M. Tech. in Sensor Technology

Sensors is one area of science and technology which has witnessed a paradigm shift from conventional bulky components to extremely miniaturized and smart devices. The technological advancements in the area of Electronics, Electrical engineering, along with the advancements in basic sciences in the areas of, nanotechnology, biotechnology and photonics have been responsible for this concomitant growth in the development of current sensors. An interdisciplinary approach that will involve materials engineering, electronics and electrical engineering along with a flavor of chemical engineering and bio-engineering, is now required to understand such sensors. The objective is to make them faster, smaller, smarter and more selective flavour. This domain has, hence, seen a large number of Industries, Institutes and small entrepreneur companies coming up in recent times. The program intends to educate and train bright fresh students in the field of sensor technology to carry out challenging responsibilities in their future careers, and meet the current challenges and foster the opportunities which the globe has to offer. This is an interdisciplinary course concerning broadly Electronics, Instrumentation, Sensors, Optics, Electromagnetism, Nanotechnology and Advanced Materials.

Eligibility

To join this course the candidate should possess Masters in science degree or equivalent in Physics, Applied Physics, Optics, Electronic Science, Photonics, Material science, Instrumentation Science **OR** B. E./ B. Tech (all disciplines)

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1: The M Tech in Sensor Technology programme aims at developing skilled human resources in the field of sensor development, control system design, wireless sensor network, artificial intelligence, machine learning etc catering to the emerging multidisciplinary problems faced by defence industry and society.

PEO2: With a focus on the DRDO requirements, the students will be trained to use their knowledge for the benefit of society and made aware of their social duty. This will enable them to pursue career in research, academics, and industry.

PEO3: At the end of the programme the officer or student should be able to undertake state of the art R&D in Sensor Technology Systemsand competitively work towardsthe development of the latest technology in line with national programmes like Make in India.

PROGRAMME OUTCOMES (POs)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program

PO4: Having adaptive thinking and adaptability in relation to environmental context and sustainable development

PO5: Having a clear understanding of professional and ethical responsibility

PO6: Having good cognitive load management skills related to project management and finance

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M. Tech. (Sensor Technology) the programme, graduates will be able to

PSO1: The MTech Sensor Technology aims at developing a skilled knowledgeable Human task force in the field of Sensor Technology catering to Defence Research and Development Organization & Tri – services (Army, Navy & Air force), Coast Guard, DGQA, DQA, Defence Public Sector units, in addition to the civilians in general. After completing M Tech course the students develop an ability to carry out independent research in the area of sensors.

PSO2: The dissertation work of the MTech students leads to publications in high-impact international journals which trains them in technical documentation and report writing.

PSO3: The M Tech Sensor Technology course aims at the development of human resources of high calibre in the field of sensor development, sensor systems, Machine learning, control system and wireless sensors.

Credit Structure

SEMESTER I

Sl. No.	Course Code	Course	Contact Hours/week		Credits
			L	T/P	
1	AP-601	Principles of Sensing: Material Science and Physics	3	1	4
2	AP-602	Sensor Data Acquisition systems	3	1	4
3	AP -603	Technologyand Packaging of MEMSSystems	3	1	4
4	AP -604	Programming for Machine learning	2	2	4
5	AP - 605	Sensor Technology Laboratory-I	3	1	4
6	EE-624	Digital system design using FPGA	3	1	4
7	PGC-601	Research Methodology and IPR	2	0	2
			Total	**18**	**26**

SEMESTER II

Sl. No.	Course Code	Course	Contact Hours/week		Credits
			L	T/P	
1	AP-606	Sensors and Actuators -I	3	1	4
2	AP-607	Sensors and Actuators -II	3	1	4

3	AP-608	Machine learning techniques for sensor data analytics	2	2	4
4	AP-609	Sensor Technology Laboratory-II	3	1	4
5		Elective I	3	1	4
6		Elective – II	3	1	4
7	PGC-602	Audit 1 and 2	0	0	0
		Total	**18**	**6**	**24**

SEMESTER III

Sl. No.	Course Code	Course	Contact Hours /week		Credits
			L	T/P	
1	AP-681	M.Tech. Dissertation Phase I	28		14
		Total	**28**		**14**

SEMESTER IV

Sl. No.	Course Code	Course	Contact Hours /week		Credits
			L	T/P	
1	AP-682	M.Tech. Dissertation Phase II	28		14
		Total	**28**		**14**

List of Electives:

Sr. No.	Course Code	Course
Elective I& II		
1	AP 610	Advanced Sensors
2	AP 611	Sensors for Defence
3	AP 612	Nanotechnology for Advanced Sensors
4	AP 651	Broadband Communication Systems
5	AP642	THz Devices and Applications
6	EE614	EMI, EMC, EMP, NEMP design
7	EE613	Electronic warfare
8	CE691	Wireless sensor network

AP-601 - Principles of Sensing: Material Science and Physics

Course Outcomes:

CO-1 :	Interpret the concepts static and dynamic characteristics of sensors and use concepts in common methods for converting a physical parameter into an electrical quantity
CO-2 :	Analyze the working principle of different materials-based sensors and choose an appropriate sensor comparing different standards and guidelines to make sensitive measurements of physical parameters like pressure, flow, acceleration, etc.
CO-3 :	Examine the working mechanism of different types of sensors
CO-4 :	Illustrated the practical implementation of using different materials in sensors and Create analytical design and development solutions for sensors.
CO-5 :	Summarize different applications of different types of materials for sensors and Locate different types of sensors used in real life applications and paraphrase their importance

Syllabus:

Units	Syllabus Details	Hrs
Unit I:	Sensor Classification, Performance and Types, Error Analysis characteristics	6
Unit II:	Structural, electrical and mechanical and thermal properties	6
Unit III	Applications of metals and semiconductors Thermal expansion devices, shape memory alloys, thermocouple, positive temperature coefficient resistor, negative temperature coefficient resistor, bolometers, strain gauges	10
Unit IV	Dielectric, Magnetic and superconducting materials Polarization, frequency response, piezoelectric, pyroelectric, ferroelectric materials, Paramagnetic, diamagnetic, antiferromagnetic, ferromagnetic, ferrimagnetic, superconducting materials	12
Unit V	Applications of Dielectric, Magnetic and superconducting materials Hall effect, magnetoresistance, SQUID	6
Unit VI	Introduction to Fiber optic sensors	6

References Textbooks:

1. Sensor Materials by P T Moseley and A J Crocker, IOP Publishing Ltd 1996
2. Handbook of Modern Sensors: physics, designs and applications by Jacob Fraden, Springer (2010).
3. Sensor Technology Handbook by John S Wilson, Elsevier,(2005)
4. Transducers and Instrumentation, DVS Murty, 2nd Edition2013
5. Material Science and Engineering by V.Raghavan
6. J. P. Dakin and B Culshaw, Optical Fiber Sensors, Vol. 1 & 2, Artech

House, Boston and London,1998.

AP-602 – Sensor Data Acquisition Systems

Course Outcomes:

CO-1 :	Interpret the concepts of how sensor data requires further processing
CO-2 :	Analyze the working principle of Data Acquisition systems
CO-3 :	Examine the working mechanism of different signal conditioners
CO-4 :	Illustrate the practical implementation of sensor systems connected to a DAS board and programming of microcontroller platform
CO-5 :	Summarize various modes of sensor data integration and acquisition for further controls / displays

Syllabus:

Units	Syllabus Details	Hrs
Unit I:	Fundamentals of Data Acquisition: Essentials of computer interfacing – configuration and structure -interface systems-interface bus.	6
Unit II:	Signal conditioning: Types of signals and signal conditioning, classes of signal conditioning, types of noises (different types) and basics of environmental aspects, shielded and twisted-pair cable, , Different type of signal conditioners- Digital and analog, applications in real systems	8
Unit III	Data Acquisition boards: A/D Boards, Single-ended vs differential signals, Resolution, dynamic range and accuracy of A/D boards, Sampling rate and the Nyquist theorem, Sampling techniques, D/Aboard. Serial and parallel data communication standards	12
Unit IV	Data Loggers: Methods of operation, stand-alone loggers/controller hardware, communications hardware interface, Data acquisition using PCMCIA cards. Device communications, Communication system basics for remote sensor data acquisition., Ethernet & LAN systems.	12
Unit V	Network data communication model for sensor data handling and communication – 7, Communication Protocols Layer Model and TCP/IP Model. Sensor Interface Demos using Arduino Interface and LabView	8

References Textbooks:

1. Ramon Pallas-Areny and John G Webster, Sensors and Signal Conditioning, Wiley India Pvt. Ltd., 2 nded.,2012.

2. 2. Maurizio Di Paolo Emilio, Acquisition systems from fundamentals to Applied Design, Springer,2013.
3. 3. Robert H King, "Introduction to Data Acquisition with LabVIEW", McGraw Hill, 2nd ed.,2012.
4. 4. John Park and Steve Mackay, Practical Data Acquisition for Instrumentation and Control', Newness publishers,2003.
5. 5. Maurizio Di Paolo Emilio, Data Acquisition systemss- from fundamentals to Applied Design, Springer,2013. 6. Robert H King

AP-603 – Technology and Packaging of MEMS systems

Course Outcomes:

CO-1 :	Students to be able to understand concepts involved in MEMS
CO-2 :	Students to understand the technologies involved in MEMS fabrication and packaging, their advantages and limitations
CO-3 :	Students to be able to understand working principles in micro sensors and actuators
CO-4 :	Students to become capable of conceptualizing the design of a microsystem

Syllabus:

Units	Syllabus Details	Hrs
Unit I:	**Evolution of Microsystems:** Concept & History of Micro systems & MEMS, Benefits of Micro Systems, Comparison between Microsystems & microelectronics, Multidisciplinary nature of microsystems development.	**2**
Unit II:	**Scaling Laws in Miniaturization:** Introduction to scaling, geometric scaling, scaling in rigid body dynamics, scaling in electrostatic forces, scaling in electromagnetic Electricity, scaling in fluid mechanics, Scaling in Heat Transfer.	**4**
Unit III	**Engineering, Science & Materials for Microsystems**: Atomic structure, Crystal Structures, Bonding in materials, Ionization, Doping in Semiconductors, Diffusion Process, Plasma Physics, Electrochemistry, Silicon as a substrate material for MEMS, Compounds of silicon, Si Piezo resistors, other Piezo electric materials, GaAs, Polymer, Materials used in packaging	**8**
Unit IV	**Fabrication of Microsystems**: Photolithography, Ion Implantation, Diffusion, Oxidation, chemical & physical vapor deposition, Epitaxial growth of films, Chemical etching, Plasma etching.	**8**
Unit V	**Micromachining processes:** Bulk Micromachining**,** Surface Micromachining, The LIGA Process.	**4**
Unit VI	**Working principles of microsystems:** Microsensors: Acoustics wave sensors, Biomedical & Bio sensors, Chemical Sensors, Optical Sensors, Pressure Sensors, Thermal Sensors. MEMS with Microactuators: Microgripper, Micromotors, Micro	**8**

	valves, Micro pumps, Micro accelerometer Microfluidics	
Unit VII	**Microsystem packaging:** Levels in microsystem packaging, Interfaces in Microsystem packaging, Essential packaging technologies, 3-d Packaging, assembly of Microsystems. Multi User MEMS Program (MUMPs)	**4**

Lab Assignments		**Hrs**
Lab 1	To study the etching process in silicon	4
Lab 2	Thin film deposition and analysis	4
Lab 3	3D Printing	4

References Textbooks:

1] Tai-Ran Hsu, 'MEMS & Microsystem, Design and Manufacture',McGraw Hill, 2012
2] Physics of Semiconductor Devices by S.M. Sze,Wiley Publications(2006)
3] Mark J Jackson, Micro and Nano-manufacturing , Springer; First Edition, (2006)ISBN
4] Zheng Cui,Micro-nanofabrication: Technologies and Applications, Springer First Edition (2006),ISBN-10:3540289224
5] R. Kassing, P. Petkov,W.Kulish, C. Popov., Functional Properties of Nanostructured Materials. Springer (ISBN: 978-1-4020-4595-0 (Print) 978-1-4020-4594-3(Online)

AP-604 – Programming for Machine learning

Course Outcomes:

CO-1 :	Learn a language, Python, for expressing computations
CO-2 :	Develop an informal understanding of computational complexity
CO-3 :	Examine the process of moving from an ambiguous problem statement to a computational formulation of a method for solving the problem
CO-4 :	Illustrate the useful set of algorithmic and problem reduction techniques
CO-5 :	Use computational tools (including simple statistical, visualization, and machine learning tools) to model and understand data

Syllabus:

Units	Syllabus Details	Hrs
Unit I:	Introduction to Python & Simple Numerical Programs Installing Python and Python IDEs, Basic elements of Python, Variables and assignment, branching programs, strings and input, loops, Simple codes, approximate solutions, Floats, Newton–Raphson	12
Unit II:	Functions, scoping, and abstraction Functions, Scoping, Using functions to modularize code, Functions as objects,	6
Unit III	Structured types and mutability Ranges and iterables,Strings, Tuples, Ranges, and Lists, SETS,	6

	Dictionaries	
Unit IV	Recursion, global variables, modules and files, classes Fibonacci Numbers, Palindromes, Global Variables, modules, files, testing and debugging, Abstract data types and classes, some important complexity classes	12
Unit V	Object-oriented programming, algorithms, data structures, Plotting Search algorithms, sorting algorithms, Matplotlib	10

References Textbooks:

1. Introduction to Computation and Programming Using Python, by John V Guttag, MIT Press

EE-624 – DIGITAL SYSTEM DESIGN USING FPGAs

Course Outcomes:

CO-1 :	Familiarized with the design of Combinational and Synchronous and Asynchronous Sequential Circuits. Gave an Overview of PLDs and PALs
CO-2 :	Covered basic introduction of VHDL and the basic language elements. Various Combinational and Sequential circuits were designed using VHDL
CO-3 :	In-depth analysis of Faults and testability in digital systems including modelling and detection
CO-4 :	Interfacing various sensors and reading/writing to/from various file formats. Implementing various modulation schemes
CO-5 :	Design of a RISC CPU, data and control path components. Introduction to various floating/fractional/fixed-point arithmetic operations. Implementing Data encryption/Decryption system, Error correction, communication modules, BERT

Syllabus:

Units	Syllabus Details	Hrs
Unit I:	**Digital system design techniques:** Combinational Circuit Design - Synchronous Sequential Circuit Design - Mealy and Moore model - State machine design - Analysis of Synchronous sequential circuit - State equivalence - State Assignment and Reduction - Analysis of Asynchronous Sequential Circuit - flow table reduction – races - state assignment - Design of Asynchronous Sequential Circuit - Designing with PLDs – Overview of PLDs – ROMs - EPROMs – PLA – PAL - Gate Arrays – CPLDs and FPGAs, Designing with ROMs - Programmable Logic Arrays - Programmable Array logic.	12
Unit II:	**IIVHDL basics and computation module designs:** Introduction to VHDL - Behavioral modeling - Data flow modeling - Structural modeling - Basic language elements – Entity – Architecture - Configurations – Arrays declaration -	6

	Subprograms & operator overloading - Packages & libraries – Advanced Features - Model simulation - Realization of combinational and sequential circuits using VHDL – Registers – Flip flops - counters – Shift registers – Multiplexers - sequential machine – Multiplier – Divider, ALU, MAC, CORDIC, Introduction to Synthesis.	
Unit III	**Fault modeling, detection and test pattern generation algorithms:** Introduction to testing – Faults in Digital Circuits – Modeling of faults – Logical Fault Models – Fault detection – Fault Location – Fault dominance – Logic simulation – Test generation for combinational logic circuits – Testable combinational logic circuit design - Introduction to Design for Testability - BIST..	6
Unit IV	**Digital system design with real-time I/O interface:** Sensors interface - uni-polar & bi-polar A/D converter - D/A converter interface - display devices interface - RS232, USB, Ethernet, VGA interface - RF data link - high voltage switch control - realy/AC/DC motor & buzzer control - PWM signal generation - PS/2 key-board & matrix keypad interface – digital camera interface, arbitrary data/signal generation – sensor data acquisition and writing/reading to/from .xlsx and .doc file - implementation of modulation schemes	12
Unit V	**Contemporary designs and solutions:** Design of data path components, Control path components - Design of a simple RISC CPU - Debugging using Embedded Logic Analyzers - Audio codec (AC97) interface – Test-bench design - ChipScope Pro Analyzer - introduction to floating/fractional/fixed-point arithmetic operations - Xilinx Sys-Gen tools - MATLAB/VHDL interface with Sys-Gen tools -BERT interface – implementation of DPCM, data encryption/decryption system, EC techniques, communication modules design, DA based computations.	10

LIST OF EXPERIMENTS:

SL No	NAME OF EXPERIMENTS
01.	The Basic FPGA Design Flow 1. To understand use of Xilinx ISE 2. To understand Xilinx Synthesis Technology or XST. 3. Familiarization of Xilinx Vivado Design Tools.
02.	Familiarization of FPGA Boards 1. Xilinx FPGA Boards (Virtex 6,Kintex7) 2.Implementation of Full adder, ALU , Memory and FIFO on FPGA
03.	Fault Detection Logic Implementation on FPGA 1. Stuck at Fault 2.Memory BIST

04.	Implementation of RISC CPU on FPGA and debugging using Embedded Logic Analyzers.

REFERENCE TEXT BOOKS:

1. Jesse H. Jenkins, "Designing with FPGAs and CPLDs", Prentice Hall, NJ,1994
2. Fundamentals of Logic Design – Charles H. Roth, 5th ed., Cengage Learning.
3. Kevin Skahill, "VHDL for Programmable Logic", Addison -Wesley, 1996
4. Z. Navabi, "VHDL Analysis and Modeling of Digital Systems", McGRAW-Hill, 1998
5. Digital Circuits and Logic Design – Samuel C. Lee , PHI
6. Smith, "Application Specific Integrated Circuits", Addison-Wesley, 1997
7. P.K. Lala, "Digital Circuit Testing and Testability", Academic Press, 2002

AP-605 – Sensor Technology Laboratory-I

Course Outcomes:

CO-1 :	Interpret the concepts of basic physics behind several sensors
CO-2 :	Analyze optical, electrical, thermal properties
CO-3 :	Examine situations where the sensors based on above properties can be used
CO-4 :	Illustrate implementation of sensor system on LabView
CO-5 :	Summarize different applications where the sensors systems can be used

Syllabus:

Units	Syllabus Details
Unit I:	Determination of various parameters of optical fiber, Micro and Macro bending for strain detection Michelson Interferometry
Unit II:	Hall effect experiment Resistive sensors
Unit III	Automation of sensor system, Humidity Sensor, Temperature Sensor
Unit IV	Ultrasonic proximity sensor, temperature sensors
Unit V	LabVIEW based automation
	Sensor Calibration Vibration Sensors GM Counter

References Textbooks:

AP-606 –Sensors and Actuators - I

Course Outcomes:

CO-1 :	Interpret the concepts of mechanical and electromechanical sensors
CO-2 :	Analyze the working principle of magnetic sensors
CO-3 :	Examine the working mechanism of different types of sensors
CO-4 :	Illustrated the practical implementation pressure sensing.
CO-5 :	Summarize different applications of above types of sensors for position, velocity and acceleration measurement

Syllabus:

Units Divisions	Syllabus Details	Hrs
Unit I:	Mechanical and electromechanical sensors: Resistive potentiometer, strain gauge, inductive sensor, capacitive sensor	10
Unit II:	Magnetic sensors: Magneto-resistive, Hall effect sensors, Inductance and eddy current sensors, LVDT, RVDT	6
Unit III	Pressure measurement: manometer, ring balance manometer, bell type manometer, thin plate diaphragms, bellows, bourdon tube, piezo-resistive and capacitive pressure sensor, optoelectronic pressure sensors, vacuum sensors- pirani gauge, ionization gage, gas drag gauge.	12
Unit IV	Force and torque measurement: helical spiral springs, cantilever, beams, diaphragm, load cell, torsion bar, flat spiral spring for torque	6
Unit V	Position and displacement, Velocity and Acceleration sensors: Electromagnetic velocity sensor, Doppler with sound or light or other EM wave, Accelerometer characteristics, capacitive, piezo- resistive, piezoelectric accelerometer, thermal accelerometer, rotor, monolithic and optical gyroscopes and mechanical gyroscopes.	12

References Textbooks:

AP-607– Sensors and Actuators - II

Course Outcomes:

CO-1 :	Students to learn the working principles of sensors and actuators
CO-2 :	Students to be able to understand and carry out applications based selection of sensors and actuators
CO-3 :	Students to become capable of characterizing a particular given sensor

Syllabus:

Units	Syllabus Details	Hrs
Unit I:	Optical properties, components, sources and detectors: types of sources : source- detector characterstics, Radiometry, Photometry, windows, mirrors, lenses, Fresnel lenses	4
Unit II:	Light Detectors : Photoconductive detectors, Photo diodes, Avalanche photodiodes, Photoresistors, Photo multipliers, CCDs, Image Intensifiers, Solar Cells, photon counting techniques to count low photon flux, Thermal detectors : Golay Cells, Thermopile Sensors, Pyroelectric Sensors, Bolometers, Active FIR Sensors, Gas Flame detectors	6
Unit III	Radiation Detectors : Scintillation detectors, Ionization Detectors : Ionization Chambers, Proportional Chambers, Geiger-Muller Counters, Semiconductor Detectors	4
Unit IV	Temperature Sensors :Thermo resistive Sensors, Thermoelectric Contact Semiconductor Junction Sensors, Optical Temperature Sensors, Acoustic Temperature Sensors, Piezoelectric Temperature Sensors	6
Unit V	Chemical Sensors : Classification of Chemical Sensing Mechanisms, Direct Sensors : MOX, Chem Fet, Electrochemical, Complex Sensors: Thermal, Pellister Catalytic, Mass detector, Biochemical and enzyme Sensors, Smart chemical sensors, Mass Spectroscopy	6
Unit VI	Actuation and actuators: Active elements: Piezoelectric, magneto-strictive, photoelectric, thermoelectric, actuator principles, actuators as system components, actuators in mechatronics and adaptronics, electrostatic/Electromagnetic actuators (types of motors) Introduction and classification of motors, PZT actuators, Smart actuators, multilayer actuator.	8

Lab Assignments		**hrs**
Lab 1	Comparative experimental study of different Temperature Sensors	4
Lab 2	Stepper motor control experiment	4
Lab 3	Demo of Radiation detector	4

References Textbooks:

1] Handbook of Modern Sensors: Physics, Designs and Applications, Jacob Fradden, Third Edition, Springer
2] Micromachined Transducers Sourcebook," G.T.A. Kovacs,McGraw Hill,1998.
3] Actuators basics and applications, H Janocha,Springer.
4] Sensors and Transducers, D Patranabis PHI Publications, 2nd edition(2013).

AP-608 – Machine Learning techniques for Sensor Data Analytics

Course Outcomes:

CO-1:	Interpret the concepts machine learning
CO-2:	Analyze different types of machine learning techniques
CO-3:	Examine situations where supervised learning can be used
CO-4:	Illustrate implementation of supervised and unsupervised learning.
CO-5:	Summarize different applications of machine learning techniques in sensors

Syllabus:

Units	Syllabus Details	Hrs
Unit I:	Introduction: Role of Machine learning techniques in sensor data analytics, Learning from data, Machine learning examples, Simple model for Machine Learning, Types of learning,	6
Unit II:	Theory of generalization: Feasibility of learning, Hoeffding inequality, complexity of hypothesis set, growth function, VC dimension, Training versus testing	6
Unit III	Supervised Learning: Perceptron, Linear classification, Linear regression, Logistic regression, Neural Network, Backpropagation algorithm, Support Vector Machines, Radial Basis Functions, K-nearest neighbour, Decision Trees, Bayesian Learning, Deep learning, Feature extraction and dimensionality reduction: Curse of dimensionality, Principal Component analysis, Linear discriminant analysis	12
Unit IV	Unsupervised Learning: Clustering, K-means clustering, hierarchial clustering	10
Unit	Machine Learning issues: Overfitting, Validation, Occam’s razor,	10

V	Agglomerative Sampling bias, Data Snooping	

References Textbooks:

1. Thomas A. Runkler, "Data Analytics: Models and Algorithms for Intelligent Data Analysis", Springer Vieweg,2012.
2. S. Haykin, “Neural Networks, A Comprehensive Foundation“, Pearson Education Inc.,2004.
3. Richard O. Duda, Peter E. Hart, David G. Stork, Pattern Classification, 2nd Edition,2001.
4. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer,2006.
5. Y. S. Abu-Mostafa, M. Magdon-Ismail, and Hsuan-Tien Lin, Learning from data,AMLbook.com
6. Y. S. Abu-Mostafa, Learning from data, Caltech lectures(online)
7. S. Sarkar, Introduction to Machine Learning, NPTEL course, IIT Kharagpur(online).

AP-609 – Sensor Technology Laboratory- II

Course Outcomes:

CO-1 :	Interpret the basic concepts of microcomputer
CO-2 :	Analyze different types of microcomputers
CO-3 :	Examine situations where they can be used
CO-4 :	Illustrate implementation of sensor system using Raspberry Pi
CO-5 :	Summarize different applications of microcomputer in real rife

Syllabus:

Units Divisions	Syllabus Details
Unit I:	Basic experiments with Raspberry Pi Smart Irrigation System
Unit II:	Modulation of the digital signal using Raspberry Pi 1. PWM generation 2. Changing the PWM parameters
Unit III	Interfacing and displaying the sensor on output LCD screen to show temperature and humidity Demonstration of Internet of Things
Unit IV	1. Data collecting and Data logging on a PC using Raspberry Pi 2. To control the actuator using RPi Servo motor

	3. Interconnecting sensor and actuator using RPi
Unit V	1. Operating Joystick using RPi and ATMEGA microcontroller 2. Controlling servo motor using joystick through RPi and ATMEGA
Unit VI	FPGA based experiments Implementation Gate Circuits Sequential Circuits (Finite State Machine) Counters UART communication with PC

Lab Assignments	
Lab 1	Mini project from what has been learned in the lab

References Textbooks:

AP-610 – Advanced Sensors

Course Outcomes:

CO-1:	To make students learn the concepts of advanced sensors that are used in various applications.
CO-2:	Demonstrate the applications of these sensors practically
CO-3:	Perform some real-time applications using advanced sensor system

Syllabus:

Units	Syllabus Details	Hrs
Unit I:	**Sensor systems for Nuclear applications:** Experimental investigation of interactions of radiation with matter. Principles and mechanisms underlying nuclear radiation detection and measurements; operation of nuclear electronic laboratory instrumentation; application of gas-filled, scintillation and semiconductor laboratory detectors for measurement of alpha, beta, gamma, and neutron radiation.	**8**
Unit II:	**Sensors in Automotive Applications:** Introduction to Automotive Engineering, Power train Sensors, Sensors for Chassis management, Sensors for vehicle body management, Sensors for automotive vehicle convenience, Air Bag and Seat Belt Pre tensioner Systems, Passenger Convenience Systems, ModernTrends	**8**

Unit III	**Sensors in Biomedical Applications:** Physical Sensors in Biomedicine, Electrochemical Sensors, EEG, EMG & ECG, Detectors in Radiology, Sound in Medicine, Amperometric Biosensor, Potentiometric Biosensor, Optical Biosensor, Immunosensors, Hybrid Biosensor, In Vivo Biosensor and CommercialBiosensor, Demonstration of NMR, PET MRI	**8**
Unit IV	**Sensors in Environmental Applications:** Measurement techniques for water quality, Measurement techniques for chemical Pollutants, Waste water treatment, Air pollution; Its sources, Measurement techniques for air quality, Sensors in exhaust gastreatment	**8**
Unit V	**Metamaterial based sensors, Wearable and implantable sensors**	**8**
Unit VI	Night vision devices, Portable and /or wearable inertial and position, motion and acceleration sensors.Miniaturised and highly sensitive vision camera system, CBW sensors (remote operation or hand-held).	8

References Textbooks:

1. Medical Instrumentation; Application and Design; J. G. Webster, Editor, 4th Edition,2015, JohnWiley&Sons,Inc.;NewYork.
2. John Turner, Automotive Sensors, Momentum Press, 1st Edition,2009.
3. Automotive Sensors, BOSCH,2002
4. Techniques of Radiation Dosimetry by K. Mahesh1985
5. Nuclear Radiation Detectors, S.S. Kapoor, V. S. Ramamurthy1986
6. Handbook Of Chemical AndBiological Sensors R.F Taylor, Jerome S. Schultz, 1996 by CRCPress

AP-611 – Sensors for Defence

Course Outcomes:

CO-1:	To make students understand the importance of sensors for various defence applications
CO-2:	To interpret the working of a variety of sensors that are useful in Defence
CO-3:	Illustrate implementation of sensor in various apparatus that are used in defence
CO-4:	Summarize different applications of sensors in defence
CO-5:	

Syllabus:

Units	Syllabus Details	Hrs
Unit I:	(Micro) μ radar for personnel use and for unmanned miniaturized vehicles, SAR, GPR principles.	8
Unit II:	Health monitoring sensors (embedded, continuous or intelligent), Condition monitoring of equipment and munitions.Drug and nutraceutical (nutrition) delivery sensors and systems. Wireless body area network	10
Unit III	Sonar sensors Ultrasonic sensors, measurements for anemometers, tank or channel level, and speed through air or water, Robot sonars, counter measures, active sonar systems, sonars for military applications, antisubmarine warfare, submarine navigation, intercept sonar.	10
Unit IV	Extra Low Frequency Electromagnetic (ELFE) sensors**(**sensors for 3-30 Hz, requirements of such sensors, submarine applications, underwater communications, other applications such as pipeline gauges, ham radio, night vision), StarSensors	10
Unit V	Hyperspectral imaging and multi-sensor data fusion and I-STAR (MW, SW, LW), weapon systems for UAV, smart sensors for long range acquisition and long range laser designation, seekers EO, Laser, IR, UV, cameras miniaturize for DRONE. Emerging technology in defence sensor design and testing (can be covered by experts in the field)	8

References Textbooks:

1. K. Biggs, M. Burris,M . Stanley, The Complete Guide to Night Vision Paperback, CreateSpace Independent Publishing Platform,2014.
2. Inputs from DRDO scientists working in the relevantfield.
3. Research papers : Wolf, S., J. Davis, and M. Nisenoff. "Superconducting extremely low frequency (ELF) magnetic field sensors for submarine communications." *IEEE Transactions on Communications* 22.4 (1974):549-554.
4. Constable, Steven, and Leonard J. Srnka. "An introduction to marine controlled-source electromagnetic methods for hydrocarbon exploration." *Geophysics* 72.2 (2007): WA3- WA12.
5. McKerrow, P. J. "Robot perception with ultrasonic sensors using data fusion." *Systems, Man and Cybernetics, 1995. Intelligent Systems for the 21st Century., IEEE International Conference on*. Vol 2. IEEE,1995.
6. Staszewski, Wieslaw, ChrBoller, and Geoffrey R. Tomlinson, eds. *Health monitoring of aerospace structures: smart sensor technologies and signal processing*. John Wiley & Sons, 2004

AP-612– Nanotechnology for Advanced Sensors

Course Outcomes:

CO-1 :	Interpret basic concepts of nanotechnology

CO-2 :	Analyze growth of nanostructures
CO-3 :	Examine different types of nanostructures and their characterization
CO-4 :	Illustrate implementation of nanostructures for exploring different properties
CO-5 :	Summarize different applications nanostrucutures for sensors

Syllabus:

Units Divisions	Syllabus Details	Hrs
Unit I:	Implications of nano size on physical and chemical properties: Density of States, 2D, 1D, 0D, Quantum size effect, large surface to volume ratio, surface functionalization, Physical Chemistry of solid surfaces, crystal structures, surface energy, chemical potential,	8
Unit II:	Fundamentals of nucleation and growth: Electrostatic Stabilization Surface charge density, Electric potential at the proximity of solid surface, Van der Waals attraction potential, Interactions between two particles: DLVO theory, Solvent and polymer, Interactions between polymer layers, Mixed steric and electric interactions	8
Unit III	Nanoscale Phenomenon: Nanoparticles, nano-clusters, nanotubes, nanowires and nanodots. Electronic structure: quantum dots, quantum wires and quantum wells, confinement of electrons energy quantization, semiconductor nanocrystals, carbon nanotubes, quantum wells.	8
Unit IV	Characterization and properties of nanomaterials: Structural Characterization, X-ray diffraction (XRD), Small angle X-ray scattering (SAXS), Scanning electron 8microscopy (SEM), Transmission electron m8icroscopy (TEM), Scanning probe microscopy (SPM), Surface plasmon resonance	8
Unit V	Nano Sensors: Metal nanoparticle-based Sensors, Quantum Dot, Nanowire-based Sensors, Carbon Nanotubes-based Sensors, Sensors Based on Nanostructures of Metal Oxide, Mass-Sensitive Nanosensors, Arrays of Nanomaterial-based Sensors, e-nose	8

References Textbooks:

1. Nanostructures & nanomaterials Synthesis, Properties & Applications, Guozhong Cao, Imperial College Press(2004).
2. Introduction to Nanotechnology, Charles Poole Jr and Frank J Owens, Wiley India, New Delhi(2006)
3. Nanophysics and Nanotechnology, Edward L Wolf, Wiley-VCH, Verlag(2006)
4. Ramsden Jeremy, Nanotechnology, an Introduction. Elsevier(2011).
5. Florinel-Gabriel Banica,Chemical Sensors and Biosensors: Fundamentals and Applications, John Wiley and Sons(2012)

PGC-601 – Research Methodology and IPR

Course Outcomes:

CO-1 :	Understanding the fundamentals of research and its methodology
CO-2 :	Choose the appropriate research design and develop appropriate 3 hypotheses for a research project
CO-3 :	Knowledge of manuscript preparation, patents and Intellectual property
CO-4 :	Technology transfer and application of IPR in various domains

Syllabus:

Units Divisions	Syllabus Details
Unit I:	Meaning of research problem, Sources of the research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of the research problem.Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations
Unit II:	Effective literature studies approach, analysis Plagiarism, Research ethics,
Unit III	Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee
Unit IV	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process ofPatenting and Development: technological research, innovation, patenting, development.International Scenario: International cooperation on Intellectual Property. Procedure forgrants of patents, Patenting under PCT.
Unit V	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications
Unit VI	New Developments in IPR: Administration of Patent System. New developmentsin IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

References Textbooks:

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for
2. science & engineering students’”
3. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
4. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”
5. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd,2007.
6. Mayall, “Industrial Design”, McGraw Hill, 1992.

7. Niebel, “Product Design”, McGraw Hill, 1974.
8. Asimov, “Introduction to Design”, Prentice Hall, 1962.
9. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.
10. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

PGC-602 – Audit I and II

Course Outcomes:

CO-1 :	
CO-2 :	
CO-3 :	
CO-4 :	
CO-5 :	

Syllabus:

Units Divisions	Syllabus Details
Unit I:	English for Research Paper Writing
Unit II:	Disaster Management
Unit III	Sanskrit for Technical Knowledge
Unit IV	Value Education
Unit V	Constitution of India
Unit VI	Pedagogy Studies
Unit VII	Stress Management by Yoga
Unit VIII	Personality Development through Life Enlightenment Skills

END OF THE COURSE CONTENT