Syllabus for M. Sc. Instrumentation Science (Choice based Credit System)

Savitribai Phule Pune University
Formerly known as University of Pune

Department of Instrumentation Science

PROSPECTUS

for
M. Sc. Instrumentation Science (Choice based Credit System)

Savitribai Phule Pune University

Pune 411007.

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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 fulfill these goals, Savitribai Phule Pune University instituted Department of Instrumentation Science and introduced M. Sc. Instrumentation Science course. This is an industry / R & D oriented professional course. It incorporates about 2 month's practical training in an industry / R & D organization and a project therein of four months. This gives exposure to the student to day-to-day life environment.

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**

SEMESTER - I:	3 Theory Courses	4 Credits each
	1 Theory Course	2 Credits
	2 Laboratory Courses	4 Credits each
SEMESTER - II:	3 Theory Courses	4 Credits each
	1 Theory Course	2 Credits
	2 Laboratory Courses	4 Credits each
SEMESTER - III:	3 Theory Courses	4 Credits each
	1 Theory Course	2 Credits
	2 Laboratory Courses	4 Credits each
	Industrial Training	**4 Credits**
SEMESTER - IV:	1 Theory Course	2 Credits
	Industrial Project	**8 Credits**

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SEMESTER - I:

Paper No	Title	Core Credits	Optional Credits
IS 1 UT 01	Integrated Circuits for Instrumentations	4	
IS 1 UT 02	Power Electronics	4	
IS 1 UT 03	Open Course *		4
IS 1 UT 04	Mathematical Methods for Instrumentations *		2
IS 1 UP 01	Analog and Digital Electronic Laboratory	4	
IS 1 UP 02	C programming Laboratory	4	

SEMESTER - II:

IS 2 UT 05	Sensors, Transducers and Signal Conditioning	4	
IS 2 UT 06	Microcontroller and Embedded Systems	4	
IS 2 UTE XX	Elective Course *		4
IS 2 UT 07	Test and Measuring Instruments *		2
IS 2 UP 03	Application Software Practices Laboratory	4	
IS 2 UP 04	Sensors, Signal Conditioning and Microcontroller Laboratory	4	

SEMESTER - III:

IS 3 UT 08	Optical Instrumentation and Photonics	4	
IS 3 UT 09	Process and Feedback control	4	
IS 3 UT 10	Industrial Automation *		4
IS 3 UT 11	Analytical Instrumentation *		2
IS 3 UP 05	Industrial Training #	4	
IS 3 UP 06	Special Instrumentation Laboratory	4	
IS 3 UP 07	Process Control and Industrial Automation Laboratory	4	

Industrial training is for the period of about 2 months during summer vacation, in an Industry / R & D organization nearby Pune (within PMC and PCMC limits). Department assists students for selecting industry for the training.

SEMESTER – IV:

IS 4 UT 12	Industrial Product Design *		2
IS 4 UP 08	Industrial Project	8	

*** Note: These are optional courses. Student can opt for equivalent courses in respective semester from other Departments in consultation with Departmental Committee and concerned Head of Department.**

ELECTIVE COURSES (UTE XX): Following alternative courses will be offered to students in Semester II depending upon availability of the staff and facilities. The detailed syllabi can be made available if required / asked for.

IS 2 UTE 13	Robotics
IS 2 UTE 14	Biomedical Instrumentation

IS 2 UTE 15	Instrumentation For Environmental Engineering
IS 2 UTE 16	Power Plant Instrumentation
IS 2 UTE 17	Agro based Instrumentation
IS 2 UTE 18	Solar cells and Photo Chemical Systems
IS 2 UTE 19	Digital Communication

Rules of Credit System for M. Sc. (Instrumentation Science)

1. M. Sc. Instrumentation science course has average 6 modular courses per semester.

2. For earning the degree of M. Sc. Instrumentation Science, every student will have to obtain 80 credits of which a minimum of 75% of the credits will have to be earned from the core / compulsory courses from the syllabi as defined by the Department of Instrumentation Science.

3. A student can opt for remaining 25% of the credits form the courses offered by other departments with proper cross matching in respective semester. This cross matching can be carried out in consultation with the Departmental Committee and concerned Head of Department.

4. No courses with similar contents can be exchanged and/or repeated against courses from Instrumentation Science Department.

5. Assessment for each theory course is divided into two parts, Continuous assessment and External term end examination in the ratio of 50:50. Teacher may select any / or combinations of the following methods for internal assessment.

   a) Series of internal tests
   b) Seminar presentation
   c) Home assignments
   d) Group Discussion
   e) Open book test
   f) Short quizzes etc,

6. Internal assessment for each laboratory course will be carried out on the basis of completion of Journal including viva-voce for each experiment. The outline of distribution of maximum marks for various aspects / mechanisms towards continuous assessment of laboratory course is as follows:

   a) Performing experiment and Journal writing - 10 marks
   b) Viva-voce at the time of submission of each practical - 10 Marks
   c) Group Discussion of 5/6 students for understanding practical - 10 marks
   d) Practical assignments - 20 marks

7. Rules for granting term for theory / practical course consists of minimum 75 % attendance for the theory course and completion of Laboratory Journal for at least 75% practicals in all respect.

8. Internal assessment for IS 4 UT 12 - Industrial Product Design, will be carried out on the basis of group assignment along with a mentor. A group of students will be assigned to a Mentor / Staff. The group will design an industrial product as mutually decided by the group and mentor. Students are supposed to carry out
   a) Various design steps involved in product design on paper.
   b) Make a model of the product.
   c) Present it in front of Mentor in the form of presentation / model demonstration with a report (at least 2 presentations) with relevant technical coverage.
   d) Granting the term for this course will be decided on the overall performance of the student.

9. Internal assessment for Industrial Training and Project will be carried out on the basis of assessment by mentor / staff during visits, periodic reporting, presentations by the student and confidential report from Industry.

10. Granting of term for Industrial Training and Project will be decided on the basis of attendance, actual work carried out by the student, assessment by the mentor / staff and confidential report from Industry.

11. The external term end examination consists of

a) Theory course	Written examination (100 marks for 4 Cr and 50 for 2 Cr to be converted to 50 and 25 marks respectively)
b) Laboratory course	Practical examination and viva-voce
c) Industrial Training	Oral presentation and question answers
d) Industrial Product Design	Oral presentation and question answers
e) Industrial Project	Oral presentation and question answers

12. For getting a credit for a particular course, student must obtain minimum 40% marks in total (internal assessment and external examination) for the course. For each course grade and grade points would be awarded as shown in the following table.

Marks Obtained %	**Grade**	**Grade Points**
80 - 100	O: Outstanding	10
70 - 79	A+: Excellent	9
60 - 69	A: Very Good	8
55 - 59	B+: Good	7
50 - 54	B: Above Average	6
45 - 49	C: Average	5
40 - 44	P: Pass	4
0 - 39	F: Fail	0
-	Ab: Absent	0

13. Award of the final grade will be decided on the basis of all the grade points obtained by the student for all 100 credits. The grade point average (GPA) will be calculated as mentioned below.

Grade Point Average	Grade
09.00 – 10.00	O
08.50 – 08.99	A+
07.50 – 08.49	A
06.50 – 07.49	B+
05.50 – 06.49	B
04.25 – 05.49	C
04.00 – 04.24	P
00.00 – 03.99	F

GPA = SUM {(GPi X CRHi)/100}

Where - GPi - Grade Points earned in a specific course, CRHi - Credit hours for that course

Remark: B+ is equivalent to 55% marks and
B is equivalent to 50% marks.
F grade would be treated as disqualification for getting a credit for the respective course.

14. **Industrial Project:** The Project work must be carried out in an industry / R & D organization for a period of around 4 months (within PMC and PCMC limits).

15. **DEGREE AND CERTIFICATE:** A detailed Statement of Cumulative Grade point shall be provided as per the University procedure. Additional credits earned by student will be indicated in the statement of cumulative grade point. However these will not be considered for final GPA calculations. The successful candidates will be awarded with the degree certificate as per the University rules.

DETAILED SYLLABUS

NOTE:
1) Theory courses may be changed, and / or replaced by special topics to keep the pace with advances in instrumentation and technology.
2) Numbers in bracket indicate tentative number of lectures.

Semester I

IS 1 UT 01: Integrated Circuits for Instrumentations (4 Cr)

Unit I: Passive / Active devices and analog electronics (15)

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: Network theorems, analysis and applications (15)

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: Operational Amplifiers Basics (15)

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: Integrated Circuits and applications (15)

Timer IC 555:internal block diagram, working and its applications in instrument design (Multivibrators, Schmitt Trigger using timer IC).

Power supply: Voltage regulator (Discrete and Integrated), IC 78XX and 79XX, IC 723- Internal block diagram and applications, designing considerations of power supply.

Reference Books:

1. Ramakant Gaikwad - Operational Amplifiers, Hall of India, 4th edition, 2009
2. William D. Stanley - Operational Amplifiers with Linear Integrated Circuits, Pearson Education India, 4th edition
3. Albert. P. Malvino, David Bates - Electronic Principles, McGraw-Hill, 8th Edition, 2016
4. J. Millman and C.C. Halkias - Integrated Electronics, Analog and Digital Circuits and Systems, Tata McGraw-Hill Edition 1991
5. Paul Horowitz, Winfield Hill - The Art of Electronics, Cambridge University Press, 3rd Edition
6. G. B. Clayton, et.al. – Operational amplifiers, Newnes publications , 5th Edition, 2003

IS 1 UT 02: Power Electronics **(4 Cr)**

Unit I: Power semiconductor devices **(15)**

Introduction to Power electronics Systems, Diodes, Transistors, MOSFETs, IGBTs and Thyristors, Switching characteristics, specifications and performance comparison of power devices, Thyristor turn on and turn off methods, Drivers and snubbers for power switches

Unit II: Power converters **(20)**

AC to DC controllers - Single and Three phase rectifiers, controlled rectifiers, Average output voltage and current for rectifiers and controlled rectifiers, Effect of Resistive / Resistive- Inductive / Inductive load,

DC to DC converters - Choppers: Study of different Chopper Circuits viz, Morgen Chopper, Jonh's Chopper etc., Four-Quadrant operation of Choppers, Applications of Choppers,

DC to AC converters – Inverters – Transistorized and Thyristorized inverters; Parallel capacitor inverter with resistive and inductive load and feedback diodes, block diagrams and waveforms, Square wave inverters, Sine wave/PWM inverters, Applications of Invertors,

AC to AC converters - Cycloconverters - Principle of operation and applications

Unit III: Power supplies **(10)**

Alternative solutions for Linear Power supplies like Low Drop out (LDO) regulators, Switch Mode Power Supplies (SMPS) - Need and Concept of SMPS, principle of operation, Different topologies of SMPS, specifications, integrated solutions for LDOs and SMPS

Uninterrupted Power Supplies - ON LINE and OFF LINE UPS, Specifications, Batteries and Battery sizing for UPS

Unit IV: Motors and Motor Drives **(15)**

Types of Motors - DC Motors, AC Motors, Induction Motors, Single and Three Phase Motors, Synchronous Motors, Stepper Motors, Servo Motors etc. Constructional details, Specifications, Characteristics of motors, Motor Driving circuits and their applications

Reference Books:

1. P. C. Sen - Power Electronics
2. M. H. Rashid - Power Electronics – Circuits, Devices and Applications

3. M. S. Barde - Thyristor Engineering
4. Cyrill W. Lender - Power Electronics
5. A. K. Jain - Power Electronics

IS 1 UT 03: Open Course (4 Cr)

Unit I: Basics of Digital electronics and Logic Families (20)

Binary, Hexadecimal, Octal numbers, number conversion and their arithmetic, Signed Binary number representation, Signed Magnitude, 1's complement and 2's Complement representation, BCD, Excess-3, Gray code, ASCII code, Truth tables and Boolean algebra, Logic gates, De-Morgan's theorems, Identities and properties of Boolean algebra**,** Truth tables, Simplification of logical functions, Don't care Conditions, Logic Reduction techniques, K-Maps (SOP and POS form), Quine-McClusky technique
Logic Families standard characteristics:Speed, power dissipation, fan in, fan out, current and voltage specifications, parameters like noise margin, noise immunity, 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 Inverter, CMOS characteristics, Comparison of TTL and CMOS logic family

Unit II: Combinational Logic Circuits (10)

Half Adder, Full Adder, Half subtractor Full subtractor, BCD adder, Look ahead and carry, Parity generator and checker, Comparators, Code convertors, Decoders.
Study of IC 74138, BCD to 7 segment decoder/driver IC 7448/7447, Encoders, priority encoders, Multiplexers and De-multiplexers, Study of MUX IC 74153, 74151, applications of MUX and De-MUX

Unit III: Sequential Logic (15)

Flip flops - SR, JK, D, T; Preset and Clear, Master and Slave Flip Flops their truth tables , excitation tables and state diagram, Conversion from one type to another type of Flip Flop, Applications of Flip - flops - Switch Bounce Elimination, Registers - Buffer register, Shift register.

Counters - Asynchronous and Synchronous counters, Pre-settable 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, Applications of Digital circuits: Digital Clock, Frequency counter, Memories like RAM, ROM, EEPROM, EPR, Flash Memory, etc.

Unit IV: Analog to Digital and Digital to Analog Converters (15)

Analog and digital representation of data, comparisons and relative merits, sampling and quantization Analog to digital converters: Flash, Counter type, Tracking, Successive approximation, Single Slope and Dual slope ADC, Sigma Delta ADC, Study of typical ADC ICs, specifications, merits and demerits, Problems on analysis and designing. Digital to analog converters: Binary weighted and R – 2R type, specifications, merits and demerits, Applications of DACs like Programmable power supplies, waveform generation and synthesis, Study of typical DAC ICs Problems on analysis and designing

Reference Books:

1. A. P. Malvino and Leach - Digital Principles and Applications, Tata McGraw- Hill, 2015
2. Thomas L Floyd- "Digital Fundamentals", Education, 11^{th} Edition, 2014
3. R P Jain- "Modern Digital Electronics", TataMcGraw- Hill Education
4. Digital Electronics, Tertulien Ndjountche, WILEY
5. TTL Data Book, Fairchild Semiconductor
6. Digital Systems, Principles and Applications, Ronald Tocci, et. Al. Pearson International, 10^{th} Edition

IS 1 UT 04: Mathematical Methods for Instrumentations (2 Cr)

Unit I: (15)

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: (15)

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.

Reference Books:

1. P. N. Wartikar, J. N. Wartikar - A textbook of Applied Mathematics Vol. I and II
2. Kanti B. Datta - Mathematical Methods of Science and Engineering: Aided with MATLAB
3. B.S. Grewal - Higher Engineering Mathematics
4. Murray R Spiegel - Schaum's outline of Theory and problems of Laplace transforms
5. Murray R Spiegel - Schaum's outline of Theory and problems of Vector analysis and An Introduction to Tensor analysis
6. George B Arfken, Hans Jurgen Weber - Mathematical methods for Physicists

IS 1 UP 01: Analog and Digital Electronics Laboratory (4 Cr)

Note: Each experiment is of four Hours duration.

List of Experiments:

1. Study of electronic and electrical components (active and passive devices, I-V Characteristics)
2. Design and implementation of Integrator, Differentiator, Clipper and Clamper circuits
3. Design, implementation and study of transistorized RC coupled amplifier
4. Design, implementation and study parameters of regulated Power Supplies
5. Determination of operational amplifier parameters (IC 741)
6. Design, implementation and study of operational amplifier application circuits like Instrumentation Amplifier, Precision Rectifier, Schmitt Trigger etc.
7. Design and implementation of oscillators (Wien bridge, UJT relaxation Oscillator etc)
8. Design, implementation and study of different circuits using IC 555 and its applications
9. Design, implementation and study of combinational logic circuits using logic gates (Code converter, Adder, Decoder, Multiplexer etc.)
10. Design, implementation and study of different circuits using digital ICs - Counters, Shift register, Latches, Decoders etc. (TTL and CMOS family)
11. Study of R - 2R ladder network DAC and DAC IC1408
12. Study of single slope ADC
13. And / or experiments of similar kind

IS 1 UP 02: C Programming Laboratory (4 Cr)

Note: Each experiment is of four Hours duration.

List of Experiments:

1. Basics of programming – 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. Multiplication of multi-dimensional matrices
7. Create and display n x n magic square
8. To change the case of the string using pointers
9. Writing user defined functions for complex calculations
10. To perform various manipulations on a string using functions
11. To perform encryption and decryption of data stored in file
12. To create a data base using structures and files
13. And / or experiments of similar kind

Semester II

IS 2 UT 05: Sensors, Transducers and Signal Conditioning (4 Cr)

Unit I: Sensor Transducers fundamentals and performance characteristics (10)

Introduction: Units and standards of measurement, functional elements of measurement system, static and dynamic characteristics or performance characteristics of transducer, Measurement and calibration systems - Requirements, Transducer terminology, Transducer classification, Performance Characteristics, Criteria for transducer selection

Unit II: Principles of Sensors and Transducers (20)

Displacement Transducers - Working principle of Resistance type, Capacitance type, Digital and Pneumatic (Flapper-Nozzle) type displacement transducers

Level Transducers - Working principle of Float, Displacer, Bubbler, Diaphragm box, DP cell, Ultrasonic, Capacitive, Radioactive, Resistance, Thermal, optical level sensors, solid level detectors

Pressure Transducers - Primary pressure sensors, Electrical / Secondary Pressure Transducers, Manometers, High Pressure Measurement and Differential Pressure Measurement, Low pressure (Vacuum) transducers

Flow Transducers - Working principle of Head Type, Variable Area Type, Electromagnetic flow sensor, Open channel flow measurement

Temperature Transducers - Working principle of Thermometers, Resistance temperature detector (RTD), Thermistors, Thermocouples, and Pyrometers

Optical sensors - Working principle of PMT, Photodiodes, CCD, LDR

Electro-chemical Sensors - pH measurement, Conductivity measurement, ORP (Oxidation Reduction Potential) Measurement, Humidity measurement, Intelligent Sensors

Unit III: Signal conditioning (15)

Need for signal conditioning, Current and Voltage standards. Signal conditioning for Resistive sensors - RTD, Thermister, 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

Unit IV: Signal conditioning case studies (15)

Signal conditioning for - Optical devices like Photo diode, LDR, PIN diode, photo transistor, photo cell, optical proximity switch

Signal conditioning schemes for - RTD with Three wire compensation and Thermocouple with cold junction compensation

Signal conditioning schemes for - Ultrasonic detector for displacement, level (single and multiple liquid), pH and conductivity measurement, Hall sensor, Electromagnetic flow meter, etc.

Reference Books:

1. E. O. Doebelin - Measurement System Application and Design
2. D. Patranabis - Principles of Industrial Instrumentation
3. R. K. Jain - Mechanical and Industrial Measurement
4. C. D. Johnson - Process Control Instrumentation Technology
5. Sawhney A. K - A Course in Electrical and Electronics Measurements and Instrumentation
6. D. V. S. Murthy - Transducers and Instrumentation
7. B. G. Liptak - Process Measurement and Analysis
8. B. E. Noltingk - Jone's Instrument Technology (Vol. 1 and Vol. 2)

IS 2 UT 06: Microcontroller and Embedded systems (4 Cr)

Unit I: Embedded Instrumentation (5)

Need and advantages of using Microcontrollers in Instrumentation, Basic concepts of embedded instrumentation, features, specifications and differences, Different blocks of embedded instruments, ideal microcontroller based Instrument, case study, Basics of microcontroller, hardware resources, introduction to other microcontrollers viz. eZ80, PIC, AVR and latest controllers,

Unit II: Architectural details of microcontroller 8051 (10)

Microcontroller support devices like Memories, Latches, Shift registers, RAM, NVRAM, ROM, PROM, UVPROM, EAPROM, FLASH, SRAM and DRAM, Serial EEPROMS, Serial RAM, external memory interfacing for microcontroller 8051, internal memory map for 8051, details of various SFR's and BIT addressable memory, Addressing modes and study of instruction set, Stack pointer, stack memory and stack operation, Input output devices in 8051, I/O ports, Timer/Counters, UART, etc.

Unit III: Programming techniques (25)

Introduction to assembly language programming Simple programs, extensive programming exercises using assembly language for 8051, Use of Integrated development environment (IDE), Keil, cross C compilers, simulator and debuggers for system integration, Interfacing of switches and LEDs, Rotary switches and related programming, interfacing of matrix type keyboard, lookup table searching, Error detection programs, Interfacing of seven segment displays and alpha numeric LCD modules, Interfacing of ADC and DAC, I / O Expansion for 8051 using serial interface, Timers and counters in 8051, various modes of operation, generation of PWM signal, Interrupts in 8051, priority of interrupts, vectored interrupts, Implementation and applications of serial interface RS 232 using 8051 UART, Extensive programming exercises using assembly and C language. Power down and Idle mode of operation in 8051, Program securities

Unit IV: Introduction to Microchip PIC microcontroller (20)

PIC microcontroller features, scaling of PIC MCU families, overview of baseline, midrange, enhanced midrange, and high-end core devices, PIC Architecture, Program memory, Addressing Modes, Instruction set, PIC MCU Hardware - Reset, Clock, Control registers, Register banks, Program memory paging etc., Detailed study of PIC 16XXX controller architecture, MPLAB IDE overview: Using MPLAB, Toolbars, Selection of development mode and device type, Project, Text Editor, Assembler, MPLAB Operations, compilers, debug tools,

Reference Books:

1. K. J. Ayala: The 8051 Microcontroller
2. Atmel: Microcontroller Handbook
3. Muhammad Ali Mazidi, Janice Gillispie Mazidi: The 8051 Microcontroller and Embedded Systems Using Assembly and C
4. Myke Predko - Programming and Customizing PIC Microcontrollers: Principals and Applications
5. Microchip: PIC 16 Microcontroller Datasheet

IS 2 UTE XX: Elective Course

Note: Currently following elective courses will be offered to students in Semester. The detailed syllabi for other courses can be made available if required / asked for.

IS 2 **UTE 13: Robotics (4 Cr)**

Unit I: Robotics Introduction (10)

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

Unit II: Transformation and Kinematics (20)

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.

Unit III: Inverse or back solution (15)

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.

Unit IV: Robot controller and programming (5)

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.

Unit V: Artificial intelligence and Robotics (10)

Artificial intelligence, Real time considerations, Event driven processes and Sensor information processes Path Planning - Co-ordination motion, Automatic programming

Reference Books:

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

IS 2 UTE 14: Biomedical Instrumentation (4 Cr)

Unit I: Bio-signals and Bio-Potential (15)

Cell Structure, Basic Cell Functions, Origin of Bio-potentials, Electrical Activity of Cells, Electrode - Electrolyte interface, Half cell potential, Polarization - polarizable and non - polarizable electrodes, Ag / AgCl electrodes

Biomedical Sensors - Electrodes for biomedical sensing, Electrode and electrode interface, polarization, Electrode behavior and circuit model, Electrode skin interface, Body surface electrodes, internal electrodes, Microelectrodes, electrode arrays

Unit II: Physiological Systems related Measurement (15)

Cardiac Measurement - Cardiovascular System, Heart Structure, Cardiac Cycle, ECG Theory, ECG Electrodes, ECG amplifier, Electrocardiograph, Measurement of continuous Cardiac output derived from aortic pressure waveforms, Cardiac Arrhythmias, Phonocardiogram

Blood pressure measurement - Foetal heart rate measurements, Plethysmography, Cardiac Pacemakers, Defibrillators, Heart - Lung Machine (HLM)

Unit III: Recording Systems (15)

Patient monitoring systems - Different Types of ECG Monitors, Ambulatory monitoring Instruments, Measurement of heart rate, Blood pressure, Temperature, Respiration rate, Apnea detectors, Computerized patient monitoring system

Pulmonary Function Analyzers - Natural Process of Breathing, O_2 and CO_2 Transport, Regulation of Breathing, Ventilators, Pulmonary function measurement, Spirometry, Pulmonary function analyzers, Respiratory gas analyzers

Unit IV: Biomedical Instruments (15)

Blood flow meters - Electromagnetic, Ultrasonic, NMR, Laser Doppler Blood Flow Meters

Methods of Cell counting - Coulter Counters, Automatic recognition and differential counting of cells, Auto analyzer

Significance of Electrical Safety - Physiological effects of electrical current, Shock Hazards from electrical equipment and methods of accident prevention

Reference Books:

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 applications

IS 2 UT 07: Test and Measuring Instruments (2 Cr)

Unit I: Characteristics of test and measuring Instruments (5)

Static and Dynamic characteristics of Instruments: Accuracy, Precision, Sensitivity, Dead zone, Hysteresis, Threshold, Resolution, Input and Output impedance, Loading effects, Types of Error, Calibration of Instruments, Traceability, Calibration report and Certification, Reliability Engineering and Concept of Reliability, failures and causes of failures, Maintainability

Unit II: Basic measurements and multimeters (10)

DC bridge concept, Whetstone's bridge, Kelvin's double bridge, DC bridge design considerations, PMMC movement, Galvanometer, Conversion of galvanometer for Current / Voltage and Resistance

Block diagram and Working of DMM, Auto Zeroing and Auto - ranging concepts, various circuit details of DMM, Study of specifications for digital multimeters

Unit III: Oscilloscopes: (10)

Working principle of general purpose (Real Time) Oscilloscope with block diagram, Details of stability of waveform, triggering modes and facilities, multi trace operation, Oscilloscope probes: Specifications

Digital Storage oscilloscope: Working principle of Storage Oscilloscopes, Digital Storage Oscilloscope block diagram, Sampling techniques, Merits and demerits of DSO and Demonstration

Unit IV: Other Test and Measuring Instruments (5)

Frequency Counters: Working principles, Study of block diagrams and timing diagrams for Frequency Counters

Signal Generators - Block schematic, working and Study of specifications, Function Generator - Block schematic, working and Study of specifications

Reference Books:

1. Oliver and Cage - Electronic Measurements and Instrumentation

2. W. Cooper - Electronic Instrumentation and measuring techniques
3. Phillips Oscilloscope Manual
4. Sawhney A. K. - A Course in Electrical and Electronics Measurements and Instrumentation
5. Kalsi H. S. - Electronic Instrumentation
6. Bell David A. - Electronic Instrumentation and Measurements
7. Rangan C. S., Sarma G. R., Mani V. S. V. - Instrumentation Devices and Systems

IS 2 UP 03: Application Software Practices Laboratory (4 Cr)

Note: Each experiment is of four Hours duration.

List of Experiments:

1. LabVIEW Basics - Introduction to Graphical Language programming, Data Type, Loops, Structures, Shift registers etc. simple programming.
2. LabVIEW - Stack sequence / Flat sequence and creating variables
3. LabVIEW - Introduction to property node
4. LabVIEW - Introduction to DAQ system
5. LabVIEW - With NI PC1 6221 and DAQ Signal Accessory
6. LabVIEW - Mini Project
7. MATLAB Basics - Command window execution, Data types, Scalars, Vectors and Matrices
8. MATLAB - Script file and basics of Plotting Functions
9. MATLAB - Advanced Plotting Functions
10. MATLAB - Plotting of Root Locus and Bode Plot
11. MATLAB – Applications
12. MATLAB - Simulink Fundamentals and Model making
13. And / or experiments of similar kind

IS 2 UP 04: Sensors, Signal Conditioning and Microcontroller Laboratory (4 Cr)

Note: Each experiment is of four Hours duration.

List of Experiments:

1. Assembly Language Programming - simple programming and simulation for 8051
2. Study of Microchip MPLAB IDE and simple programming for Microcontroller PIC 16FXXX
3. Microcontroller interfacing – Switches and LEDs
4. Microcontroller interfacing – Timer / Counter and Interrupt based applications
5. Microcontroller interfacing – Serial Interface
6. Microcontroller interfacing – 8 - bit ADC and 16 X 2 dot matrix Liquid Crystal Display Interfacing
7. Microcontroller interfacing - DC and Stepper motor control
8. Study of linear displacement transducer and its signal conditioning circuit
9. Study and calibration of Pt – 100 as a temperature sensor and its signal conditioning circuit
10. Study of capacitive level sensor and its signal conditioning circuit
11. Study of optical sensors: LDR and photo diode and their signal conditioning circuit
12. Study of Strain gauge as load sensor and its signal conditioning circuit
13. Study of pH sensor and its signal conditioning circuit
14. And / or experiments of similar kind

Semester III

IS 3 UT 08: Optical Instrumentation and Photonics (4 Cr)

Unit I: Geometrical and Physical Optics (25)

Light Rays, Plane and spherical surfaces, Thin and Thick lenses, Spherical Mirrors, Aperture / Stops, effects of Aperture / stops, Ray tracing, Lens Aberrations, Optical Instruments, Radiative transfer in optical system, Types of Optical filters, specifications, interference, diffraction, polarization, types of gratings

Unit II: Optical Systems in LASER **(14)**

Radiometry and Photometry, Properties of Laser, Basics of Laser Principles: active medium, laser pumping, optical feedback, laser output - line shape broadening, laser modes: optical resonance, pump rate, power output, modification of LASER output: Q switching mode locking etc.

Unit III: Laser Exposition: **(10)**

Working principle and construction of Gas lasers, Solid-state lasers, Dye lasers Semiconductor lasers, and Applications of lasers

Unit IV: Optical Fiber **(12)**

Introduction to Optical fiber, principle in optical fiber, numerical aperture, multimode and single mode fibers, losses in fiber - dispersion, absorption, scattering losses, types of couplers and connectors, losses due to couplers, splicing techniques, fabrication techniques, Applications of optical fiber viz. Fiber Optic sensors, Communication System etc.

Reference Books:

1. Jenkins and White - Optics
2. Ghatak - Instrumental methods of analysis
3. Khandpur, Kaiser, Zanger and Zanger - Optical fiber communications
4. R. Sirohi, M. P. Kothiyal - Optical Components, Systems and Measurement techniques
5. W. T. Silfvast - Laser Fundamentals, R. Papannareddy - Light wave Communication
6. O'shea Callen Rhodes – An Introduction to LASER's and their Applications
7. John M. Senior - Optical Fiber Communications - Principles And Practice
8. Gerd Keiser - Optical Fiber Communications

IS 3 UT 09: Process and Feedback Control **(4 Cr)**

Unit I: Transfer Function of Physical Systems **(15)**

Introduction to control systems, Introduction to design process, Industrial of feed forward and feedback control system, Uncertainty and disturbances, Review of Laplace and inverse Laplace transform, Modeling 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

Unit II: Process Dynamics **(15)**

Dynamic elements in a control loop, Dead time processes and smith predictor compensator, Inverse response, Dynamic behavior of first and second order systems

Process Control Action - Elements of Process control, Controller Principle, Process Characteristics, Control system parameters, Study of Electronic and Pneumatic Controllers, Control loop characteristics, Control system configuration, Single variable, Multi variable, Cascade controllers, Feedback and Feed forward controller

Control Schemes - Feedback, feed forward, cascade, ratio, split range, selective control, adaptive control, and model based control, Steady state gain, Process gain, Valve gain, Process time constant etc.

Process reaction curve method, Zigler - Nichols method, Cohencoon correction for quarter amplitude, Frequency response method, Relay based tuning, Tuning of Multivariable controllers,

Unit III: Process Controllers (15)

General features, Construction and working of Pneumatic, Hydraulic and Electronic controller, Continuous and Discontinuous controllers - On - Off controller, Proportional controller, Proportional - Integral (PI) controller, Proportional - Integral - Derivative (PID) controller

Discrete state system characteristics, Process specifications, Sequential control, Programmable Logic Controllers, Ladder diagrams, PLC programming and operation, Introduction to Computers in process control, Data logging, Supervisory controllers, Factory automation

Unit IV: Time and Frequency Domain Analysis (15)

Standard test signals - Impulse response signal, step signal, ramp signal, parabolic signal, first order systems, second order systems, State Variable Representation of Systems, 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, root locus analysis, Bode Plot, Nyquist stability criterion and closed loop frequency response

Reference Books:

1. Norman Nise - Control System Engineering
2. Nagrath and Gopal - Control System Engineering
3. G. Goodwin, S.Graebe, Mario Salgado - Control System Design
4. G. Franklin, J.Powell, A. Naeini - Feedback Control of Dynamic Systems
5. Donald Eckman - Automatic Process Control
6. B. G. Liptek - Instrument Engineers Handbook
7. P. W. Murrill - Fundamentals of Process Control
8. B.Wayne Bequette - Process Control: Modeling, Design and Simulation

IS 3 UT 10: Industrial Automation (4 Cr)

Unit I: Introduction to Industrial Communication (15)

OSI reference model, Transmission media - Copper cable, Coaxial cables, 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: Role of Networking in Automation (15)

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

Unit III: Automation Fundamentals and PLC (20)

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

Unit IV: DCS and SCADA **(10)**

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

Reference Books:

1. Samuel M. Herb - Understanding Distributed Processor Systems for Control
2. Thomas Hughes - Programmable Logic Controller
3. Stuart A. Boyer - SCADA supervisory control and data acquisition
4. Gruhn and Cheddie - Safety Shutdown Systems
5. Poppovik Bhatkar - Distributed Computer Control in Industrial Automation
6. Gary Dunning - Introduction to Programmable Logic controller
7. John. W. Webb, Ronald A Reis - Programmable Logic Controllers - Principles and Applications
8. Bela G. Liptak - Instrument Engineers handbook - Process control
9. D. J. Smith , K.G.L. Simpson - Functional Safety - A Straight forward Guide to IEC61508 and Related Standards

IS 3 UT 11: Analytical Instrumentation **(2 Cr)**

Unit I: Spectrophotometers **(10)**

Colorimeters, Flame Photometer, UV-visible spectrophotometer - Principle, working, applications, IR spectrophotometer - Principle, working, applications

Unit II Separative Methods **(8)**

Chromatography - Principle, working, applications, Gas Chromatography (GC) detectors, High Performance Liquid Chromatography (HPLC) - Principle, constructional details, HPLC detectors

Unit III: Radioactive instrumentation and Refractometry **(12)**

X-ray spectrometry - Instrumentation for X - ray Spectrometry, Principle and working of X-ray Difractometer, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM)

Reference Books:

1. H. H. Willard, L. L. Merritt, J.A. Dean and Frank A. Settle - Instrumental Methods of Analysis
2. Galen W. Ewing - Instrumental Methods of Chemical Analysis
3. Robert D. Braun -Introduction to Instrumental Analysis

4. D. A. Skoog, F. J. Holler - Principles of Instrumental Analysis

IS 3 UP 06: Special Instrumentation Laboratory **(4 Cr)**

Note: Each experiment is of four Hours duration.

List of Experiments:

1. Study of optical components characteristics and simple applications
2. Study of He-Ne LASER characteristics - Beam diameter, Divergence and Wavelength and its application
3. Study of Radiation Pattern of LED
4. Study of optical fiber characteristics
5. Optical Fiber Communication
6. Study of Optical Transducer
7. Study of UV-VIS spectroscopy
8. Study of Fourier Transform Infra Red spectroscopy
9. Study of Field emission scanning electron microscopy
10. Study of Transmission Electron Microscopy
11. Study of X - Ray Diffraction (XRD)
12. Study of Liquid chromatography (LCMS)
13. And / or experiments of similar kind

IS 3 UP 07: Process Control and Industrial Automation Laboratory **(4 Cr)**

Note: Each experiment is of four Hours duration.

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

Semester IV

IS 4 UT 12: Industrial Product Design **(2 Cr)**

Unit I: Introduction **(15)**

Stages in product design - Market survey, Product Specifications (Electrical, Mechanical, Environmental), Formulation of design problem, Product planning, Product conceptualization, Concepts of drawing and various types of drawing, Creative thinking, Free hand sketching, Presentation drawings, Engineering drawings, Exploded views and enlarged details, Study of AUTOCAD and its implementation for product design, Product specifications, Product planning and system breakup, Sub-system interaction,

Instrument ergonomics, Design of controls, Displays and graphics, Aesthetics of colour and form, Value engineering and Value analysis, Creativity tools like brain storming, Vicarious imagination, Lateral thinking and Spatial management, Environmental factors for successful operation, Anthropology and Anthropometry principles,

Electronic Products Classification - Consumer, Industrial and Military, Their peculiarities in terms of cost / performance ratio and Reliability

Unit II: Hardware / Software design issues (15)

Signal conditioning, choice of amplifiers, ADC, DAC specifications from design view point, Interfacing techniques, Human interface issues, Role of Microcontroller in product design and its selection criterion

PCB Design practices for Analog and Mixed signal circuits - Ground Loops, Precision circuits, shielding and guarding. PCB Design Practices for High Speed Digital Circuits, Signal integrity and EMC

Different approaches to development of application software for Electronic Product, Factors affecting choice between Assembly language and High level language like C, Documentation practices and templates for software

R&D and Engineering Prototypes, Pilot Production Batch, Environmental testing, Documentation, Manufacturing, Model making

Reference Books

1. D. Bowman - Understanding CAD / CAM
2. D. Raker and H. Rice - Inside Auto CAD.
3. Kumar and Zha - Technology of CAD and Manufacturing
4. C. B. Basat and C.W.K. Liu - Computer aided design and manufacturing
5. Rogers and Adams -Mathematical elements of computer graphics.
6. Zimmer and Groover - CAD-CAM
7. N. D. Bhatt - Engineering Drawing
8. David B. Oborne - Ergonomics at work
9. Neville Stanton Alan Hedge Karel Brookhuis Eduardo Salas Hal Hendrick - Handbook of Human Factors and Ergonomics Methods
10. Applied Ergonomics - CRC Press Book
11. Ergonomics in Design - Methods and Techniques - CRC Press Book