Department of Electronic & Instrumentation Science

Savitribai Phule Pune University

Pune 411007.

Syllabus for M. Sc. Instrumentation Science

(According to NEP-2020 Regulations)

[To be implemented from 2023-24]

July 2023

BACKGROUND

All over the world the growth of an Industrial society in a Nation is measured by its use of Scientific Instruments. This is because the R & D achievements in research organizations and Industries depend on the availability of advanced instruments. Further the instruments can be utilized to its full capacity only if well trained manpower is available for design, development, its use and timely repair and maintenance. This is possible when the gap between Pure Sciences and Engineering; that is in effect the gap between Academic Society and Industrial Sector is bridged. This is a well-established fact today.

It is the requirement that has led to the emergence of Instrumentation Science – a new discipline of not only Science but technology as well and has become frontline area today. The discipline of Instrumentation Science necessarily needs the understanding of latest trends and achievements in the field of Physical, Chemical and Biological Sciences. The main objective of Instrumentation Science is to logically translate the proven research ideas into a reliable and effective but simple, elegant and handy instruments and gadgets. This will facilitate not only development of high-tech products in diverse fields but also the teaching of advanced techniques in the frontline research.

To fulfil these goals, Savitribai Phule Pune University instituted Department of Electronic & Instrumentation Science and introduced M. Sc. Instrumentation Science course. This is an industry / R & D oriented professional course.

M. Sc. Instrumentation Science
(Two Years Master's Course in Instrumentation Science)

1. **ELIGIBILITY:** B.Sc. with Physics / Electronics / Instrumentation Science / Computer Science / Vocational Physics / Electronics or B.E. (E & TC) / (Instrumentation)

2. **DURATION**: Two years (Four semester course)

   Note: This is Industry oriented TWENTY-FOUR months professional course.

3. **COURSE STRUCTURE:**

   The MSc. Instrumentation Science course would consist of total eighty-eight credits to be completed. The total course structure consists of 42 credits of major core theory courses and 30 credits of major core laboratory courses. The remaining 16 credits are split into 10 credits of major elective theory and 6 credits of major elective practical courses. Each semester, students have to choose one theory course and one laboratory course from a list of options. Accordingly, the student is required to finish 22 credits each semester. Students are required to complete 4 credits of on-the-job training in the second semester, followed by a 10-credit research project in the third and fourth semesters.

   Further to complete the eighty-eight credits to complete the master program, the student could go for courses from electives / MOOCs / opt for courses offered by other departments with the permission from Departmental Committee.

	Semester-I	
Subject Code	**Name of the Subject**	**Credits**
	Major Core	
IS 501 MJ	Integrated Circuits for Instrumentation	4
IS 502 MJ	Advanced Digital Electronics	4
IS 503 MJ	Mathematical Techniques for Instrumentation	2
IS 504 MJP	Analog and Digital Electronics Laboratory	4
IS 505 MJ	Research Methodology	4
	Major Elective (Theory)	
IS 510 MJ	Industrial Power Electronics	2
IS 511 MJ	Signal and Systems	2
IS 512 MJ	Field Instrumentation and Components	2
	Major Elective (Practical)	
IS 513 MJP	C programming Laboratory	2
IS 514 MJP	Simulation Software Practices Laboratory	2
	Number of credits to be completed in Semester I	**22**

	Semester-II	
Subject Code	**Name of the Subject**	**Credits**
	Major Core	
IS 551 MJ	Sensors, Transducers and Signal Conditioning	4
IS 552 MJ	Feedback Control System	4
IS 553 MJ	Industrial Internet of Things	2
IS 554 MJP	Sensor and Virtual Instrumentation Laboratory	4
IS 555 OJT	On Job Training	4
	Major Elective (Theory)	
IS 560 MJ	Microcontroller and Embedded System	2
IS 561 MJ	Automotive Electronics	2
IS 562 MJ	Industrial Networking	2
	Major Elective (Practical)	
IS 563 MJP	Microcontroller Laboratory	2
IS 564 MJP	Advanced Virtual Instrumentation Laboratory	2
	Number of credits to be completed in Semester II	**22**

	Semester-III	
Type of Subject	**Name of the Subject**	**Credits**
	Major Core	
IS 601 MJ	Process control	4
IS 602 MJ	Robotics	4
IS 603 MJ	Industrial Automation	2
IS 604 MJP	Process Control and Industrial Automation Laboratory	4
IS 605 RP	Research Project-I	4
	Major Elective (Theory)	
IS 610 MJ	Process Instrumentation	2
IS 611 MJ	Optical Instrumentation	2
IS 612 MJ	Analytical Instrumentation	2
	Major Elective (Practical)	
IS 613 MJP	Process Instrumentation Laboratory	2
IS 614 MJP	Special Instrumentation Laboratory	2
	Number of credits to be completed in Semester III	**22**

	Semester-IV	
Type of Subject	**Name of the Subject**	**Credits**
	Major Core	
IS 651 MJ	Machine Intelligence	4
IS 652 MJ	Elements of Mechanical Design	4
IS 653 MJP	Industry 4.0 Laboratory	4
IS 654 RP	Research Project-II	6
	Major Elective (Theory-I)	
IS 660 MJ	Instrumentation Project Management	2
IS 661 MJ	Intellectual Property Rights	2
	Major Elective (Theory-II)	
IS 662 MJ	Power Plant Instrumentation	2
IS 663 MJ	Biomedical Instrumentation	2
	Number of credits to be completed in Semester IV	**22**

Subject Code	**Subject Title**	**Credits**
To be decided by University	Cyber Security/Information security	4
	Human Rights-I	1
	Human Rights-II	1
	Introduction to Indian Constitution	2
	Skill Development Courses	4

Course Information	
Year and Semester: M.Sc.-I Semester-I	**Major Core**
Course Code: IS 501 MJ	**Course Title: Integrated Circuits for Instrumentations**
Credit: 04	

Course Objectives:

1) To strengthen the basic concepts of semiconductor device, performance characteristics and their application.
2) To introduce important techniques that are necessary to build core concepts in different signal processing circuit.
3) To develop skills to understand working principle of different electronic circuit and their application in real life.

Course Contents:

Unit I	**Credits: 1**	**10 L, 5 T**
	Passive/Active devices and analog electronics: Study of passive components like Resistors, Capacitors, Inductors, Transformers, Relays, Switches, wires and cables etc., Study of Data sheets provided by manufacturers, understanding of various parameters specified and limitations, Different types of components available in market, Selection of component/s for specific applications, Data sheets referencing, testing, Diodes, Zener diodes, Light emitting diodes. BJT: construction, Input and output characteristics of CE, CB and CC configurations, UJT, FET: Types, construction, V-I characteristics. Small signal model of transistor, Design of single stage and multistage CE /CS amplifier, frequency response, transistor as switch, FET as VVR.	
Unit II	**Credits: 1**	**10 L, 5 T**
	Network theorems, analysis and applications: Basic circuit analysis and simplification techniques - Voltage and Current laws (KVL/KCL), Network Analysis – Mesh and Node analysis, Network Theorems - Superposition, Thevenin‘s, Norton‘s and Maximum Power Transfer Theorems etc. Consideration of worst-case specifications / conditions for circuit designing, Use of basic test instruments like Multimeter, Signal Generator, Oscilloscope, etc. Basics wave shaping circuits - RC circuit as a differentiator / integrator, Clipping and clamping circuits, Voltage multipliers.	
Unit III	**Credits: 1**	**10 L, 5 T**

	Operational Amplifiers Basics: Basics of Operational Amplifiers: Differential Amplifier using transistor, Operational Amplifier - construction, working, characteristics, performance specifications of IC LM 741, LM 324, OP07, LF351/356 etc., Operational Amplifier with negative feedback: Effect of negative feedback on input resistance, output resistance, bandwidth, gain, offset voltage for inverting, non-inverting and differential amplifier. Summing, scaling and averaging applications of Operational Amplifiers with inverting, non-inverting and differential configurations, Instrumentation Amplifier, Wave shaping circuit using op-amp in inverting / non inverting configuration, Log Antilog configurations, Operational Amplifier with positive feedback: Effect of positive feedback on performance of amplifier, Oscillators, Wien Bridge, Phase shift, Comparators, Zero crossing detector, Schmitt trigger, Precision Rectifier, Sample and Hold circuits, Multivibrators using Op-amp and logic gates.	
Unit IV	Credits: 1	10 L, 5 T
	Integrated Circuits and applications: Timer: IC 555, internal block diagram, working, modes, specifications and its applications, 8038 pulse generator, Voltage Regulator: Theory, Perfor- mance specifications, Linear and Switch mode regulators, IC723, Theory and applications, IC 78XX, IC 79XX regulators, Power Supply Design.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Define semiconductor device and different operating condition and their performance parameter
2) Choose proper semiconductor devices depending upon application.
3) Be prepared to undertake advanced topics in Integrated Circuits and its applications subject.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *Ramakant Gaikwad, — Operational Amplifiers‖ Prentice-Hall of India, 4th edition, 2009*
2) *William D. Stanley, —Operational Amplifiers with Linear Integrated Circuits‖, Pearson Education India, 4th edition, 2004.*
3) *Albert.P. Malvino, David Bates, —Electronic principles‖, McGraw-Hill, 8th Edition 2015.*
4) *Paul Horowitz, Winfield Hill, —The Art of Electronics‖, Cambridge University press, 3rd edition, 2015.*

Course Information	
Year and Semester: M.Sc.-I Semester-I	**Major Core**
Course Code: IS 502 MJ	**Course Title: Advanced Digital Electronics**
Credit: 04	

Course Objectives:

1) To teach principles of digital electronics.
2) To teach topics including Boolean algebra, basic gates, logic circuits, flip-flops, registers, arithmetic circuits, counters, interfacing with analog devices, and computer memory.

Course Contents:

Unit I	**Credits: 1**	**10 L , 5 T**
	Number System & Logic Design Minimization Techniques: Introduction: Binary, Hexadecimal numbers, octal numbers, number conversion and their arithmetic, Signed Binary number representation: Signed Magnitude, 1‘s complement and 2‘s Complement representation. Binary, Octal, Hexadecimal Arithmetic: 2‘s complement, arithmetic. Codes: BCD, Excess-3, Gray code, Error detecting & correcting Codes, ASCII Code and code, conversions., BCD Arithmetic. Boolean algebra: Truth tables and Boolean algebra. Idealized logic gates and symbols. DeMorgan's rules Axiomatic definition of Boolean algebra, Basic theorems and properties of Boolean algebra. Logic minimization: Representation of truth-table, SOP form, POS form, Simplification of logical functions, Minimization of SOP and POS forms, Don‘t care Conditions. Reduction techniques: K-Maps up to 4 variables and Quine-McClusky techniques.	
Unit II	**Credits: 1**	**10 L , 5 T**
	Logic Families Standard characteristics: Speed, power dissipation, fan-in, fan-out, current and voltage, parameters, noise margin, operating temperature etc. ECL, NMOS, PMOS families: Basic circuits, Standard TTL characteristics, Operation of TTL NAND gate. TTL Configurations- Active pull-up, Wired AND, totem pole, open collector. CMOS: CMOS Inverter, CMOS characteristics, CMOS configurations- Wired Logic, Open drain outputs, Detail comparison, of TTL & CMOS Interfacing: TTL to CMOS and CMOS to TTL, Tristate Logic.	
Unit III	**Credits: 1**	**10 L , 5 T**
	Combinational Logic Circuits:Half- Adder, Full Adder, Half Subtract or, Full Subtractor, BCD adder, look ahead and carry, parity generator and checker , magnitude comparator ,code convertors Decoders- Working of decoder, implementation of expressions using decoders ,IC 74138 , BCD to 7 segment decoder circuits , BCD to 7 segment decoder/driver IC 7448/7447, Encoders-- working of encoders, priority encoders, IC 74148 Multiplexers (MUX):- Working of MUX, Implementation of expression using MUX (IC 74153, 74151). Demultiplexers (DEMUX):- Working of DeMUX, Implementation of expression using DEMUX.	

Unit IV	Credits: 1	10 L , 5 T
	Sequential Logic Introduction: Sequential Circuits. Difference between combinational circuits and Sequential circuits Flip flop:- SR, JK, D, T; Preset & Clear, Master and Slave Flip Flops their truth tables and excitation tables, Conversion from one type to another type of Flip Flop. Application of Flip-flops:- Switch Bounce Elimination Registers: - Buffer register; shift register; IC 7495 Counters: definition of Modulus of counter, Asynchronous counters. Synchronous counters, state diagram representation, Design of Synchronous counters, Presettable and programmable counters, Decade/BCD counters, ring and Johnson counters, Divide by N counter, timing diagram of counters, Realization of counters using ICs 7490, 7492,7493 and 74193, Sequence Generator: using shift registers and counters PLDs & Introduction to Microprocessor PLD: PLA- Input, Output Buffers, AND, OR, Applications of Digital circuits: Digital Clock, Frequency counter, Stepper motor sequence generator, Alarm annunciator. Memory: RAM, ROM, EEPROM, EPR, Flash Memory, bubble memory, CD ROM	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Represent numerical values in various number systems and perform number conversions between different number systems.
2) Demonstrate the knowledge of operation of logic gates, Boolean algebra, Karnaugh map reduction method.
3) Demonstrate the knowledge of operation of basic types of flip-flops, registers, counters, decoders, encoders, multiplexers, and de-multiplexers.
4) Analyse and design digital combinational circuits including arithmetic circuits (half adder, full adder, and multiplier).
5) Analyse sequential digital circuits. Students will demonstrate knowledge of the nomenclature and technology in the area of memory devices: ROM, RAM, PROM, PLD, FPGAs, etc.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *Albert P Malvino and leach , — Digital Principles & Applications‖, Tata McGraw-Hill delhi, 8th Edition, 2015. Thomas L Floyd —Digital Fundamentals‖, Pearson Education, 11th Edition, 2014.*
2) *R.S. Gaonkar, —Microprocessor Architecture Programming and Applications with 8085‖, Penram International Publishing, 6 th Edition, 2013.*
3) *Thomas L Floyd, —Digital Fundamentals‖, Pearson Education, 11th edition, 2014.*
4) *M. Morris Mano, Michael D. Ciletti, —Digital Design‖, Pearson Education Asia, 4th Edition 2011 / international Edition 2013.*

Course Information	
Year and Semester: M.Sc.-I Semester-I	**Major Core**
Course Code: IS 503 MJ	**Course Title: Mathematical Techniques for Instrumentation**
Credit: 02	

Course Objectives:

1) To teach principles basics of differential equations.
2) To teach basics of integral calculus, Fourier series.

Course Contents

Unit I	**Credits: 1**	**10 L, 5 T**
	Matrix algebra, Inverse of a matrix such as Orthogonal, Hermitian, Unitary matrices, First order (linear and nonlinear) differential equations, Curve fitting, Higher order linear differential equations with constant coefficients, Applications to LCR circuits, Fourier series, Fourier transform, Laplace and inverse Laplace transform, Applications.	
Unit II	**Credits: 1**	**10 L, 5 T**
	Functions of two or more variables, Partial derivatives, Maxima and Minima, Jacobians, Revision of vector algebra, Vector calculus – Scalar and vector point functions, Gradient, divergence, curl with their physical significance, Vector identities, Line, surface and volume integrals, Gauss divergence theorem and Stoke's theorem, Probability distributions, Normalization, Mean, mode, median and standard deviation, Binomial distribution and Gaussian distribution.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Solve differential equations.
2) Know the use of differential equations and calculus.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *P. N. Wartikar, J. N. Wartikar, ―A textbook of Applied Mathematic‖, Vol. I & II, Pune Vidyarthi Griha Prakashan.*
2) *Kanti B. Datta , ―Mathematical Methods of Science and Engineering: Aided with MATLAB‖, 1st Edition, 2012*
3) *B. V. Ramana, ―Higher Engineering Mathematics‖, Tata Mc-Graw Hill Publication 1st Edition, sixth reprint, 2008.*

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4) *B.S. Grewal, ―Higher Engineering Mathematics‖, Khanna Publication, 43rd Edition, 2014.*

Course Information	
Year and Semester: M.Sc.-I Semester-I	**Major Core**
Course Code: IS 504 MJP	**Course Title: Analog and Digital Electronics Laboratory**
Credit: 04	

Course Objectives:

1) To introduce components such as diodes, BJTs and FETs.
2) To know the applications of components.
3) To give understanding of various types of amplifier circuits.
4) To learn basic techniques for the design of digital circuits and fundamental concepts used in the design of digital systems.
5) To understand the concepts of combinational logic circuits and sequential circuits.

Course Contents:

List of Laboratory Experiments:

1) Study of input / output characteristics of BJT- CB, CE, and CC Configuration.
2) Study of input and transfer characteristics of FET.
3) BJT amplifier frequency response.
4) FET amplifier frequency response.
5) Measurement of operational amplifier parameters.
6) Clipper and Clamper circuits using Opamp.
7) Precision rectifiers using Opamp.
8) Adder and Subtrator using Opamp.
9) Wien bridge oscillator using Opamp. RC phase shift oscillator using Opamp.
10) Implementing study of Gates and Logic Operations like, NOT, AND, OR, NR, OR and XNOR using (i) all NAND Gates (ii) all NOR Gates.
11) Implementing a binary to gray, gray to binary or binary to XS3 code converter using gate ICs.
12) Simplifying 3, 4 variable logic functions and implementing them using gate ICs AND/OR, OR/AND, ALL NAND and ALL NOR.
13) Implementation of Half and Full Adder Circuit.
14) Study of Multiplexer and Demultiplexer using ICs.
15) Constructing flip flops like SR, D, JK and T using all NAND gates and a de-bounce switch.
16) Designing a mod N counter. Design a ripple counter/or a two bit comparator using gate ICs. Building a ring counter and a twisted ring counter using D f/f ICs.

Note: The concerned faculty may conduct any other experiment based on the course apart from the given list.

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Know the characteristics of various components.
2) Understand the utilization of components.
3) Design and analyze small signal amplifier circuits.
4) Postulates of Boolean algebra and to minimize combinational functions
5) Design and analyze combinational and sequential circuits
6) Known about the logic families and realization of logic gates.

Instructional design: Hands on Experiments

Evaluation Strategies:

1) Lab execution
2) Viva for each experiment
3) File submission

Course Information	
Year and Semester: M.Sc.-I Semester-I	**Major Core**
Course Code: IS 505 MJ	**Course Title: Research Methodology**
Credit: 04	

Course Objectives:
To impart knowledge and skills required for research methodology:

1) Problem formulation, analysis and solution.
2) Technical paper writing/presentation without violating professional ethics

Course Contents:

Unit I	**Credits: 1**	**10 L, 5 T**
	History of research. Indian, Egyptian, Greek ideas methodologies and research in agriculture, chemistry, metallurgy, medical. Ancient Indian research methodology applications.	
Unit II	**Credits: 1**	**10 L, 5 T**
	Statistical analysis and its significance, Exploratory and confirmatory research, Planned and ad-hoc methods of data collection, Non-response and methods of recovering the missing response, Various software's for statistical analysis. The module will consist of case studies of the research performed in various subjects using statistical methods. Error and noise analysis, curve fitting.	
Unit III	**Credits: 1**	**10 L, 5 T**
	Creating questionnaire. Data analysis from answers, Selection of research topic (case study based). Selection of research topic (case study based) Literature search, selection of research topic (case study based), maintaining laboratory records (case study based). Safety in Laboratories, Ethical considerations, effective verbal and non-verbal communication, field data collection, safety in field.	
Unit IV	**Credits: 1**	**10 L, 5 T**
	Writing research paper and/or thesis, making a presentation, writing a research proposal, and patents in Science, technology. Writing research paper and/or thesis, making a presentation, writing a research proposal.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Ability to formulate research problem
2) Ability to carry out research analysis
3) Ability to follow research ethics

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *'History of the Scientific Methods' by Martin Shuttleworth*
2) *'The Statistical Analysis of Experimental Data' by, John Mandel, ISBN: 0486646661, ISBN13: 9780486646664.*
3) *'Research Methodology', C. R. Kothari, New Age International Publisher*

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Course Information	
Year and Semester: M.Sc.-I Semester-I	**Major Elective**
Course Code: IS 510 MJ	**Course Title: Industrial Power Electronics**
Credit: 02	

Course Objectives:

1) To introduce students to the basic theory of power semiconductor devices and passive components, their practical applications in power electronics.
2) To familiarize students to the principle of operation, design and synthesis of different power conversion circuits and their applications.
3) To provide strong foundation for further study of power electronic circuits and systems.

Course Contents:

Unit I	**Credits: 1**	**10 L, 5 T**
	Study of switching devices: Frame, Driver and snubber circuit of SCR, TRIAC, BJT, IGBT, MOSFET, Commutation circuits for SCR. Step-down and step-up chopper, Time ratio control and current limit control Buck, boost, buck- boost converter, concept of Resonant switching - SMPS. Converters: Half controlled and fully controlled converters, single phase dual converters – power factor Improvements.	
Unit II	**Credits: 1**	**10 L, 5 T**
	Three Phase Converters – Half controlled and fully controlled converters. Design of SCR based DC power circuits including UJT as triggering device AC power control using SCR-UJT & TRIAC-DIAC like universal speed controller fan regulator. Design of SCR/TRIAC based AC power control circuits including UJT/DIAC as a triggering device. AC to AC Controllers: On Off controller, Single phase AC voltage controllers–single and three phase cyclo-converters. Inverters: Single phase and three phase (both 1200 mode and 1800 mode) inverters - Series resonant inverter - Current source inverter.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Competency in function of various power electronics devices
2) Skill of analyzing power electronic devices.
3) Understand working of Controlled Rectifiers, Inverters and DC to DC converters.
4) Understand the Working of AC/DC Drives.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

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1) *M.H. Rashid, Power Electronics: Circuits, Devices and Applications', Pearson Education, 4th Edition, 2013.*
2) *P.S. bimbhra, —Power Electronics‖, Khanna publishers, 13th reprint, 2004.*
3) *Alok Jain, —Power Electronics & its applications‖, PENRAM International Publishing (India) Pvt. Ltd,2nd Edition, 2008.*
4) *Ashfaq Ahmed, —Power Electronics for Technology‖, Pearson Education, Indian Edition, 2003.*
5) *P.S. bimbhra —Power Electronics‖ Khanna Publishers,.13th reprint, 2004.*

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Course Information	
Year and Semester: M.Sc.-I Semester-I	**Major Elective**
Course Code: IS 511 MJ	**Course Title: Signal and Systems**
Credit: 02	

Course Objectives:

1) To introduce students to the idea of signal and system analysis and characterization in time and frequency domain.
2) To provide foundation of signal and system concepts to areas like communication, control and comprehend applications of signal processing in control systems.

Course Contents:

Module-1	**Credits: 1**	**10 L, 5 T**
	Introduction to Signals: Continuous time signals (CT signals), discrete time signals (DT signals) - Step, Ramp, Pulse, Impulse, Exponential. Classification of CT and DT signals, CT systems and DT systems. Basic properties of systems Analysis of CT Signals: Fourier series analysis, Spectrum of C.T. signals, Impulse response, Convolution integral, frequency response, Differential equation, Block diagram representation, Fourier Transform and Laplace Transform in Signal Analysis.	
Module-2	**Credits: 1**	**10 L, 5 T**
	Analysis of DT Signals: Sampling of CT signals and aliasing, Impulse response, Convolution sum DTFT and its properties. Z Transform, Convergence of Z Transform, Properties of Z Transform, Inverse Z Transform. Difference equations, Block diagram representation, LTI systems analysis using DTFT and Z-transforms, Analysis of recursive and Non-Recursive Systems. Representation of sequences by Fourier transforms. Symmetry properties and Theorems of Fourier transform, Discrete Fourier Transform (DFT): DFT and IDFT, Properties of DFT, Circular convolution, linear convolution using DFT and IDFT.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Students will be able to understand significance of signals and systems in the time and frequency domains.
2) Students will be able to interpret and analyse signal and report results.
3) Students will be able to evaluate the time and frequency response of continuous and discrete time, system which is useful in understanding behaviour of communication and control systems.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *H P Hsu, Rakesh Ranjan— Signals and Systems, Schum's Outlines, Tata McGraw Hill, Indian*

Reprint, 2007.

2) *Simon Haykins and Barry Van Veen, ―Signals and Systems‖ John Wiley & sons, Inc, 1 st Edition 2004.*
3) *S.Salivahanan, A. Vallavaraj, C. Gnanapriya, ―Digital Signal Processing‖, McGraw Hill International/ TATA MCGRAW HILL, 1 st Edition 2007.*

Course Information	
Year and Semester: M.Sc.-I Semester-I	**Major Elective**
Course Code: IS 512 MJ	**Course Title: Field Instrumentation and Components**
Credit: 02	

Course Objectives:

1) To familiarize students with concepts of hydraulic components and pneumatic components used in the industries.
2) To comprehend the fundamentals of process control loop.
3) To provide foundation of process instrumentation by introducing all the field instrumentation and components.
4) To understand different field instruments used in the field.

Course Contents:

Module-1	**Credits: 1**	**10 L, 5 T**
	Industrial Control Devices Switches: construction, symbolic representation, working, application of toggle switch, slide switch, DIP switch, rotary switch, thumbwheel switch, selector switch, push button, limit switch, emergency switch, micro-switches, review of process switches, switch specifications. Relays: construction, working, specifications, terminologies and applications of Electromechanical relay, hermetically sealed relay, reed relay, solid-state relays and timing relay. Contactors: construction, working, specifications and applications of contactors. Comparison between relay and contactor. Development of electrical wiring diagram using standard symbols of above components.	
Module-2	**Credits: 1**	**10 L, 5 T**
	Hydraulic Components: Hydraulics: principle, block diagram, advantages, disadvantages, applications, hydraulic fluid desirable properties, Types of hydraulic oil and its selection. Hydraulic components: hydraulic power pack, hydraulic pumps, actuators, filters, piping, heat exchangers valves and motors. Hydraulic circuits: development of hydraulic circuits using standard symbols, hydraulic circuits like meter in, meter out, reciprocating, speed control, sequencing of cylinders, direction control, deceleration, regenerative circuit, etc. troubleshooting in hydraulic circuits. Introduction to circuit design. Pneumatic Components: Pneumatics: principle, block diagram, advantages, disadvantages, applications. Fluidic elements and its applications Pneumatic components: pneumatic power Supply, types of pneumatic relay, FRL unit, pneumatic actuator (cylinders and air motors), pneumatic valves, Pneumatic circuits: development of pneumatic circuits using standard symbols, sequence diagram (step-displacement) for implementing pneumatic circuits, different pneumatic circuits like reciprocating, sequencing, block transfer, speed regulation, job sorting, electro-pneumatic circuits, etc.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Explain the working of electrical, hydraulic, pneumatic components.
2) Select and size the electrical, mechanical, hydraulic and pneumatic components to solve a problem.

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3) Identify, formulate and solve a problem using electrical, mechanical, hydraulic and pneumatic system.
4) Develop electrical wiring diagrams, hydraulic and pneumatic circuits for given application.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *Majumdar, "Pneumatic Systems: Principles and Maintenance", TMH Publications.*
2) *F. D. Petruzella "Industrial Electronics", Glancor Publications.*
3) *C.T. Kilian, "Modern Control Technology: Components & Systems", Thomson Learning Publications.*
4) *"Industrial Hydraulic Technology Parker Motion & Control, Training Department.*
5) *Festo Controls, "Fundamentals of Pneumatic Control Engineering", Banglore.*

Course Information	
Year and Semester: M.Sc.-I Semester-I	**Major Elective**
Course Code: IS 513 MJP	**Course Title: C programming Laboratory**
Credit: 02	

Course Objectives:

1) To introduce complete knowledge of C language.
2) To develop logics which will help them to create programs, applications in C.
3) Also, by learning the basic programming constructs they can easily switch over to any other language in future.

Course Contents:

List of Laboratory Experiments:

1) Logic development, algorithm, flow charts etc.
2) Simple programming and use of computer environment for testing and debugging
3) C - Programming - Data types, control statements, for loop, if-else
4) C - Programming - while loop, do while loop
5) Sorting of array using switch and case statement
6) Writing user defined functions for complex calculations
7) Introduction to Python

Note: The concerned faculty may conduct any other experiment based on the course apart from the given list.

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Read, understand and trace the execution of programs written in C language.
2) Write the C code for a given algorithm.
3) Implement Programs with pointers and arrays, perform pointer

Instructional design: Hands on Experiments

Evaluation Strategies:

1) Lab execution
2) Viva for each experiment
3) File submission

Course Information	
Year and Semester: M.Sc.-I Semester-I	**Major Elective**
Course Code: IS 514 MJP	**Course Title: Simulation Software Practices Laboratory**
Credit: 02	

Course Objectives:

1) To provide background and fundamentals of Simulation tool like PSPICE / LtSpice for the analysis and processing basic AC/ DC circuits.
2) Ability to measure different parameters while doing DC and transient analysis.
3) To provide fundamental basics for PCB designing and use of software.

Course Contents:

List of Laboratory Experiments:

1) AC/ DC analysis of the given circuit.
2) PCB designing of the given circuit with manual routing.

Note: The concerned faculty may conduct any other experiment based on the course apart from the given list.

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Creation of schematics, BOM and Simulation of circuit.
2) Do PCB designing with standard guidelines.

Instructional design: Hands on Experiments

Evaluation Strategies:

1) Lab execution
2) Viva for each experiment
3) File submission

Course Information	
Year and Semester: M.Sc.-I Semester-II	**Major Core**
Course Code: IS 551 MJ	**Course Title: Sensors, Transducers and Signal Conditioning**
Credit: 04	

Course Objectives:

1) To strengthen the basic concepts of Sensors, transducers and signal conditioning circuits
2) To introduce various important parameters of sensors and classification of sensors
3) To develop the skill related to signal conditioning of each type of sensor

Course Contents:

Module-1	**Credits: 1**	**10 L, 5 T**
	Introduction: Units and standards of measurement, functional elements of measurement system, static and dynamic characteristics or performance characteristics of transducer, Measurement and calibration systems-Requirement. Displacement Transducers: Working principle of Resistance type, Capacitance type, Digital, Pneumatic (Flapper-Nozzle) displacement transducer. Level Transducers: Working principle of Float, Displacer, Bubbler, Diaphragm box, DP cell, Ultrasonic, Capacitive, Radioactive, Resistance, Thermal, optical level sensors, solid level detectors, intelligent level measuring instruments. Pressure Transducers: Primary pressure sensors, Electrical/Secondary Pressure Transducers, Manometers, High Pressure Measurement and Differential Pressure Measurement.	
Module-2	**Credits: 1**	**10 L, 5 T**
	Flow Transducers: Working principle of Head Type, Variable Area Type, and Open channel flow measurement. Temperature Transducers: Working principle of Thermometers, Resistance temperature detector (RTD), Thermistors, Thermocouples, and Pyrometers. Electro-chemical Sensors: pH measurement, Conductivity measurement, ORP (Oxidation Reduction Potential) Measurement, Humidity measurement. Intelligent Sensors.	
Module-3	**Credits: 1**	**10 L, 5 T**
	Need for signal conditioning, Current and Voltage standards. Signal conditioning for Resistive sensors: RTD, Thermistor, load cell, potentiometric sensors. Signal conditioning for capacitive sensors: Level sensor, displacement sensor, proximity detector, humidity sensor, differential pressure cell. Signal conditioning for inductive sensors: Displacement transducer (LVDT/RVDT), proximity detector, inductive pick-up.	
Module-3	**Credits: 1**	**10 L, 5 T**

	Signal conditioning for optical devices: LEDs, Photo diode, LDR, PIN diode, photo transistor, photo cell, optical proximity switch. Signal conditioning schemes for following devices: Thermocouple with cold junction compensation, ultrasonic detector for displacement, level (single and multiple liquid), pH and conductivity measurement, Hall sensor, Electromagnetic flow meter.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) have understood the fundamental concepts of Sensors and Transducers.
2) have acquired the problem-solving skills essential to developing the sensors module
3) be prepared to undertake advanced topics in sensors.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *E. O. Doebelin, ―Measurement System Application and Design‖, McGraw-hill International, 5 th Edition, 2007.*
2) *D. Patranabis, ―Principles of Industrial Instrumentation‖, Tata McGraw-Hill, 3 rd Edition, 2010.*
3) *R.K.Jain, ―Mechanical and Industrial Measurement‖, Khanna Publications, 9th print 2013.*
4) *C. D. Johnson, ―Process Control Instrumentation Technology‖, Prentice-Hall of India, 8 th Edition, 2009.*
5) *Sawhney A. K., "A Course in Electrical And Electronics Measurements and Instrumentation", Dhanpat Rai & Sons, 11th Edition, 2005.*
6) *D. V. S. Murthy, ―Transducers and Instrumentation‖, Prentice-Hall of India, 2 nd Edition, 2010.*
7) *B. G. Liptak, ―Process Measurement and Analysis‖, Butterworth Heinemann, 8 th Edition, 2009.*
8) *B. E. Noltingk, ―Jone's Instrument Technology‖ (Vol. 1 and Vol. 2),4th Edition 1985.*

Course Information	
Year and Semester: M.Sc.-I Semester-II	**Major Core**
Course Code: IS 552 MJ	**Course Title: Feedback Control System**
Credit: 04	

Course Objectives:

1) To familiarize students with concepts of control systems and mathematical modelling of the System.
2) To understand the concept of transient and steady-state response analysis for control systems and to assess the stability of control systems through the root-locus method and the frequency-response method.

Course Contents:

Module-1	**Credits: 1**	**10 L, 5 T**
	Transfer Function of Physical Systems: Introduction to control systems, Introduction to design process, Industrial of feed forward and feedback control system. Review of Laplace and inverse Laplace transform, modelling of dynamic systems (mechanical, electrical, electromechanical systems). Equivalent Systems: Block diagram reduction techniques, signal flow graphs, Mason 's gain formula, signal flow graph from block diagram, DC gain.	
Module-2	**Credits: 1**	**10 L, 5 T**
	Time Domain Analysis: System Equations, Differential Equations And Difference Equations, Partial and Ordinary Differential Equations, Time Variability and Time Invariance, Linear And Nonlinear Differential and Difference Equations, The Differential Operator and The Characteristic Equation, Linear Independence and Fundamental Sets, Solution of Linear Constant-Coefficient Ordinary Differential Equations ,The Free Response, The Forced Response, The Total Response, The Steady State and Transient Responses. Singularity Functions: Steps, Ramps, and Impulses, Second-Order Systems, State Variable Representation of Systems Described by Linear Differential Equations, Solution of Linear Constant-Coefficient Difference Equations, Time response analysis (1st, 2nd order, higher order approximation), System response with additional poles. System response with additional zeros. Steady state errors for unity feedback systems, Static error constants and system type, Steady state errors for disturbances, Design system parameters from steady state errors.	
Module-3	**Credits: 1**	**10 L, 5 T**
	Graphical tool and Stability Analysis: Nominal sensitivity functions, closed loop stability based on characteristic Polynomial, Routh-Hurwitz criteria, Root locus techniques: Introduction, Variation of Closed-Loop System Poles: The Root Locus, Angle and Magnitude Criteria, Number of Loci, Real Axis Loci, Asymptotes, Breakaway Points, Departure and Arrival Angles, Construction Of The Root-Locus, The Closed-Loop Transfer Function and The Time-Domain Response, Gain and Phase Margins From The Root-Locus, Damping Ratio from The Root-Locus For Continuous Systems.	

Module-4	Credits: 1	10 L, 5 T
	Frequency Domain Analysis Bode Plot: Frequency domain design limitations, Frequency response analysis, Bode plot, Asymptotic approximations, Stability, Gain Margin, and Phase Margin via Bode plot. Nyquist Plot: Relationship between time domain and frequency domain, Polar plot, Nyquist plot, Stability, Gain Margin, Phase Margin via Nyquist plot.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Students will able to represent the mathematical model of a system and determine the response of different order systems.
2) Students will have the ability to analyse the stability of the system.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *Norman Nise , ―Control System Engineering‖, John Wiley & Sons International, 6th Edition, 2013.*
2) *Nagrath and Gopal , ―Control System Engineering‖, New Age International Publication, 5th Edition, 2009.*
3) *G. Goodwin, S.Graebe, Mario Salgado, ―Control System Design‖, PHI, 1 st Edition, 2015.*
4) *G. Franklin, J.Powell, A. Naeini, ―Feedback Control of Dynamic Systems‖, Pearson Education, 7th Edition, 2015.*

Course Information	
Year and Semester: M.Sc.-I Semester-II	**Major Core**
Course Code: IS 553 MJ	**Course Title: Industrial Internet of Things**
Credit: 02	

Course Objectives:

1) To provide students with good depth of knowledge of Designing Industrial IOT Systems for various application.
2) To provide knowledge for the design and analysis of Industry 4.0 Systems for Process and Automation industry.

Course Contents:

Unit I	**Credits: 1**	**10 L, 5 T**
	Introduction to Internet of Things – Definition & Characteristics, Physical Design of IOT, Logical Design ofIOT, IOT Enabling technologies, IOT Levels & Deployment Templates Domain specific IOTs – Home automation, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health & Lifestyle IoT andM2M, IoT System Management with NETCONF-YANG. IOT Platform Design Methodology – Purpose & Requirements Specification, Process Specification, Domain Model Specification, Information model Specification, Service specification,IOT level Specifications, Functional View Specifications, Operational View Specification, device and component integration, application development, case study on IOT system for weather monitoring. Embedded suite for IoT Physical device – Arduino / Raspberry Pi Interfaces, Hardware requirement of Arduino / Pi, Connecting remotely to the Arduino /Raspberry Pi , GPIO Basics, Controlling GPIO Outputs Using a Web Interface,– Programming , APIs / Packages, Arduino Interfaces, Integration of Sensors and Actuators with Arduino, Introduction to Python programming – Python data types & data structure, Control flow (if, for, while, range, break/continue, pass), Functions, Modules, packages, file handling, date/time operations, classes, Python packages of interest for IOT.	
Unit II	**Credits: 1**	**10 L, 5 T**

	Connectivity Technologies and Communication Protocols in IOT RFID: Introduction, Principle of RFID, Components of an RFID system, Wireless Sensor Networks: WSN Architecture, the node, connecting nodes,Networking Nodes, Securing Communication WSN specific IoT applications, Protocols in IOT: CoAP, XMPP, AMQP, MQTT. Communication Protocols: IEEE 802.15.4, Zigbee, 6LoWPAN, Bluetooth, WirelessHART IOT Physical Server and Cloud Offeringscloud architecture standards and interoperability- Cloud types; IaaS, PaaS, SaaS.Benefits and challenges of cloud computing, public, private clouds community cloud, Fog Computing, SDN Cloud Storage Models & Communication APIs, Web Application Messaging Protocol (WAMP), Python webapplication framework – Django, Developing Application with Django, Developing REST web services, SkyNet IoT Messaging Platform Case Studies Illustrating IOT Design – Smart lighting, Home Intrusion Detection, Smart Parking, Weather Monitoring System, WeatherReport Bot, Air Pollution Monitoring, Forest fire Detection, Smart Irrigation, IoT Printer.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Knowledge of theory and practice related to Industrial IoT Systems.
2) Ability to identify, formulate and solve engineering problems by using Industrial IoT.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *Industry 4.0: The Industrial Internet of Things Alasdair Gilchrist Publications*
2) *The Concept Industry 4.0 An Empirical Analysis of Technologies and Applications in Production Logistics Authors: Bartodziej, Christoph Jan Springer: Publication in the field of economic science.*
3) *Embedded System: Architecture, Programming and Design by Rajkamal, TMH3.*
4) *Dr. OvidiuVermesan, Dr. Peter Friess, "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers.*

Course Information	
Year and Semester: M.Sc-I Semester-II	**Major Core**
Course Code: IS 554 MJP	**Course Title: Sensor and Virtual Instrumentation Laboratory**
Credit: 04	

Course Objectives:

1) To strengthen the basic concepts of Sensor, signal conditioning circuits and virtual instrumentation
2) To introduce various important parameters of sensors and classification of sensors
3) To develop the skill related to signal conditioning of each type of sensor

Course Contents:

List of Laboratory Experiments:

1) Study and plot characteristics of Thermistor
2) Study and plot characteristics of various Thermocouples.
3) Study Liquid Level Measurement using Capacitance Type Level Sensor
4) Study Displacement Transducer using LVDT.
5) Study and plot characteristics strain guage sensor
6) Study and plot characteristics of LDR
7) To develop a VI to calculate speed, convert degree Celsius to degree Fahrenheit, compute the given equations etc.
8) To develop a VI to calculate factorial of a given number, addition of first 10 numbers etc. using structures
9) Build a VI to plot circle in XY graph, generate and plot random numbers on chart different colors in an intensity graph etc with graph, chart properties and options.
10) To create VI student database, library database etc. using array and cluster functions.
11) Develop a VI to storing all the points of simulated signal, storing all iterations from experiment etc. using File I/Os.

Note: The concerned faculty may conduct any other experiment based on the course apart from the given list.

Learning Outcomes:

1) Upon completion of the course, the student will be able to design sensor signal conditioning circuits and VI
2) have understood the fundamental concepts of Sensors and Transducers and VI.
3) have acquired the problem-solving skills essential to developing the sensors module
4) be prepared to undertake advanced topics in sensors and VI

Instructional design: Hands on Experiments

Evaluation Strategies:

1) Lab execution
2) Viva for each experiment
3) File submission

REFERENCES:

1) *E. O. Doebelin, ―Measurement System Application and Design‖, McGraw-hill International, 5 th*

Edition, 2007.

2) *D. Patranabis, —Principles of Industrial Instrumentation‖, Tata McGraw-Hill, 3 rd Edition, 2010.*
3) *R.K.Jain, —Mechanical and Industrial Measurement‖, Khanna Publications, 9th print 2013.*
4) *C. D. Johnson, —Process Control Instrumentation Technology‖, Prentice-Hall of India, 8 th Edition, 2009.*
5) *Sawhney A. K., "A Course in Electrical And Electronics Measurements and Instrumentation", Dhanpat Rai & Sons, 11th Edition, 2005.*
6) *D. V. S. Murthy, —Transducers and Instrumentation‖, Prentice-Hall of India, 2 nd Edition, 2010.*
7) *B. G. Liptak, —Process Measurement and Analysis‖, Butterworth Heinemann, 8 th Edition, 2009.*
8) *B. E. Noltingk, —Jone's Instrument Technology‖ (Vol. 1 and Vol. 2),4th Edition 1985.*

Course Information	
Year and Semester: M.Sc.-I Semester-II	**Major Core**
Course Code: IS 555 OJT	**Course Title: On Job Training**
Credit: 04	

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Course Information	
Year and Semester: M.Sc.-I Semester-II	**Major Elective**
Course Code: IS 560 MJ	**Course Title: Microcontroller and Embedded System**
Credit: 02	

Course Objectives:

1) Differentiate between microprocessors and microcontrollers.
2) Explain the architecture of PIC processor with its instruction set.
3) Identify the applicability of the embedded system

Course Contents:

Unit I	**Credits: 1**	**10 L, 5 T**
	Introduction to microchip PIC microcontroller: PIC microcontroller features, scaling of PIC MCU families, overview of baseline, midrange, enhanced mid-range, and high-end core devices. Core architecture: PIC Architecture, Program memory, Addressing Modes, Instruction set. PIC MCU Hardware: reset, clock, controlregisters, register banks, program memory paging etc. MPLAB IDE overview: Using MPLAB, Toolbars, Select Development Mode and Device Type, Project, Text Editor, Assembler, MPLAB Operations. PIC resources: Port programming, interrupts, Timer and Counter, ADC module, watchdog timer, power up timer,sleep mode, state machine programming. Syllabus for M. Sc. Instrumentation Science (Choice Based Credit System) April 2016 22 of 47 Interfacing with PIC: Switch, relay, Keypad, LCD display, Stepper motor, DAC,etc. Overviews of PIC tools: Development software 's, compilers, debug tools.	
Unit II	**Credits: 1**	**10 L, 5 T**
	Introduction to Embedded Systems: Embedded System definition, Embedded Systems v/s general purpose computing systems, Classification of Embedded System, Embedded system applications, Embedded System components, microprocessors v/s microcontrollers, Von-Neumann v/s Harvard architectures, CISC and RISC architectures, memory, peripherals, reset circuits, oscillator circuits. Embedded System Development: Microcomputer Development Systems (MDS), MDS development steps, Development Tools: Integrated Development Environment (IDE), IDE components: Editor, Project wizard, Assembler, Compiler, Simulator, In Circuit Emulator (ICE)/On Chip Debugger (OCD), Logic Analyzer.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Describe the architectural features and instructions of PIC microcontroller.
2) Apply the knowledge gained for Programming PIC for different applications.
3) Interface external devices and I/O with PIC microcontroller.
4) Interpret the basic hardware components and their selection method based on the characteristics and attributes of an embedded system.
5)

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *Tim Wilmshurst, ―Designing Embedded Systems with PIC Microcontrollers‖, Elsevier/BSP Books, 2nd Edition, 2010.*
2) *David W Smith, ―PIC in Practice: A Project-based Approach‖, Newnes, 2nd Edition, 2006.*
3) *John Morton, ―PIC: Your Personal Introductory Course‖, Newnes 3rd Edition,.2005*
4) *Qing Li, Caroline Yao, ―Real-Time Concepts for Embedded Systems‖, CMP Books. 1st Edition, 2003*
5) *David E. Simon, ―An Embedded Software Primer‖, Pearson Education, 2003.*

Course Information	
Year and Semester: M.Sc.-I Semester-II	**Major Elective**
Course Code: IS 561 MJ	**Course Title: Automotive Electronics**
Credit: 02	

Course Objectives:

1) To acquire knowledge and skills in electronics and computation in wider aspects of automotive domain to excel in modern industry, academia or research.
2) To comprehend, analyse, design, and create novel solutions to problems in the areas of Automotive Electronics that are viable and acceptable technically, economically and socially.

Course Contents:

Unit I	**Credits: 1**	**10 L, 5 T**
	Evolution of Automotive Electronics, Automobile Physical Configuration, Survey of Major Automotive Systems, The Engine - Engine Block, Cylinder Head, Four Stroke Cycle, Engine Control, Ignition System- Spark plug, High voltage circuit and distribution, Spark pulse generation, Ignition Timing, Diesel Engine, Drive Train - Transmission, Drive Shaft, Differential, Suspension, Brakes, Steering System. Automotive Control System applications of Sensors and Actuators - Variables to be measured, Airflow rate sensor, Strain Gauge MAP sensor, Engine Crankshaft Angular Position Sensor, Magnetic Reluctance Position Sensor, Hall effect Position Sensor, Shielded Field Sensor, Optical Crankshaft Position Sensor, Throttle Angle Sensor (TAS), Engine Coolant Temperature (ECT) Sensor, Exhaust Gas Oxygen (02/EGO) Lambda Sensors, Piezoelectric Knock Sensor.	
Unit II	**Credits: 1**	**10 L, 5 T**
	Electronic Engine Control- Exhaust Emissions, Fuel Economy, Concept of an Electronic Engine control system, Definition of General terms, Definition of Engine performance terms, Engine mapping, Effect of Air/Fuel ratio, spark timing and EGR on performance, Control Strategy, Electronic Fuel control system, Analysis of intake manifold pressure, Electronic Ignition. Introduction to Advanced driver assistance systems (ADAS), Electric vehicles Automotive Bus Systems- Classification, Applications in the vehicle, Coupling of networks, Examples of networked vehicles, Buses - CAN Bus, UN Bus, MOST Bus, Bluetooth, Flex Ray, Diagnostic Interfaces, Future trends in automotive electronics.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Ability to understand the fundamentals of vehicle systems and regulations.
2) Ability to identify various components of a vehicle and explain its functions.
3) Ability to gain fundamental knowledge to develop electronic controls for automotive subsystems.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *V.A.W. Hillier: Fundamentals of Automotive Electronics, 2005.*
2) *Tom Denton: Automobile Electronic & Electronic Systems, 2013.*
3) *Bosch TI: Emissions control technology for gasoline engines, 2016, Bentley Publishers.*
4) *Bosch Fuel Injection and Engine Management, 2016, Bentley Publishers*

Course Information	
Year and Semester: M.Sc.-I Semester-II	**Major Elective**
Course Code: IS 562 MJ	**Course Title: Industrial Networking**
Credit: 02	

Course Objectives:

1) To introduce the basic principles of networking
2) To learn industrial protocols and the way of data processed and transferred in industrial network
3) To equip the students with the relevant knowledge to understand and solve technical problems in Industrial Automation systems.

Course Contents:

Unit I	**Credits: 1**	**10 L, 5 T**
	Introduction to Industrial Communication: OSI reference model, Transmission media - Copper cable, Coaxialcables, Twisted pair cable, Connector standards, Earthing / grounding, Fiber-optic cable components, RS-232 interface, RS-485 interface, Current loop, TCP/IP, Internet layer protocols, Modbus protocol structure.	
Unit II	**Credits: 1**	**10 L, 5 T**
	Role of Networking in Automation Different Network protocols - ASI, CAN, Devicenet, Industrial Ethernet, Profibus – PA / DP / FMS, Fieldbus, HART, Physical layer and wiring rules, Safety Instrumented System (SIS) - Need for safety instrumentation- risk and risk reduction methods, hazards analysis, Process control systems and SIS, Safety Integrity Levels (SIL) and availability, Introduction to the international functional safety standard IEC61508.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Identify the need for network protocols during data exchange
2) Demonstrate the use of serial standards as required in an industrial plant environment.
3) Analyze and identify the methods of communications

Instructional design:

1) Lecture method
2) Tutorial method

3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *John Park, Steve Mackay, Edwin Wright, Practical Data Communications for Instrumentations and Control, 1st Edition ELSEVIER, 2003.*
2) *Deon Reynders, Steve Mackay, Edwin Wright, Practical Industrial Data Communications, 1st Edition ELSEVIER, 2005.*
3) *William C. Dunn, Fundamental of industrial instrumentation and process control, Mc GrawHill, 2005.*
4) *Behrouz A. Forouzan, Data Communications and Networking, 2nd Edition, Mc Grow – Hill, 2001.*

Course Information	
Year and Semester: M.Sc.-I Semester-II	**Major Elective**
Course Code: IS 563 MJP	**Course Title: Microcontroller Laboratory**
Credit: 02	

Course Objectives:

1) To expose students to the operation of microcontroller trainer kit.
2) To prepare the students to be able to solve different problems by developing different programs.
3) To develop the quality of assessing and analyzing the obtained data.

Course Contents:

List of Laboratory Experiments:

1. Applications Logical operation
2. Code conversion
3. Generating square wave on port pins.
4. Generation of square wave using timer
5. Interfacing keyboard, 7 segments displays.
6. Interfacing LCD display
7. Interfacing ADC
8. Interfacing DAC and its application

Note: The concerned faculty may conduct any other experiment based on the course apart from the given list.

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Set up programming strategies and select proper mnemonics and run their program on the training boards.
2) Practice different types of programming keeping in mind technical issues and evaluate possible causes of discrepancy in practical experimental observations in comparison.
3) Develop testing and experimental procedures on Microprocessor and Microcontroller analyze their operation under different cases.

Instructional design: Hands on Experiments

Evaluation Strategies:

1) Lab execution
2) Viva for each experiment
3) File submission

Course Information	
Year and Semester: M.Sc.-I Semester-II	**Major Elective**
Course Code: IS 564 MJP	**Course Title: Advanced Virtual Instrumentation Laboratory**
Credit: 02	

Course Objectives:

1) To introduce complete knowledge of C language.
2) To develop logics which will help them to create programs, applications in C.
3) Also, by learning the basic programming constructs they can easily switch over to any other language in future.

Course Contents:

List of Laboratory Experiments:

1. Applications of LabVIEW in analog electronics—simulation of RC circuit characteristics, diode characteristics etc.
2. Applications of LabVIEW in digital electronics—half adder, full adder, binary to decimal conversion etc.
3. Applications of LabVIEW in Sensor / Instrumentation / data acquisition lab – Design of temperature data acquisition and control system, design of LabVIEW data acquisition application of finite samples.
4. Applications of LabVIEW in process — tank level/temperature control, alarm Announciator, batch process controls etc.
5. Application of LabVIEW in Digital Signal Processing – implementation of test signals,implementation of filters.
6. Hardware interfacing with LabVIEW.

Note: The concerned faculty may conduct any other experiment based on the course apart from the given list.

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Use Lab VIEW to create data acquisition, analysis and display operations
2) Create user interfaces with charts, graph and buttons
3) Use the programming stuctures and data types that exist in Lab VIEW

Instructional design: Hands on Experiments

Evaluation Strategies:

1) Lab execution
2) Viva for each experiment
3) File submission

Course Information	
Year and Semester: M.Sc.-II Semester-I	**Major Core**
Course Code: IS 601 MJ	**Course Title: Process control**
Credit: 02	

Course Objectives:

1) The objective of the course is to make the students familiar with different process dynamics in Process industries and different control schemes generally used to get best output.
2) It also makes students aware of various analysis and design methods for multivariable systems.
3) In addition, the subject also introduces about discrete state process control and Batch process.

Course Contents:

Module-1	**Credits: 1**	**10 L, 5 T**
	Process Dynamics: Dynamic elements in a control loop, Dead time processes and smith predictor compensator. Inverse response behaviour of processes and compensator. Dynamic behaviour of first and second order systems. Interacting and non-interacting systems. Process Control Action: Elements of process control, Controller Principle, Process Characteristics, Control system parameters, discontinuous, continuous and composite controller modes/actions (P, I, D, PI, PD and PID).	
Module-2	**Credits: 1**	**10 L, 5 T**
	Process Controllers and Tuning: General features, construction and working of Pneumatic, Hydraulic and Electronic controller. Process reaction curve method, Zigler-Nichols method, Cohencoon correction for quarter amplitude, Frequency response method, Relay based tuning. Control Schemes: Feedback, feedforward, cascade, ratio, split range, selective control, adaptive control, and model-based control.	
Module-3	**Credits: 1**	**10 L, 5 T**
	Analysis of Control Loop: Steady state gain, Process gain, Valve gain, Process time constant, Variable time Constant, Transmitter gain, linearizing an equal percentage valve, Variable pressure drop. Analysis of Flow Control, Pressure Control, Liquid level Control, Temperature control, SLPC-features, faceplate, functions, MLPC- features, faceplate, functions, SLPC and MLPC comparison. Scaling: types of scaling, examples of scaling. Nonlinear Systems: Nonlinear Elements in Loop: Limiters, Dead Zones, Backlash, Dead Band Velocity Limiting, Negative Resistance, Improvement in nonlinear process performance through: Deterministic Control Loop Calculations, Calculations of the measured variable, final control element selection, cascade control design, Real time implementation issues.	
Module-4	**Credits: 1**	**10 L, 5 T**

	Multivariable Control: Block diagram analysis of multivariable systems, Interaction, Tuning of Multivariable controllers, relative gain analysis, Decoupler design. Intelligent Controllers: Step analysis method for finding first, second and multiple time constants and deadtime. Model Based controllers: Internal Model control, Smith predictor, optimal controller, Model Predictive controller, Dynamic matrix controller (DMC). Self-Tuning Controller. Fuzzy logic systems and Fuzzy controllers, Introduction, Basic Concepts of Fuzzy Logic, Fuzzy Sets, Fuzzy Relation, Fuzzy Graphs, and Fuzzy Arithmetic, Fuzzy If-Then Rules, Fuzzy Logic Applications, Neuro-Fuzzy Artificial Neural networks and ANN controller.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) The students will be able to handle any kind of process by framing it in block diagram, mathematical model and different process variables.
2) The students will be able to handle different types of controller like electronic, pneumatic and hydraulic.
3) The students will be able to implement different control schemes to various processes.
4) The students will be able to design relay logic for various processes.
5) The students will be able to understand batch process with an example.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *Donald Eckman, ―Automatic Process Control‖, Wiley Eastern Limited, 1st Edition, 1966*
2) *Thomas E Marlin, ―Process Control- Designing processes and Control Systems for Dynamic Performance‖, McGraw-Hill International Editions, 1 st Edition , 1995.*
3) *F.G.Shinskey, ―Process control Systems‖, TATA MCGRAW HILL, 3 rd Edition, 1988.*
4) *Krishna Kant, ―Computer Based Industrial Control‖, Prentice hall of India, 2nd Edition, 2010.*
5) *B Liptek, ―Instrument engineers handbook‖, Chilton book Co, 1 st Edition, 1969.*
6) *P.W.Murrill, ―Fundamentals of Process Control‖, International Society of Automation, 1 st Edition, 2000.*
7) *Stephanopoulos George, ―Chemical Process Control‖, Prentice hall of India, United States Edition, 1983.*
8) *P.W.Murrill, ―Applications concepts of Process control‖, International Society of Automation, 3rd edition, 2012.*
9) *B.Wayne bequette, ―Process Control:Modeling, Design and Simulation‖, Prentice hall of india, 1st Edition, 2002.*

Course Information	
Year and Semester: M.Sc.-II Semester-I	**Major Core**
Course Code: IS 602 MJ	**Course Title: Robotics**
Credit: 04	

Course Objectives:

1) To analyse mobile robots' control and able to understand path planning.
2) To analyse robot programming method
3) To recognize importance of case studies and will be able to select suitable robot for particular application.

Course Contents:

Module-1	**Credits: 1**	**10 L, 5 T**
	Robotics Introduction: Evolution of Robots and Robotics, Laws of Robotics, Automation and Robotics, Robot Anatomy, Classification of Robots based on co-ordinate system, Method of control, Major components of Robotics system, Fixed and flexible automation. Brief view of Robot Components of Manipulator, Controller, Sensors, Power conversion unit, Mechanical System - Robot Anatomy - Links, joints, Degrees of Freedom (DOF), arm configuration, Wrist configuration, End Effecter and its types.	
Module-2	**Credits: 1**	**10 L, 5 T**
	Transformation and Kinematics: Motion conversion - Rotary to rotary, Rotary to Linear, Linkages, Modeling of Mechanical systems - Translational, Rotational, Kinematics' chain, Lagrangian analysis of manipulator, End effectors, Control of Robotic joints. Homogeneous co-ordinates, Vector operations, Matrix operations, Co-ordinate reference frames, Homogeneous transformation and manipulator orientation, Relative points reference frames forward solutions - Link co-ordinate frames, Denavit Hartenberg (D-H) Matrix.	
Module-3	**Credits: 1**	**10 L, 5 T**
	Inverse or back solution: Problem of obtaining inverse solution, Techniques using direct and geometric approach, Motion generation - On and off-line trajectory, Velocity profile, Acceleration profile, Cartesian motion of manipulator, Joint interpolated control, Jacobian in terms of D-H matrix.	
Module-4	**Credits: 1**	**10 L, 5 T**
	Robot controller and programming: Selection of Robot controller and Robot programming - Fixed instruction sequence control, General programming language, Specific programming e.g. Microcontroller, PLC, Virtual Instrumentation control and programming etc. Artificial intelligence, Real time considerations, Event driven processes and Sensor information processes Path Planning - Co-ordination motion, Automatic programming.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) The students will be able to identify and describe the classification of robot manipulators and will be able to list manufacturers of robot
2) The students will be able to elaborate various characteristics of manipulator arms and will be able to describe various applications of machine vision in robots and will be able to select controller for machine vision.
3) students will be able to understand robot kinematics, dynamics, simulate robot inverse-kinematics, compare robot programming methods.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) R.J. Schilling - Fundamental of Robotics - Analysis and control
2) R. Jain, R. Kasturi and B. J. Shunck - Machine Vision
3) M. P. Groover - Automation, production systems and computer integrated manufacturing
4) M. T. Puranik and R. R. Ghorpade - Robotics fundamentals
5) K. S. Fu, R. c. Gonzalez, C. S. G. Lee: Robotics - Control, Sensing, Vision and Intelligence
6) R. K. Mittal, I. J. Nagrath - Robotics and Control
7) R. D. Klafter, T. A. Chmielewski, M. Negin - Robotic Engineering- An Integrated Approach
8) S. B. Niku: Introduction to Robotics - Analysis, Systems, Applications.

Course Information	
Year and Semester: M.Sc.-II Semester-III	**Major Core**
Course Code: IS 603 MJ	**Course Title: Industrial Automation**
Credit: 02	

Course Objectives:

1) Understand automation technologies and identify advantages, limitations and applications of the same.
2) Develop ability to recognize, articulate and solve industrial problems using automation technologies.

Course Contents:

Unit I	**Credits: 1**	**15 L, 5 T**
	Automation Fundamentals and PLC Automation hierarchy and hierarchical control, Control system architecture Programmable Logic Controller Hardware - Evolution of PLC, definition, architecture, working, types, specifications and ratings, wiring diagrams, Components – timer and counters, I/O modules, memory organization, I/O addressing, hardware to software interface, Logic Ladder Diagram, PLC Programming methods as per IEC 61131, Relay logic diagram, Ladder programming, File handling, Monitoring and Control, PLC Programming and Application.	
Unit II	**Credits: 1**	**5 L, 5 T**
	DCS and SCADA Distributed Control System (DCS) - Introduction, Flow sheet symbols, Architecture, Specifications, Supervisory computer functions and Algorithm, Computer displays, Control Techniques and Strategies, Computer interface with DCS, System integration with PLCs, Computer - HMI, DCS programming Supervisory Control and Data Acquisition (SCADA) - Introduction, Elements of SCADA, MTU, RTU, Real Time system communications in SCADA, GUI development using SCADA software	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Understand the basics of PLC programming.
2) Understand the different parameters of PLC.
3) Design different process control applications through ladder logic.
4) Explain different functions of PLC.
5) Build and experiment with PLC based SCADA systems for various industrial applications.
6) Implement HMI, distributed control system and Industry standard 4.0

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) Samuel M. Herb - Understanding Distributed Processor Systems for Control

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2) *Thomas Hughes - Programmable Logic Controller*
3) *Stuart A. Boyer - SCADA supervisory control and data acquisition*
4) *John. W. Webb, Ronald A Reis - Programmable Logic Controllers - Principles and Applications*

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Course Information	
Year and Semester: M.Sc.-II Semester-I	**Major Core**
Course Code: IS 604 MJP	**Course Title: Process Control and Industrial Automation Laboratory**
Credit: 04	

Course Objectives:

1) To control temperature, pressure, flow, level using PC with the help of different control modes.
2) To provide experience on control of various industrial processes using different control paradigms
3) To provide experience in development of virtual instrumentation systems for industry applications

Course Contents:

List of Experiments:

1) Study of Pneumatic components and circuits
2) Study of Dead weight tester and testing of Pressure gauges
3) Study of SCADA - Indusoft 6.0
4) Interfacing SCADA with Modbus 485
5) Study of PLC- HMI Trainer - Vijeo Designer HMI software
6) Study of Programmable Logic Controller - Mitshubhishi FX series
7) Application on PLC trainer on GX Developer Software - Mitshubishi PLC
8) Study of Programmable Logic Controller - Allen Bradly Micrologic 1400
9) Application on PLC trainer on RS Logix Software - Allen Bradly PLC
10) Study of AUTOMATION STUDIO software
11) Study of Programmable Logic Controller - Fatek FBs series
12) Application on PLC trainer on WinProladder Software - Fatek PLC
13) And / or experiments of similar kind

Note: The concerned faculty may conduct any other experiment based on the course apart from the given list.

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Able to verify operation of temperature, level, flow, pressure transmitter.
2) Familiarizing various PLC software and Ladder Logic
3) Familiarizing GUI software like SCADA and HMI
4) Implementing various control systems.

Instructional design: Hands on Experiments

Evaluation Strategies:

1) Lab execution
2) Viva for each experiment
3) File submission

Course Information	
Year and Semester: M.Sc.-II Semester-I	**Major Core**
Course Code: IS 605 RP	**Course Title: Research Project-I**
Credit: 04	

The aim of the course is to give the students an opportunity to perform a research project within industrial environment under supervision according to an individual study plan, to summarize the results in a research report and present the results of the project.

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

1) apply experimental methods to solve a given scientific task,
2) perform a research project according to an individual study plan,
3) show independence, critical and creative thinking,
4) document results by writing a research report,
5) present and discuss the research results with colleagues and mentors

Course Information	
Year and Semester: M.Sc.-II Semester-I	**Major Elective**
Course Code: IS 610 MJ	**Course Title: Process Instrumentation**
Credit: 02	

Course Objectives:

1) To define the use of mechanical components and control panels.
2) To apply and analyse instrumentation & controls.
3) To learn the piping and Instrumentation diagram and its different applications.

Course Contents:

Module-1	**Credits: 1**	**10 L, 5 T**
	Need of transmitter (concept of field area and control room area), need for standardization of signals current, voltage and pressure signal standards, concept of live, dead zero, two and four wire transmitters. Electronic Capacitive Differential Pressure Transmitter: Types, installation, calibration setup, application of DPT for level and flow measurement, zero elevation and suppression, manifold. SMART: Comparison with conventional transmitter, block schematic, specifications. Converters: Difference between converter and transmitter, current to pressure converter, pressure to current converter.	
Module-2	**Credits: 1**	**10 L, 5 T**
	Piping and Instrumentation Diagram (P&ID): Examples of ISA Instrumentation diagramming symbols, Examples of SAMA Instrumentation diagramming symbols, Piping and Instrumentation diagramming. Engineering fluid diagrams. Electrical diagrams. Electronic diagrams. Logic diagrams. DCS diagrams. Construction diagrams. Format. Equipment. Instrumentation and Controls. Application of P&I diagrams in HAZOPS and Risk analysis, SIS analysis.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Define the use of mechanical components and control panels
2) Develop electrical wiring diagrams, P&ID, PFD, Fluid diagrams.
3) Develop and represent process control loops using standard ISA S5.1.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *C. D. Johnson, "Process control and Instrument technology", Tata McGraw Hill Publications.*
2) *N.A. Anderson, Boca Ratan, "Instrumentation for Process measurement and control", Radnor Pennsylvania, CRC Press.*

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3) *B. G. Liptak, "Process Control", Instrument Engineering Hand book CRC Press.*
4) *"Tuning of industrial control systems", ISA. 3. "Control valve Handbook", ISA.*

Course Information	
Year and Semester: M.Sc-II Semester-I	**Major Elective**
Course Code: IS 611 MJ	**Course Title: Optical Instrumentation**
Credit: 02	

Course Objectives:

1) To strengthen the basic concepts, principles of optical grating, filters, optical fibre, lasers etc
2) To develop the skill related to instrumentation of optical systems.

Course Contents:

Module-1	**Credits: 1**	**10 L, 5 T**
	Optical components Filters: absorption filters and interference filter, gratings- equation of diffraction grating, resolving power, concave grating, volume diffraction grating, holographic grating. Lenses, Polarizer and Beam splitters, Monochromator Optical instruments: Eye, telescopes, microscopes, optical projection systems, cameras, basic principles of Holography, OTDR, polarimeter. Optical Fiber and Their properties: Ray theory, wave guiding principles, Theory of optical wave propagation, Types and classification of optical fibers, optical fiber mode, single mode fiber, special fiber, fiber materials, fiber fabrication, transmission characteristics of fiber, absorption losses, scattering losses, dispersion, polarization, nonlinear phenomena Optical Fiber Measurements: Measurement of attenuation, dispersion, refractive index profile of fiber and cut off wavelength, numerical aperture, OTDR, Measurement of flow, pressure, Temperature, displacement, acceleration and fluid level vibration measurement. Fiber Optic Sensing Principles and Techniques: Classification and principle of fiber optic sensors, fiber grating and fiber Bragg grating technology and distributed optical fiber sensing.	
Module-2	**Credits: 1**	**10 L, 5 T**
	Laser Fundamentals: Properties of laser, Laser modes- axial and transverse, single mode operation. Frequency stabilization. Mode locking, Mode hopping, Q-switching techniques. Laser Types: Doped insulator lasers, Semiconductor lasers, Gas lasers, Liquid Dye lasers. Laser safety: Biological effects, safety standards, risk of exposure, laser hazard classification and assessment, laser safety system, safe industrial laser laboratory, laser eye protection, laser accidents. Applications of Laser: Biomedical, process, etc.	

Learning Outcomes: Upon completion of the course, the student will be able to,

5) have understood the fundamental concepts of optical components.
6) be prepared to undertake advanced topics in optical instrumentation

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

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Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1. *J. Wilson, —Optoelectronics, Prentice-Hall of India.3 rd Edition, 1988.*
2. *Electro-Optical Instrumentation: Sensing and Measuring with Lasers, Pearson Education, Inc., 1 st Edition, 2004.*
3. *Charles M. Vest, —Holographic Interferometry, John Wiley & sons, 1 st Edition, 1979.*
4. *Joseph T Verdeyen, —Laser electronics, Prentice Hall of India , 3 rd Edition, 1995.*
5. *J.M. Senior, —Optical fiber communications principles and practice, Prentice Hall of India, 3 rd Edition, 2010.*
6. *H. Zanger and C. Zanger, —Fiber optics - communication and other application, McGraw Hill, 1 st Edition, 1992.*
7. *Kao C.K., —Optical fiber systems, Technology, Design & Application, McGraw Hill, 1 st Edition, 1982.*
8. *Allen H. Cherin, —Introduction to optical fibers, McGraw Hill., 1 st Edition, 1983.*
9. *S.C.Gupta, —Text book on optical fiber Communication & other application, Prentice hall of India, 2 nd Edition, 2012.*
10. *Dr. S. Kumar, —Basics of Remote Sensing & GIS, Laxmi publications, 1st edition, 2005.*

Course Information	
Year and Semester: M.Sc-I Semester-III	**Major Elective**
Course Code: IS 612 MJ	**Course Title: Analytical Instrumentation**
Credit: 02	

Course Objectives:

1) To strengthen the basic concepts, principles of spectroscopy, microscopy etc
2) To develop the skill related to instrumentation of analytical techniques

Course Contents:

Module-1	**Credits: 1**	**10 L, 5 T**
	Introduction to Chemical instrumental analysis, advantages over classical methods, classification: Spectral, electro analytical and separative methods, Interaction of radiation with matter, Laws of photometry (Beer and Lambert's law), Deviation from Beer‘s law, working of filters, prism and grating monochromators, concept of design of analytical instrument. Introduction to Electroanalytical methods, potentiometry, voltametry, coulometry Spectrometric Methods A. Laws of Photometry, Instrument components, UV-visible instrument component, photocolorimeters, single and double beam instruments, various types of UV-visible spectrophotometers. B. Atomic absorption spectrophotometer: Principle, working, hollow cathode lamp, atomizer, back-ground correction. C. IR spectroscopy: Principle, IR sources, IR detectors, dispersive and Fourier Transform IR spectroscopy. D. Atomic Emission Spectroscopy: Principle, types, Flame photometer, DC arc and AC arc excitation, plasma excitation.	
Module-2	**Credits: 1**	**10 L, 5 T**
	Colorimeters, online colorimeter for process applications, turbidity meter, UV-Visible spectrophotometers and its types with its optical system design, IR spectrophotometers, Xray spectroscopy Emission Spectra, Quantitative measurements, Flame Photometer and its applications , concept of design atomic absorption spectrophotometer, spectrum interpretation, interferences, applications of atomic absorption spectrophotometer, X-ray spectrometry: Instrumentation for X-ray spectrometry, X-ray diffractometer: Bragg‘s law, Auger emission spectroscopy, Electron spectroscopy for chemical analysis(ESCA). B. Radiation detectors: Ionisation chamber, Geiger-Muller counter, proportional counter, scintillation counters, C. Refractometry: Principle, Abbe and Differential refractometer.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) have understood the fundamental concepts of optical components.
2) be prepared to undertake advanced topics in optical instrumentation

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminar

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Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *H. H. Willard, L. L. Merritt, J.A. Dean and Frank A. Settle, ―Instrumental Methods of Analysis‖, CBS Publishers & Distributors, New Delhi, 7 th sub Edition, 1988.*
2) *Galen W. Ewing, ―Instrumental Methods of Chemical Analysis‖, McGraw-Hill Book Company, 5 th edition, 1985.*
3) *Robert D. Braun, ―Introduction to Instrumental Analysis‖, McGraw-Hill Book Company, 1st Edition, 1986.*
4) *D. A. Skoog, F. J. Holler, Stanlay cronch, ―Principles of Instrumental Analysis,‖ Thomson brooks-cole publications, 6th Edition, 2006.*

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Course Information	
Year and Semester: M.Sc.-I Semester-I	**Major Elective**
Course Code: IS 613 MJP	**Course Title: Process Instrumentation Laboratory**
Credit: 02	

Course Objectives:

1) To design process control system components to meet desired needs within realistic constraints.
2) To use the techniques, skills and tools to identify formulate and solve engineering problems.

Course Contents:

List of Experiments:

1. To design data model from feed to process and detail engineering, retrofitting and maintenance.
2. To produce P&I Diagrams using software packages
3. Development of Process flow diagram
4. Instrumentation and circuit diagram creation

Note: The concerned faculty may conduct any other experiment based on the course apart from the given list.

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Demonstrate practical knowledge, communication and team skills, by constructing models for real time applications
2) Develop electrical wiring diagrams, P&ID, PFD, Fluid diagrams.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

Course Information	
Year and Semester: M.Sc-I Semester-III	**Major Elective**
Course Code: IS 614 MJP	**Course Title: Special Instrumentation Laboratory**
Credit: 02	

Course Objectives:

1) To give hands on training of various optical, spectroscopy and microscopy techniques
2) To develop the skill related to instrumentation of optical and analytical techniques

Course Contents:

List of Experiments:

1. LED radiation pattern
2. Find diameter and divergence of laser diode.
3. Find wavelength of laser diode using grating and a slit
4. To study the characteristics of optical transducers: PIN photodiode, phototransistor, photoconductive cell and photovoltaic cell.
5. Laser beam wavelength, diameter and divergence
6. Study of optical fiber kit
7. To find out transmittance and absorbance of a given sample using colorimeter
8. Qualitative and quantitative analysis using UV-Visible spectrophotometer
9. Study on fourier transform infrared spectroscopy
10. Study on X-ray Diffractometer
11. Study on field emission scanning electron microscopy
12. Study on transmission electron Microscopy

Note: The concerned faculty may conduct any other experiment based on the course apart from the given list.

Learning Outcomes: Upon completion of the course, the student will be able to,

1) understood the fundamental instrumentation of optical and analytical components.
2) be prepared to undertake advanced topics in optical and analytical instrumentation

Instructional design: Hands on Experiments

Evaluation Strategies:

1) Lab execution
2) Viva for each experiment
3) File submission

Course Information	
Year and Semester: M.Sc.-II Semester-II	**Major Core**
Course Code: IS 651 MJ	**Course Title: Machine Intelligence**
Credit: 04	

Course Objectives:

1) To understand the basic theory underlying machine learning
2) To comprehend a wide variety of learning algorithms

Course Contents:

Module-1	**Credits: 1**	**10 L, 5 T**
	Supervised Learning – line fitting, residuals, correlation; line fitting by least squares regression; outliers in linear regression; Inference for linear regression; Multiple regression; Model selection; Logistic regression, Nearest Neighbor Classification – Knn; Naïve Bayes Classification – Bayesian methods, Bayes algorithm; Classification using decision trees and learners.	
Module-2	**Credits: 1**	**10 L, 5 T**
	Regularization: The Problem of Over fitting, Cost Function, Regularized Linear Regression. Neural Networks representation and learning: Introduction to Neural networks, architecture, applications of Neural networks, Learning, back propagation algorithm, learn parameters for a neural network, implementation. Support Vector Machines: Support vector machines learning algorithm for classification, Optimization Objective, Large Margin Intuition, applications of Support vector machines, implementation.	
Module-3	**Credits: 1**	**10 L, 5 T**
	Learning, Forms of learning, Statistical methods: naive-Bayes, nearest neighbor, kernel, neural network models, noise and over fitting., Decision trees, inductive learning, Clustering - basic agglomerative, divisive algorithms based on similarity/dissimilarity measures, Applications to NLP, vision, robotics, etc.	
Module-4	**Credits: 1**	**10 L, 5 T**
	Unsupervised Clustering - K-means clustering; Evaluation of model performance – Confusion matrices, sensitivity, specificity, kappa statistics, precision, recall, F-measure, ROC curve etc.; Methods of cross-validation, Bootstrapping; Meta-learning through ensemble approach – Bagging, boosting, Random Forests strategies. Classifier performance measurement metrics – Training & Testing strategies – Resubstitution, Hold-out, Cross validation, Bootstrap; Confusion matrix, Performance measures – Accuracy, Error rate, Sensitivity, Specificity, Precision, Recall, F-Measure, Receiver Operating Characteristics curves.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Apply ML algorithms for classification
2) Be able to formulate machine learning problems corresponding to different applications

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

3) Descriptive written examinations
4) Assignments

REFERENCES:

1) *S. Rogers and M. Girolami, A First Course in Machine Learning, 2nd edition, Chapman & Hall/CRC 2016, ISBN: 9781498738484.*
2) *K. Murphy, "Machine Learning: A Probabilistic Perspective" MIT Press 2012.*
3) *D. Barber, Bayesian Reasoning and Machine Learning Cambridge University Press 2012.*
4) *C. Bishop, Pattern Recognition and Machine Learning, Springer 2011.*
5) *R. Duda, P. Hart, D. Stork, Pattern Recognition (2nd Edition) Wiley 2000.*
6) *Goodfellow, Bengio and Courville, "Deep learning". Available for free on the web. In print from MIT press on Amazon.*
7) *Artificial Intelligence, Elaine Rich & Kevin Knight, TMH Publication*
8) *Introduction to Turbo PROLOG, Carl Townsend, BPB Publication*
9) *Introduction to AI & Expert Systems, Dan W. Patterson, PHI Publication*

Course Information	
Year and Semester: M.Sc.-II Semester-II	**Major Core**
Course Code: IS 652 MJ	**Course Title: Elements of Mechanical Design**
Credit: 04	

Course Objectives:

1) Enable students to attain the basic knowledge required to understand, analyze, design and select machine elements required in transmission systems.
2) Develop a holistic design approach to find out pragmatic solutions to realistic domestic and industrial problems

Course Contents:

Unit I	**Credits: 1**	**10 L, 5 T**
	Introduction: General considerations in the design of Engineering Materials and their properties – selection –Manufacturing consideration in design.BIS codes of steels. DESIGN FOR STATIC STRENGTH: Simple stresses – Combined stresses – Torsional and Bending stresses – Impact stresses – Stress strain relation – Various theories of failure – Factor of safety – Design for strength and rigidity – preferred numbers. The concept of stiffness in tension, bending, torsion and combined situations.	
Unit II	**Credits: 1**	**10 L, 5 T**
	Riveted, Welded and Bolted Joints: Riveted joints- Methods of failure of riveted joints-strength equations- efficiency of riveted joints-eccentrically loaded riveted joints. Welded joints -Design of fillet welds-axial loads-circular fillet welds under bending, torsion. Welded joints under eccentric loading. Bolted joints – Design of bolts with pre-stresses – Design of joints under eccentric loading – locking devices – bolts of uniform strength.	
Unit III	**Credits: 2**	**15 L, 15 T**
	Basic drawing and modifying techniques for drafting and technical drawing, using AutoCAD or similar software to create drawings that can be used to build and real objects both mechanical and architectural.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Ability to apply Knowledge of Engineering Graphics, Machine Drawing, Basic Science and Basic Applied Mathematics, Basic Machining Processes, Material Science, for design procedures of Mechanical components use in Industries and incorporated in Machine Design.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1. *Black P. H. and O. E. Adam, "Machine Design", Tata McGraw Hill Publication. Co. Ltd, New Delhi*
2. *Burghardt M. D., "Introduction to engineering design and Problem Solving", McGraw Hill Publications*
3. *K. Lingaiah, "Machine Design Data book", Tata McGraw Hill Publication. Co. Ltd, New Delhi*
4. *Alfred Hall, Alfred Holowenko, Herman Laughlin, S. Somani, "Machine Design", Tata McGraw Hill Publication. Co. Ltd, New Delhi*

Course Information	
Year and Semester: M.Sc.-II Semester-II	**Major Elective**
Course Code: IS 653 MJP	**Course Title: Industry 4.0 Laboratory**
Credit: 04	

Course Objectives:

1) To study IOT, their characteristics of components and basic awareness of Arduino/ Raspberry Pi.
2) Make use of Data sets in implementing the machine learning algorithms
3) Implement the machine learning concepts and algorithms in any suitable language of choice.

Course Contents:

List of Experiments:

1. Arduino / Raspberry Pi interface Sensor
2. Arduino / Raspberry Pi interface to to GSM module
3. Arduino / Raspberry Pi interface to Wi-fi module
4. Arduino / Raspberry Pi interface Bluetooth module
5. Cloud interfacing and programming like Thingspeak
6. Sensor data acquisition on Mobile / Developing Application with Django
7. To design shapes using 3D Printer
8. Implement Simple and Multiple Linear Regression Models.
9. Develop Logistic Regression Model for a given dataset.
10. Develop Decision Tree Classification model for a given dataset and use it to classify a new sample.
11. Build KNN Classification model for a given dataset.
12. Write a program to implement K-Means clustering Algorithm.
13. Build Artificial Neural Network model with back propagation on a given dataset.

Note: The concerned faculty may conduct any other experiment based on the course apart from the given list.

Learning Outcomes:

1) Students will be able to understand IOT, Arduino/ Raspberry Pi, and also able to install software setup of Arduino/ Raspberry Pi.
2) Understand the implementation procedures for the machine learning algorithms
3) Apply appropriate data sets to the Machine Learning algorithms
4) Identify and apply Machine Learning algorithms to solve real world problems

Instructional design: Hands on Experiments

Evaluation Strategies:

1) Lab execution

2) Viva for each experiment
3) File submission

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Course Information	
Year and Semester: M.Sc.-II Semester-II	**Major Core**
Course Code: IS 654 RP	**Course Title: Research Project-II**
Credit: 06	

The aim of the course is to give the students an opportunity to perform a research project within industrial environment under supervision according to an individual study plan, to summarize the results in a research report and present the results of the project.

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

1) apply experimental methods to solve a given scientific task,
2) perform a research project according to an individual study plan,
3) show independence, critical and creative thinking,
4) document results by writing a research report,
5) present and discuss the research results with colleagues and mentors

Course Information	
Year and Semester: M.Sc.-II Semester-II	**Major Elective**
Course Code: IS 660 MJ	**Course Title: Instrumentation Project Management**
Credit: 02	

Course Objectives:

1) To let student, know the role and responsibilities in the project organization team
2) The tools of Project Planning and scheduling and planning
3) Plan and prepare the documents/activities required during different phases of the project.
4) The standards need to be used in the project development.

Course Contents:

Unit I	**Credits: 1**	**10 L, 5 T**
	Introduction to project management, Definition of project purpose - Scope, time, quality and organization structure. Basic and detailed engineering: Degree of automation, Project S curves, manpower considerations,inter-department and inter-organization interactions, Multi agency interaction. Types of projects and types ofcontracts e.g. EPC, BOOT etc. Controlling, directing, project authority, responsibility, accountability, interpersonal influences and standard communication formats, project reviews. project planning and scheduling, life projectengineering and management cycle phases, the statement of work (SOW), projects specifications, bar charts,milestones, schedules, work breakdown structures, cost breakdown structures and planning cycle.	
Unit II	**Credits: 1**	**10 L, 5 T**
	Project engineering documents and drawing: Process flow sheets, Mechanical flow sheets, Instrument index sheets, loop wiring diagram, panel drawings and specifications, plot plans, installation details, special drawings, purchase requisition, other documents. Information required: Process information, Instrument specifications and standards, piping specifications, Electrical specifications, bid documents, project procedure, project schedule, Equipment Information, Vendor drawing Work coordination: Project manager, process engineer, equipment engineer, Piping design supervisor, Structural, architectural and civil, Electrical, purchasing and expediting and others Planning hints and Project check list.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Apply selection criteria and select an appropriate project from different options.
2) The tools of Project Planning and scheduling and planning
3) The standards need to be used in the project development understand the fundamentals of vehicle systems and regulations.

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1. *Management systems by John Bacon (ISA).*
2. *Project Management A System Approach to Planning, Scheduling and Controlling by Harold Kerzner (Van Nostrand Reinhold Publishing).*
3. *Applied instrumentation in process industries by Andrew & Williams (Gulf Publishing).*

Course Information	
Year and Semester: M.Sc.-II Semester-II	**Major Elective**
Course Code: IS 661 MJ	**Course Title: Intellectual Property Rights**
Credit: 02	

Course Objectives:

1) The main objective of the IPR is to make the students aware of their rights for the protection of their invention done in their project work.
2) To get registration in our country and foreign countries of their invention, designs and thesis or theory written by the students during their project work and for this they must have knowledge of patents, copy right, trademarks, designs and information Technology Act.

Course Contents:

Module-1	**Credits: 1**	**10 L , 5 T**
	Knowledge, Innovation and Entrepreneurship, Knowledge – characteristics and role in economic growth, Tacit and codified knowledge, Knowledge as public good and 'market failure', Market for knowledge, Incentives for creation of new knowledge, Fundamentals of Innovation, Creativity and Problem Solving, Types and sources of innovation, Design Thinking, Innovation ecosystems, Capturing value from innovation, The innovative organization, Innovation opportunities identification Fundamentals of, Discovery of Entrepreneurial Opportunities, Stakeholders, relationships, networks and resources. A description of the business - The market analysis (SWOT analysis, industry background, competitor analysis, market analysis) based on primary and secondary resources - The strategic plan - The financial plan, Developing and refining product-market fit, Marketing research in an environment of innovation and dynamism, gaining marketing advantages in spite of limited marketing resources, Tools, processes, the Business Model Canvas, Building and communicating the case, how new ventures evolve.	
Module-2	**Credits: 1**	**10 L , 5 T**
	Intellectual Property Rights: An Introduction, Appropriation of knowledge: knowledge monopoly and its consequences, PreIPR system of protection: Secrecy/Trade guilds/Cartel. IPR: Consequentiality, right based justification and economic justification, Evolution of IP Statutes – Origin and Internationalization, International organizations and Treaties (preTRIPs era): Paris Convention, Berne Convention, Rome convention, IPIC Treaty, Budapest Treaty. CBD, UPOV convention. WIPO, GATT, FAO, UNCTAD, Basic forms of IPRs: Patent, copyright, trademark, industrial design, Patents and Patent information Need for Patent, Patentable and Non-Patentable Invention, Types of Patent application in India, PCT System, Guidelines for Registration of Patent, Patent filing, Opposition and Grant.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) The students once they complete their academic projects, they get awareness of acquiring the patent
2) They also learn to have copyright for their innovative works.
3) They also get the knowledge of plagiarism in their innovations which can be questioned legally.

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Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1. *Csikszentmihalyi, M., "Creativity: Flow and the psychology of discovery and invention", Harper Perennial. Michalko, M., "Thinkertoys a handbook of creative-thinking techniques" Ten Speed Press.*
2. *Pink, D. H., "A whole new mind. Why right-brainers will rule the future", The Berkley Publishing Group.*
3. *Prabuddha Ganguli "Intellectual Property Rights" Tata McGraw Hill.*
4. *R. Radhakrishnan, S. Balasubramanian, "Intellectual Property Rights: Text and Cases", Excel Books.*
5. *Richard Stim, "Intellectual Property: Patents, Trademarks and Copyrights", Cengage Learning*

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Course Information	
Year and Semester: M.Sc.-II Semester-II	**Major Elective**
Course Code: IS 662 MJP	**Course Title: Power Plant Instrumentation**
Credit: 02	

Course Objectives:

1) To know the fundamentals of power plant to power generation, transmission and distribution.
2) To analyse the impact of power plant operation on environmental and social context.
3) To know the conventional & non-conventional energy power plants

Course Contents:

Module-1	**Credits: 1**	**10 L, 5 T**
	Introduction: Energy sources, their availability, worldwide energy production, energy scenario of India. Introduction to Power generation, load curve, load factor. Classification of energy generation resources. Thermal Power Plant: Method of power generation, layout and energy conversion process. Types of Turbines & their control. Types of Boilers and their control. Types of Generators and their control, Condensers. Types of Pumps and Fans, variable speed pumps and Fans, Material handling system, study of all loops-water, steam, fuel etc. Schematics of Gas turbine and Diesel power plant. Application of DCS in power plants. Solar thermal energy system: Principle, solar collector and its types, solar concentrator and its types safety. Introduction to Modern Biomass, Bio-fuels, Geothermal energy, Tidal energy and Ocean thermal energy.	
Module-2	**Credits: 1**	**10 L, 5 T**
	Nuclear Power Plant: Concept of energy generation from nuclear fission, control of chain reaction. Schematics of Nuclear power plant, types of reactors, reactor control, safety measures. Comparison of different types of power plant: thermal power plant, hydroelectric power plant, wind, solar, nuclear power plant on the basis of: Performance, efficiency, site selection, Economics-capital and running, safety. Introduction to Hybrid Power Generation concept. Non-conventional Energy Resources: Wind Energy: Power in wind, Conversion of wind power, Aerodynamics of wind turbine, types of wind turbine and their modes of operation, power control of wind turbines, Betz limit, Pitch & Yaw control, wind mill, wind pumps, wind farms, different generator protections, safety. Solar Energy: Solar resource, solar energy conversion systems. Solar PV technology: Block diagram of PV system, advantages and limitations.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Develop Instrumentation and control required for the power plant.
2) Select suitable sensors and automation for monitoring and safety purpose
3) Understand the importance of power plant and its instrumentation for Environment protection purpose

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1) *P.K.Nag, —Power plant engineering‖, McGraw Hill, 4 th Edition, 2014.*
2) *K.Krishnaswamy, M. Ponni Bala, —Power Plant Instrumentation‖, Prentice Hall India, 1st Edition, 2011. 3. R.K.Rajput, —A Textbook of Power Plant Engineering‖, Laxmi Publications, 1st Edition, 2010.*
3) *Domkundwar, —Power Plant Engg.‖, Dhanpat Rai & Co. Pvt. Ltd, 1st Edition.*
4) *B. H. Khan, —Non-conventional energy resources‖, McGraw Hill, New Delhi, 2 nd Edition,2009.*
5) *Chetan Singh Solanki, —Renewable energy Technology‖, Prentice Hall Publication, 1st Edition, 2008.*
6) *S. P. Sukhatme, —Solar Energy‖, Tata McGraw Hill, New Delhi, 2nd Revised Edition,1997.*
7) *G. D. Rai, —Nonconventional energy sources‖ Khanna Publication, 1st Edition, 2004.*
8) *Dickinson & cheremisinoff, —Solar Energy Technology handbook vol I & II‖ Marcek Dekker Inc. 1 st Edition, 1980.*

Course Information	
Year and Semester: M.Sc.-II Semester-II	**Major Elective**
Course Code: IS 663 MJP	**Course Title: Biomedical Instrumentation**
Credit: 02	

Course Objectives:

1) To introduce a fundamental of transducers as applicable to physiology
2) To explore the human body parameter measurements setups
3) To make the students understand the basic concepts of forensic techniques.
4) To give basic ideas about how multimedia evidences are useful in crime investigation.

Course Contents:

Module-1	**Credits: 1**	**10 L , 5 T**
	Bio-Potential and Measurement: Structure of Cell, Origin of Bio-potential, electrical activity of cell their characteristic and specifications. Measurement of RMP and AP. Electrode Electrolyte interface and types of bio-potential electrodes. Cardiovascular Measurement: Blood Pressure- Direct and Indirect types, Blood Flow Electromagnetic and Ultrasonic types, Blood Volume- Types of Plethysmography. (Impedance, Capacitive and Photoelectric), Cardiac Output- Flicks method, Dye-dilution and Thermo-dilution type, Heart sound measurement. Life support Instruments: Pacemaker- Types of Pacemaker, mode of pacing and its application, Defibrillator- AC and DC Defibrillators and their application, Heart Lung machine and its application during surgery, Haemodialysis system and the precautions to be taken during dialysis.	
Module-2	**Credits: 1**	**10 L , 5 T**
	Physiological Systems and Related Measurement: Respiratory system- Physiology of respiration and measurements of respiratory related parameters. Cardiovascular system: Structure of Heart, Electrical and Mechanical activity of Heart, ECG measurements and Cardiac arrhythmias. Nervous system- Nerve cell, neuronal communication, nerve-muscle physiology, CNS, PNS. Generation of EEG and its measurement. Normal and abnormal EEG, evoked potential and epilepsy. Muscular system- Generation of EMG signal, specification and measurement. Design of ECG amplifier. Imaging Techniques: X-Ray- Generation, X-ray tube and its control, X-ray machine and its application, CT Scan- CT Number, Block Diagram, scanning system and application, Ultrasound Imaging- Modes of scanning and their application, MRI- Concepts and image generation, block diagram and its application.	

Learning Outcomes: Upon completion of the course, the student will be able to,

1) Understand the physiology of biomedical system.
2) Measure biomedical and physiological information
3) Discuss the application of Electronics in diagnostics and therapeutic area

Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

Evaluation Strategies:

1) Descriptive written examinations
2) Assignments

REFERENCES:

1. *J. J. Carr and J. M. Brown - Introduction to Biomedical Equipment Technology*
2. *J. G. Webster - Medical Instrumentation - Application and Design*
3. *L. Veeerakumari - Bioinstrumentation*
4. *R. S. Khandpur - Handbook of Biomedical Instrumentation*
5. *S. Chatterjee, A. Miller - Biomedical Instrumentation Systems*
6. *L. A. Geddes, L. E. Baker - Principles of Applied Biomedical Instrumentation*
7. *John E Hall - Guyton's Medical Physiology*
8. *Richard Aston - Principles of Biomedical Instrumentation and Measurements*
9. *Harry.N. Norton - Biomedical Sensors- Fundamentals and application*

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