Department of Technology,
Savitribai Phule Pune University
(Formerly University of Pune)

STRUCTURE OF ONE YEAR FULL TIME POST GRADUATE DIPLOMA IN
Industry 4.0 Based Mechatronics and Robotics (PGD-MR)

Each Trimester is of 15 weeks followed by examination in subsequent week.

Trimester 1

Sr. No.	Course Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1	PGMR101	Concepts in Electronics Engineering	3	1		4
2	PGMR102	Microcontrollers and Programmable Logic Controllers	3	1		4
3	PGMR103	Industrial Drives and Controls for Automation	3	1		4
4	PGMR104	Sensors and Signal Conditioning	3	1		4
		Total Credits				**16**

Trimester 2

Sr. No.	Course Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1	PGMR201	Industry 4.0 Siemens Mindsphere Cloud	3	1		4
2	PGMR202	Industrial Robotics	3	1		4
3	PGMR203	Industrial Automation and Mechatronics Lab			6	3
4	PGMR204	Industrial Robotics Automation Lab			6	3
		Total Credits				**14**

Trimester 3

Sr. No.	Course Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1.	PGMR301	Industry Internship				10
		Total				**10**
		Total Course Credits				**40**

AUDIT COURSES				
Sr. No.	**Subject Code**	**Subject Name**	**Credits**	**Semester/ Trimester**
1	CYSA	Cyber Security	2	I
2	HRE101	Human Rights & Duties	1	II
3	HRE102/HRE103	Human Rights & Vulnerable Groups/Law Policy , Society & Enforcement mechanism	1	III

1. CONCEPTS IN ELECTRONICS ENGINEERING

To understand the basics and working principles of electronic components and their applications . This course is intended for learning the Fundamentals, properties and applications of Electronic Components, Devices, analog circuits, digital circuits, test and measuring instruments . ELECTRONIC COMPONENTS AND DEVICES : Resistors, Capacitors, Inductors, Transformers – types and properties,- Junction diodes, Zener diodes, Bipolar transistors, Field Effect transistors, Uni junction Transistors, MOS Devices, LEDs – Characteristics and applications; Thyristor Devices – SCR, DIAC, TRIAC, QUADRAC – operating mechanism, characteristics and applications.
ANALOG ELECTRONICS: Rectifiers and Filters; Regulated Power Supply – Switching Power Supplies, Thermal Considerations, Feedback and power amplifiers , Sine wave oscillators, OPERATIONAL AMPLIFIERS AND APPLICATIONS :Operational amplifiers – Principles, Specifications, characteristics and ,applications-. Arithmetic Operations, Integrator, Differentiator, Comparator, Schmitt Trigger, Instrumentation Amplifier, Active filters, Linear Rectifiers, Waveform Generators, D/A converters. DIGITAL ELECTRONICS : Number systems – Logic gates – Boolean algebra – Simplification of Boolean functions using Map method. Tabulation method – Combinational logic circuits: Full adder, Code Converters, Multiplexers, Decoders – Sequential logic circuits: Flip-flops, Counters, Shift registers – A/D Converters. TEST AND MEASURING INSTRUMENTS : Measurement of voltage, current ,frequency and power using Multi meters , oscilloscopes, recorders, data loggers, signal sources, counters, analyzers and printers.

TOTAL: 45 Hrs

REFERENCES:

1. Mill Man and Halkias ":Electron devices and circuits" McGraw-Hill 2004.
2. Jocob Mill Man, Micro electronics Digital and Analog circuits & Systems – McGraw-Hill 2004.
3. Ray & Chaudary, Linear Integrated Circuits, New Age 2006.
4. Malvino & Leach, Digital Principals & application, TMH 2002.
5. Helfrick A.D and Cooper .W. D. " Modern Electronic Instrumentation and Measurements Techniques" Printice Hall 2008.

2. MICROCONTROLLER AND PROGRAMMABLE LOGIC CONTROLLERS (PLC)

To understand the programming interfacing and applications of various microcontrollers and programmable logic controller. This course is intended for learning the Introduction and Architecture of Microcontroller, Fundamentals of Assembly language Programming, Programming of Microcontroller and Interfacing of Microcontroller. This course is also gives the ideas of Fundamentals. Architecture and Operations of programmable logic controller, Problem solving using logic ladder diagrams and communication in PLCs.

INTRODUCTION TO MICRO CONTROLLER : Microprocessors and Microcontrollers – CISC and RISC - Fundamentals of Assembly language Programming – Instruction to Assembler – C Programming for Microcontrollers – Compiler and IDE – Introduction to Embedded systems - Architecture 8051 family - PIC 18FXXX – family – Memory organization. PROGRAMMING OF 8051 MICROCONTROLLER : Instruction set – Addressing modes – I/O Programming-Timer/Counter - Interrupts – Serial communication of 8051. PROGRAMMING OF PIC18FXXX MICROCONTROLLER. Instruction set – Addressing modes – I/O Programming-Timer/Counter - Interrupts – Serial communication,CCP, ECCP PWM programming of PIC18FXXX. PERIPHERAL INTERFACING : Interfacing of Relays, Memory, key board, Displays – Alphanumeric and Graphic, RTC, ADC and DAC, Stepper motors and DC Motors, I^2C, SPI with 8051 and PIC family . PLC PROGRAMMING : Fundamentals of programmable logic controller – Functions of PLCs – PLC operations – Evaluation of the modern PLC – Memory– Selection of PLC – Features of PLC – Architecture – Basics of PLC programming – Developing Fundamental wiring diagrams – Problem solving using logic ladder diagrams – communication in PLCs – Programming Timers – Programming counters – Data Handling. COMMUNICATION PROTOCOLS **NETWORK PROTOCOLS:** LAN, WAN and MAN Networks – RS485, RS 422, LXI Protocols – Modbus – Field bus – Ethernet – CAN bus – SCADA and DCS. **DATA ACQUSITION SYSTEM :** Continuous and Discrete signals – Sampling theorem – Quantization – Sampling and Hold – ADC – DAC – Resolution and Sampling Frequency – Multiplexing of input signals – Single ended and differential inputs – Sampling of Multi-channel analog signals – Concept of Universal DAQ card – Timer & Counter and analog output in Universal DAQ card. **PROGRAMMING TECHNIQUES**

Algorithm – Flowchart – Variables & Constants – Expressions – Data types – Input output operations . Conditional Statements – Looping – Sub-programs/Functions – Arrays, Structures and Classes – Inheritance – Polymorphism – Debugging. GRAPHICAL PROGRAMMING

GUI – Graphical Programming – Data Flow techniques – Processing Data in GP – Loops and Structures – Event based & Schedule based operations – Global and Local Variables – File I/O operations – Parallel processing of data – Virtual Instrument and control – VISA & SCPI

TOTAL: 45 Hrs

REFERENCES

1. Muhammad Ali Mazidi and Janice GillispicMazdi, “The 8051 Microcontroller and Embedded Systems” Pearson Education, Inc 2006.

2. John B. Peatman, PIC programing, McGraw Hill International, USA, 2005.
3. John B. Peatman, Design with Micro controllers, McGraw Hill International, USA, 2005.
4. Kenneth J. Aylala, "The 8051 Micro controller, the Architecture and Programming applications":2003..
5. James W. Stewart, "The 8051 Micro controller hardware, software and interfaciung, regents Prentice Hall, 2003.
6. Frank D. Petro Zella, "Programmable logic controller" McGraw – Hill Publications, 1998
7. Mill Man and Halkias ":Electron devices and circuits" McGraw-Hill 2004.
8. Jocob Mill Man, Micro electronics Digital and Analog circuits & Systems – McGraw-Hill 2004.
9. Ray & Chaudary, Linear Integrated Circuits, New Age 2006.
10. Malvino & Leach, Digital Principals & application, TMH 2002.
11. Helfrick A.D and Cooper .W. D. " Modern Electronic Instrumentation and Measurements Techniques" Printice Hall 2008.
12. Muhammad Ali Mazidi and Janice GillispicMazdi, "The 8051 Microcontroller and Embedded Systems" Pearson Education, Inc 2006.

13. Wayne Wolf, Computers as Components – Principles of Embedded Computing System Design, Morgan Kaufmann Publishers 2009.
14. Ball S.R., Embedded microprocessor Systems – Real World Design, Prentice Hall, 2006
15. C.M. Krishna, Kang G. Shin, Real Time systems, McGraw Hill 2009
16. Frank Vahid and Tony Givagis , Embedded System Design
17. Tim Wilmshurst, An Introduction to the design of small – scale Embedded Systems.
18. Morris Mano M., Computer System Architecture, Prentice Hall of India, Third Edition, 2002.
19. John P. Hayes, Computer Architecture and Organization, McGraw Hill International, Third Edition, 1998.
20. William Stallings, "Computer Organization and Architecture", VI Edition, Prentice Hall of India, 2003.
21. Krishna Kant , 'Computer based Industrial Control', Prentice Hall of India, 1997.
22. Gary Johnson, 'LabVIEW Graphical Programming', II Ed. , McGraw Hill, 1997.
23. Sanjeev Gupta, 'Virtual Instrumentation using Labview' Tata McGraw Hill, 2004.
24. Jovitha Jeome 'Virtual Instrumentation using Lab View' PH1 Learning Pvt Ltd,2009.

3. INDUSTRIAL DRIVES AND CONTROLS FOR AUTOMATION

To impart knowledge in the area of hydraulic , pneumatic electric actuators and their control.

To make the students to learn the basic concepts of ac DRIVES , dc DROIVES , Leniear and Rotary actuators ,hydraulic, pneumatics and electric drives and their controlling elements in the area of Mechatronics systems.To train the students in designing the hydraulics and pneumatic circuits using ladder diagram. And designing control circuits for electric drives.

FLUID POWER SYSTEM GENERATION AND ACTUATORS Need for automation, Classification of drives-hydraulic, pneumatic and electric –comparison – ISO symbols for their elements , Selection Criteria. Generating Elements-- Hydraulic pumps and motor gears, vane, piston pumps-motors-selection and specification -Drive characteristics – Utilizing Elements-- Linear actuator – Types, mounting details, cushioning – power packs –accumulators CONTROL AND REGULATION ELEMENTS : Control and regulation Elements—Direction, flow and pressure control valves--Methods of actuation, types, sizing of ports. spool valves-operating characteristics-electro hydraulic servo valves-Different types-characteristics and performance. CIRCUIT DESIGN FOR HYDRAULIC AND PNEUMATICS :

Typical Design methods – sequencing circuits design - combinational logic circuit.design--cascade method - -Karnaugh map method-- Electrical control of pneumatic and hydraulic circuits-use of relays, timers, counters, Programmable logic control of Hydraulics Pneumatics circuits, PLC ladder diagram for various circuits, motion controllers, use of field busses in circuits. ELECTRICAL ACTUATORS .

D.C Motor--Working principle ,classification, characteristics, Merits and Demerits, Applications- AC Motor-- Working principle, Types, Speed torque characteristics, Merits and demerits, Applications Stepper motor- principle ,classification, construction. Piezo electric actuators – Linear actuators - Hybrid actuators – Applications. ELECTRICAL DRIVE CIRCUITS DC Motors - Speed ,direction and position control using H-bridge under PWM mode**.** Control of AC motor drives – Need for V/ F drives – Energy saving AC drives. – Stepper Motor – Drive circuits for speed and position control, BLDC motor – Controller – Switched reluctance motor .

TOTAL: 45 Hrs

REFERENCES:

1. Antony Esposito, Fluid Power Systems and control Prentice-Hall, 2006
2. Peter Rohner, Fluid Power logic circuit design. The Macmillan Press Ltd.,London, 1979
3. E.C.Fitch and J.B.Suryaatmadyn. Introduction to fluid logic, McGraw Hill, 1978.
4. W.Bolton, Mechatronics, Electronic control systems in Mechanical and Electrical Engineering Pearson Education, 2003.
5. Gopal K.Dubey, Fundamentals of electrical drives. Narosa Pubilcations, 2001

4. SENSORS AND SIGNAL CONDITIONING

To impart knowledge on various types of sensors and transducers for Automation in Mechatronics Engineering.To study basic concepts of various sensors and transducers with I/O Link connectivty .To develop knowledge in selection of suitable sensor for mechatronics systems. To design suitable signal conditioning circuits for mechatronics systems.To Study I/O Link with Sensors . Basics of Measurement – Classification of errors – Error analysis – Static and dynamic characteristics of transducers – Performance measures of sensors – Classification of sensors – Sensor calibration techniques – Sensor Output Signal Types **MOTION, PROXIMITY AND RANGING SENSORS** : Motion Sensors – Brush Encoders, Potentiometers, Resolver, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT – RVDT – Synchro – Microsyn , Accelerometer.,– GPS, Range Sensors – RF beacons, Ultrasonic Ranging, Reflective beacons, Laser Range Sensor (LIDAR). FORCE,MAGNETIC AND HEADING SENSORS Strain Gage, Load CellMagnetic Sensors –types, principle, requirement and advantages: Magneto resistive – Hall effect – Current sensor Heading Sensors – Compass, Gyroscope, Inclinometers. OPTICAL, PRESSURE AND TEMPERATURE SENSORS . Photo conductive cell, photo voltaic, Photo resistive, LDR – Fiber optic sensors – Pressure – Diaphragm, Bellows, Piezoelectric, Temperature – IC, Thermistor, RTD, Thermocouple, SIGNAL CONDITIONING : Need for Signal Conditioning – DC and AC Signal conditioning – Filter and Isolation Circuits – Operational Amplifier Specifications, Characteristics and Circuits – Voltage and Current Amplifiers – Transmitting Circuits – Fundamentals of Data Acquisition System.

TOTAL: 45 Hrs

REFERENCES:

1. PatranabisD.,Sensor and Actuators, Prentice Hall of India (Pvt) Ltd. 2005.
2. Ernest O. Doeblin, Measurement system, Application and design, , Tata McGraw Hill Publishing Company Ltd., Fiftieth Edition, 2004
3. Bradley D.A., and Dawson, Burd and Loader, Mechatronics, Thomson Press India Ltd., 2004
4. RenganathanS.,Transducer Engineering, Allied Publishers (P) Ltd., 2003.
5. Bolton W., Mechatronics, Thomson Press, 2003.

5. INDUSTRY 4.0 SIEMENS MINDSPHERE CLOUD

To impart knowledge on Siemens Mindsphare Cloud DEVELOPMENT ENVIRONMENT PLATFORM : Web Serve, Internate Connections, Data Import, Developer Plan, access to your account, small Cloud Foundry development space and Developer Plan – Tools ,Developer Cockpit for application registration and defining rolls and scope of applications,Usage Transparency for visualization of platform uses like outbound traffic API transactions,User Management should provide interface define rolls and scope of users kike talent admin and standard users,Asset Manager for user-friendly interface for onbaording of field assets. Developer Cockpit : Use Developer Cockpit to Assign a new application to your own developer tenant. Manage versions of your application. A User can perform an update of an application. For detailed information for individual process/steps documentation should be available on internate or service provided platform., Usage Transparency and Management . Usage Transparency provides information regarding your resource consumption e.g. API calls,Number of Users,Inbound and outbound traffic .User Management allows managing User rights, permissions and subtenants. For every User, an individual login is required. A third party User which you permit to test the application for such third parties' end use shall not be granted with administration rights, except for administration rights that are offered by the user management of a subtenant. .Asset Manager : Use Asset Manager to Onboard and off board agents to your Account, Configure assets. asset types,Cloud Foundry Org (CF Org):- CF Org is an environment to test and deploy applications , Visualization Applications,Launchpad,Application Interface facility,Identity management Service, Asset management service, Agent Management service,IOT Time series service,IOT time series aggregates service, Event analytic service etc. Platform as –a Service: - Development platform should be open source platform as a service powered by cloud foundry for developing cross platform applications and lowering development efforts Software based Gateway : This software-based gateway platform like JAVA based Connectivity element for OPC UA server, Node-Red based connectivity element Hardware based Gateway : support of all IEC 61131-3 programming languages (LAD/FBD, STL, SCL, Graph and direct connectivity to cloud) and of high-level languages such as C++ enable efficient programming of the Advanced Controllers in the shared engineering framework TIA Portal,Web connectivity facility

TOTAL: 45 Hrs

REFERENCES:

1. www.siemens.com

6. INDUSTRIAL ROBOTICS

Types of Industrial Robots, definitions – classifications based on work envelope – Generations configurations and control loops, co-ordinate system – need for robot – basic parts and functions – specifications. MECHANICAL DESIGN OF ROBOT SYSTEM 12

Robot motion – Kinematics of Robot motion – Direct and Indirect kinematics Homogeneous transformations – linkages and joints – mechanism – method for location and orientation of objects – drive systems – end effectors – types, selection, classification and design of grippers – gripper force analysis. SENSORS . Functions of Sensors – Position and proximity's sensing – tactile sensing – sensing joint forces – vision system – object recognition and image transformation – safety monitoring sensor systems – image analysis – application of image processing. .ROBOT PROGRAMMING & AI TECHNIQUES 8

Types of Programming – Teach pendant programming – Basic concepts in A1 techniques – Concept of knowledge representations – Expert system and its components. ROBOTIC WORK CELLS AND APPLICATIONS OF ROBOTs . Robotic cell layouts – Inter locks – Application of robots in Manufacturing industries i.e Vision , Palletisation , Pick and Place ,

TOTAL: 45 Hrs

REFERENCES:

1. Groover.M.P. Industrial Robotics, technology, programming and application Mc-Graw Hill book and co. 2012
2. Fu.K.S , Gonzalac R.C ,Lee C.S.G, Robotics Control, sensing ,vision and intelligence, Mc- Graw Hill book co 2011.
3. Yoram Koren , Robotics, McGraw Hill 2006
4. Janakiraman P.A. Robotics and Image Processing, Tata McGraw Hill, 2002
5. Saeed B.Niku ,Introduction to Robotics , analyses , systems, applications, Prentice Hall Pvt Ltd. 2005

7. INDUSTRIAL AUTOMATION & MECHATRONICS LAB

LAB work :

- To study & Experimentation of Industrial Automation plant
- To study & Experimentation of PLC Programing & execution
- To study & Experimentation of PLC using HMI and SCADA
- To study & Experimentation Sensor interfacing
- To study & Experimentation Mindsphare interfacing
- Study of Pneumatic and Hydraulic Circuits.
- Study and exprementaion of Vertual Automation software
- To study and setup Advance Manufacutring Systems using various Sensors , Pneumatics Drives and PLC.

8. INDUSTRIAL ROBOTICS AUTOMATION LAB

LAB work :

- To study & Experimentation of Industrial Robot Automation plant
- To study & Experimentation for Pick and Place , Drawing and Vision Application
- To study & Experimentation of Palletisation using Robot
- To study & Experimentation using Robotic offline Simulation software