Credit	1.5
Course Category	Lab Course

Syllabus

Laboratory classes based on the topics covered in **RME 4102: Embedded Systems and Interfacing**.

RME 4113: Research Methodology and Scientific Writing Lab

Basic Information

Semester	3rd Year 2nd Semester
Course Code	RME 4113
Course Title	Research Methodology and Scientific Writing Lab
Course Credit	2
Course Category	Core Course
Foundation Knowledge	None

Syllabus

Introduction: Definition of Research, Objectives, Motivation, Concept and Importance in Research, Features of a Good Research Design.
Types of Research: Qualitative and Quantitative Research, Fundamental Research, Applied Research, Engineering Research.
Methodologies for Research: Research Proposals, Research Planning, Legal Research.
Research Ethics: Ethical Issues Related to Publishing, Plagiarism and Self Plagiarism, Uses of References, Copyright.
Scientific Paper/Report/Thesis Writing: Layout of a Research Paper, Making Effective Charts, Graphs, Tables, Accuracy Clarity, Simplicity, Precision, Logic, Style, Language, Editing and Proof Reading, Impact Factor of Journals, Hands on Training on Latex and different types of AI tools for research.
Skills: Presentation Skills and Communication Skills.

Text and Reference Materials

- Textbook:
  - *C. R. Kothari*, **Research Methodology: Methods and Techniques**, New Age International Pvt Ltd.
  - *C. George Thomas*, **Research Methodology and Scientific Writing**, Springer.
- References:
  - *Hilary Glasman-deal*, **Science Research Writing**, World Scientific Publishing.
  - *Stefan Kottwitz*, **LaTeX Beginner's Guide**, Packt Publishing.

RME 4100: Research Project

Basic Information

Semester	4th Year 1st Semester
Course Code	RME 4100
Course Title	Research Project
Course Credit	2.0
Course Category	Core Course
Foundation Knowledge	None

Syllabus

In this course, students are required to undertake a major project in engineering analysis, design development of research. The objective is to provide an opportunity to develop initiative, self-reliance, creative ability and engineering judgment. In this semester, students will submit their intermediate work and in the next semester (Semester VIII) they will submit the final projectwork (RME 4200).

ROB 4104: Generative Artificial Intelligence

Basic Information

Semester	4th Year 1st Semester
Course Code	ROB 4104
Course Title	Generative Artificial Intelligence
Course Credit	3.0
Course Category	Core Course (Robotics Stream)
Foundation Knowledge	Artificial Intelligence, Deep Learning & Neural Networks, Linear Algebra

Syllabus

Introduction to Generative AI: What is Generative Modeling, Generative vs. Discriminative Modeling, The Rise of Generative Modeling, Generative Modeling and AI, The Generative Modeling Framework, Representation Learning.

Introduction to NLP: What is Natural Language Processing? What are The Features of Natural Language? What Makes NLP Hard? Building A Rule-Based Classifier, Training A Bag-Of- Words Classifier.

Word Representation and Text Classification: Sub Word Models, Continuous Word Embeddings, Training More Complex Models, Visualizing Word Embeddings.

Language Modeling: Problem Definition, Count-Based Language Models, Measuring Language Model Performance: Accuracy, Likelihood, Perplexity, Log-Linear Language Models, Neural Network Basics, Feed-Forward Neural Network Language Models.

Generation Algorithms: Sampling from Language Models, Beam Search And Variants, Minimum Bayes Risk, Constrained Decoding, Human-In-The-Loop Decoding, Fast Inference.

Prompting: Prompting Methods, Sequence-To-Sequence Pre-Training, Prompt Engineering, Answer Engineering, Multi-Prompt Learning, Prompt-Aware Training Methods.

Fine Tuning and Instruction Tuning: Multitasking, Fine-Tuning and Instruction Tuning, Parameter-Efficient Fine-Tuning, Instruction Tuning Datasets, And Synthetic Data Generation.

Retrieval and RAG: Retrieval Methods, Retrieval Augmented Generation, Long-context Transformers, State-of-the-art RAG Methods.

Language Models as Agents: Tasks and Applications, Training-free Methods for Building Agents, Evaluation Environment and Benchmark, Training Methods for Improving Agents.

Safety, Ethics, and Bias: Bias in Models, Privacy Concerns, Ethical Considerations, Challenges, and Future Directions.

Text and Reference Materials

- Textbook:
  - *Jacob Eisenstein*, **Introduction to Natural Language Processing**, MIT Press.
  - *Yoav Goldberg*, **Neural Network Methods in Natural Language Processing**.
  - *Lewis Tunstall, Leandro von Werra, and Thomas Wolf*, **Natural Language Processing with Transformers**, O'Reilly.
- References:
  - *Delip Rao and Brian McMahan*, **Natural Language Processing with PyTorch**, O'Reilly.

ROB 4114: Generative Artificial Intelligence Lab

Basic Information

Semester	4th Year 1st Semester
Course Code	ROB 4114
Course Title	Generative Artificial Intelligence Lab
Course Credit	1.5
Course Category	Lab Course (Robotics Stream)

Syllabus

Laboratory classes based on the topics covered in **ROB 4104: Generative Artificial Intelligence**.

ROB 4105: Human Robot Interaction

Basic Information

Semester	4th Year 1st Semester
Course Code	RME 4105
Course Title	Human Robot Interaction
Course Credit	3.0
Course Category	Core Course (Robotics Stream)
Foundation Knowledge	Robotics-I and II, Object Oriented Programming

Syllabus

Introduction: Overview of Human-Robot Interaction, Difference between Human Robot Interaction (HRI), Robotics and Human Computer Interaction (HCI), Evolution of HRI, HRI taxonomies.
Design: Desing in HRI, Antropomorphization in HRI, Design methods, Culture in HRI.
Spatial interaction: Role of Space in Human-Robot Interaction. Spatial Interaction for Robots.
Nonverbal Interaction in HRI: Categories of Nonverbal Interaction, Importance of Nonverbal Interaction, How Robot Perceive Nonverbal Cues, and How Robot Can Generate Nonverbal Cues during Interaction.
Verbal Interaction: Speech Recognition, Dialogue Management and Speech Production for HRI.
Emotion in HRI: Expression and Perception of Emotion HRI, Models of Emotions.
Research Methods: Defining Research Question and Approach, Different Methods of Research, Choosing a Robot and Setting up the Mode of Interaction, Selecting Appropriate HRI Measures, Research Standards.
Application: Application of HRI, Role of Robot in Society, Ethical Concerns in HRI, Future of HRI.

Text and Reference Materials

- Textbook:
  - *Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M. and Šabanović, S.*, **Human-robot interaction: An introduction**, 2020, Cambridge University Press.
- References:
  - *Diana Coleman*, **Human-Robot Interactions: Principles, Technologies and Challenges**, Nova Science Pub Inc..
  - *Takayuki Kanda, Hiroshi Ishiguro*, **Human-Robot Interaction in Social Robotics**, CRC Press.

ROB 4115: Human Robot Interaction Lab

Basic Information

Semester	4th Year 1st Semester
Course Code	ROB 4115
Course Title	Human Robot Interaction Lab
Course Credit	1.5
Course Category	Lab Course (Robotics Stream)

Syllabus

Laboratory classes based on the topics covered in **ROB 4105: Human Robot Interaction**.

ROB 4106: Cloud Robotics

Basic Information

Semester	4th Year 1st Semester
Course Code	RME 4106
Course Title	Cloud Robotics
Course Credit	3.0
Course Category	Core Course (Robotics Stream)
Foundation Knowledge	Computer Programming, Machine Learning and Robotics I

Syllabus

Introduction: Basic Intro in Cloud Robotics, Supports for Cloud Computing. Limitations and Characteristics of Programmable Robots. Development Tools and Software. Robot Operating Systems and Software Services. Latest Development and Current Trends of Cloud Robotics Computing.

Programmable robots: Microprocessors such as Arduino/Raspberry Pi with Consumer Robotic Appliances, Robotics Design, Navigation Planning, Simultaneous Localisation and Mapping Algorithm, Robot Operating Systems and its Architecture.

Cloud Computing and Networking: Cloud Computing Systems. Client-server Programming and Programming API in the Cloud. Software Programming and API Services to Integrate ROS and the Cloud.
Cloud Robotics and Automation Architectures: Robotics and Human Automation by Cloud Computing, Current Trends of Networked Robotics using Internet and the Cloud. System Components and Architectures of the Internet of Things. Optimisation and Data Analytics Algorithms.

Text and Reference Materials

- Textbook:
  - *Shakil Akhtar*, **Mastering AI and Cloud Robotics: Art of building intelligent cloud-based robots**, BPB Publications.
- References:

ROB 4116: Cloud Robotics Lab

Basic Information

Semester	4th Year 1st Semester
Course Code	ROB 4116
Course Title	Cloud Robotics Lab
Course Credit	1.5
Course Category	Lab Course (Robotics Stream)

Syllabus

Laboratory classes based on the topics covered in **ROB 4106: Cloud Robotics**.

RME 4107: Mobile Robotics

Basic Information

Semester	4th Year 2nd Semester
Course Code	ROB 4107
Course Title	Mobile Robotics
Course Credit	3.0
Course Category	Core Course (Robotics Stream)
Prerequisite Course	Robotics I

Syllabus

Introduction to the Fundamentals of Mobile Robotics, Basic Principles of Locomotion, Kinematics, Sensing, Perception, and Cognition that are Key to the Development of Autonomous Mobile Robots. Perception and Planning for Autonomous Operation. Sensor Modeling, Vehicle State Estimation using Bayes Filters, Kalman Filters, and Particle Filters as well as Onboard Localization and Mapping. Vehicle Motion Modeling and Control, as well as Graph Based and Probabilistic Motion Planning, Case Study.

Text and Reference Materials

- Textbook:
  - *Siegwart and Nourbakhsh*, **Autonomous Mobile Robots**, MIT Press.

ROB 4117: Mobile Robotics Lab

Basic Information

Semester	4th Year 1st Semester
Course Code	ROB 4117
Course Title	Mobile Robotics Lab
Course Credit	1.5
Course Category	Lab Course (Robotics Stream)

Syllabus

Laboratory classes based on the topics covered in **ROB 4107: Mobile Robotics**.

ROB 4108: Robot Vision

Basic Information

Semester	4th Year 1st Semester
Course Code	ROB 4108
Course Title	Robot Vision
Course Credit	3.0
Course Category	Core Course (Robotics Stream)
Foundation Knowledge	Linear Algebra, Calculus, Statistics, AI, Object Oriented Programming, Digital Image Processing, Machine Learning

Syllabus

Introduction: What is computer vision?, Intro of Image Processing, A brief history, Three R's in Computer Vision.

HVS and Image Formation: Basic Facts about Light, Visual Cortex, Horopter, Panum's Fusion Area, Monocular and Binocular Vision, Camera Autonomy, The Digital Camera, Geometric Primitives and Transformations, Photometric Image Formation.

Image Processing: Point Operators, Linear Filtering, Non-linear Filtering, Fourier Transforms, Pyramids and Wavelets, Geometric Transformations, Color Representations and Color Vision, Color Balancing and Gamma.

Features: Local Descriptors: Corner, SIFT, LBP, HOG; Edge Detection and Linking: LoG, Canny; Image Segmentation, Image Features: Steerable Filters, Shape & Texture, DL based Perceptual Features; Quality Assessment: Full-reference Quality: SSIM, FSIM, Reduced and No Reference.

Image Alignment and Stitching: Pairwise Alignment, Image Stitching, Global Alignment, Compositing, Feature Matching.

Depth Estimation: Epipolar Geometry, Sparse and Correspondence, Dense Correspondence, Local Methods, Global Optimization, Multi-view Stereo, Monocular Depth Estimation, Depth from Structure, DL based Depth, Structure & Depth from Egomotion.

Motion Estimation: Optical Flow, Block Matching, Parametric Motion, Global Motion, Layered Motion, Flownet.

Structure from Motion and SLAM: Geometric Intrinsic Calibration, Pose Estimation, Two-Frame Structure from Motion Multi-frame Structure from Motion, Simultaneous Localization and Mapping (SLAM).

Robotic Visual Servoing: Visual Sensing, Visual Data in Control, A fully Integrated System, Visual Tracking, Visual Tracking Applications, Motion Control Algorithm, 3D Visual Servoing, Visual Servoing HRI, HRI with Virtual Visual Fixtures, Grasping using VF.

Decision Making: Saliency Computation: Image and Video Saliency, DL based Image and Video Saliency, Segmentation: Superpixels, Mean Shift and Mode Seeking Segmentation, CNN based Semantic Image and Video Segmentation, Object Detection and Recognition: Contrast based Salient Object Detection (SOD), DL based SOD, Video SOD, You Only Look Once (YOLO).

Text and Reference Materials

- Textbook:
  - *Richard Szeliski*, **Computer Vision: Algorithms and Applications**, Springer.
  - *Peter Corke*, **Robotics, Vision and Control**, Springer.
- References:

- *R. C. Gonzalez and R. E. Woods*, **Digital Image Processing**, Pearson Publications.

ROB 4118: Robot Vision Lab

Basic Information

Semester	4th Year 1st Semester
Course Code	ROB 4118
Course Title	Robot Vision Lab
Course Credit	1.5
Course Category	Lab Course (Robotics Stream)

Syllabus

Laboratory classes based on the topics covered in **ROB 4108: Robot Vision**

ROB 4109: Control Systems Design

Basic Information

Semester	4th Year 1st Semester
Course Code	ROB 4109
Course Title	Control Systems Design
Course Credit	3.0
Course Category	Core Course (Robotics Stream)
Foundation Knowledge	Calculus, Linear Algebra, Differential Equations and Coordinate Geometry, Robotics-I, Physics, Solid Mechanics, Statics and Dynamics.

Syllabus

Review of Classical Control Techniques: Compensation, Pole Placement Technique- Pole Placement with State Feedback for Compensator Design, PD Compensation, PI Compensation, PID Compensation.

State-Space Design: State Space Representation- State Equations of Continuous and Discrete Systems, State Transition Matrix, Stability Analysis. Estimator Design, Compensator Design, Integral Control and

Robust Tracking.

Digital Control Systems: State Equations of Digital Systems - Discretization using Sample-and-hold, Zero-order Hold (ZOH), Digital Approximation of Continuous-time Models, Solution of Discrete State Equations - Solution using the Z-transform: Stability, Causality, Transient Analysis, State Diagrams and Transfer Functions, State Plane Analysis and Time-domain Simulations, Stability in Digital Control - Jury's Stability Criterion, Nyquist Criterion for Digital Systems.

Digital System Design and Simulation: Digital Simulation and Approximation -Simulation of Digital Systems using MATLAB/Simulink, Digital Redesign Techniques (e.g., Bilinear Transformation, Backward Difference), Time Domain and Frequency Domain Analysis - Impulse, Step Response of Digital Systems, Frequency Response using Bode plot, Nyquist plot.

Advanced Digital Control Techniques: Controllability and Observability - Kalman Decomposition, Design for Systems with State Feedback, Output Feedback, Optimal Linear Digital Regulator Design - Linear Quadratic Regulator (LQR), Linear Quadratic Gaussian (LQG) Controller Design.

Digital State Observers: State Observer Design - Full-order and Reduced-order Observers, Kalman Filter for State Estimation in Noisy Environments.

Microprocessor and Embedded Control: Microprocessor Control Systems - Implementation of Digital Control Algorithms in Microcontrollers, Sample and Hold Circuits in Embedded Systems, Digital Filters for Control - FIR/IIR Filter Design in Control Loops.

Adaptive and Nonlinear Control: Introduction to Adaptive Control - Self-tuning Regulators, Model Reference Adaptive Control (MRAC), Nonlinear Control Techniques - Sliding Mode Control, Backstepping Control.

Fuzzy Logic Control: Design of Fuzzy Control Systems, Application to Nonlinear Systems, Handling Uncertainty.

Robust Control Design: H-infinity Control, Disturbance Rejection, Uncertainty Modeling.

Predictive Control: Model Predictive Control (MPC) for Real-time Control, Constraints Handling and Optimization in Control Loops.

Text and Reference Materials

- Textbook:
  - *Gene F. Franklin, J. David Powell, and Michael Workman*, **Digital Control of Dynamic Systems**, Addison-Wesley.
- References:
  - *Katsuhiko Ogata*, **Modern Control Engineering**, Prentice Hall.
  - *Karl J. Åström and Björn Wittenmark*, **Adaptive Control**, IEEE.

ROB 4119: Control Systems Design Lab

Basic Information

Semester	4th Year 1st Semester
Course Code	ROB 4119
Course Title	Control Systems Design Lab
Course Credit	1.5
Course Category	Lab Course (Robotics Stream)

Syllabus

Laboratory classes based on the topics covered in **ROB 4109: Control Systems Design**.

MTE 4104: Automobile Engineering

Basic Information

Semester	4th Year 1st Semester
Course Code	MTE 4104
Course Title	Automobile Engineering
Course Credit	3.0
Course Category	Core Course (Mechatronics Stream)
Prerequisite Course	Fundamentals of Mechanical Engineering

Syllabus

Basic Concepts of Internal Combustion Engines (ICEs): Operation and Testing, Exhaust Gas Analysis, Noise Characteristics.

Introduction to Road Vehicles: Performance, Construction, Tractive Effort Curves.

Fundamentals of Road Vehicle Performance: Basic Vehicle Equation. Engine Power, Rolling Resistance, Aerodynamic Drag, Gradients, Acceleration. Free Tractive Effort Diagrams. Vehicle Monograms. Prime Mover Performance, Torque, and Transmission Ratio. Power to Weight Ratio in Alternative Power Systems. Specific Power vs. Specific Work Diagrams. Equation of Motion and Maximum Tractive Effort for Front Wheel, Rear Wheel and Four Wheel Drive. Prediction of Vehicle Performance Acceleration, Time and Distance.

Handling Characteristics of Road Vehicles: Braking Performance of Twin Axle Vehicles. Effect of Weight Distribution. Stability in Front and Rear Wheel Skids.Braking Efficiency and Stopping Distance. Leading and Trailing Brake Shoe Characteristics. Disc Brakes. Anti-lock Brake Systems (ABS).

Tyre Characteristics: Theory of Frictional Coupling between Tyre and Road. Mechanisms of Rubber Friction. Longitudinal Slip, its Nature and Relation with Tractive and Braking Effort. Cornering Properties of Tyres, Slip, and Cornering Force. Tyre to Wet Road Friction. Tyre Construction. Characteristics of Road Surface and Relation to Tractive (Skid) Effort. Tyre Noise.

Handling Characteristics of Road Vehicles: Cornering, Steering Geometry, Ackerman Criterion, Steady State Handling Characteristics, and Slip Angle, Oversteer, Understeer, Neutral Steer. Lateral Acceleration Response, Yaw Velocity Response, Curvature Response. Transient Response Characteristics. **Testing of Handling:** Characteristics of Constant Radius, Constant Speed and Constant Steer Angle Test.

Automobile Transmissions System: Design, Principles and Operation of Modern Car Transmission Systems.

Electrical Systems: Electrical Control System.

Electric Vehicles: Types of Electric Vehicles, Energy Storage in Electric Vehicles, Advantages of Electric Vehicles, System Configuration and Drive Train Structure. Battery, Flywheels, and Supercapacitors. Modeling and Simulation for Electric Vehicle Applications. Electric Fuel. Electric Vehicle Modeling and Design Consideration, Variable Frequency Drive Applications in HVAC Systems, New Applications of Electric Drives, Future of Electric Vehicles.

Text and Reference Materials

- Textbook:
  - *Wong JY*, **Theory of Ground Vehicles**, John Wiley Sons.
- References:
  - *Heisler*, *H*, *Edwin Arnold*, **Advanced Vehicle Technology**, McGraw Hill India.
  - *Mukesh Pandey*, **Small Electric Vehicles**, Arcler Press.

MTE 4114: Automobile Engineering and Electric Vehicle Lab

Basic Information

Semester	4th Year 1st Semester
Course Code	MTE 4114
Course Title	Automobile Engineering Lab
Course Credit	1.5
Course Category	Lab Course (Mechatronics Stream)

Syllabus

Laboratory classes based on the topics covered in **MTE 4104: Automobile Engineering**.

MTE 4105: Biomedical Sensors and Signals

Basic Information

Semester	4th Year 1st Semester
Course Code	MTE 4105
Course Title	Biomedical Sensors and Signals
Course Credit	3.0
Course Category	Core Course (Mechatronics Stream)
Foundation Knowledge	Instrumentation and Measurement, Fundamentals of Mechatronics Engineering

Syllabus

Fundmaental of Biosignals: Definition and Model of Biosignals, Classification of Biosignals, Trends in Biosignal Monitoring.

Physiological Phenomena and Biosignals: Parameters of Vital Phenomena, Including Heartbeat, Respiration, Blood Circulation, Blood Oxygenation, and Blood Temperature; Behaviors of Parameters Related to Different Vital Phenomena.

Sensing by Acoustic Biosignals: Overview of Body Sounds, Including Heart Sounds, Snoring Sounds, Apneic Sounds, etc.; Transmission of Body Sounds, Sensing of Body Sounds- Coupling of Body Sounds, Registration of Body Sounds.

Sensing by Optic Biosignals: Formation Aspects of Induced Optic Biosignals, Including Artificial Source of Incident Light, Coupling of Incident Light in the Body, and Propagation of the Light Through the Body Tissue; Penetration and Probing of Light, Transmission and Reflection Modes, Adverse Health Effects and Exposure, Registration of Optic Biosignals.

Sensing by Electric Biosignals: Formation of Electric Biosignals- Permanent Biosignals, Induced Biosignals, Transmission of Electric signals; Sensing and Coupling of Electric Biosignals- Tissue, Skin, and Electrode Effects, Signal Coupling in Diagnosis and Therapy; Biosignal Interfacing and Coupling.

Text and Reference Materials

- Textbook:
  - *Eugenijus Kaniusas*, **Biomedical Signals and Sensors I**, Springer.

  - *Eugenijus Kaniusas*, **Biomedical Signals and Sensors II**, Springer.
  - *Eugenijus Kaniusas*, **Biomedical Signals and Sensors III**, Springer.

- References:
  - *Tatsuo Tagawa*, *Toshiyo Tamura*, *P. Ake Oberg*, **Biomedical Sensors and Instruments**, CRC Press.
  - *Walter Welkowitz*, **Biomedical Instruments- Theory and Design**, Academic Press.

MTE 4115: Biomedical Sensors and Signals Lab

Basic Information

Semester	4th Year 1st Semester
Course Code	MTE 4115
Course Title	Biomedical Sensors and Signals Lab
Course Credit	1.5
Course Category	Lab Course (Mechatronics Stream)

Syllabus

Laboratory classes based on the topics covered in **MTE 4105: Biomedical Sensors and Signals** .

MTE 4106: Networking and Internet of Things

Basic Information

Semester	4th Year 1st Semester
Course Code	MTE 4106
Course Title	Networking and Internet of Things
Course Credit	3.0
Course Category	Core Course (Mechatronics Stream)
Foundation Knowledge	Algorithm, Programming, Linear Algebra, Artificial Intelligence, Digital Signal Processing, Electrical Machines.

Syllabus

Computer Network: Data Transmission Media, Modulation Techniques, Wired and Wireless Services, Multiplexing, Switching Techniques, OSI Model, Communication Protocols, TCP/IP. Network Protocols, Service Models, Packet Switching, Circuit Switching, TCP, UDP, Forwarding and Routing Algorithims, IPv4 and IPv6, Wireless and Mobile Networks, Mobility Management.

Introduction to IoT: Overview, Applications, Potential & Challenges, Components of IoT solutions, Standards for IoT.

IoT Elements and Architecture: Different Elements of IoT, 3-layered, 4-layered and 7-layered IoT Architectures, Security Threats in Different Layers of IoT Architecture

IoT Sensors and Devices: IoT Devices and Sensor Types, Sensors and Data Collecting Points, Sensing, Actuation, How They Work and Connect.

IoT Protocols: Basics of IoT Networking, Connectivity Technologies, IoT Communication Protocols (REST, CoAP, MQTT, DDS, AMQP), Sensor Networks, Machine-to-Machine Communications, UAV Networks, Connected Vehicles, SDN for IoT.

IoT and Cloud: Cloud Computing Fundamental, Cloud Computing Service models and Security, Sensor-Cloud, Big Data Proecssing Pattern, Big Data and Big Stream Oriented Architecture, IoT and Cloud Integration, Fog Computing.

Cyber security and Privacy in IoT: The Security and Privacy Implications of IoT.

IoT Application and Case Study: Smart Cities and Smart Homes, Industrial IoT, Agriculture, Healthcare.

Text and Reference Materials

- Textbook:
  - *Jim Kurose*, *Keith Ross*, **Computer Networking: A Top Down Approach**, Pearson Publications.
  - *Sudip Misra*, *Anandarup Mukherjee*, *Arijit Roy*, **Introduction to IoT**, Cambridge University Press.
  - *Chintan Patel*, *Nishant Doshi*, **Internet of Things Security: Challenges, Advances, and Analytics**, CRC Press.
- References:
  - *Simone Cirani*, *Gianluigi Ferrari*, *Marco Picone*, *Luca Veltri*, **Internet of Things: Architectures, Protocols and Standards**, Wiley.
  - *B. B. Gupta*, *Aakanksha Tewari*, **A Beginner's Guide to Internet of Things Security**, CRC Press.

MTE 4116: Networking and Internet of Things Lab

Basic Information

Semester	4th Year 1st Semester
Course Code	MTE 4116
Course Title	Networking and Internet of Things Lab
Course Credit	1.5
Course Category	Lab Course (Mechatronics Stream)

Syllabus

Laboratory classes based on the topics covered in **MTE 4106: Networking and Internet of Things Lab** .

MTE 4107: Finite Element Analysis

Basic Information

Semester	4th Year 1st Semester
Course Code	MTE 4107
Course Title	Finite Element Analysis
Course Credit	3.0
Course Category	Core Course (Mechatronics Stream)
Foundation Knowledge	Calculus, Linear Algebra, Differential Equations, Statics and Dynamics, Solid Mechanics, Fundamentals of Programming

Syllabus

Introduction to Finite Element Analysis (FEA): History and Development of FEA, Applications of FEA in Engineering, Overview of the FEA Process.

Mathematical Foundations: Linear Algebra Review, Differential Equations and Boundary Value Problems, Variational Methods and the Principle of Minimum Potential Energy.

Finite Element Method Fundamentals: Discretization of the Domain, Elements and Shape Functions, Assembly of the Global Stiffness Matrix, Boundary Conditions and Constraints.

Element Types and Properties: 1D Elements (Bar, Beam), 2D Elements (Triangular, Quadrilateral), 3D Elements (Tetrahedral, Hexahedral), Higher-Order Elements.

Formulation of Element Matrices: Derivation of Stiffness and Mass Matrices, Integration Techniques (Gauss Quadrature), Handling of Nonlinearities.

Static Structural Analysis: Static Equilibrium Equations, Solving Linear Static Problems, Stress, Strain, and Displacement Calculations. **Dynamic Analysis**: Time-Dependent Problems, Modal Analysis and Natural Frequencies, Time Integration Methods (Implicit and Explicit).

Heat Transfer Analysis: Steady-State and Transient Heat Transfer, Thermal Boundary Conditions, Coupled Thermal-Structural Analysis.

Fluid Mechanics and Flow Analysis: Basics of Fluid Flow Equations, Finite Element Formulation for Fluid Flow, Applications in Fluid-Structure Interaction.

Nonlinear Finite Element Analysis: Geometric Nonlinearity, Material Nonlinearity, Solution Strategies for Nonlinear Problems.

Error Analysis and Mesh Refinement: Sources of Errors in FEA, Convergence and Accuracy, Adaptive Mesh Refinement Techniques.

Text and Reference Materials

- Textbook:
  - *Nam-Ho Kim and Bhavani V. Sankar* , **Robotics: Designing the Introduction to Finite Element Analysis and Design**, Wiley.
- References:
  - *K.J. Bathe*, **Finite Element Procedures**, Pearson.
  - *Saeed Moaveni*, **Finite Element Analysis: Theory and Application with ANSYS**, Prentice Hall.
  - *Nitin S. Gokhale*, **Practical Finite Element Analysis**, Finite To Infinite.
  - *J.N. Reddy*, **An Introduction to the Finite Element Method**, McGraw-Hill.
  - *M. Gopal*, **Finite Element Analysis: Theory, Applications and Programming**, McGraw-Hill.
  - *Jacob Fish and Ted Belytschko*, **A First Course in Finite Elements**, Wiley.
  - *J.N. Reddy*, **Engineering Analysis with ANSYS Software**, Pearson.
  - *Y. Nakasone and S. Yoshimoto*, **An Introduction to the Finite Element Method**, Butterworth-Heinemann.
  - *Thomas J. R. Hughes*, **The Finite Element Method: Linear Static and Dynamic Finite Element Analysis**, Dover Publications.

- *John Edward Akin*, **Finite Element Analysis Concepts: Via SolidWorks**, World Scientific Publishing Company.

MTE 4117: Finite Element Analysis Lab

Basic Information

Semester	4th Year 1st Semester
Course Code	MTE 4117
Course Title	Finite Element Analysis Lab
Course Credit	1.5
Course Category	Lab Course (Mechatronics Stream)

Syllabus

Laboratory classes based on the topics covered in **MTE 4107: Finite Element Analysis Lab** .

MTE 4108: Manufacturing Process and CNC Programming

Basic Information

Semester	4th Year 1st Semester
Course Code	MTE 4108
Course Title	Manufacturing Process and CNC Programming
Course Credit	3.0
Course Category	Core Course (Mechatronics Stream)
Foundation Knowledge	Calculus, Linear Algebra, Differential Equations, Multivariate and Vector Calculus, Physics, Solid Mechanics, Programming Languages.

Syllabus

Manufacturing Processes

Introduction: Basic Concepts of Manufacturing Processes, Classification of Manufacturing Processes.

Metal Casting: Casting Processes for Ferrous and Non-Ferrous Metals, Casting Defects, Design of Molds, Riser, Gate Sprue and Core.

Joining Methods: Soldering, Brazing, Welding- Gas, Arc, TIG, MIG etc.

Different Machining Processes: Various Operations, Cutting Tools and Their Analyses in Turning, Milling, Drilling, Shaping, Grinding etc.

Forming and Shaping: Sheet Metal Forming, Punching, Blanking, Drawing, Injection Molding, Compression Molding, Blow Molding etc.

CNC Programming

Introduction to CNC: Introduction to the Fundamentals of Computer Numerical Controlled (CNC) Milling Machines and their Programming. Basic Operation of CNC Machines, CNC Machine Safety, Simulation, Tooling with Tool Selection, and Machine Zeroing. Absolute and Incremental Positioning, Circular Interpolation, Program Interpolation, and Cycle Pausing.

CNC Machine Operation: Machine Speeds and Feeds, Feed Rate, and Cycle Time Optimization, Drilling Cycles, Subprograms, Cutter Compensation, and Scaling/Mirroring, CAM-Mill Processes, Contouring, Cycle Time Estimation, Tool Selection, Material Selection, Cutter Compensation, Contour Applications, Roughing, Finishing and Tool Paths.

Case study: Import a CAD model into Computer Aided Manufacturing (CAM) Software.

Text and Reference Materials

- Textbook:
  - *Laurence E. Doyle*, **Manufacturing Processes and Materials for Engineers, Prentice Hall**.
  - *B. Stuad and H. Amsteard*, **Manufacturing Processes, McGraw Hill**.
  - *B.H. Amstead and Philip F. Ostwald*, **Manufacturing Process, John Wiley and Sons**.
  - *Serope Kalpakjian and Steven Schmid*, **Manufacturing Processes for Engineering Materials, Pearson**.
- References:
  - *Ralph Bagnall*, **Beginner's Guide to CNC Machining in Wood: Understanding the Machines, Tools, and Software, Plus Projects to Make**, 1st Edition, Fox Chapel Publishing.

MTE 4118: Manufacturing Process and CNC Programming Lab

Basic Information

Semester	4th Year 1st Semester
Course Code	MTE 4118
Course Title	Manufacturing Process and CNC Programming Lab
Course Credit	1.5
Course Category	Lab Course (Mechatronics Stream)

Syllabus

Laboratory classes based on the topics covered in **MTE 4108: Manufacturing Process and CNC Programming** .

MTE 4109: Smart Materials and Structures

Basic Information

Semester	4th Year 1st Semester
Course Code	MTE 4109
Course Title	Smart Materials and Structures
Course Credit	3.0
Course Category	Core Course (Mechatronics Stream)
Foundation Knowledge	Physics, Mechanics of Solids

Syllabus

Introduction to Materials Science and Engineering: Historical Overview, Classification of Materials, Importance of Materials in Engineering.
Atomic Structure and Bonding: Atomic Models, Types of Chemical Bonds, Crystal Structure and Defects.
Mechanical Properties of Materials: Stress and Strain, Elasticity and Plasticity, Hardness, Toughness, and Ductility.

Thermal Properties of Materials: Heat Capacity and Thermal Conductivity, Thermal Expansion, Phase Transformations.

Electrical and Magnetic Properties of Materials: Conductivity and Resistivity, Dielectric and Magnetic Materials, Superconductors.

Phase Diagrams and Phase Transformations: Binary and Ternary Phase Diagrams, Solidification and Phase Transformations, Microstructural Evolution.

Mechanical Behavior of Materials: Tensile Testing, Creep and Fatigue, Fracture Mechanics.

Processing of Engineering Materials: Steady-State and Transient Heat Transfer, Thermal Boundary Conditions, Coupled Thermal-Structural Analysis.

Ferrous and Non-Ferrous Metals: Properties and Applications of Steel, Aluminum, Copper, and Titanium, Alloy Design and Selection.

Polymers and Composites: Polymer Structure and Properties, Composite Materials and their Reinforcement Mechanisms.

Ceramics and Glasses: Types of Ceramics and their Properties, Glass-Ceramic Materials.

Smart Materials and Structures: Shape Memory Alloys, Piezoelectric Materials, Magnetostrictive Materials.

Nanomaterials and Nanotechnology: Introduction to Nanomaterials, Fabrication Techniques, Applications in Engineering.

Materials Selection and Design: Material Selection Criteria, Design Considerations.

Text and Reference Materials

- Textbook:
  - *William D. Callister Jr. and David G. Rethwisch*, **Materials Science and Engineering: An Introduction**.
- References:
  - *James F. Shackelford*, **Introduction to Materials Science for Engineers**.
  - *Thomas H. Courtney*, **Mechanical Behavior of Materials**.
  - *David A. Porter, Kenneth E. Easterling, and Mohamed Y. Sherif*, **Phase Transformations in Metals and Alloys**.
  - *Charles Gilmore*, **Materials Science and Engineering: Properties**.
  - *Michael F. Ashby and David R. H. Jones*, **Engineering Materials 1: An Introduction to Properties, Applications, and Design**.
  - *A. S. Edelstein and R. C. Cammarata*, **Nanomaterials: Synthesis, Properties and Applications**.

- *Jadranka Travas-Sejdic and Anthony E. G. Cass*, **Smart Materials: Properties, Design, and Applications**.
- *Michael F. Ashby*, **Materials Selection in Mechanical Design**.
- *John Wanberg*, **Composite Materials: Fabrication Handbook**.

MTE 4119: Smart Materials and Structures Lab

Basic Information

Semester	4th Year 1st Semester
Course Code	MTE 4119
Course Title	Smart Materials and Structures Lab
Course Credit	1.5
Course Category	Lab Course (Mechatronics Stream)

Syllabus

Laboratory classes based on the topics covered in **MTE 4109: Smart Materials and Structures** .

RME 4200: Research Project

Basic Information

Semester	4th Year 2nd Semester
Course Code	RME 4200
Course Title	Research Project
Course Credit	4.0
Course Category	Core Course
Foundation Knowledge	None

Syllabus

Students will finalize a major research project in engineering, focusing on developing initiative, creativity, analysis and engineering judgment. In this semester they will submit the final project work based on the intermediate submitted work (RME 4100) of the previous semester (Semester VII).

RME 4300: Internship / Industry Oriented Project

Basic Information

Semester	4th Year 2nd Semester
Course Code	RME 4300
Course Title	Internship / Industry Oriented Project
Course Credit	3.0
Course Category	Core Course
Foundation Knowledge	None

Internship

The internship is mandatory for all students. Students will work in the relevant industry / industry oriented project for two months to gain real-world industry experiences.