COURSE CONTENTS
DEPARTMENT OF MECHATRONICS AND CONTROL ENGINEERING

Course Name	**Calculus and Analytic Geometry**
Description	The course is conducted by the Mathematics department.
Course Code	**MA-113**
Credit Hours	3 (3, 0)
Textbook	1. Calculus by Thomas & Finny, 14th Edition 2018, Pearson. 2. Advanced Engineering Mathematics by E. Kreyszig, 10th Edition 2011, John Wiley& Sons. 3. Calculus by Howard Anton, 10th Edition 2012, Wiley. 4. Calculus by Swokowski, 6th Edition 1996, Brooks Cole.
Contents	A review of differentiation; Geometrical interpretation of a derivative; Infinitesimal; Differential coefficient; Derivatives of higher order; Indeterminate forms and L'Hospital's rule; Asymptotes; Curvatures; Approximation and error estimates. Further techniques of Integration; Integration by reduction formula; Fundamental Theorem of Integral Calculus; Definite integral and its properties; Area enclosed between curves; Arc length; Volume of a solid; Volume of a solid of revolution; Area of surface of revolution; Moments; Centroids. Cartesian, Cylindrical and Spherical coordinates; The ratio formula; Equations of a straight line in R3; Direction ratios and direction cosines; Angle between two straight lines, Distance of a point from a line; Equation of a plane; Angle between two planes; The sphere; Directional derivatives. The concept of limit, continuity and differentiation in functions of several variables; Geometric interpretation of partial derivatives; Total differential; Chain rule; Implicit differentiation; Maxima and minima of functions of two independent variables, Taylor's and Maclaurin's series for functions of two variables. Double integration; Fubini's Theorems; Change of order; Geometrical interpretation of double integral; Applications to find volumes and areas.

Course Name	**Engineering Graphics and Drawing**
Description	In this course, students will be introduced to the role of graphics in engineering design process. They will be able to visualize and communicate design intent of

	mechanical components. In this context, both manual sketching techniques and 3D parametric modeling CAD tool will be introduced. They will learn how to draw 2D views of existing 3D engineering parts and vice versa as per the engineering drawing rules. So, by the end of the course, students will be able to produce engineering drawings of mechanical parts and assemblies, in accordance with a specified drafting standard.
Course Code	**MCT-111**
Credit Hours	3 (1, 2)
Textbook	1. N.D. Bhatt, V.M. Panchal, Engineering Drawing (Plane and Solid Geometry), Fiftieth Edition, 2011, Charotar Publishing. 2. K Venkata Reddy, Textbook of Engineering Drawing, 2nd Edition, 2008, BS Publications
Contents	**Theory:** Role of graphics in general engineering design process, Basic sketching, construction and visualization of geometric shapes, orthographic projection, auxiliary views, sectional and detailed views, isometric Views, geometric dimensioning and Tolerancing (ASME standard), 3D modeling of engineering components such as fasteners, gears, pulleys, etc. (to name a few); Study and understanding of industrial drawings, **Lab:** Use of CAD software for 2D and 3D modeling,

Course Name	**Electric Circuits**
Description	Students will learn about electrical concepts and their applications in the practical world. Understanding and solving a particular electric circuit problem through the simplest of the techniques available is one hidden objective of this course. Students will be analyzing, both, AC and DC electric circuits involving resistors, capacitors, and inductors with dependent and independent power sources. Theory portion of this course will be supplemented with the associated lab work, where students will be playing with practical components connecting bookish knowledge to hands-on experience. This course will also aim to plant a seed of interest, in students, for advanced electronic courses as electronics is one of the resting pillars for Mechatronics & Control Engineering

Course Code	**MCT-121 & MCT-121L**
Credit Hours	4 (3, 1)
Textbook	1. Introductory Circuit Analysis by Robert L Boylestad,13th Edition, Pearson, 2016. 2. Basic-Engineering-Circuit-Analysis by David Irwin, 12th Edition, Wiley, 2021
Contents	**Introduction:** Current, voltage and resistance concepts, Ohm's law,power, energy and efficiency of simple as well cascaded systems **DC Portion:** Kirchhoff's Laws, Voltage & Current Divider Rules, Mesh- Nodal Analysis, Wye-Delta transformation. Superposition Principle, Thevenin, Norton & Maximum Power Transfer Theorem. Capacitors and inductors, their Charging & Discharging behavior in DC Circuits with RC, RL and RLC components **AC Portion**: AC Sources, Average and RMS values of AC sources. Response of resistors, Capacitors and Inductors to AC sinusoidal sources. Impedance in AC Circuits, AC waveforms and phasors.

Course Name	**Islamic and Pak Studies - I / Ethics and Pak Studies - I**
Description	The course is conducted by the Islamiat department.
Course Code	**IS-101 / HU-101**
Credit Hours	3 (3, 0)
Textbook	1. Selected Surahs and Verses from The Holy Quran 2. Arbaeen Nawavi by Abu Zakrya Yahya bin Sharf Al Nawavi 3. Seerat ul Nabi by Shibli Nomani 4. Comprehensive book of Pakistan Studies by M. Ikram Rabbani
Contents	**Islam and basic beliefs:** Qualities of believers, Tawheed Fundamentals and types, Prophethood and its finality, The Day of Judgment, Characteristics of Ibad-ur-Rehman (Slaves of Allah) Ideology of Pakistan, Definition and Explanation, Importance of intention (Niyya) in human actions, Islam, Iman (belief), Ihsan (excellence) and the Hour, Sincerity to Allah, His Books, His Messengers, leaders of the Muslims and common people, Ideology of Pakistan With reference to Allama Iqbal and Quaid-i-Azam. **Islamic teachings regarding social behavior:** Etiquettes regarding seeking knowledge, Importance of good talk and silence, Prevention from inventing a lie Ideology of Pakistan, Aims and Objectives of the creation of Pakistan, Brotherhood, Efforts to compose the quarrels of groups and reconciliation between them,

	Elimination of social evils such as to laugh at people in contempt, calling others by offensive nick names and suspicion etc, Backbiting, Muslim Rule in South Asia, Arrival of Muhammad bin Qasim and successors, Importance of modesty (Al-Haya), Good behavior towards people, Fair speaking to the people, To control anger, Ihsan (excellence) with regards to everything, Tolerance, Religious Freedom and kind treatment towards Non-Muslims. **Prophetic life as a role model:** Life of The Holy Prophet (Peace be upon him) from prophet-hood to Hijra, Difficulties in preaching Islam in Makka and opposition of Quresh, Reasons of hijra (migration) to Madina and impact of this migration, Historical Background of Ideology of Pakistan, Services of Mujadid Alf Sani. **History of the Holy Qur'ān:** Revelation, Compilation, Significance, Reformative movement, Social and religious services of Shah Waliullah, Efforts for sectarian harmony. **Importance of hadith:** Definition, Importance, Authenticity, Reformative movement, Syed Ahmad Shaheed, Biography, Creation of Islamic State, Opposition from Local tribes and Martyrdom at Balakot. **Prophetic ethical behaviours**: Significance of moral values in the light of the life of the Holy Prophet peace be upon him: Tolerance, Patience, Endurance , Generosity, Honesty **Sir Syed Ahmad Khan:** Educational and Social services, Political aspect of Aligarh movement. **Islamic teachings regarding social behavior:** Stress on fulfillment of uqud (obligations), Sanctity of religious symbols, Arise of Political consciousness among Muslims, Establishment of All India Muslim League (AIML): Objective and achievement. **Islam and Halal & haram:** Concept of Halal (lawful) and haram (forbidden) in Islam, Halal and haram animals and food, Rules of hunting the animals for food, Lawful, unlawful and doubtful matters, Importance of lawful food, drink, clothing and nourishing Pakistan Movement, Muslim Nationalism, Khilafat Movement, Non cooperation Movement. **Islamic rules of purity and cleanliness:** Importance of purity and cleanliness in life, Rules of purity and cleanliness, Non cooperation movement, Role of Ali Brothers, Role of Mr.Ghand, Failure and effects of Khilafat movement. **Relationship with other religions:** Respect of other religions and their believers,

	Relationship with Ah'l Al-Kitab (people of the Book), Social relationships with non-Muslims, The Covenant of Bani-Israel (The children of Isreal) with Allah, Address of prophet Moses (peace be upon him) to his people Pakistan Movement, Allahabad Address of Allama Iqbal, Idea of independent Muslim State **Islam and ethics:** Definition, importance and significance of Ethics, Concept of Ethics in the light of Qur'ān and Hadith **Pakistan Movement:** Provincial Elections 1937, Establishment of Congress Ministries, Behaviour towards Muslims, Comparative Religious Morals (i) Hinduism (ii) Buddhism (iii) Judaism (iv) Christianity (v) Islam **Philosophy of Ethics in revealed and non revealed religions:** an analysis **Pakistan Movement:** Lahore/ Pakistan Resolution of 23rd March 1940 **Islam and Modern Science:** The Holy Qur'ān as s guide for the modern scientific development,, Importance of science education in the modern age, Introduction of Muslim scientists, Contribution of Muslim Scholars towards science, Pakistan Movement, Establishment of Pakistan.

Course Name	**Applied Physics**
Description	The course is conducted by the Physics department.
Course Code	**PHY-118 & PHY-118L**
Credit Hours	3 (2, 1)
Textbook	1. Fundamentals of Physics by Halliday, Resnick and Walker 11th Edition 2018, Wiley. 2. Physics for Scientists and Engineers with Modern Physics by Douglas C. Giancol, 10th Edition 2018, Cengage Learning.
Contents	What is Physics? Newton's Law of Gravitation, Gravitation and the Principle of Superposition, Gravitation near Earth's Surface, Damped Simple Harmonic Motion, Forced Oscillations and Resonance. Introduction, Types of Waves, Transverse and Longitudinal Waves, Wavelength and Frequency. The Principle of Superposition for Waves, Interference of Waves, Standing Waves, Standing Waves and Resonance. Introduction, Sound Waves, The Speed of Sound, Heat and Work, The First Law of Thermodynamics, Some Special Cases of the First Law of Thermodynamics, Heat Transfer Mechanisms. Coulomb's Law, Charge is Quantized, Charge Is Conserved. What is Physics? The Electric Field, Electric Field Lines, The Electric Field Due to a Line of Charge, The Electric Field Due to a Charged Disk, A Dipole in an Electric

	Field. Electric Potential Energy, Electric Potential, Calculating the Potential from the Field, Potential Due to a Point Charge. The definition of B, Crossed Fields: Discovery of the Electron, Crossed Fields: The Hall Effect. A Circulating Charged Particle, Ampere's Law, Faraday's Law of Induction, and Gauss' Law for Magnetic Fields, Induced Magnetic Fields, Displacement Current, Maxwell's equations. Thin Lenses, Lasers and Laser Light, How Lasers Work, Semiconductors, Doped Semiconductors, The p-n Junction. The Junction Rectifier, Discovering the Nucleus, Some Nuclear Properties, Radioactive Decay, Alpha Decay, and Beta Decay, Radioactive Dating, Measuring Radiation Dosage.

Course Name	**Workshop Practice**
Description	It is a compulsory university course.
Course Code	**ME-100L**
Credit Hours	1 (0, 1)
Textbook	1. Workshop Technology Part-1, by W. A. J. Chapman, 5th Edition 2019, Routledge. 2. Workshop Processes, Practices and Materials by Bruce J. Black, 5th Edition 2015, Routledge. 3. Mechanical Workshop Practice by K. C. John, 2nd Edition 2010, Prentice-Hall.
Contents	**Basic/Elementary Machine Shop:** Detailed study of centre lathe and accessories, Plain and Taper turning; basic lathe operations including turning, facing, simple screw cutting/threading, knurling, grooving (drilling and boring), cutting tools and their grinding; brief introduction of shaper, milling shearing and surface grinding machine; assigning of practical jobs. **Fitting and Fabrication Shop:** The use and care of fitter's tools; marking out of job; practice in metal filing; sawing; drilling; dieing; tapping and reaming; brief introduction and use of power hack saw; arbor press, sheet shearing machine; sheet rolling machine, punching machine and drilling machine; assigning of practical jobs. **Carpentry Shop:** The use and care of tools; type of timber, its defects and preservation methods practice in planning and sawing; different types of wood joints; study of sawing, planning, turning mortise and tenon machines; assigning of practical jobs. **Electrical Shop:** Electric shocks and treatment; the use and care of tools used by electricians; types and uses of cable and electrical accessories for house wiring,

	practice in simple house wiring; testing methods; switchgear used on domestic installation and DB systems; Earthing system; assigning of wiring arrangements practical. **Smithy/Forge Shop:** The use and care of forging tools and blacksmith, open hearth forge; practice in upsetting, drawing out, spreading, bending, cutting and punching; hardening and tempering of small cutting tools; assigning practical jobs. **Casting/Foundry Shop:** Brief introduction of casting, tools and accessories; types of furnaces, casting methods; types of sand; casting defects; assigning of practical jobs.

Course Name	**Translation of the Holy Quran - I**
Description	The course is conducted by the Islamiat department.
Course Code	**QT-101**
Credit Hours	1 (1, 0)
Textbook	
Contents	The contents are designed by the Islamiat Department.

Course Name	**Computer Programming - I**
Description	One key component of Mechatronics Engineering is related to Computer Science. Computer Programming is the first foundational course in this domain. In this course students will learn the process of transforming abstract ideas into tangible outcomes by means of efficient programming techniques. The ultimate objective of the course is to equip students with the ability to develop programs and algorithms for a variety of practical scenarios. So, by the end of this course, students should acquire the necessary knowledge to work on any programming framework.
Course Code	**MCT-142L**
Credit Hours	2 (0, 2)
Textbook	(Example text books for C++. Similar can be used for some other programming language) 1. Starting Out with C++ by Tony Gaddis, Judy Walters, Godfrey Muganda, 10th Edition 2022, Pearson. 2. Object Oriented Programming in C++ by Robert Lafore, 4th Edition 2001, Sams.

Contents	**Introduction to Programming:** Components of a Computer Program, Data Types, Arithmetic Operations, Identifiers, Reserved Words, Inputs and Outputs. Community Style Guidelines and Conventions **Basics of Programming:** Assignment Statement, Errors, Logical statements, Decisions and Loops, Functions, Recursion, Preprocessor Directives, Qualifier, Type Casting, Variable Scope **Arrays:** Arrays, Manipulating Arrays, Searching an Array, Sorting Arrays **Structures and Pointers**: Structures and Introduction to Pointers. **File Handling**: Basic File Handling System including Text and CSV **Engineering applications of computer programming**

Course Name	**Communication Skills**
Description	It is a university level course conducted by the Humanities department.
Course Code	**HU-111**
Credit Hours	1 (0, 1)
Textbook	1. Effective Business Communications by Murphy Hildebrandt and Thomas, 7th Edition, McGraw-Hill, 1997. 2. Basic Communication Skills for Technology by AJ Rutherford, 2nd Edition, Pearson, 2000. 3. Basic Business Communications by Lesikar, 8th Edition, Tichard D Irwin, 1999. 4. A Practical English Grammar by Thomson and Martinet, 4th Edition, Oxford University Press, 1986. 5. English for Undergraduates by Howe and Kirkpartrick, 1st Edition, Oxford University Press Karachi, 2014
Contents	**Introduction to Communication Skills:** Communication principles, process of communication, importance of good communication skills in business environments, communication in business organizations, challenge of communication in the global market. **Study Skills:** Brainstorming, time management, effective reading strategies, note-taking, organization, summarizing. **Components of Communication:** Context, sender-encoder, message, medium, receiver-decoder, feedback. **Non-Verbal Communication:** Appearance and dress codes, body language, silence, time and space, importance of listening in communication.

	Public Speaking: Difference between speaking and writing, reading texts of good public speeches and analysis of their components, listening to famous public speeches, exercise in public speaking. **Formal Presentations:** Difference between informal and formal presentations, modes of formal presentation, purpose of oral presentations, mechanics of presentations, mode of presentations both with and without AVAs. **Resume/CV Writing** **Interview Skills** **Formal Presentations**

Course Name	**Differential Equations and Transforms**
Description	The course is conducted by the Mathematics department.
Course Code	**MA-225**
Credit Hours	3 (3, 0)
Textbook	1. Advanced Engineering Mathematics by E. Kreyszig, 10th Edition 2011, Wiley. 2. Elementary Differential Equations and Boundary Value Problems by Boyce and Diprima, 10^{th} Edition 2012, Wiley 3. Advanced Engineering Mathematics by H.K. Dass, 22nd Edition 2018, S. Chand & Company, New Delhi.
Contents	**Formation of differential equations;** Solution of various types of first order differential equations; Orthogonal trajectories, Application in physical problems, Linear differential equations of second order, Complementary function and particular integral. Solution of non-homogeneous linear differential equations of second order and higher by (i) the method of undetermined coefficients (ii) the method of variation of parameters; Application of second order differential equations; System of differential equations. **Formation of partial differential equations;** Equations reducible to ordinary differential equations; Equations of the form Pp+Qq=R; Solution by the method of separation of variables; Waves, heat and Laplace equations. **Introduction to Laplace transform;** Laplace transform of elementary functions, Laplace transform theorems, Inverse Laplace transform, Applications to the solutions of initial value problems, Convolution theorem and applications. **Periodic functions;** Even and odd functions, Fourier series of functions of period 2π and arbitrary period; Half range series, Complex Fourier series, Fourier transform

	and applications. **Difference Equations and Z-transforms**

Course Name	**Manufacturing Processes**
Description	Students will be able to learn about basic manufacturing processes used in industry as well as develop an understanding about the machining processes and machine tools utilized to make numerous products. The processes are explained with the associated engineering materials to enhance the student's ability to choose the right material along with the preferred manufacturing technique, design constraints, production costs and product quality. The students are also introduced to the basics of CNC programming. The students will also learn the basics of process planning and production control.
Course Code	**MCT-113 & MCT-113L**
Credit Hours	4 (3, 1)
Textbook	1. Fundamentals for Modern Manufacturing - Materials, Processes, and Systems by Mikel P. Groover, 7th Edition, 2019, Wiley 2. Machine Tool Practices, Richard R. Kibbe, John E. Neely, Roland O. Meyer, Warren T. White, 10th Edition, 2014, Pearson
Contents	• Introduction to Manufacturing • Engineering materials and their properties • Solidification Processes (Casting, Shaping etc) • Particulate Processing (Powder Metallurgy); • Metal Forming and Sheet Metal Working (Rolling, Forging, Extrusion, Drawing and sheet metal related processes); • Material Removal Processes (Machining processes and Related Machines); • Joining and Assembly Processes; • Computer Numerical Control programming • Process planning, production planning and control, lean production, 6-sigma, TPM, TQM

Course Name	**Engineering Mechanics**
Description	Students will be able to learn about how forces act on physical systems and how to resolve those forces for systems in equilibrium. Forces cause motion in a body,

	changing their shape, and maintaining balance. We encounter numerous forces in our everyday life, like using our cell phones, pressing on a button, opening doors etc. The students will also learn about resolving the forces in structures and trusses and understand how friction affects the machines and mechanisms.
Course Code	**MCT-117 & MCT-117L**
Credit Hours	4(3,1)
Textbook	1. Engineering Mechanics - Statics by J.L Meriam and L.G Kraige, 7th Edition 2012, Wiley. 2. Engineering Mechanics - Dynamics by J.L Meriam and L.G Kraige, 7th Edition 2012, Wiley. 3. Engineering Mechanics - Statics by Russell C. Hibbeler, 14th Edition Pearson, 2016 4. Engineering Mechanics - Dynamics by Russell C. Hibbeler, 14th Edition Pearson, 2016 5. Vector mechanics for Engineers - dynamics", Beer, Johnston and Clausen, McGrawHill.
Contents	Force and its rectangular and oblique axis components (two and three dimensional system Moment and resultant couple (two and three dimensional systems) Equilibrium Mechanical systems, free body diagram and equilibrium conditions for two dimensional system Introduction to Structures Kinematics for rigid bodies Kinetics for rigid bodies including the concepts of friction Work and energy principle for rigid bodies Impulse and momentum principle for rigid bodies. Connection points with other courses such as Modeling and Simulation, Mechanisms, etc.

Course Name	**Electronic Devices and Circuits**
Description	Electronic Devices and Circuits is an advanced course with its foundation laying on Electric Circuits. This course provides an overview of electronics and semiconductor devices with real life applications. The course intends to provide an overview of the principles, operation and application of the analog building blocks like diodes, BJT, MOSFET etc. for performing various functions.At the end of this course students will have the capability to design and construct circuits, take measurements of circuit behavior and performance, compare with predicted circuit models and explain discrepancies.
Course Code	**MCT-122 & MCT-122L**
Credit Hours	4 (3, 1)
Textbook	1. Introductory Electronic Devices and Circuits by Robert T Paynter, 6th Edition, Prentice Hall, 2002. 2. Electronic Devices and Circuit Theory, by R. L. Boylestad and L. Nashelsky, 11th edition, Pearson, 2017. 3. Microelectronics Circuits, By A.S. Sedra & K. C. Smith, 8th Edition 2019, Oxford University Press.
Contents	**Diode:** physics of p-n junction, semiconductor diodes and its characteristics, diode types and applications (zener diodes, LEDs, diode rectifiers, clipping and clamping circuits) **Bipolar Junction Transistors:** Basic principles and physical structure of bipolar junction transistors, DC biasing of BJTs, configurations, introduction to BJT small-signal analysis, use of BJTs as amplifiers and switches. **DC--DC Power Converters:** Buck, Boost, Buck-Boost converters, their working principle, analysis and brief discussion on their application in Mechatronic engineering **Field Effect Transistors:** Basic principles and physical structure of Field Effect transistors (JFETs , MOSFETs), MOSFET types, DC biasing and application circuits including H-Bridge and Logic gates **Integrated Circuits:** Converting discrete components electronic circuit into an integrated circuits with the help of case-studies, for example, differential amplifiers **Operational Amplifiers:** Linear Operational amplifiers circuits with emphasis on the common-mode noise rejection

Course Name	**Community Service**
Course Code	**MCT-100**
Credit Hours	0
Contents	Compulsory non-credited course, as decided by the university

Course Name	**Electrical Machinery**
Description	This course enables us to use basic principles to model DC machines, AC machines and power electronics converters. Formulate advanced control algorithms for induction motor control. Design and feedback control of DC-DC converters and Inverters for electrical drive systems. Integrate simulation tools to control power electronics converters for a specific machine
Course Code	**MCT-223 & MCT-223L**
Credit Hours	3 (2, 1)
Textbook	1. Electric Machinery by Stephen D. Umans, 7th Edition 2013, McGraw-Hill. 2. Electrical Machines, Drives and Power Systems By Theodore Wildi, 2013, Pearson. 3. Electric Motors and Drives Fundamentals, Types and Applications By Austin Hughes, Bill Drury, Elsevier Science, 2019 4. Electric Machinery Fundamentals by John Chapman, 2001, McGraw-Hill.
Contents	**Electro-magnetism:** Fundamentals of electricity and magnetism, Transformers, Transformer coupled circuits, Principles of Electro-mechanical energy conversion and rotating machines. **Generators:** Direct-current generators, direct-current motors, efficiency and heating of electrical machines, active, reactive and apparent power, special transformers. **Motors:** Three-phase induction motors, selection and application of three-phase induction motors, equivalent circuit of the induction motor, synchronous motors, single-phase motors, stepper motors, DC motors, brushless DC motors. **Drives of Motors:** Introduction to drives of motors with special emphasis on stepper motors, DC and brushless motors

Course Name	**Mechanisms**
Description	The course is aimed to enable the students to understand various forms of mechanical motion: translational, rotational and everything in between, along with various possibilities of its transformation. It is also desired that the students are able to analyze the kinematics (position, velocity and acceleration) of such systems. The course material and associated lab/project-work is structured to be mathematical yet motivational.
Course Code	**MCT-217 & MCT-217L**
Credit Hours	4 (3,1)
Textbook	1. Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines by R.L. Norton, 6th Edition 2019, McGraw Hill 2. Kinematics, Dynamics, and Design of Machinery by K.J. Waldron and G.L. Kinzel, 3rd Edition 2016, Wiley
Contents	**Introduction to Mechanisms:** past, present and future, motion: types and mobility (DOF), fundamentals (including but not limited to pairing, linkages, chains, inversions and transmissions). **Kinematics (including graphical and analytical methods)**: position analysis, velocity analysis, acceleration **Linkages and Mechanisms:** design and analysis of four bar mechanisms, applications and case studies. **Compliant mechanisms:** design and analysis **Cams:** design and analysis **Gears:** types (spur, bevel, helical and worm gears) and applications, design and analysis techniques, gear trains **Spatial Mechanisms** **Robotic Applications and State-of-the-art Mechanisms**

Course Name	**Computer Programming - II**
Description	Computer Programming-II builds upon the foundational knowledge and skills gained in Computer Programming-I, with a focus on advanced programming topics. The course covers concepts such as object-oriented programming, advanced data structures and algorithms, and the time- and space-complexity for efficient

	programming. Through individual/group projects, students will work on designing complete end-user applications with proper graphical user interfaces. By the end of the course, students will have a strong foundation in object-oriented programming and the ability to develop efficient programs for a variety of practical scenarios
Course Code	**MCT-243L**
Credit Hours	2 (0, 2)
Textbook	(Example text books for C++. Similar can be used for some other programming language) 1. Starting Out with C++ by Tony Gaddis, Judy Walters, Godfrey Muganda, 10th Edition 2019, Pearson. 2. C++ How to Program, 10th Edition Paul Deitel, Deitel & Associates, Inc. Harvey M. Deitel, Deitel & Associates, Inc. 3. Object Oriented Programming in C++ by Robert Lafore, 4th Edition 2001, Sams.
Contents	**Data Structure**: Different types of object collections and variety of data formats. **Time and Space Complexity:** Resource Management, Memory Allocation, Garbage Collection and Code Optimization **Exceptions**: Exception Handling **Object-Oriented Programming**: Classes, Objects, Inheritance, Overloading, Polymorphism, Encapsulation, Constructors, Destructors **GUI:** Variety of GUI widgets with a focus on fully functional application.

Course Name	**Vector and Complex Analysis**
Description	The course is conducted by the Mathematics department.
Course Code	**MA-129**
Credit Hours	3 (3, 0)
Textbook	1. Advanced Engineering Mathematics by E. Kreyszig, 10th Edition 2011, Wiley. 2. Vector Analysis by M.R. Spiegel, 2nd Edition 2009, McGraw Hill 3. Elements of Complex Variables by Pennisi, L.L., 2nd Edition 2009, Holt, Rinehart and Winston, USA.
Contents	A review of vector algebra, scalar and vector products; Scalar triple product; Vector triple product; Scalar and vector point functions; Differentiation and integration of vector point functions; Gradient of a function; Divergence, curl and their physical

	interpretations; Green's theorem in the plane; Gauss's divergence theorem and Stoke's theorem; Cartesian tensors. Polar and exponential forms of complex numbers; Product and quotient of complex numbers in polar form; Properties of complex numbers; Logarithm of a complex number; De Moivre's Theorem, The nth roots of a number; Solution of equations; Circular and hyperbolic functions; Inverse hyperbolic functions; Limit, Continuity and differentiability of complex functions; Analytic functions; Harmonic functions; Cauchy fundamental theorem and its consequences; Cauchy Integral formula; Derivatives of an analytic function; Singularities and calculus of residues; Contour integration.

Course Name	**Digital Logic Design**
Description	Students will be able to learn basic principles and concepts of a digital system. The objective of the course is to explain how digital circuits of large complexity can be built in a methodological way, starting from Boolean logic and applying a set of rigorous techniques. Numerous examples and case studies will be used to illustrate how the concepts presented in the lectures are applied in practice, and how the need to accommodate different practically-motivated trade-offs can lead to alternative implementations. The students will apply their knowledge in the labs by building increasingly more complex digital logic circuits. This course acts as a foundation course to all other hardware and computer architecture courses.
Course Code	**MCT-241 & MCT-241L**
Credit Hours	4(3,1)
Textbook	1. Digital Design by M Morris Mano, 6th Edition 2017, Pearson 2. Digital Fundamentals by Floyd and Jain, 11th Edition 2014, Pearson 3. Sarah Harris, David Harris - Digital Design and Computer Architecture RISC-V Edition (2021, Morgan Kaufmann) 4. Digital Systems Principles and Applications by Tocci and Widmer, 12th Edition 2016, Pearson
Contents	Introduction to basic gates, introduction to Boolean equations and algebra, Theorems for Boolean algebraic minimization. Introduction to K-maps. Number systems. Basic Verilog structural models of combinational logic. Building blocks for combinational logic design, Combinational logic description in

	HDLs. Sequential Logic: introduction, flip-flops, analysis of clocked sequential circuits, flip-flops excitation tables, design procedure, design of counters, design with state equations. Synchronous and asynchronous counters: introduction, design procedure of synchronous counter, design procedure of asynchronous counter, registers with parallel load, sequential logic implementation, shift registers, serial transfer Introduction to State-Transition Graphs and State Machine Design. Mealy and Moore state machines. Timing diagrams of state machines. Memory and Programmable Logic: RAM, ROM, PLA, PAL, error detection and correction. Introduction to architecture design. Introduction to Single-Cycle RISC-V processor. Intro to Hardware Description languages: Verilog and VHDL Verilog description of a Single-Cycle reduced RISC-V processor.

Course Name	**Entrepreneurship I, II, III**
Description	This series of courses are designed to provide the students with an understanding of how entrepreneurial ventures work and how a Mechatronics graduate can aspire to solve a problem and create a product opportunity. The central theme of this course will be to build business-related support to the existing technology-oriented knowledge of mechatronics students. Case-studies, expert talks and mentorship will be integral parts of this learning.
Course Code	**MCT-206, MCT-306, MCT-406**
Credit Hours	(1,0), (1,0), (1,0)
Textbook	Entrepreneurship – Theory Process Practice, Donald F. Kuratko 11th Edition 2019, South Western - Cengage Learning. The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses" by Eric Ries, 2011 Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers" by Alexander Osterwalder and Yves Pigneur, 2010
Contents	**Course 1: Introduction to Entrepreneurship** • Definition, importance, and characteristics of entrepreneurship.

	• Understanding the entrepreneurial mindset and its application to Mechatronics engineering. • Techniques for identifying and evaluating business opportunities • Customer discovery and customer validation • Talking to customers - customer interview and interactions **Course 2: Business Planning and Strategy** • Market analysis, customer needs analysis, and competitive analysis. • Developing a business plan and strategy for a startup, including market positioning, pricing, sales, and distribution strategies • Understanding financial statements and preparing a financial plan • Branding and Naming. • Legal forms of entrepreneurship. **Course 3: Startup management** • Techniques for leading and managing a Mechatronics startup • Intellectual property and its protection • Legal issues related to entrepreneurship, including business formation, contracts, and liability • Outsourcing and other development related decisions • Startup Valuation • Pitching your ideas- Creating a pitchdeck. • (If time permits) Scaling and growth strategies

Course Name	**Translation of the Holy Quran - II**
Description	The course is conducted by the Islamiat department.
Course Code	**QT-201**
Credit Hours	1 (1, 0)
Textbook	
Contents	The contents are designed by the Islamiat Department.

Course Name	**Machine Design and Elements**
Description	Students will be able to learn the mechanical design of machine elements such as belts, gears, shafts, etc, under different types of loading. An emphasis is put on the use of appropriate materials according to the design requirements. The course is accompanied by a lab where design and analysis software such as Solidworks is taught to enable the students to design, test, and validate their mechanical systems before taking them to production. Case studies are introduced to help with the learning.
Course Code	**MCT-216 & MCT-216L**
Credit Hours	4 (3, 1)
Textbook	1. Machine Elements in Mechanical Design, by Robert L. Motte, 6th edition (2018), Pearson 2. Shingley's Mechanical Engineering Design by Richard Budynas, 11th edition, 2019, McGraw-Hill
Contents	**Principles of design** - The design process, Functions and Design Requirements, design calculations, unit systems **Materials in Mechanical Design** -Properties of materials and their selection, stresses in structural members, Stress-strain diagram and Hooke's Law. **Design of Belt and Chain Drives** - Kinematics of belts and chain systems, V-belt drives, synchronous belt drives, chain drives. **Design of Gear Drives** - Kinematics of gears, gear geometry and angles, gear types, gear trains, forces, torques and power in gears, stress analysis for gears, design of spur gears based on stress analysis. **Keys, Couplings, and universal joints** - Keys, its types, selection and stress analysis for keys, types of couplings, selection of couplings, types of universal joints, selection of universal joints. Seals and its types, means of axial location on shafts. **Design of Shafts /Beams-** Forces in shafts, Stress concentrations, shear and bending moment diagrams design of shafts for bending and torsion. **Bearings** - Types of bearings, bearing materials, design life, selection of bearings. **Integration of machine elements** - How different machine elements come together in a system, other design considerations like casing, environment protection, design alternatives, general layout.

Course Name	**Signal Processing**
Description	Signals processing is an introduction to analog and digital signal processing, a topic that forms an integral part of engineering systems in many diverse areas, including communications, speech processing, image processing, electronics, and digital control systems. The course presents and integrates the basic concepts for both continuous-time and discrete-time signals and systems. Signal and system representations are developed for both time and frequency domains. These representations are related through the Fourier transform and its generalizations, which are explored in detail.
Course Code	**MCT-244 & MCT-244L**
Credit Hours	3 (2, 1)
Textbook	1. Signals, Systems and Inference by AV Oppenheim and G Verghese, 1st Edition 2015, Pearson. 2. Signal and Systems by AV Oppenheim, AS Willskyand SH Nawab, 2nd Edition 1996, Pearson. 3. Digital Signal Processing By Alan V. Oppenheim, Ronald W. Schafer, 2015.
Contents	**Introduction**: Signals, their properties, and operations, exponential signals, **LTI systems**: Analysis of linear time invariant (LTI) systems, convolution and time domain response of systems. **Frequency Domain Representation**: Time and frequency domain representation of linear signals and systems, Fourier series, continuous and discrete time Fourier transform. **Sampling**: Sampling and sampling theorem **Filter Design** **Z-Transforms**

Course Name	**Embedded Systems - I**
Description	This course covers the microcontrollers, the core of a digital system. The architecture, assembly/C language, system development/simulation tools for a modern RISC microcontroller are introduced. Complete digital systems with different peripherals and external components are designed and implemented. This is a hands-on, learn-by-doing course that shows you how to build solutions to real-

	world problems using embedded systems. The course uses a bottom-up approach to problem solving, building gradually from simple interfacing of switches and LEDs to complex concepts like analog to digital conversion and motor driving.
Course Code	**MCT-236 & MCT-236L**
Credit Hours	4 (3, 1)
Textbook	1. ARM Microprocessor Systems: Context-M Architecture, Programming, and Interfacing by Muhammad Tahir and Kashif Javed, CRC Press 2. Embedded Systems: Introduction to Arm® Cortex™-M Microcontrollers by Jonathan W. Valvano, Fifth Edition (Volume 1) 3. Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C by Yifeng Zhu, Third Edition 2017, E-Man Press LLC
Contents	**Introduction:** Introduction to embedded systems, its applications, and major components, e.g., processor, memory, input/output etc. **Architecture:** Basic concepts of computer architecture: microprocessor vs microcontroller, microprocessor classification based on memory interfacing (Harvard vs von Neumann architecture) and ISA, RAM/ROM types, Input/Output Ports, Bus, Read/Write cycle, and instruction pipeline architecture. Overview of the special function registers, program counter, processor operating modes, concept of memory mapped peripherals and processor reset sequence and interrupts. **Programming:** Overview of the assembler, assembler directives, assembly language instruction format and encoding. Explain different types of assembly language instructions (data processing instructions, memory access instructions, branch and control instructions) with examples. Writing a complete assembly language program. Introduction to embedded C language for programming the microcontroller. Explanation of embedded tools for writing, downloading, and debugging firmware written in both C and assembly language. **Interfacing:** Overview of both digital and analog interfacing by reading datasheets, connecting components with the microcontroller, and programming in assembly/C language. Interfacing of simple components like LED, push-buttons, displays, keypad, temperature sensor, motor drivers for stepper and servo etc.

Course Name	**Islamic and Pak Studies - II/ Ethics and Pak Studies - II**
Description	The course is conducted by the Islamiat department.
Course Code	**IS-201 / HU-201**

Credit Hours	3 (3, 0)
Textbook	1. Selected Surahs and Verses from the Holy Quran 2. BuloogUlMaram by Ibn Hajir Asqlani 3. SeeratunNabi by Shibli Nomani 4. Comprehensive book of Pakistan Studies
Contents	**Characteristics of the righteous people:** Al-Mohsineen and their reward, Explanation of Law al-Hadith and torment for its buyer, Stress on fear of Allah the Lord and the Judgment Day **National integration:** Role of Ulama & Mashaikh in Pakistan Movement, Role of students, women and journalists in Pakistan Movement **Advices of Luqman a wise man:** No to associate anyone with Allah, To establish Salat (prayer), To enjoin good, To forbid evil, To bear the difficulties , No to speak others with your face turned away, Not to walk proudly and lower you voice **National integration:** Initiatives of Muhammad Ali Jinnah to strengthen the state Scientific study of the universe: Universal arguments on Allah as the creator, Conquering the universe **Initial problems of Pakistan and Efforts to resolve:** Refugees crisis, Water disputes, Kashmir issues, Distribution of asserts **Pillars of Islam:** Shahadat, Salat, Saum, Zakat, Hajj **Striving in the cause of Allah (Jihad):** Importance and significance, Kinds, Against one's soul: to control its ego and desires (the greatest jihad), Against Satan, Against the enemy, Against disbelievers by the Holy Quran etc. **Land of Pakistan:** Geographical importance of Pakistan, China-Pakistan Economic Corridor (CPEC), TAPI Gas Pipeline Project **Social Manners:** Obligations on Muslim for a Muslim, Golden Principal to and lead a satisfied life and to control one's greed, What is righteousness? What is sin, Emphasis on the respect of human sentiments, Awareness of a meal blessed with auspiciousness **Resources of Pakistan:** Agriculture: potential and performance Social manners: Manners of salam and greeting Muslims and non-Muslims, Manners regarding sneeze, eating, drinking, wearing clothes, putting on and off shoes and walking with shoes, Restriction of trailing garments arrogantly, Restriction of overspending Resources of Pakistan: Industry: problems and viable solution

	Quran sciences: Miracles of Holy Quran, Usul-e-Tafseer State and constitution of Pakistan: Objectives resolution 1949 **History of Hadith:** Compilation of Hadith, A brief introduction of Sihah and its compilers **State and constitution of Pakistan:** Fundamental rights in the constitution of 1956 and 1962 **Human rights:** Human rights, Rights of parents, Rights of relatives Rights of neighbors, Women rights, Privacy **State and constitution of Pakistan:** Islamic provisions of 1973 constitution Foreign policy of Pakistan: Determinants and objectives of foreign policy **Islamic Criminal Law:** Qad'f (false accusation), Li'an (accusation of a wife zina), Zina (adultery, fornication) **Relations with neighboring countries:** India, China, Afghanistan, iran **Islamic Criminal Law:** Drinking intoxicating liquors and narcotics, Theft, Dacoity & robbery, Rebellion **Relations with Muslim World:** Pakistan and Saudi Arabia, Pakistan and Turkey **Islamic Criminal Law:** Murder , Retaliation, Apostasy **Pakistan and contemporary world:** United Nations , America, Russia, Europe **Prophetic life as a role model:** The Holy Prophet (SAW), as a role model, Life of The Holy Prophet (SAW), after migration, **Principal of foreign policy:** Bilateralism , Non-alignment, Peaceful Co-existence, Nuclear non-proliferation **Islam and ethics:** Ethical behavior of the Prophets , Impacts of belief on ethics, Concept of worship and manners/social relations in religion and their impact on ethics , Ethics and character building, significance of moral values Charity, tolerance, simplicity, respect of mankind social etiquettes of meetings, eating & drinking and conversation, right of people **Pakistan and regional organizations:** SAARC, OIC, ECO, SCO

Course Name	**International Language**
Description	The course is conducted by the Humanities department.
Course Code	**HU-003**
Credit Hours	0 (0, 0)

Textbook	
Contents	The contents are designed by the Humanities Department.

Course Name	**Linear Algebra**
Description	This course starts with the basic concepts of matrices and matrix algebra, methods of solving systems of linear equations basic concepts of Linear spaces in the concrete setting of real linear space Rn.Then it describes abstract vector spaces and linear transformations, relation between matrices and linear transformation. similarity of matrices, methods of computing eigenvalues and eigenvectors, diagonalization, Jordan canonical forms.
Course Code	**MA-234**
Credit Hours	3 (3, 0)
Textbook	1. Elementary linear algebra, Howard Anton, 12th edition 2019, Wiley. 2. Linear Algebra and Its Applications, Gilbert Strang, 4th edition 2006, Cengage Learning. 3. Linear Algebra with applications, W. Keith Nicholson, 6th edition 2009, McGraw Hill. 4. Advanced Engineering Mathematics, E. Kreyszig, 10th edition 2015, Wiley.
Contents	Introduction to Systems of Linear Equations, Gaussian Elimination, Matrices and Matrix Operations Inverses; Rules of Matrix Arithmetic, Elementary Matrices and a Method for finding A-1, Further Results on Systems of Equations and Inevitability. Evaluating Determinants by Row Reduction, Properties of the Determinant Function, Cramer Rule, Euclidean n-Space, Real Vector Spaces, Subspaces Basis and Dimension, Linear dependence and Independence Spanning set, Row Space, Columns Space, and Null space, Rank and Nullity. Inner Products, Orthogonality in Inner Product Spaces, Orthonormal Bases; Gram-Schmidt Process; Orthogonal Matrices. Eigenvalues and Eigenvectors, Diagonalization., Orthogonal Diagonalization, Non-diagonalizable matrices and Jordan canonical forms. Linear Transformations, General Linear Transformations Kernel and Range, Matrices of General Linear Transformations, Similarity, Isomorphism

Course Name	**Hydraulics and Pneumatics**
Description	The objective of this course is to inculcate in our students the concepts of hydraulic and pneumatic system development, as per the industrial needs. In this pursuit, the course aims to enable our students to understand key concepts of applied fluid mechanics, and later use them in the development of hydraulic and pneumatic systems, together with the necessary but realistic assumptions. The "systems engineering" approach will be employed herein, alongside following the standard industrial protocols, for the design, development, testing (both using software and hardware), and deployment of such solutions. Since the contents also include electro-pneumatics and electro-hydraulics, this course should be connected with the subsequent course of Industrial Automation.
Course Code	**MCT-361 & MCT-361L**
Credit Hours	3 (2, 1)
Textbook	1. Fundamentals of Fluid Mechanics by Bruce R. Munson, Donald F. Young and Theodore H. Okiishe, 9th Edition 2021, Wiley 2. Hydraulics and Pneumatics by Andrew A. Parr, 3rd Edition 2011, Elsevier Science & Technology Books 3. Engineering Applications of Pneumatics and Hydraulics, by Ian C Turner 2020, Routledge. 4. Festo Didactic Resources on Pneumatics, Electropneumatics, Hydraulics and Electrohydraulics, Latest Eds., Festo
Contents	**Fluidic Systems:** Compressible and incompressible flows with basic principles; introduction to pneumatics and hydraulics; their significance, characteristics and applications; ingredients of basic pneumatic systems; ingredients of basic hydraulic systems; **Representation and Simulations:** standard representation scheme (ISO 1219); simulation platforms of pneumatic and hydraulic systems (e.g. FluidSim, Automation Studio, SimScape, etc.); **Compressed Air Generation and Distribution:** compressors, reservoirs, pressure regulators, air-dryers, air service units, and valves, etc., with emphasis on their working and selection; distribution networks; **Pneumatic Components**: pneumatic actuating devices, pneumatic valve types, configuration and characteristic responses, sensors, selection of pneumatic

	components as per the application requirements **Pneumatic Circuits:** direct and indirect control of pneumatic actuators; logic-based, flow-based, pressure-based, time-based, and motion-based controls of pneumatic circuits; coordinated control of multiple actuators using displacement-step diagrams; safety, maintenance and troubleshooting of pneumatic systems; Electropneumatic systems (discussed in detail to connect with subsequent course of Industrial Automation) **Hydraulic Circuits**: Applications; hydraulic oils; components; basic circuits; pressure valves and their different applications in hydraulic circuits (e.g., for speed control, counter pressure, brakes, etc.); electrohydraulic systems (discussed in detail to connect with subsequent course of Industrial Automation) **Modern Applications:** modern pneumatic and hydraulic systems and applications; related work at the department of Mechatronics Engineering

Course Name	**Numerical Analysis**
Description	The course is conducted by the Mathematics department.
Course Code	**MA-240 & MA-240L**
Credit Hours	3 (2, 1)
Textbook	1. Numerical Methods for Engineers by S. C Chapra & R. P Canale, 8th Edition 2021, McGraw-Hill. 2. Numerical Methods using MATLAB by John H. Mathews, 4th Edition 2010, Pearson Education. 3. Applied Numerical Methods for Engineers using MATLAB and C by Robert J. Schilling & Sandra L. Harris, 2000, Brooks/Cole. 4. Numerical Methods for Engineers and Scientists by D. Joe Hoffman, 2nd Edition 2018, CRC Press. 5. A First Course in Numerical Analysis with FORTRAN and C by Saeed Akhtar Bhatti and Naeem Akhtar Bhatti, 3rd Edition, A-One Publishers.
Contents	**Basic concepts:** round-off errors, floating point arithmetic, Convergence. **Solution of nonlinear equations:** Simple iterations; Bisection method; Newton's method; Secant method; Method of false position. **Solution of linear simultaneous equations:** Jacobi's method; Gauss-Seidel method; **Finite differences:** Difference operators and tables; Newton's interpolating

	techniques for equally spaced data; Newton divided difference table and interpolation; Lagrange's formulation of interpolation. **Numerical differentiation:** approximating the derivative. **Numerical integration:** Review of integration concepts and their physical significance for engineering; Trapezoidal and Simpson's rules. **Solution of differential equations:** Euler's methods; Runge Kutta methods. **Computations:** Numerical techniques in context of engineering applications and solutions of problems by using Matlab.

Course Name	**Embedded Systems - II**
Description	The course aims to enhance the foundational embedded system skill set with advanced functionalities of microcontroller for prototyping real-life applications. All course contents will be covered in the light of typical Mechatronic system constraints and design requirements, ultimately converging the entire discussion to an integrated solution to the engineering problems. Although both theory and practical components will synergistically architect the core ideas, course objectives will remain unfulfilled unless several complex exercises, mapping advanced embedded system problems, are carried out in lab experiments.
Course Code	**MCT-336 & MCT-336L**
Credit Hours	3 (2, 1)
Textbook	1. Embedded Systems: Real-time Operating Systems for ARM® Cortex™-M Microcontrollers by Jonathan W. Valvano, Fourth Edition (Volume 3) 2. Hands-On RTOS with Microcontrollers: Create high-performance, real-time embedded systems using FreeRTOS, STM32 MCUs and SEGGER debug tools, 2nd Edition 3. Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems, and the Internet of Things by Peter Marwedel, 4th edition 2021, Springer
Contents	Communication protocols and their interfacing like SSI/SPI, I2C, CAN/Ethernet, Bluetooth, etc. Input capture, sampling, synchronization and data acquisition techniques for digital data processing. Control systems with real-time sensor feedback (e.g. PID controller for motor

	speed/position control) Real-time Operating Systems (RTOS) embedded system for time critical applications: task creation, scheduling, notification, deletion, Hook functions, Scheduling Policies, Queue Management, etc. Case-studies detailing complete embedded systems design cycle, implementation, integration and deployment Brief overview of safety critical embedded systems and their applications.

Course Name	**Modeling and Simulation**
Description	The fundamental aim of this course is to model and analyze the different categories of Dynamic systems by implying various physical laws along with certain realistic assumptions. By the end of this course, the students will learn the development of mathematical models of mechanical, electrical, hydraulic/pneumatics, thermal, and mixed disciplinary systems. They will be able to model complex engineering systems using basic principles and simulate it using computer softwares.
Course Code	**MCT-331 & MCT-331L**
Credit Hours	4 (3, 1)
Textbook	1. Dynamic Systems: Modeling, Simulation, and Control by Craig A. Kluever, 2nd Edition 2019, Wiley 2. Modeling and Simulation of Dynamic Systems by RL Woods and KL Lawrence, 1st Edition 1997, Pearson 3. Control Systems Engineering by Norman S Nise, Sixth Edition.
Contents	**Fundamentals of Modeling and Simulation:** Systems, states, inputs, outputs and dynamics, linearization, schematic, and block diagrams. **System's Representation:** differential equations, state-space models, transfer functions. **Simulation Techniques:** ODE solvers, fixed and variable step integrators, Simulink for multiparametric analysis of the dynamic systems. **Mechanical Systems:** Fundamental principles enacting building blocks of translational, rotational, and geared elements. Systems modeling in both transfer functions as well as State Space Domains. Combined Elemental (Translational+Rotational+Geared) Systems.

	Electrical Systems: Fundamental principles enacting building blocks of passive and active elements. Analog devices, operational amplifiers, comparators, integrators and analog computing devices. Modeling of cascaded Operational Amplifier. **Electromechanical Systems:** Transfer Function and State Space of (a) DC Motor (b) DC Geared Motor. Implying the static torque-speed characteristics in obtaining the transfer function. **Hydraulic and Pneumatic Systems:** Modeling of various types of hydraulic and pneumatic systems, characteristic curves and system response. Transfer Function and State Space of the Coupled Tanks (Two & Three Tanks System) and pneumatic bellows. **Hydro-Mechanical Systems:** Modeling of hydro-mechanical position servo system. **Thermal Systems:** Fundamental principles enacting background knowledge of thermal resistance as well as capacitance. Transfer function as well as state space representation of different thermal systems. **Lagrangian Approach:** Difference between lagrangian and Newtonian approaches. Modeling the Single-Link manipulator with DC geared motor using the Lagrangian Approach.

Course Name	**Probability and Statistics**
Description	This course provides an introduction to probability and statistics with applications. The course is aimed to develop skills in understanding and applying basic statistical methods and develop an appreciation for the use of statistical inference in practical data analysis. It will also introduce new techniques for carrying out probability calculations and identifying probability distributions. Students will learn Python in this course building upon the existing programming skill acquired during computer programming courses. Some state-of-the-art framework for data analytics e.g., Pandas in Python will also be learned.
Course Code	**MCT-305**
Credit Hours	3 (3, 0)
Textbook	1. Applied Statistics and Probability for Engineers by Douglas C Montgomery and GC Runger, 7th Edition, Wiley, 2018. 2. Probability and Statistics for Engineering and the Sciences by Jay L. Devore,

	9th Edition, Cengage Learning, 2016. 3. Python Data Science Handbook by Jake VanderPlas, 1st Edition, O'Reilly Media, Inc, 2016
Contents	**Probability:** Basic concepts, Probability laws and techniques of counting, Marginal and Conditional Probabilities, Independence and Bayes' theorem, Random Variable, Probability Distribution and Probability Mass Function, Mean and Variance of Continuous and Discrete Random Variables, Some Discrete Random Variables e.g. Binomial, Geometric, Negative Binomial, Hyper Geometric, Poisson, Gamma, Beta, etc., Some Continuous Random Variables e.g. Continuous Uniform, Normal, Exponential, etc., Normal approximation of Binomial and Poisson, Monte Carlo method, Joint distributions, covariance, correlation. **Statistics:** Bayesian inference with known priors, probability intervals,Conjugate priors, Bayesian inference with unknown priors,Frequentist significance tests and confidence intervals, Resampling methods: bootstrapping, Linear regression. Population and Sample, types of variables and data, Measurement scales, Cross-section vs. time-series data, Presentation of data-frequency distribution, Collection of data, Sources of data, presentation of data charts and graphs, Stem and Leaf plots, Histogram, Frequency curves, Pie charts, Bar charts, etc. Descriptive statistics, Measures of center, Mean, Median, Mode and Position, Range, Variance, Standard Deviation and Skewness, Percentile, Quartiles, Box and Whisker Plot, Covariance and Correlation, Linear Regression.

Course Name	**Translation of the Holy Quran - III**
Description	The course is conducted by the Islamiat department.
Course Code	**QT-301**
Credit Hours	1 (1, 0)
Textbook	
Contents	The contents are designed by the Islamiat Department.

Course Name	**Control Systems - I**
Description	This course provides the basics of the control system theory including system

	stability, sensitivity analysis, effect of parameter variation and stability margins. By the end of this course, students should be able to analyze the given mathematical model, evaluate various system characteristics and design simple controllers to stabilize an unstable system.
Course Code	**MCT-333 & MCT-333L**
Credit Hours	4 (3, 1)
Textbook	1. Modern Control Systems by Dorf and Bishop, 13th Edition, Pearson, 2017. 2. Control System Engineering by N Nise, 8th Edition,Wiley, 2019.
Contents	**Feedback Control System Characteristics:** open loop and closed loop systems, sensitivity to parameter variation, control of transient response, disturbance signals, steady state errors, and cost of feedback. **The Performance of Feedback Control Systems:** test signals, performance of 2nd order systems, damping ratio estimation, s-plane, steady state errors, linear system simplification, Routh-Hurwitz stability criterion, stability of state variable systems, **Root Locus Method:** fundamentals of root-locus design, parameter design by root locus method, design of controller on using root-locus method. **The Frequency Response Methods:** introduction of bode plots, plotting bode using manual techniques, log magnitude and phase diagrams, bode plot for minimum and non minimum phase systems, system identification, relation between transient response and bode plot, error constants and bode plot. **Stability in Frequency Domain:** Nyquist criterion, system bandwidth, stability of control systems with time delays, PID controllers in frequency domain, **Design of Feedback Control Systems:** Cascade compensation networks, phase lead design and phase lag design using root locus and bode plot methods, integrating networks design.

Course Name	**Instrumentation and Measurements**
Description	This course introduces measurements and instrumentation with applications. The course is aimed to explain the role of sensors and instruments in a control process; explains sensor principle, design and operation and to make students understand design, interfacing and signal conditioning for each sensor type. Upon completion of this course students will be able to select, interface and calibrate various types of

	sensors or instruments.
Course Code	**MCT-335 & MCT-335L**
Credit Hours	3 (2, 1)
Textbook	1. Measurement and Instrumentation Principles, 3rd Edition - Alan S Morris, 2012 2. Introduction to Instrumentation and Measurements– Robert B. Northrop, 3rd Edition 2014
Contents	**Introduction:** applications of instrumentation and measurement, sensors and transducers, static and dynamic characteristics, accumulated errors of measuring devices, calibration **Data Acquisition and Conditioning:** Analog to digital conversion. Systems for signal processing, transmission, shielding and filtering. Data recording and data acquisition systems. **Force, Inertia, Torque and Pressure Measurement:** force measurements, torque measurements, pressure measurement with pressure transducers, IMUs and Gyros. **Displacement, Velocity and Acceleration Measurement:** Linear and rotational displacement, velocity and acceleration measurements, seismic transducer model, seismic motion transducer **Temperature Measurement:** resistance thermometers, integrated circuit temperature sensor, radiation methods **Fluid Flow and Level Measurements:** Flow velocity and flow rate measurements in open and closed systems, Level measurements **MEMS Transducers & Applications:** Piezoresistive, Thermal, Capacitive, Piezoelectric transducers **Smart and Intelligent Sensors:** Clear discrimination between smart and intelligent sensors, SMART sensors (working principle, functions, features, Prototype smart sensors, Digital smart sensors for IoT applications, Case studies. Sensors used in Robotic applications.

Course Name	**Robotics**
Description	The course of Robotics will aim to introduce the students to a range of robotic systems that play pivotal roles in any modern-day industry. Though the topic of Robotics is quite vast, the discussion in this course shall be confined to robotic manipulators with seldom examples and peeks towards mobile, aerial, and few other

	kinds of robots. The course will lead students in directions like Final Year Projects, Postgraduate research, industrial jobs, and entrepreneurship opportunities. So, one can say that applications and opportunities after going through this course are literally limitless. To fully harness the advantages of this course, students shall be introduced to the history of robots, evolution, modern-trends, and state-of-the-art. Concurrently, the lab portion will use simulation software and physical hardware to help impart understanding of the fundamental concepts. Moreover, students through complex engineering activity shall learn the complete workflow of design and development of robotic manipulators. Software like MATLAB, LabView, ROS, etc. shall be utilized for implementation of the robot's software.
Course Code	**MCT-352 & MCT-352L**
Credit Hours	4 (3, 1)
Textbook	1. Modern Robotics by Kevin M. Lynch, Frank C. Park, 1st Edition 2017, Cambridge University Press. 2. Introduction to Robotics: Mechanics and Control by John J. Craig, 4th Edition 2017, Pearson. 3. Elements of Robotics by Mordechai Ben-Ari and Francesco Mondada, 2020, Saint Philip Street Press.
Contents	**Introduction:** overview, evolution, taxonomy and robot's real-world applications. **Robotic Manipulators:** degrees of freedom of robot, homogeneous transformations, forward kinematics, and inverse kinematics. **Motion planning methods:** Velocity kinematics, Jacobian, Trajectory planning through Artificial Potential Fields, PRM, etc. **Robot Dynamics and Control:** Manipulator dynamics, Robot control (PI, PD, PID), Force/Torqe Control (Computed Torqe Control, Impedance Control etc.) **Introduction to modern robots:** such as Cobots and state-of-the-art industrial robotic systems.

Course Name	**Data Sciences and Analytics**
Description	Students will learn about data science while working with modern programming languages such as Python or R, and the various data formats used in the industry. The course covers data cleaning, preprocessing, and visualization, as well as fundamentals of machine learning and statistical modeling. Additionally, students

	will gain hands-on experience in creating effective dashboards for decision making using tools such as Tableau or Power BI or Google Looker Studio. Upon completion of the course, students will have a strong foundation in data science and analytics, with skills to work with different data formats, build effective models, and present their findings through interactive dashboards
Course Code	**MCT-341L**
Credit Hours	1 (0, 1)
Textbook	1. Python for Data Analysis: Data Wrangling with pandas, NumPy, and Jupyter by Wes McKinney, 3rd Edition, 2023, O'Reilly Media Inc. 2. Practical Statistics for Data Scientists: 50+ Essential Concepts Using R and Python, by Andrew Bruce, Peter Bruce, and Peter Gedeck, 2nd Edition, 2021, O'Reilly Media Inc. 3. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems by Aurélien Géron, 3rd Edition, 2022, O'Reilly Media Inc. 4. Storytelling with Data: A Data Visualization Guide for Business Professionals by Cole Nussbaumer Knaflic, 1st Edition, Wiley
Contents	**Introduction to Data Science:** Overview of data science and analytics, Ethical considerations in data science. **Data Collection and Preparation:** Types of data and sources of data, Data cleaning and pre-processing, Data transformation and feature engineering **Data Exploration and Visualization:** Exploratory data analysis (EDA) Data visualization techniques and best practices **Dashboard Development and Deployment:** Introduction to dashboards, Data visualization using Tableau, Power BI, Google Looker Studio or other tools, Designing effective dashboards for decision-making, Deployment of dashboards and interactive visualizations.

Course Name	**Technical Writing & Presentation Skills**
Description	It is a compulsory university course conducted by the Humanities department.
Course Code	**HU-221**
Credit Hours	3 (3, 0)
Textbook	1. Technical Communication. A reader-Centered Approach by Anderson, V.

	Paul, 5th Edition, Thomson Wadsworth, 2003. 2. Technical Writing. Process and Product by Gerson & Gerson, 5th Edition, Pearson Education Inc, 2006. 3. English for Science and Technology by Huckin & Olsen, 1st Edition, McGraw-Hill Inc, 1983. 4. Power Tools for Technical Communication, McMurrey, D. 1st Edition, Wadsworth Publishing Company, 2001.
Contents	**Introduction to technical communication:** What is technical communication? Factors to consider in technical communication, Examining your purpose, Determining how to provide content, **The writing process:** Writing effective paragraphs for technology, developing a clear pattern of organization, **GettingsStarted with technical writing:** Recognizing different audiences, involving the audience, **Making writing effective:** Achieving parallelism in writing, constructing effective sentences. **Memos** **Letter writing:** Emails **Parts of a formal/technical report:** Title, abstract, outline/contents, introduction, body/procedures, conclusion, appendices, use of illustration (tables and figures) **Parts of research report:** Title, abstract, contents, introduction, literature review, methodology, analysis/results, discussion/interpretation, conclusion, recommendations, references **Report defence**

Course Name	**Product Design**
Description	This course is aimed to equip our prospective mechatronics engineers with modern approaches of product designing which may enable them to design better final-year projects, in short term, and help them pursue entrepreneurial ventures, in the long run. This may also help them to remain relevant with the fast-changing technology and business horizons. The course material and associated project-work will enable the students to design, plan and execute such tasks using prevailing product-design practices, incorporating philosophical, psychological, and ecological consideration,

	without overlooking the engineering details. Relevant case-studies, and semester project shall comprise a vital part of this course; a few experts from industry should also be invited.
Course Code	**MCT-403 & MCT-403L**
Credit Hours	3 (2, 1)
Textbook	1. K. Ulrich, K.T. Ulrich, S.D. Eppinger, and M.C. Yang. Product Design and Development. McGraw-Hill Education, 2019 2. M. Lewrick, P. Link, and L. Leifer. The Design Thinking Playbook: Mindful Digital Transformation of Teams, Products, Services, Businesses and Ecosystems. Wiley, 2018 3. W. Lidwell, K. Holden, J. Butler, and K. Elam. Universal Principles of Design: 125 Ways to Enhance Usability, Influence Perception, Increase Appeal, Make Better Design Decisions, and Teach Through Design. Rockport Publishers, 2010
Contents	**Product Design Philosophy**: introduction;, ingredients of successful product and its design process; Introduction to different design philosophies: Human-centered Design, Meaning-centered Design, Technology-based Design, etc.; **Human-centered Design:** the *Design Thinking* paradigm; introduction to Inspiration, Ideation and Implementation phases; building personas; identifying customer needs; writing story beats; other HCD topics covered in the subsequent discussions; **Universal Principles of Design:** introduction; color, psychology, aesthetics, proportions, symmetry/asymmetry, emotions, structures and concepts of space (just a brief introduction to some important aspects of effective product design) **Design Process:** problem/mission statement, idea and opportunity, opportunity identification, product planning, customer needs, product specifications; concept generation, selection and testing; prototyping (virtual and physical) **Engineering Design:** detailed engineering design using CAD and simulations; Design for Manufacturing and Assembly (DFMA); Design for Experience (DFX) including human-factors and ergonomics; **Sustainable Product Design:** product reuse; green design; design for disassembly, etc.; reliability and failure; risk assessment; eco-friendly design **Modern practice of product design**

Course Name	**Industrial Automation**
Description	This course introduces the student to practical methods of automatic control of machines, processes and systems. All major parts of a modern industrial control system will be described and their principle explained. These include the Programmable Logic Controller (PLC), as the system 'brain', various field devices, which allow the system to 'sense' and 'affect' the controlled environment, and communication between the system components. The principles of developing PLC programs and practical examples of control systems will be also presented. The course provides individual hands-on experience in PLC programming.
Course Code	**MCT-434 & MCT-434L**
Credit Hours	3 (2, 1)
Textbook	1. Automation, Production Systems, and Computer Integrated Manufacturing, by Mikell P. Groover, 5th Edition 2019, Pearson 2. Programmable Logic Controllers, by W. Bolton, 6th Edition 2015, Newnes 3. Programmable Logic Controllers, Basic Level TP301 Textbook – Festo Didactic 4. A Guide to the Automation Body of Knowledge by Nicholas Sands and Ian Verhappen, 3rd Edition, 2018, International Society of Automation 5. Automation, Production Systems and Computer-Integrated Manufacturing by MP Groover, 4th Edition 2016, Pearson.
Contents	**Introductory topics:** Need for automation and how modern manufacturing, production and assembly systems are being utilized. Introduction to Industry 4.0 and its impact on industrial automation, Internet of Things (IoT), Cyber-Physical Systems (CPS), Cyber-security in Industrial Automation, cloud computing, and big data analytics in the context of automation. Sustainability and Green Automation: How automation can contribute to sustainable manufacturing and energy-efficient processes, aligning with modern industry trends. **Programmable Logic Controllers:** Introduction to PLC hardware and its architecture. Programming using IEC 61131-3 standard programming (with special focus on Ladder Logic Diagrams, Structure Text Programming, and Sequential Function Charts). Advanced topics such as PID control, motion control, and data handling along with its applications. **Fieldbus and Industrial Protocols:** Networks and layers, Industrial Ethernet,

	Profibus, Modbus, and DeviceNet alongwith overview of other industrial protocols commonly used in automation. **Supervisory Control and Data Acquisition (SCADA):** Introduction, design, configuration, and security aspects of SCADA systems. **HMI Design:** Process Visualization through designing user-friendly and effective Human-Machine Interfaces (HMIs) with a focus on usability and ergonomics. **Case Studies and Industry Projects:** Real-world case studies to expose students to practical challenges in industrial automation.

Course Name	**Control Systems - II**
Description	Major portion of Control Systems II deals with state space techniques and other modern methods for controller design to modify the response of stable systems or stabilize an unstable system. These advanced techniques include Optimal Control, Internal-Model control, Fuzzy-Logic design and adaptive control. An intro-level knowledge of advanced concepts like Robustness analysis and Digital Systems is given at the end of course. This course enables students to implement advanced control design techniques and prepares them for graduate level courses in Control System Design and Analysis. In-class demonstrations of the relevant topics will also be covered in this subject.
Course Code	**MCT-435**
Credit Hours	3 (3, 0)
Textbook	1. Modern Control Systems by R Dorf and R Bishop, 13th Edition, Pearson, 2017. 2. Automatic Control Systems by BC Kuo, 10th Edition, Wiley ,2017 3. Control System Engineering by N Nise, 8th Edition, Wiley ,2019.
Contents	**State Variable Feedback Systems:** controllability, observability, pole placement, Ackerman's formula for controller and observer, state space control design with observer in loop, separation principle, system with reference inputs, optimal control design using state space methods, linear quadratic regulator, internal model principle, internal model design using transfer function and state-space techniques. **Robust Control Systems:** sensitivity, analysis of robustness, system with uncertain parameters, Design of robust control system, design of robust PID control system, robust internal model control, pseudo-quantitative feedback systems **Digital Control Systems:** review of difference equations, z transform and sampling, stability analysis in z plane, root locus of digital control systems, deadbeat control

	Intelligent Controllers: fuzzy control, adaptive control, model reference adaptive control **Controller implementation using software tool**

Course Name	**Translation of the Holy Quran - IV**
Description	The course is conducted by the Islamiat department.
Course Code	**QT-401**
Credit Hours	1 (1, 0)
Textbook	
Contents	The contents are designed by the Islamiat Department.

Course Name	**Final Project - I**
Description	The final project is a group undertaking and is meant to let student groups create a mechatronic product or application. Each group should consist of at the most 4 students. A midterm evaluation will be carried out at the end of 7th semester in the presence of all teachers of the department.
Course Code	**MCT-498**
Credit Hours	3 (0, 3)
Textbook	N/A
Contents	The students are required to complete a project from one or more core areas of Mechatronics Engineering. The project will be evaluated throughout the year through various means like presentations, project report, demos, posters etc. The project is to be completed in a group of 2-3 students.

Course Name	**Professional Ethics**
Description	It is essential for our graduates to have an understanding of the ethical problems and principles. Part of professional ethics is the understanding of the ethics of other professions, and in return having a reflection of one's own professional ethics. In this context, the general principles of professional ethics will be examined including but not limited to Business Ethics, Medical Ethics, Legal Ethics, and Research Ethics. The role of professional ethics in life-long career objectives will be central to this learning.
Course Code	**MCT-404**

Credit Hours	2 (2, 0)
Textbook	1. Engineering Ethics: Concepts and Cases by Charles E Harris Jr., Michael S Pritchard and Michael J. Rabins, 6th Edition 2018, Cengage Learning 2. Ethics in Engineering by Mike W. Martin and Roland Schinzinger, 4th Edition 2004, McGraw Hill 3. Ethics and Professionalism by John. H. Kultgen, 2010, University of Pennsylvania Press
Contents	**Introduction:** Ethics and various ethical theories. **Human values and ethics:** Work ethics, integrity, honesty, self-confidence, moral values,self-respect, Empathy and leadership. **Engineering ethics:** Overview and scope, Purpose for Engineering ethics, professional and professionalism, professional ethics, engineering and ethics. **Workplace Responsibilities and Rights:** Team work, confidentiality and conflict of interest, occupational crime, social norms and rights. **Safety Responsibilities and Rights:** assessment of safety and risks, safety and risk analysis, ethics and risk management. **Global Issues:** Environmental ethics, intellectual property, technology transfer, computer ethics and internet.

Course Name	**Final Project - II**
Description	It is the continuation of the Final Project-I. Students are supposed to complete their projects and submit the project report before the end of 8th semester.
Course Code	**MCT-499**
Credit Hours	3 (0, 3)
Textbook	
Contents	The students are required to complete a project from one or more core areas of Mechatronics Engineering. The project will be evaluated throughout the year through various means like presentations, project report, demos, posters etc. The project is to be completed in a group of 2-3 students.

Course Name	**Principles of Management**
Description	Students will acquire basic management concepts and would learn to apply those in various settings to ensure safety, improve productivity, maintain quality standards

	and manage human resources.
Course Code	**MGT-211**
Credit Hours	3 (3, 0)
Textbook	1. Principles of Management by T Bauer, B Erdogan and J Short, Version 4.0 2018, FlatWorld. 2. Management: A Global, Innovative and Entrepreneurial Perspective by Weihrich and H Koontz, 14th Edition 2013, McGraw Hill. 3. Management: Building Competitive Advantages by TS Bateman and SA Snell, 3rd Edition 1996, Richard D Irwin.
Contents	**Introduction:** significance of management, evolution of management thought, engineers and management, managerial functions **Management and Society:** economics, social, political and legal environment, the social responsibility, ethics in management **Productivity:** basic concepts, classification of productivity, productivity measurement and improvement, variety control **Quality:** reasons for quality, types of quality, quality dimensions, customers satisfaction **Organizational Structure:** types, organizational hierarchy, narrow and wide spans **Planning and Forecasting:** the purpose and nature of planning, types of plans, need for demand forecasting, forecasting approaches **Human Resources:** job evaluation, recruitment and training, work study, work measurement, motivation and incentives, performance appraisal **Economic Considerations:** value and cost concepts, time value for money, discounted cash flow, depreciation and obsolescence, cost factors, breakeven analysis **Project Management:** introduction to projects, work breakdown structure, network planning and scheduling.

Course Name	**Condition Monitoring**
Description	The course initially provides an overview of all the maintenance techniques with an emphasis on condition based maintenance. It covers the testing methods used to monitor the condition of machines. Among the testing methods, vibration based condition monitoring will be discussed in detail. The knowledge will be further applied on rotating and reciprocating machines to detect and diagnose their faults.

	Students will also learn the simulated and experimental ways of doing vibration analysis to detect faults in machines. By the end of this course, students will be able to differentiate the type of fault present based on the vibration signature of the machine.
Course Code	**MCT-412 & MCT-412L**
Credit Hours	3 (2, 1)
Textbook	1. Vibration-based Condition Monitoring: Industrial, Automotive and Aerospace Applications, by Robert Bond Randall, 3rd Edition, John Wiley & Sons. 2. Practical Machinery Management for Process Plants (Vol 2), by Bloch & Geitner, 2nd Edition
Contents	**Overview of the course:** Introduction, Predictive maintenance, Principles of vibration analysis, Mechanical defects detected with vibration analysis, Vibrations standards, Measuring vibrations, Vibration Characteristics. **Conventional Analysis Techniques:** Failure modes, effects and criticality analysis (FMECA), Time and Frequency domain analysis, Energy analysis, Orbit & Order analysis. **Vibration Signals from Rotating & Reciprocating Machines:** Signal Classification, Signals generated by Rotating machines, Signals generated by Reciprocating Machines. **Faults in Machines:** Use of Vibration analysis techniques to detect the unbalance, misalignment, crack and looseness in machines. **Signal Processing of Machine Vibration Signal:** Probability Distribution and density, Fourier analysis, Cepstrum analysis, Hilbert transform and demodulation. **Fault Detection in Rotating & Reciprocating Machines:** Vibration Criteria, Use of Frequency Spectra, CPB Spectrum comparison, Time-Frequency Diagrams, Torsional Vibrations. **Diagnostics Techniques:** Harmonic and sideband cursors, Gear diagnostics, Rolling Element Bearing Diagnostics, Reciprocating M/Cs and IC engines

	diagnostics. **Fault Trending and Prognostics:** Trend Analysis, Advanced Prognostics. **Experimental vibration analysis:** vibration test devices and vibration measuring sensors, experimental methods and modal testing, modal identification. (LAB)

Course Name	**Mechanical Vibrations**
Description	Students will initially be familiarized with the concept of vibrations and its importance in engineering. Basic elements and different terminologies related to vibrating systems will be explained, followed by the concept of extracting natural frequencies along with the modal analysis. By the end of the course, the students will acquire the ability to formulate mathematical models of problems in vibrations, determine a complete solution to mechanical vibration problems using mathematical or numerical techniques, and determine physical and design interpretations from the results.
Course Code	**MCT-415 & MCT-415L**
Credit Hours	3 (2, 1)
Textbook	1. Engineering Vibrations by Daniel J. Inman, 5th Edition 2021, Pearson 2. Mechanical Vibrations by Singiresu S. Rao, 6th Edition 2017, Pearson
Contents	**Fundamentals of vibration:** problems associated with vibrations and their solutions, measurement of vibrations, complex vibration, vibration analysis procedure; **Free & forced vibration analyses of undamped and damped systems:** mathematical modeling, equation of motion, interpretation of response; **Two-degree-of-freedom model:** modal analysis, eigenvalues and eigenvectors, normalization of modes w.r.t unity and mass matrix; **Vibration isolation:** protecting the base, protecting the machine, displacement and force transmissibility, isolator design, transducers for vibration measurements, design of transducers, rotor imbalance; **Vibration absorbers:** tuning condition of absorber, response of primary and secondary masses, design of a vibration absorber. **Vibration analysis using ANSYS:** modal, harmonic and transient analysis

	Experimental vibration analysis: vibration test devices and vibration measuring sensors, experimental methods and modal testing, modal identification. **Applications of mechanical vibrations in engineering; special topics.**

Course Name	**Digital Signal Processing**
Description	The Advanced course of Signal Processing stands on the foundation of Signal and Systems. Digital signals will be examined in detail and will be analyzed mathematically. Students will be learning about Linear Time Invariant Systems and their analysis using Fourier Transform and its variants (DFT, DTFT, FFT etc.). Whenever we are dealing with signals, the inherent problem in their processing is "noise" and the obvious solution is "filtering". Class will be introduced to Filters, their structures and their designing using Z-Transform. By the end of the course, the students will be able to understand different types of digital signals, their mathematical background and different analysis techniques.
Course Code	**MCT-421 & MCT-421L**
Credit Hours	3 (2, 1)
Textbook	1. Discrete-Time Signal Processing by AV Oppenheim, Ronald W Schafer and John R Buck, 3rd Edition, Pearson. 2. Digital Signal Processing: Principles, Algorithms and Applications by JG Proakis and DG Manolakis, 4th Edition, Pearson. 3. Digital Signal Processing: A Computer-Based Approach by SK Mitra, 2nd Edition, McGraw Hill.
Contents	**Introduction**: continuous time and discrete time signals and systems **Review of Basics of Digital Signal Processing**: signal representation, sampling of CT signals (A/D and D/A conversion, multi-rate signal processing), linear time invariant (LTI) systems, convolution, difference equations and Z-transforms. **Analysis of LTI Systems** **Filter Design**: Techniques and implementation (FIR and IIR filter structures) **Discrete Fourier Transform (DFT)**: design, computation via FFT, applications of DFT

Course Name	**Power Electronics**
Description	This course encompasses the use of modern power electronic devices, their application and control. The theory and operational principles of power

	semiconductor devices is discussed in detail, and complemented by practical use in the lab. Different power conversion techniques are discussed in detail. The effect of real loads (like inductive loads, motors etc) is discussed along with the ideal examples to develop a better understanding of the real time constraints placed on the design of power conversion circuits. The control of the power electronics devices is performed by microcontroller /processor based systems. The students are encouraged to handle the practical constraints in implementing the control scheme for the devices by working on a semester project.
Course Code	**MCT-422 & MCT-422L**
Credit Hours	3 (2, 1)
Textbook	1. Power Electronics: Circuits, Devices and Applications by Muhammad H Rashid. 4th edition. 2013. Pearson 2. Power Electronics: Converters, Applications, and Design by Ned Mohan. 3rd edition. 2002. Wiley 3. Fundamentals of Power Electronics by Robert W. Erickson and Dragan Maksimović. 3rd edition. 2020. Springer
Contents	**Introduction:** applications, power semiconductor devices and characteristics **Power Semiconductor and Diodes:** semiconductor basics, characteristics, Diodes with RL and RC load, freewheeling diode, recovery of trapped energy with diode **Diode Rectifiers:** single phase (half wave, full wave and bridge) rectifiers, rectifiers with RL load, performance parameter of rectifiers **Power Transistors:** bipolar junction transistors and their characteristics, power MOSFETs, IGBTs, comparison of transistors **DC to DC Converters:** introduction, step down operation with RL load, step up converter with RL load, converter classifications **PWM Inverters:** principle of operation, performance parameter, single phase bridge inverter, three phase inverter, voltage control of three phase inverter, advanced modulation techniques **Thyristors:** introduction, model of thyristors, turn-on and turn-off techniques Resonant Pulse Inverters: introduction, series resonant inverters, frequency response of series resonant inverters, parallel resonant inverters, voltage control of resonant inverters **Controlled Rectifiers:** introduction and principle of phase controlled converter,

	single phase full converter, single phase dual converters, three phase half wave converter, three phase full wave converter **AC Voltage Controllers:** principle and operation of on off control, principle of phase control, single phase bidirectional controllers, single phase controllers with inductive load **Motor Drives:** Case-study motor driver circuits for robotics, drones and/or electric vehicles applications

Course Name	**Digital Control Systems**
Description	This course begins with the basics of discrete time and sampled data systems, sampling, holds, A/D and D/A conversions and basics of Z transform / Inverse Z-Transform of sampled signal and continuous time transfer functions. It covers the transient response, analysis of stability, sampling limitations and design of discrete time feedback systems. Major portion of course discusses discrete control design using pulse transfer function based methods like root locus and bode plot. Discrete time state space analysis and controller design is also covered. At the end of this course students should be able to analyze the digital and sampled-data system and understand the effects of quantization and sample rate, design a discrete time controller using transfer function and state-space techniques etc.
Course Code	**MCT-432 & MCT-432L**
Credit Hours	3 (2, 1)
Textbook	1. Discrete TIme Signal Processing, Oppenheim, 3rd Edition 2014, Pearson. 2. Discrete Time Control Systems, by Katsuhiko Ogata, 2nd Edition 1995, Pearson
Contents	**Introduction:** Applications and Design Approach, Difference equations, z-transforms, properties and theorems of z-transform, inverse z-transform, solving difference equation using z-transform **Sampling:** Sampling Theorem, Sampling and Hold, Spectrum and aliasing of sampled signals, zero and first order holds, block diagram for sampled data system and evaluation of pulse transfer function for various block diagram configurations. **Design of Digital Control System using conventional methods:** Continuous transfer function and their discrete equivalents, mapping between S plane and Z plane, transient and steady state response analysis and error constants, sampling rate and its relation with system transients, stability in discrete domain and Jury Stability method, design of digital control systems using z-domain root locus method,

	controller design using frequency response methods, mapping from Z to W domain and bode plot method for discrete control design, limitation on sampling rate. **Analysis of Discrete Systems using state space techniques:** State-space representation of discrete time systems, stability, controllability and observability in discrete domain, design of discrete time controller and observer using state space techniques, separation principle, discrete time system with reference inputs. State space analysis of discrete time optimal controller.

Course Name	**Estimation and Filtering**
Description	This course provides a comprehensive analysis of estimation of dynamic systems. After completing this course, the student will be able to understand the measurement process and model input/output behavior use estimation techniques to estimate system parameters/states of dynamic system. They use computer tools to design estimator and simulate the complete systems.
Course Code	**MCT-433**
Credit Hours	3 (3, 0)
Textbook	1. Optimal Estimation of Dynamic Systems by J. L. Crassidis and J. L. Junkins
Contents	**Review of linear dynamical systems, matrix algebra:** Random variables, Gaussian Processes, Covariance and Correlation Function, Maximum Likelihood, Matrix norms, definiteness, decompositions and calculus, State Space representations of linear systems, controllability, observability, stability, parametric differentiation, discrete-systems **Least squares estimation:** Linear least squares, Nonlinear least squares estimation, Maximum likelihood estimation, Bayesian estimation **State & Parameter Estimation:** Linear Kalman Filter (continuous, discrete, hybrid), Neighboring Optimal Linear Estimator, Extended Kalman Filter for nonlinear systems, Factorization methods, colored-noise Kalman filtering, Adaptive filtering, and Robust filtering, Batch state estimation, Fixed interval smoothing (continuous, discrete, nonlinear), Innovations Processes **Advanced Topic:** Covariance Decompositions, Smoothing Algorithms, Unscented Kalman Filtering, Particle Filter

Course Name	**Intelligent Systems**
Description	The course covers the breadth of modern artificial intelligence topics including

	search algorithms, probabilistic reasoning models, filtration and machine learning techniques to solve mechatronic engineering problems
Course Code	**MCT-452 & MCT-452L**
Credit Hours	3 (2, 1)
Textbook	2. Artificial Intelligence: A Modern Approach by Stuart Russell and Peter Norvig, 4th edition 2021, Pearson 3. Neural Networks and Learning Machines by SO Haykin, 3rd edition 2016, Pearson Education. 4. Introduction to AI Robotics by RR Murphy, 2nd edition 2019, A Braford Book.
Contents	**Intelligent Systems:** overview, scope, time and space complexity definitions **Informed search algorithms:** Breadth-first, depth-first search, A* and D* algorithms **Uninformed search algorithms:** Simulated annealing and genetic algorithm **Probabilistic models:** Bayesian networks, hidden markov models, viterbi algorithm, dynamic bayesian network and filtration, simultaneous localization and mapping **Supervised machine learning**: Perceptron, support vector machine, k nearest neighbor algorithm, artificial neural networks **Reinforcement learning**: Value iteration and policy iteration algorithms, basics of Q-learning **Unsupervised learning:** Bayesian learning (maximum-likelihood), unsupervised clustering: k-means clustering, gaussian mixture models

Course Name	**Machine Vision**
Description	Students will learn the tools to acquire and subsequently process the images using a *problem solving* approach. This approach requires assessing the needs first and employing the solution components accordingly from a list of available procedures and algorithms. Although the course can be thought of as a mixture of algorithm development and their mathematical implementation, the focus would be on *algorithm understanding and development*. The course material and associated lab-work, therefore, is aimed to enable the students to have a multitude of image processing techniques to be used later in the development of their semester projects. The course also aims to motivate the students by introducing *state of the art* in the field of machine vision.
Course Code	**MCT-453 & MCT-453L**

Credit Hours	3 (2, 1)
Textbook	1. Computer Vision: Principles, Algorithms, Applications, Learning by E.R. Davies, 5th Edition ELSEVIER, 2017 2. Computer Vision and Image Processing; Fundamentals and Applications, by Manas Kamal Bhuyan, CRC Press, 2019 3. Image Processing, Analysis and Machine Vision by Milan Sonka, Vaclav Hlavac and Roger Boyle, 3rd Edition, 2008
Contents	**Introduction:** What is Machine Vision? Practical Mechatronic applications **Image Acquisition and Representation:** Concepts of representation of images, Digitization, binary, gray and color (RGB, CMYK, HSI etc.) images, elementary image processing functions (enhancement and filtration of digital image in spatial as well as in frequency domain), image properties, adjacency conventions **Fundamentals of Digital Image Processing:** Point, Neighborhood, and Geometric operations, Image restoration, Mathematical Morphology **Segmentation:** Thresholding, Edge-based segmentation, Region-based Segmentation, Mean Shift Segmentation **Image Analysis:** Template Matching, Decision-theoretic approaches, The Hough transform **Object Recognition:** Statistical Pattern Recognition, Neural Nets, Syntactic Pattern recognition, Optimization techniques in recognition, Fuzzy Systems **Motion Analysis:** Differential motion analysis methods, Optical Flow, Analysis based on correspondence of interest points, Video tracking, Motion models to aid tracking Applications to robotics and intelligent machine interaction will also be included.

Course Name	**Mobile Robotics**
Description	This course aims to present the fundamentals of Autonomous Mobile Robotics, including but not limited to kinematics, perception and planning for autonomous operation. Moreover, an overview of the fundamental problems/approaches in mobile robotics shall also be introduced and addressed. Different techniques in onboard perception like sensor modeling, state estimation using probabilistic filters as well as onboard localization and mapping will also be discussed. Motion and path planning will be introduced in the form of vehicle motion modeling and control. Graph based and probabilistic motion planning techniques will also be studied along

	with examples from recent research trends in the field.
Course Code	**MCT-454 & MCT-454L**
Credit Hours	3 (2, 1)
Textbook	1. Introduction to Mobile Robots by Siegwart, R., Nourbakhsh, I. R., & Scaramuzza, D, 2nd Edition 2011, The MIT Press. 2. Principles of Robot Motion: Theory, Algorithms, and Implementations, by Howie Choset, Kevin M. Lynch, 1st Edition 2005, A Bradford Book. 3. Probabilistic Robotics by Sebastian Thrun, Wolfram Burgard, Dieter Fox, 1st Edition 2005, The MIT Press. 4. Mobile Robotics: Mathematics, Models, and Methods by Alonzo Kelly, 1st Edition 2014, Cambridge University Press.
Contents	**Introduction:** Overview of mobile robots (Ground and Aerial), configuration and types of mobile robots, development in mobile robots and their applications, **Kinematics and Perception:** Kinematics of robot locomotion and motion modeling (including velocity-based and odometry-based models), introduction to mobile robot sensors and their modeling, **Localization and Mapping:** Challenges in localization, position estimation, map representation, state estimation techniques using parametric and non-parametric filters, study of different techniques for localization, mapping techniques including feature/grid-based and SLAM **Planning and Navigation:** configuration/workspaces, obstacle avoidance, a study of the different path planning algorithms, exploration and roadmaps, probabilistic methods.

Course Name	**Wearable Robotics**
Description	This course covers the design and control aspects of wearable devices such as orthoses, prostheses, and exoskeletons. Students are taught about human skeleton biomechanics, limb kinematic and dynamic trajectories, wearable robotics design, control, ethical constraints and future challenges in this domain. This course helps the students to contribute to biomechatronic related research such as the design of assistive and/or rehabilitative devices for patients with limb impairments.
Course Code	**MCT-455 & MCT-455L**

Credit hours	3(2, 1)
Text Books	1. Biomechanics and Motor Control of Human Movement by David A. Winter, 4th edition, October 2009, John Willey and Sons 2. Research Methods in Biomechanics by D. Gordon E. Robertson, Graham E. Caldwell, 2nd edition, November 2013, Human Kinetics 3. Wearable Robotics Systems and Applications By Jacob Rosen, 1st edition, November 2019, Elsevier.
Contents	**Introduction:** Introduction to Wearable Robotics, Lower-limb Biomechanics, anatomical planes, joints movements and anatomical axes, Gait cycle, lower limbs abnormalities, Static and dynamic bipedal balance control. **Kinematics and Dynamics:** Forward and inverse kinematics, motion capture system, coordinate systems and transformations, markers configuration, Inverse kinematics numerical examples, Inverse Dynamics, anthropometry, model development, FBD, force transducers and force plates, Newtonian equations of motion, Euler's equations of motion, numerical example of computing inverse dynamics. **Design and Control of wearable devices:** Design of wearable devices using hard and soft robotics approaches, Wearable sensors, Wearable hard and soft actuators, Multilayer controller design schemes, Examples of Control Algorithms, Design assemblies and Performance assessment, Ethical Considerations. Applications of wearable robotics for lower limbs and future.

Course Name	**Internet of Things**
Description	This course will cover the key components that make up an IoT system. The students will apply the knowledge and skills acquired during the course to build and test a complete, working IoT system involving prototyping, programming and data analysis. This course will help the students understand where the IoT concept fits within the broader ICT industry and possible future trends. It will appreciate the role of big data, cloud computing, and data analytics in a typical IoT system.
Course Code	**MCT-456 & MCT-456L**
Credit Hours	3 (2, 1)
Textbook	1. Learning internet of things by Peter Waher, 1st Edition 2015, Packt Publishing

	2. The internet of things by Samuel Greengard, 2015, The MIT Press 3. Internet of things Principles and Paradigms by Rajkumar Bayyu & AmirVahid Dastjerdi, 1st Edition, 2016, Morgan Kaufmann.
Contents	**Introduction to the IoT:** What is the IoT and why is it important?, IoT applications, potential & challenges, and architecture, Elements of an IoT ecosystem, Technology and business drivers, IoT applications, trends and implications; **Sensors and sensor nodes:** Sensing components and devices, Sensor modules, nodes and systems; **Connectivity and networks:** Wireless technologies for the IoT, Edge connectivity and protocols, Wireless sensor networks; such as Bluetooth, Wi-Fi, Zigbee, LoRaWAN and MQTT. **Data Management:** data collection, storage, and analysis, data security and privacy concerns. **IoT platforms:** IoT platforms such as Arduino, Raspberry Pi, and ESP8266 to build IoT applications. Knowledge of at least one object-oriented programming language such as Java or Python. A firm understanding of how to compile code, use libraries, and use a debugger; **Case studies:** , e.g. Home automation, Health care, transportation, Irrigation monitoring systems etc.

Course Name	**Biomedical Devices**
Description	This course is aimed to equip our students with theoretical knowledge as well as practical skills to design and develop prototype devices for biomedical uses. Students will further enhance their knowledge of mechatronic system development and use it in the development of such devices. Relevant case-studies and visits to different hospitals and research labs will be integral part of the learning process. Students will also be assigned a semester project to develop some prototype biomedical devices.
Course Code	**MCT-457 & MCT-457L**
Credit Hours	3 (2, 1)
Textbook	1. Paul H. King, Richard C. Fries, Arthur T. Johnson, Design of Biomedical Devices and Systems, 4th Edition, Taylor & Francis, 2019 2. Peter J. Ogrodnik, Medical Device Design: Innovation from Concept to Market, Academic Press Inc; 1st Edition, 2012

	3. Lam, Raymond HW, and Weiqiang Chen. Biomedical devices: materials, design, and manufacturing. Springer, 2019.
Contents	**Biomedical Device Systems:** Design and development paradigms; Mechatronics as central component of such devices **Biomedical Device Elements:** Sensors, Amplifiers, Filters, Actuators **Electrophysiological Devices:** Biopotentials, Electrodes, EMG, ECG, EEG **Cardiovascular Devices:** Blood Pressure, Flow, Volume & Sound Measurements **Respiratory Devices:** Gas Flow & Composition Measurements, Blood Gas Monitoring **Chemical Devices:** Measuring the chemical composition of body fluids **Laboratory Instruments:** Spectrophotometry, imaging **Therapeutic Devices** **Life-saving Devices** **Minimally Invasive Devices** **Surgical Tools and Implants** **Device Safety, Bioethics and Privacy** **Biomedical Device Systems:** Design and development paradigms; Mechatronics as central component of such devices **Biomedical Device Elements:** Sensors, Amplifiers, Filters, Actuators **Electrophysiological Devices:** Biopotentials, Electrodes, EMG, ECG, EEG **Cardiovascular Devices:** Blood Pressure, Flow, Volume & Sound Measurements **Respiratory Devices:** Gas Flow & Composition Measurements, Blood Gas Monitoring **Chemical Devices:** Measuring the chemical composition of body fluids **Laboratory Instruments:** Spectrophotometry, medical imaging e.g., Ultrasound, X-Rays, MRI **Therapeutic Devices** **Life-saving Devices**: Cardio-pulmonary Resuscitator, Ventilators **Minimally Invasive Devices** **Surgical Tools and Implants** **Device Safety, Bioethics and Privacy**

Course Name	**Human Centered Robotics**

Description	Students will learn the basics of human-centered robotics which includes smart sensing and actuation, various modes of interactions with humans and relevant control paradigms. This knowledge is essential to design and develop integrated modern robotic systems for and around humans. Relevant case-studies are a vital part of this course; a semester project may also be assigned in this pursuit.
Course Code	**MCT-458 & MCT-458L**
Credit Hours	3 (2, 1)
Textbook	1. Haddadin, Sami. Towards safe robots: approaching Asimov's 1st law. Springer, 2014. 2. Human Centered Robot Systems: Cognition, Interaction, Technology by Helge Ritter, Gerhard Sagerer, Rüdiger Dillmann, Martin Buss (Eds.), Springer, 2012 3. Research Publications / Report of Human-Centered Robotics Lab of the National Center of Robotics and Automation at UET Lahore
Contents	**Introduction:** overview, basics and scope **Interactions:** physical interaction among robots and humans; social and cognitive interaction among robots and humans; physiological integration with the human body **Actuation:** variable compliance; soft-actuators in robotics **Sensing:** full-body sensing for robots; force/torque sensing; active tactile sensing **Control:** basic approaches and challenges, impedance control, shared control, real-time optimal controls, intention-based control, etc. **Robotics systems:** collaborative robots, wearable robots, service robots, social robots etc., (primarily focusing on industrial, health care and domestic use for human augmentation, rehabilitation and companionship); human-centered designs and approaches; autonomy for human environments; bidirectional adaptation and learning; safety-compliance in robot systems **Applications and challenges in human-centered robotics**

Course Name	**Aerial Robotics**
Description	In this course, students will learn about the concepts of aerial robots and their types, including multi-rotor, fixed-wing, VTOLs, and blimps. Students will learn about the sensory and communication systems of aerial robots, as well as dynamical modeling

	and simulations. The course also includes an introduction to computer vision for aerial robots and discusses their applications in various fields. Modern trends in aerial robotics will also be explored.
Course Code	**MCT-459 & MCT-459L**
Credit Hours	3 (2, 1)
Textbook	1. Aerial Robotic Manipulation, Anibal Ollero, Bruno Siciliano (2019), Springer 2. Aerial Robots: Aerodynamics, Control and Applications, Omar D Lopez Mejia, Jaime Escobar (2017), Intech Open
Contents	Basic concepts of aerial robots and their types (including multi-rotor, fixed-wing, VTOLs, and blimps) Motors (electric & gasoline), propellers and their controls Wings, ailerons, flaps and rudders: their designs, aerodynamics, and flow simulations Sensory & communications systems of the aerial robots: IMUs, GPS, radio/wireless comm, etc. Selection and assembly of drones Dynamical modeling of aerial robots and simulations Flight controllers: configurations and programming Introduction to computer-vision for aerial robots Load transport Applications of aerial robots in agriculture, drug/food delivery, surveillance, terrain mapping, etc. Modern trends in aerial robotics

Course Name	**Smart Electric Vehicles**
Description	This course covers the types of Electric Vehicles (EVs), including their powertrain, battery systems, and mechatronic systems. Students will learn about the sensory and actuation systems inside an EV, as well as its auxiliary systems. The course also includes modeling, simulation, and control of EV's subsystems, as well as sensory systems and algorithms for autonomous driving. Modern trends in EVs will also be explored.
Course Code	**MCT-461 & MCT-461L**
Credit Hours	3 (2, 1)

Textbook	1. Automated and Electric Vehicle: Design, Informatics and Sustainability. (2022). Springer Nature. 2. Electric Vehicles: Modern Technologies and Trends. (2020). Germany: Springer Nature
Contents	Basics and types of Electric Vehicles (EVs) Powertrain of EVs: electric traction motor, reducers and transmission, converters and inverters, controllers, and cooling systems Battery systems of EVs: battery pack, battery management system, health monitoring, charging, drives, etc. Mechatronic systems inside an EV including its sensory and actuation systems Auxiliary systems of EVs: suspension, cabin, health management, etc. Modeling, simulation and control of EV's subsystems Sensory systems and algorithms for autonomous driving Modern trends in EVs

Course Name	**Special Topics in Mechatronics**
Description	In this course, a multitude of different topics related to modern mechatronics may be discussed. It is hoped that students are provided with a window to peep into the future and come up with innovative ideas which can be implemented with today's technology. *Innovation-through-entrepreneurship* can be one mantra of this class.
Course Code	**MCT-491 & MCT-491L**
Credit Hours	3 (2, 1)
Textbook	1. Di Paola, Annalisa Milella Donato, and Grazia Cicirelli. Mechatronic systems simulation modeling and control. 2010. 2. Bishop, Robert H., ed. Mechatronic systems, sensors, and actuators. CRC press, 2017. 3. Any book relevant to the selected topics
Contents	Some of the topics from the list below can be selected from a standpoint of the current market demands and futuristic innovations. Some new topics may also be added as required.

	• Quantum Computing Systems • Electric Vehicles (EVs) • Biomechatronics, Bionics • Cyberware: Interfaces and Prostheses • Automotive Subsystems (e.g., intelligent steer control, etc.) • Mobile App Design-and-Development Centered on Mechatronic Systems • Smart Consumer Devices • Entrepreneurship with Mechatronics • Smart Communication Network • Classification, Clustering and Regression • MEMS (micro electro mechanical systems). • Renewable Energy Resources and Energy Harvesting • Advanced Embedded Systems Design • Introduction to structural Health monitoring/Non-Destructive Testing (NDT) • Automation in Construction