JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. (MECHATRONICS)
Effective from Academic Year 2017-18 admitted Batch

COURSE STRUCTURE AND SYLLABUS

I Semester

Category	Course Title	Int. marks	Ext. marks	L	T	P	C
PC -1	Applied Industrial Pneumatics	**25**	**75**	**4**	**0**	**0**	**4**
PC -2	Automation in Manufacturing	25	75	4	0	0	4
PC -3	Industrial Electrical & Electronics	25	75	4	0	0	4
PE -1	Precision Engineering Advanced CNC Technology Photo Voltaic & Solar Thermal Systems	25	75	3	0	0	3
PE-2	Control systems Instrumentation & Sensor Technology Programmable Logic Controller & Applications	25	75	3	0	0	3
OE-1	***Open Elective - I**	25	75	3	0	0	3
Laboratory I	Control Lab: (Pneumatic, Hydraulics, Electrical & Electronics Control)	25	75	0	0	3	2
Seminar I	Seminar I	100	0	0	0	3	2
Total		**275**	**525**	**21**	**0**	**6**	**25**

II Semester

Category	Course Title	Int. marks	Ext. marks	L	T	P	C
PC -4	Micro Controller & Applications	25	75	4	0	0	4
PC -5	Additive Manufacturing Technologies	25	75	4	0	0	4
PC -6	Industrial Robotics	25	75	4	0	0	4
PE -3	MEMS Design for Manufacturing & Assembly Fuzzy Logic & Neural Networks	25	75	3	0	0	3
PE-4	Intelligent Manufacturing Systems Computer Aided Metrology & Machine Vision Nano Composites – Design & Synthesis	25	75	3	0	0	3
OE-2	***Open Elective - II**	25	75	3	0	0	3
Laboratory II	Applied Mechatronics Lab: (Robotics, CNC, PLC)	25	75	0	0	3	2
Seminar II	Seminar II	100	0	0	0	3	2
Total		**275**	**525**	**21**	**0**	**6**	**25**

III Semester

Course Title	Int. marks	Ext. marks	L	T	P	C
Technical Paper Writing	100	0	0	3	0	2
Comprehensive Viva-Voce	0	100	0	0	0	4
Project work Review II	100	0	0	0	22	8
Total	**200**	**100**	0	**3**	22	**14**

IV Semester

Course Title	Int. marks	Ext. marks	L	T	P	C
Project work Review III	100	0	0	0	24	8
Project Evaluation (Viva-Voce)	0	100	0	0	0	16
Total	**100**	**100**	**0**	**0**	**24**	**24**

***Open Elective subjects must be chosen from the list of open electives offered by OTHER departments.**

 # For Project review I, please refer 7.10 in R17 Academic Regulations.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. (Mechatronics)

APPLIED INDUSTRIAL PNEUMATICS
(PC-1)

UNIT-I:
Merits of Fluid power & its utility for increasing productivity through Low Cost Automation, Transmission of Fluid Power through various types of Cylinders), Symbolic representation of Pneumatic elements (CETOP), Compressors and Air supply system including airline installations, signaling & control system.

UNIT-II:
Pneumatic control elements (control valves & remote control system), Basic pneumatic circuits for controlling single & double acting cylinder, Basic pneumatic circuits, Advanced pneumatic circuits for controlling multi-cylinders (operable).

UNIT-III:
Advanced pneumatic circuits for controlling multi-cylinders (inoperable circuits), Electro pneumatics with relay logic, Pneumatics system with PID controls, Application of fluidics a non-moving part logic.

UNIT-IV:
Programmable sequential control using pneumatic modular elements, Stepper controls.

UNIT-V:
Programmable logic controllers-introduction, architecture hardware. Components-basics of PLC programming – Programming timers counters-master and jump controls- data manipulations and instructions.

REFERENCES:

1. Pneumatic Hand Book by Trade and technical press ltd.
2. Pneumatics Circuits and Low Cost Automation by Fawcett, Trade and technical press.
3. Pneumatic Systems by Majumdar. S.R, Tata McGraw-Hill
4. Hydraulics & Pneumatics Power for Production by Stewart, Industrial press.
5. Fluid Power Logic Circuit Design by Peter Rohner, The Macmillan press 1979.

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M. Tech – I Year – I Sem. (Mechatronics)

AUTOMATION IN MANUFACTURING
(PC-2)

UNIT-I:

Introduction to Automation: Automation in Production Systems-Automated Manufacturing Systems, Computerized Manufacturing Support Systems, Reasons for Automation, Automation Principles and Strategies. Manufacturing operations, Production Concepts and Mathematical Models. Costs of Manufacturing Operations, , Basic Elements of an Automated Systems, Advanced Automation Functions, Levels of automation.

UNIT-II:

Introduction to Material Handling, Overview of Material Handling Equipment, Considerations in Material Handling System Design, The 10 Principles of Material Handling, Material Transport Systems, Automated Guided Vehicle Systems, Monorails and other Rail Guided Vehicles, Conveyor Systems, Analysis of Material Transport Systems, Storage Systems, Storage System Performance, Storage Location Strategies, Conventional Storage Methods and Equipment, Automated Storage Systems, Engineering Analysis of Storage Systems.

UNIT -III:

Manual Assembly Lines, Fundamentals of Manual Assembly Lines, Alternative Assembly Systems, Design for Assembly, Analysis of Single Model Assembly Lines, Line balancing problem, largest candidate rule, Kilbridge and Wester method, and Ranked Positional Weights Method, Mixed Model Assembly Lines, Considerations in assembly line design.

UNIT-IV:

Transfer lines, Fundamentals of Automated Production Lines, Storage Buffers, Applications of Automated Production Lines. Analysis of Transfer Lines with no Internal Storage , Analysis of Transfer lines with Storage Buffers.

UNIT-V:

Automated Assembly Systems, Fundamentals of Automated Assembly Systems, Design for Automated Assembly, and Quantitative Analysis of Assembly Systems- Parts Delivery System at Work Stations, Multi- Station Assembly Machines, Single Station Assembly Machines, Partial Automation.

TEXT BOOKS:

1. Automation, Production systems and computer integrated manufacturing/ Mikel P. Groover/ Pearson edu.,/2e.
2. CAD CAM: Principles, Practice and Manufacturing Management / Chris Mc Mohan, Jimmie Browne, / Pearson edu. (LPE)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. (Mechatronics)

INDUSTRIAL ELECTRICAL AND ELECTRONICS
(PC-3)

UNIT-I:

Basic Electrical Engineering, AC & DC Motor characteristics, Speed controls, Starting principles, Selection of proper motors for various applications.

Special Purpose Electrical Machines:- Induction generators self excitation requirements, steady state analysis, voltage regulation, different methods of voltage control, application to mini and micro hydel systems.

UNIT-II:

Doubly fed induction machines:- control via static converter, power flow, voltage/frequency control (generation mode), application to grid connected wind and mini/micro hydel systems.

Switched Reluctance Motor: Construction, operating performance, control and applications.

Brushless DC Machines: construction operation, performance, control and applications.

UNIT-III:

Linear Machines:- Linear Induction Machines and Linear Synchronous Machines. Construction, operation, performance, control and applications. Application of permanent magnets in electrical machine:- structure, magnetic materials used, types of motors e.g. PMDC and PM Synchronous Machine, control and applications. Recent developments in electrical machines.

UNIT-IV:

Basic Electronics, Diodes, Transistor configurations, SCR Controls, FET, UJT, A/D Conversion, D/A Conversion, Optoelectronic devices: photo diode/transistor, LDR, LED and LCD and PLASMA displays, opto-coupler, opto-interrupter, high speed detectors – PIN and avalanche photo diodes, DC Power Supplies, AC Power Supplies, Special operational amplifiers, Timing and counting circuits

UNIT-V:

Digital Control Theory :- Basic Digital concepts, Structure of a computer controlled system. Review of Z-transform. Computation of time response of Discrete Data system. Bilinear Transformation. W-plane, prewar ping, inverse transformation.Design of discrete controllers. Z-domain compensation, w-plane compensation, state variable feedback, deadbeat controller sampled data version of PID controllers. Effect of Data Digitization.Effect of finite word size, limit cycle determination. Programmable logic devices: PLA, PLD, CPLD, FPGA and its application.

REFERENCE BOOKS:

1. Electrical Machines by P. S. Bimbra
2. Power Plant Management by Z. Aghoni
3. Power Electronics by P. S. Bimbra
4. Low Power Electronics by Allen Helberg
5. Micro Electronics by Sedra Smith

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. (Mechatronics)

PRECISION ENGINEERING
(PE-I)

UNIT I:

Concepts of Accuracy:

Introduction – Concept of Accuracy of Machine Tools – Spindle ad Displacement Accuracies – Accuracy of numerical Control Systems – Errors due to Numerical Interpolation Displacement Measurement System and Velocity Lags. **Geometric Dimensioning and Tolerancing:** Tolerance Zone Conversions – Surfaces, Features, Features of Size, Datum Features – Datum Oddly Configured and Curved Surfaces as Datum Features, Equalizing Datums –Datum Feature of Representation – Form Controls, Orientation Controls – Logical Approach to Tolerancing.

UNIT II:

Datum Systems: Design of freedom, Grouped Datum Systems – different types, two and three mutually perpendicular grouped datum planes; Grouped datum system with spigot and recess, pin and hole; Grouped Datum system with spigot and recess pair and tongue – slot pair – Computation of Transnational and rotational accuracy, Geometric analysis and application.

UNIT III:

Tolerance Analysis: Process Capability , Mean, Variance, Skewness, Kurtosis, Process Capability Metrics, Cp, Cpk, Cost aspects, Feature Tolerances, Geometric Tolerances.

Tolerance Charting Techniques-Operation Sequence for typical shaft type of components, Preparation of Process drawings for different operations, Tolerance worksheets and centrally analysis, Examples. Design features to facilitate machining; Datum Features – functional and manufacturing. Components design – Machining considerations, Redesign for manufactured, Examples

UNIT IV

Surface finish, Review of relationship between attainable tolerance grades and different machining process. Cumulative effect of tolerances sure fit law, normal law and truncated normal law.

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UNIT V:

Fundamentals of Nanotechnology: System of nanometer accuracies – Mechanism of metal Processing – Nano physical processing of atomic bit units. Nanotechnology and Electrochemical atomic bit processing. MEASURING SYSTEMS PROCESSING :In processing or in-situ measurement of position of processing point-Post process and on-machine measurement of dimensional features and surface-mechanical and optical measuring systems.

REFERENCE BOOKS:

1. Nano Technology / Norio Taniguchi / Oxford University Press, 1996
2. Engineering Design – A systematic Approach / Matousek / Blackie & Son Ltd, London.
3. Precision Engineering in Manufacturing / murthy R. L., / New Age International (P) limited, 1996.
4. Geometric Dimensioning and Tolerancing / James D. Meadows / Marcel Dekker Inc.1995.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. (Mechatronics)

ADVANCED CNC TECHNOLOGY
(PE-I)

UNIT I:
Features of NC Machines Fundamentals of numerical control, advantage of NC systems, classification of NC systems, point to point, NC and CNC, incremental and absolute, open and closed loop systems, Features on N/C Machine Tools, design consideration of NC machine tool, methods of improving machine accuracy.

UNIT II:
NC part Programming: Manual programming-Basic concepts, Point to Point contour programming, canned cycles, parametric programming. Tooling for CNC Machines: Interchangeable tooling system, preset and qualified tools, coolant fed tooling system, modular fixturing, quick change tooling system, automatic head changers.

UNIT III:
DNC Systems and Adaptive Control: Introduction, type of DNC systems, advantages and disadvantages of DNC, adaptive control with optimization, Adaptive control with constraints, Adaptive control of machining processes like turning, grinding.

UNIT IV:
Rapid Prototyping: Introduction, Stereo-lithography, Selective Laser Sintering, Fusion Deposition Modeling (FDM), LOM, Rapid Tooling.

UNIT V:
Post Processors for CNC:
Introduction to Post Processors: The necessity of a Post Processor, the general structure of a Post Processor, the functions of a Post Processor, DAPP-based-Post Processor: Communication channels and major variables in the DAPP-based Post Processor, the creative of a DAPP-Based Post Processor.

REFERENCE BOOKS:

1. Computer Control of Manufacturing Systems / Yoram Korem / McGraw Hill Int.1983.
2. Machine Tools Hand Book vol 3, (Automation & Control) / Manfred Weck / John Wiley and Sons, 1984.
3. P.N. Rao, N K Tewari, T K Kundra, “Computer Aided Manufacturing “McGraw Hill Publisher.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. (Mechatronics)

PHOTOVOLTAIC AND SOLAR THERMAL SYSTEMS
(PE-I)

Unit-I

Solar Radiation and Measurements : Solar radiation - Energy Balance, Earth sun-angles-Types of Radiation, Measurements, solar Charts-Empirical equations for predicting the availability of solar radiation – Computation of radiation on inclined surfaces- Solar radiation data

Unit-II

Photovoltaic Fundamentals: Place of PV in energy supply – PV Modules and cost-review of semiconductor physics and Operating principle-–Introduction to P-N junction: Equilibrium and non equilibrium conditions-Design of solar cells: Cell parameters limits-Losses in solar cells-Solar cell design for high $I_{sc,}$, V_{oc} and FF.

Unit-III

Solar cell technologies: Si wafer based solar cell: Process of solar cell technology-Efficiency of Si cells; Thin film technologies: Materials-deposition techniques-Amorphous Si cells- Cadmium telluride celss-Thin film crystalline and poly crystalline Si cells-concentrator technologies-Optics for concentrators PV-Tracking requirements-High concentrator solar cells-Emerging solar cell technologies.

Unit-IV

PV module and PV System applications: Solar PV modules-Mismatch in series and parallel connection-design & structure of PV modules-PV module power output-Batteries for PV systems-DC to DC and DC to AC converters-charge controllers-MPPT; Stand alone PV systems-Design methodology of PV systems-Wire sizing in PV systems-Grid connected and hybrid PV systems

Unit-V

Solar Thermal Systems and applications: Solar Flat plate collectors, Concentrating Collectors, Compound Parabolic Collector, Collector Efficiency. Solar water heating Systems, Solar Cookers, Solar Dryers and Industrial Process heating.

REFERENCE BOOKS:

1. Generating Electricity from the Sun/Edited by Fred C. Treble/Pergamon Press
2. Solar photovoltaics-Fundamentals, technologies and Applications/Chetan Singh Solanki/PHI Learning private Ltd. New Delhi
3. Terrestrial Solar photovoltaics/Tapan Bhattacharya/Narosa Publishing House
4. Solar Electricity /Edited by Tomas Markvart/John Wiley and Sons
5. Solar Cells – Operating Principles, Technology and System Applications /Martin A. Green/Prentice Hall Inc
6. Modelling Photovoltaic Systems using P Spice/Luis Castaner and Santiago Silvestre/John Wiley and Sons
7. Solar Energy – Fundamentals and Applications/H.P. Garg and J. Prakash / Tata McGraw-Hill
8. Amorphous Silicon Solar Cells/K. Takahashi and M. Konagai/North Oxford Academic
9. Photovoltaic Systems Engineering/Roger Messenger/CRC Press

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M. Tech – I Year – I Sem. (Mechatronics)

CONTROL SYSTEMS
(PE-II)

UNIT-I

Mathematical Model For Physical Systems - Open loop – closed loop control – Differential equations of physical systems – Transfer functions – Block diagram algebra – Signal flow graphs - Reduction using Mason's gain formula.

Industrial Automatic Controls - Classification – Proportional derivative and integral control actions – Liquid level control systems with proportional and integral control – Pneumatic, hydraulic and electronic controllers

UNIT-II

Transient Response Analysis - Standard signals – transient response of first and second order systems – Steady state errors and error constants.

UNIT-III

Transfer Function Representation: Transfer function of DC servomotor – AC servomotor – Synchronous transmitter and receiver. Block diagram representation of systems – Representation by signal flow graph.

UNIT-IV

Stability Analysis: Concepts of Stability - Necessary conditions for stability – Hurwitz stability criterion – Routh's stability criterion – Relative stability. Frequency Response Analysis - The root locus concept – Frequency response, polar plot, Bode plot – Nyquist stability criterion.

UNIT-V

State Variable Model and Analysis - Concepts of state & state variables – Derivation of state models from Block diagrams - State space representation of systems – Transfer matrix - Solution of state equation – State transition matrix – Concepts of controllability and observability.

REFERENCE BOOKS

1. Control systems, Principles and Design / M Gopal / TMH
2. Modern Control Engineering/ K.Ogata / Prentice Hall
3. Control Systems /Anand Kumar / Prentice Hall
4. Control Systems Engineering /Nagrath & M. Gopal/ Wiley Eastern
5. Automatic control systems/ B.C.Kuo/John Wiley & Sons\ Modern Control Systems/ Richard C.Dorf and Robert H. Bishop

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M. Tech – I Year – I Sem. (Mechatronics)

INSTRUMENTATION & SENSOR TECHNOLOGY
(PE-II)

UNIT-I

Measurement and Characteristics: Elements of a Measurement System; Classification of Instruments; Static Performance Parameters; Loading and Impedance Matching; Errors and Uncertainties in Measurement; Process and Standards of Calibration; Dynamic Characteristics-Transfer Function Representation of a Measurement System, Impulse and Step Responses of First and Second Order Systems, Frequency Response of First and Second Order Systems.

UNIT-II

Mechanical Transducers: Temperature- Bimetallic Element and Fluid Expansion type Thermometers; Pressure- Manometers and Bourdon Gauges; Force- Balances, Helical Spiral Springs, Load Cells and Elastic Force Devices; Torque- Torsion Bars and Flat Spiral Springs; Liquid Level- Float Systems and Level to Pressure Converters; Flow- Pitot Static Tubes and Turbine type Flow Meters. Hot Wire Anemometer.

Proximity Sensors- Reed Sensors, Inductive proximity sensor, Capacitive proximity sensor, Optical sensor with through beam, Ultrasonic sensors.

UNIT-III

Electrical Transducers: Resistance Thermometers; Interfacing Resistive Transducers to Electronic Circuits; Thermistors- Measurement of Temperature and Thermal Conductivity, Temperature Control; Resistance Strain Gauges- Gauge Factor, Bonded and Unbonded Strain Gauges; Self Generating and Non Self Generating Inductive Transducers; Linear Variable Differential Transformers; Capacitive Transducers - Potentiometric Transducers; Thermoelectric Transducers and Sources of Errors in Thermocouples; Piezoelectric Transducers;

UNIT-IV

Basic Signal Conditioning Elements: Amplifiers- Non Electrical and Electrical types; Op Amps-Inverting, Non Inverting, Summing, Differential, and Charge Amplifiers; Differentiating and Integrating Elements; Filters; Data Transmission Elements- Electrical, Pneumatic, Position and Radio Frequency Transmission types; Compensation Elements for First and Second Order Systems - Basic Indicating, Recording, and Display Elements.

UNIT-V

Feedback in Instruments- Principles of Feedback and Advantages & Disadvantages of Feedback; Digital Voltmeters-Ramp and Dual Slope types; Servo type Potentiometric and Magnetic Tape Recorders; Digital Recorders of Memory type; Data Displays-Analog and Digital types.

REFERENCE BOOKS:

1. Electronic Measurements and Instrumentation, K. Lal Kishore, Pearson Education Publications
2. Electronic Instrumentation, H. S. Kalsi-TMH Publications
3. Albert D Helfrick and William D Cooper; Modern Electronic Instrumentation and Measurement Techniques; 2004, PHI
4. BC Nakra, and Chaudhry; Instrumentation, Measurement and Analysis; 2004, Tata McGraw-Hill.
5. DVS Murthy; Transducers and Instrumentation; 2003, PHI.

6. CS Rangan, GR Sarma, and VSV Mani; Instrumentation Devices and Systems; Tata McGraw-Hill
7. Doeblin and Ernest; Measurement Systems Application and Design; 2004, Tata McGraw-Hill.
8. Tilak Thakur “ Mechatronics ” Oxford University Press 2016

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M. Tech – I Year – I Sem. (Mechatronics)

PROGRAMMABLE LOGIC CONTROLLERS AND THEIR APPLICATIONS
(PE-II)

UNIT-I:
PLC Basics PLC system, I/O modules and interfacing CPU processor programming equipment programming formats, construction of PLC ladder diagrams, devices connected to I/O modules.

UNIT-II:
PLC Programming input instructions, outputs, operational procedures, programming examples using contacts and coils. Drill-press operation.
Digital logic gates programming in the Boolean algebra system, conversion examples Ladder diagrams for process control Ladder diagrams and sequence listings, ladder diagram construction and flow chart for spray process system.

UNIT-III:
PLC Registers: Characteristics of Registers module addressing holding registers input registers, output registers. PLC Functions Timer functions and industrial applications counters counter function industrial applications, Architecture functions, Number comparison functions, number conversion functions.

UNIT-IV:
Data handling functions: SKIP, Master control Relay Jump Move FIFO, FAL, ONS, CLR and Sweep functions and their applications. Bit Pattern and changing a bit shift register, sequence functions and applications, controlling of two axes and three axis Robots with PLC, Matrix functions.

UNIT-V:
Analog PLC operation: Analog modules and systems Analog signal processing multi bit data processing , analog output application examples, PID principles position indicator with PID control, PID modules, PID tuning, PID functions

REFERENCE BOOKS:

1. Programmable Logic Controllers – Principle and Applications by John W Webb and Ronald A Reiss Fifth edition, PHI
2. Programmable Logic Controllers – Programming Method and Applications by JR Hackworth and F.D Hackworth – Jr- Pearson, 2004.
3. Tilak Thakur " Mechatronics " Oxford University Press 2016

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. (Mechatronics)

CONTROL LAB
(PNEUMATIC, HYDRAULICS, ELECTRICAL & ELECTRONICS CONTROL)

LIST OF EXPERIMENTS

Any TEN of the following Experiments

1. Study of Pneumatic, Electro-Pneumatic control Valves and various components.
2. Study of Hydraulic, Electro-Hydraulic Control Valves and various components.
3. Draw the Circuit diagram to operate Double Acting Hydraulic Cylinder using 4/2 Direction Control Valve (Manual type).
4. Draw the Circuit diagram to operate Double Acting Hydraulic Cylinder using 4/2 Direction Control Valve (Solenoid Control) using Push Button Switch / Latch Switch.
5. Draw the Circuit diagram to operate Double Acting Hydraulic Cylinder using 4/2 Direction Control Valve (Solenoid Control) using Push Button Switch / Latch for varying flow rate using variable throttle valve.
6. Draw the Circuit diagram to operate Single Acting Pneumatic Cylinder using 3/2 Push Button Direction Control Valve.
7. Draw the Circuit diagram to operate Double Acting Pneumatic Cylinder using 5/2 Direction Control Valve using Push Button Momentary Switch / Push Button Latch.
8. Simulation of working of Double Acting Hydraulic Cylinder using various Direction Control Valves with H Simulator.
9. Simulation of Double Acting Hydraulic Cylinder using 4/2 Direction Control Valve (Manual type) using H – Simulator.
10. Simulation of Single Acting / Double Acting Pneumatic Cylinder using 3/2 Push Button Direction Control Valve using P- Simulator.
11. Draw the Circuit diagram to operate Double Acting Hydraulic Cylinder using 4/2 Direction Control Valve (Solenoid Control) using PLC.
12. Draw the Circuit diagram to operate Double Acting Hydraulic Cylinder using 4/3 Direction Control Valve (Solenoid Control) using PLC.
13. Draw the Circuit diagram to operate a Single Acting Pneumatic Cylinder using 5/2 Air Spring Valve and PLC.
14. Draw the Circuit diagram to operate a Double Acting Pneumatic Cylinder using 5/2 Air Spring Valve and PLC.

LIST OF EQUIPMENTS

1. Hydraulic Trainer Kit (Manual Control) – 1 No. Consisting of
    - i) Hydraulic Power Pack.
    - ii) Double Acting Hydraulic Cylinder.
    - iii) 4/2 directional Control Valve.
    - iv) 4/3 Direction Control Valve.
    - v) Variable Flow Control Valve.
    - vi) Pressure Gauges.
2. Electro-Hydraulic Trainer Kits – 2 No.'s consisting of
    - i) Hydraulic Power Pack.
    - ii) Double Acting Hydraulic Cylinder.
    - iii) 4/2 directional Control Valve (Single Solenoid-Spring Return).

iv) 4/2 directional Control Valve (Solenoid Control).
v) 4/3 direction Control Valve (Solenoid Control).
vi) Accumulator.
vii) Variable Flow Control Valve.
viii) Pressure Gauges.
ix) Proximity Sensors.
x) PLC ABB make (12 inputs – 8 outputs)
xi) PLC – KEYENCE make (6 inputs 4 outputs)
xii) Electrical Controls – Push Button Momentary Switch and Latch Switch.

3. Pneumatic Trainer Kit (Manual Control)- 1 No. consisting of
   i) Air Compressor.
   ii) FRL Unit.
   iii) Single Acting Pneumatic Cylinder.
   iv) Double Acting Pneumatic Cylinder.
   v) 3/2 Push Button Directional Control Valve.
   vi) 5/2 Directional Control Valve (Manual Control).
   vii) 5/2 Directional Control Valve (Single Pilot & Spring Return).
   viii) 5/2 Directional Control Valve (Double Pilot).
4. Electro-Pneumatic Trainer Kits – 2 no.'s consisting of
   i) Air Compressor.
   ii) FRL Unit.
   iii) Single Acting Pneumatic Cylinder.
   iv) Double Acting Pneumatic Cylinder.
   v) 5/2 directional Control Valve (Solenoid Control).
   vi) 5/2 Directional Control Valve (Single Solenoid).
   vii) Variable Flow Control Valve.
   viii) Pressure Gauges.
   ix) Proximity Sensors.
   x) PLC ABB make (12 inputs – 8 outputs)
   xi) PLC – KEYENCE make (6 inputs 4 outputs)
   xii) Electrical Controls – Push Button Momentary Switch and Latch Switch.
5. Simulation Software
   i) H-Simulator.
   ii) P- Simulator.