

Syllabus	:	Trade Certificate in Instrumentation
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1. Organization of the Institute, Departments various trades & functions. Types of work, responsibility to be undertaken, incentives and future planning of profession. Safety precautions to be observed in the trade both during 'theoretical Periods' and 'Practical hours/workshop hours' Elementary First Aid. Safety and hazards. Sign boards and types. Hazardous and nonhazardous. Environmental pollution related to the trade- caused, consequences, mitigation and control.
2. Basic hand tools, types, classification use & metal cutting fundamentals. Filing- Flat, square and Parallel to an accuracy of 0.5mm. Measurement & measuring instruments, Marking tools, Fasteners & Fastening devices
3. Precision Measuring Instruments, gauge blocks, sine bar, dial indicators, vernier calipers, micrometers, bevel protractor, thickness gauges. Element & types of screw threads used in instruments, Calculation of drill size for tapping.
4. Types of tubes used for instrumentation. Tube cutter, Flaring tools, swedging tools, equipment's & fixture required for pipe bending, straightening, thread cutting, method of installation.
5. Electrical components - conductor, semiconductor & insulators. Standard wire gauge (SWG). Introduction of electricity- static electricity. Current, voltage, P.D, E.M.F, resistance. Electrical circuit - D.C & A.C circuit differences. Importance of grounding.
6. Uses of multimeter. Resistor, Resistivity and colour code, Types of resistors used in instrumentation. Definition and purpose of soldering and desoldering. Soft soldering. Types of soldering irons. Solder & flux. Care & precaution of soldering. De-soldering tools and method of use. Ohm's law & Kirchhoff's laws. Series & parallel circuits. Primary & secondary cells and batteries. {Liquid & dry}. Maintenance free batteries construction-charging, efficiency-use, advantage.
7. Switches and types. Magnet and magnetism, magnetic properties. Magnetic compass and its uses. Explanation of Electro-magnetism, Advantages, disadvantages application-types E.M. relays. Types - uses of Solenoids. Circuit breakers and their working
8. Principles of alternating current, A.C & DC electricity, types of wave forms, time period and frequency, peak to peak values, RMS value Average values
9. Inductor and Inductance, types of inductors, Factors affecting the value of inductance, self-inductance (L), Mutual inductance (M), Inductors in series and parallel, Q factor of the coil. Capacitance, types of capacitor, unit of capacitance, factors affecting the value of capacitors, charge, energy stored in capacitors. Capacitors in series and parallel. Capacitors in DC circuit, RC time constant.
10. A.C.-impedance, Inductive reactance, capacitive reactance. AC current through - R, L, C circuits. Resonance in RLC circuit. Importance - of series and parallel resonance, properties. Impedance, Admittance, Q- factor.
11. Introduction of AC and DC generators working principles, construction. Operation, field magnets, armature windings commutator and brushes, EMF equation. Faraday's Law, Lenz's Law, Fleming's left Hand and right-hand rules. DC motors working principles, construction, operation, types. Different speed controlling techniques of DC motors. AC motors, induction motors, three phase motors, stepper motors.
12. Transformer, types, transformation ratio. Open circuit test and short circuit test, regulation Autotransformer. Current measurement. Instrument transformer. Potential transformer and current transformer.

13. **Basics of electrical measuring instruments**- Types - absolute and secondary instruments. Types of secondary instruments, Essential of electrical measuring instruments deflecting torque, controlling torque, damping torque etc, Types of controlling torquesspring control, gravity control. Types of damping - air friction damping, fluid friction damping, eddy current damping

DC instruments - 'D1 Arsonval meter, PMMC meter- working principle, method of working, moving coil operation. Construction-damping, magnetic shielding, bearings. Terminology - parallax error, (FSD) full scale deflection reading, measurement value, meter sensitivity, accuracy. Meter resistance, maximum power, capability etc. Ideal and practical characteristics of ammeter, voltmeter.

Meter range extension - Converting galvanometer into ammeter, voltmeter. Range extension of voltmeter, ammeter. Shunt resistance and series resistance value calculation. Meter resistance, meter FSD identification techniques.

14. **Ohm meters**- measuring electrical resistance. Basic construction of Ohm meter, working method of ohmmeter. Types of Ohm meter - series and shunt type of ohm meters. Megger/insulation tester, earth tester - construction working advantages and disadvantages of various types of ohm meter.

AC instruments - types of AC measuring instruments -MI, electro dynamometer type, Working principle, construction, advantages and disadvantages of MI instruments and electro dynamometer instruments. Various applications.

Electro dynamometer applications - as voltmeter, ammeter, power measuring instrument, energy measuring instrument, power factor meter etc. AC voltage and current measurement using PMMC meter (rectifier type).

Induction type meters - working principle construction and operation of induction type instruments. Construction and Applications - single phase and three phase energy meter, watt meter. Walt hour meter, Ampere Hour meter, power factor meter etc. Special instruments: voltage tester, continuity tester, rotation test, phase sequence indicator, synchronizing, the synchroscope, frequency meter. Thermocouple type ammeters

15. Semiconductor, Covalent bond, Doping, Intrinsic and extrinsic semiconductor. PN junction diode, Forward and Reverse characteristics. Specification of diodes (data sheets). Applications of diode. Special semiconductor diode- Zener diode, tunnel diode, Photo diode.

Transistors. Defining transistors, NPN& PNP transistor, Symbol, operation, Biasing of Transistor & mode of Application. Transistor CB, CC, CE Amplification, current gain, voltage gain, and power gain. Introduction to FET, MOSFET.

Rectifiers: half wave rectifier, full wave (bridge & center tapped) rectifier. Voltage multipliers. Filters: Introduction, purpose and use of ripple filter. Types of filters. Capacitance filter, inductance filters, RC filters, LC filters, voltage dividers and bypass filters.

Voltage regulators. Introduction & purpose Zener regulators, shunt regulators, series regulators, IC regulators, variable regulators

16. **Power Supply units**: Introduction, purpose & use. UPS and SMPS, inverters and converters and their applications.

Thyristor devices: basic description and applications of SCR, TRIAC, DIAC.

17. General characteristics of an amplifier, Concept of amplification. Types of Amplifiers. Effect of temperature. DC load line and AC load line. PCB basic construction, applications. Lay outting circuit on PCB.
18. **Oscillator's** : oscillations, oscillation frequency, basic working principle and working of Tank circuit, Crystal controlled oscillators, Phase shift oscillators, RC phase shift oscillators, Colpitt, Clapp, Hartley, and LC oscillators
19. **Operational Amplifier:** Differential amplifier, ideal opamp. Op-amp with feedback, advantages of feedback Inverting and Non inverting and inverting amplifier, Opamp as summer, differential amplifier. V to I converter and I to V converter, Instrumentation amplifier Basics of op- amp applications - integrator, differentiator, Introduction of timers (555) and its applications.
20. **Number systems:** binary, octal, decimal and hexadecimal number system. Conversion of number systems. Boolean algebra, binary addition, subtraction, multiplication and division. 1's and 2's compliment, BCD code, ASCII code, gray code.

Logic Circuits: Basic gates-AND, OR and NOT gates. De-Morgan's Theorem. Universal gates - NAND and NOR gates. Special gates - Ex-OR, Ex-NOR gates and Buffer and its applications. Basic digital ICs, function, digital application, logic symbols. Adders - Half adder, full adder Subtractor - Half subtractor, full subtractor. Flip flops - RS flip flop, clocked RS flip flop, JK flip flop, Basics of Counters and registers. Multiplexer and de-multiplexer. Encoder and decoder. BCD display, BCD to decimal decoder. BCD to 7 segment display circuits.

Digital meters: displays: LED, 7 segment display, LCD, CRT, electro-luminescent displays, electro-phoretic image display, liquid vapor display, dot matrix display.

A/D and D/A converters: Introduction, weighted register D / A converter, binary(R-2R) ladder D / A converter, specification for D / A converter, Ramp or counter type A/D converter, GPIB (general purpose interface bus) IEEE - 488, RS 232.

Digital meters: frequency meter, phase measuring meter, and time measuring instruments. Digital capacitance meter.

21. CRO : introduction and applications of CRO, functional block diagram of CRO, CRT power supply Various types of probes. Applications of various types of CROs like dual beam CRO, Dual trace CRO, storage oscilloscope.
22. Introduction to Computer, Block diagram of PC, software familiarization of Multimedia System consisting of CD ROMS, DVD ROMS, Sound Cards. Computer Hardware, Computer systems, computer hardware, CPU, CPU operations, ROMs and RAMs, I/P and O/P and peripheral equipments, terminals, printers, MODEMS, Data interface, ADC and DAC.
23. Introduction to microprocessor microcomputers, Memories Intel 8085. Architecture Instruction set of 8085, Microprocessor. 1. Data transfer group. 2. Arithmetic group. 3. Logic group. Basic Programming of 8085 such as adding, subtraction of two 8-bit numbers, etc. Block diagram and pin' diagram 8255 and its operation. Microprocessor application
24. Scope and necessity of instrumentation. Fundamentals of measurement systems-functional block diagram of measurement system. Calibration and calibration standards- basic standards, secondary standards, working standards. Fundamental units - The metric system, Base & supplementary units, Derived Units, Multiplying factors and standards of length, mass, time &

frequency. Temperature & electrical units. Instrument characteristics Static characteristics—accuracy, precision, sensitivity, resolution dead zone, repeatability, reproducibility, drift, Deadband, backlash, hysteresis. Dynamic characteristics— speed response, fidelity, lag. Error, deviation, true value, data. Types of errors- systematic, random & illegitimate error. Certainty/uncertainty, validity Of result. Measuring system Response. Introduction, amplitude responses, Phase response, Delay, rise time & slew rate. Damping & its importance. Statistical analysis – arithmetic mean, deviation from the mean average deviation, standard deviation. Stress & Strain Measurement. Introduction to Strain gauges, types of strain gauges and differences. Applications of strain gauges, load cells. LVDT, RVDT, advantages and limitations.

25. Measurement of motion, velocity / vibrometer and acceleration. Difference between tachometer and speedometers. Types of tachometers-Eddy current type, AC and DC tachometer. Stroboscope and its applications. seismic instrument
26. Principle of Pressure in Liquids & Gases. Properties of matter Principles of liquid pressure, units of pressure Liquids pressure and volume, density and specific gravity. Factors affecting liquid pressure. Pressure relation with volume, temperature and flow. Units of pressure and unit conversions. Types of pressure: absolute, gauge, atmospheric and vacuum pressure and their relationships. Barometers, manometers types and applications.

Types of pressure sensing elements-bourdon tube, diaphragms, capsules, and bellows. Each one types, shapes, material used for various applications, range advantages and limitations. Pressure switches types and applications.

Electrical pressure transducers. Method of conversion, primary and secondary pressure transducers. Potentiometric type. Transducers, Capacitive type. Transducers, reluctance-servo pressure transducers, strain gauge pressure transducers, piezo electric pressure transducer. Differential pressure transducers.

Low Pressure Measurement. Vacuum, gauges, thermal conductivity gauges, pirani gauges, thermocouple gauges, slack diaphragm. Ionization gauge, McLeod gauge, capacitance manometers. Method of pressure instrument calibration. Dead weight tester and comparators/manifolds.

Pressure Instrument Installation and Servicing. Elements of pressure transmitters, Installation components, pressure taps, Isolation valve, instrument piping, connections and fittings blow down valve, instrument valve, pulsation damper, diaphragm seal, pressure transmitter, Installation, procedure, locating and mounting, piping, electrical wiring placing into service, guidelines for periodic maintenance, troubles shooting and repair, instrument shop safety.

27. **Properties of Fluid Flow.** Basic properties of fluids, fluids in motion, getting fluids to flow, units of flow rate and quantity flow, factors affecting flow rate, Reynolds number relation between flow rate and pressure, area, quantity.

Types of flow meters –head type, variable area type, quantitative flow meters. Mass flow meters. Head type of flow meters: working principle, types venturi tube, orifice plates and its shapes. Pitot tube, flow nozzles, constructions, tapings, advantages, limitations, applications, materials used for various flows. Types of secondary devices used to measure for flow rates.

Open channel flow meters : principle of open channel flow, weirs, notches and flumes. Various shapes and their applications, maintenance, Variable area type flow meter- Rota meter, constructions, working principle, applications. Various shapes of float, type of materials used for

body and float. Factors affecting rotameter performance, measuring gas and liquid flow. Positive Displacement Meters.

Advantages and disadvantages of positive displacement meters, piston meter, oscillating piston meter, rotating vane meter, rotating disk meter, lobed impeller and oval flow meter, calibrating positive displacement meters. Target flow meters, turbine flow meter, magnetic flow meters, vortex flow meter. Construction, working principle, advantages and disadvantage, applications. Coriolis mass flow meter, thermal flow meters and summary basics of ultrasonic flow meters. The Doppler hit method. The beam deflection method, frequency difference method.

28. Metering the flow of solid particles. Measuring volumetric and mass flow rate of solids, volumetric solids flow meter, mass flow meter for solids, belt type solid meters belt type solid meters belt speed sensing and signal processing, slurries, constant weight feeders.

29. Principles of level measurement. Types of level measurements-solid and liquid, volume and mass, mechanical and electrical type. Surface sensing gauges, storage tank gauges, sightglasses, magnetic gauges, buoyancy, displacement gauges. Factors need to consider for open and closed channel level measurements level switches, mercury level switches in high pressure tank, level detectors, magnetic reed switches.

Pressure head instruments: Hydrostatic pressure, specific gravity, pressurized fluids, pressure head instrumentation, air bellows, U-tube manometers, air purge systems, liquid purge systems, force balance diaphragm system.

Electrical method conductivity and capacitance method for. Measuring the liquid level, capacitance probes, zero and span adjustments, sonic level detectors, point level detection.

Solid level measurement Using weight to determine level, sonic solid level measurement with microwaves, using capacitance probes to measure solid level, diaphragm switches, nuclear gauges, microwave solid level detectors

30. Temperature measurement. Temperature, heat, specific heat, changing physical state Fahrenheit and Celsius temperature scales Rankin and Kelvin scales, calibration of temperature scales primary and secondary standards. Industrial application of temperature measuring instruments with compensating link & precautions to be taken. Bimetallic and fluid filled temperature instruments Bimetallic thermometers, liquid-in-glass thermometers, filled system thermometers, thermometer bulbs, capillary & bourdon tube, temperature transmitters for filled system, advantages & disadvantages of filled systems

31. Electrical temperature instrument. Resistance thermometer, how it works, RTD bridge circuits, lead wire error, RTD elements. Protecting wells for RTD, advantages and disadvantages of RTDs, thermistors, thermocouples, Extension wires, compensating for changes in reference junction temperature, construction of thermocouple junction, types of thermocouple, advantages and disadvantages of thermo couple Pyrometry. Molecular activity and electromagnetic radiation, defining pyrometry, effects of emittance, effects of temperature, wavelength and radiated energy, pyrometers and wavelengths, using of optical and radiation pyrometer, Measurement of humidity. Thermal imagers

32. Recorders introduction to recorders, Construction, working principle, various parts installation and use of pneumatic and electronic recorders. Strip-chart, circular chart.

33. Final control elements in process loops. Final control elements, actuators, load set Point compensation, feedback loops, control variables, effects of disturbances on performance, parts of final control sub-system, control signal, electric control signals, fluidic control signals, Pneumatic and Hydraulic Actuators. Pneumatic principles, effects of changing pressure, pressure /volume/ temperature relationship, effects of changing temp. Pneumatic actuators, diaphragm actuator, spring and springless actuators, direct and reverse acting actuator, piston actuator, positioner, Electrical actuators and their advantages

control valves. Control valves functions and components, types of control valves, based on valve flow characteristics liner, equal percentage, quick opening valves, globe valves, cage valves, butterfly valves, ball valves, sliding gate valves, diaphragm valves, split body valves, capacitive, inductive type valve, proximity switch, IR switch, micro switch, limit switch, other control valves, control valve mechanical considerations, selecting control valves, valve position.

Control elements applications. Feed water control system works, sequential. valve control, control and block valves, applying relays in final control elements, relay logic in operation, automatic valve control, controllers and activators, turbine control System, throttle and governor valves and activators. Introduction of internal parts of different types of control valves.

34. **Introduction to controllers.** Basic block diagram of control systems. Advantages Process variable and set point, analog controllers, digital controllers, control angles and limits, control loop measuring Pv, amplifying signals final control elements, current proportioning. Hunting & its effect on the product. Types of controller and their operation. Types of controller, range limit of controllers. ON/OFF controllers, direct and reverse acting controllers proportional controllers, automatic/manual split control, pneumatic control. Adaptive, limiting and batch control, ratio control system, feed forward, feedback control systems and cascade control system. Comparison between pneumatic and electronic control systems. Basic knowledge on communication protocol

35. Controller models and tuning. Controller tuning, setting, controller modes, proportional mode, off-set, integral mode, reset mode, derivative mode(rate), single mode controller, two mode controller, three mode controllers, tuning the control loop, step-change- response method

36. **Introduction to programmable controllers.** History of programmable controllers, general characteristics of programmable controllers, some limitation of PLCs, method of developing PLC programming.

Input/output devices. Definition of input /output devices, I/O interface, input modules, output modules, input devices encoders, output devices, the opto-isolators, safety.

Processing and programming functions. The processor unit, the memory, memory organization, ladder diagrams, data logger, most used programming symbols, start, stop, station example, other programming symbol timers and counters, data manipulation instructions, alternate PLC symbols.

37. **Digital control systems:** need of smart devices, HART transmitters futures, advantages, applications. Working method of HART devices, HART protocol. HART communicators and PC based HART device configuration. Steps in calibration of HART devices Communication.

Networking: types of networks used in digital instrument systems. LAN, WAN, Ethernet. Point to point and multi networking. Ring, delta, star connections. Redundant Net. TCP/IP addresses and descriptions.

Types of Cable categories (CAT), and their descriptions. Various types of Cable connectors. Advantages and disadvantages of co-axial cable and fiber optic cables. Various tools used in networking- wire cutter, crimp tool, memory blade holder, memory blade cartridge, cable strip tool with blade cassettes. Terminators and extra connectors, taps, calibration tool etc. **fundamentals:** modulation and demodulation signal to noise ratio, digital communication basics-PWM, PCM, FSK.

38. Fundamentals of SCADA and DCS. History of DCS development. Basic architecture, description advantages and disadvantages, applications. Terminology- RTU (remote transmitting unit, central monitoring station, types of communications, field instruments and types.

Field bus: futures, advantages, architecture, basic block diagram, working. Work station, Human Machine Interface (HMI). Controller (with basic types), field bus interfacing modules, gateway, network manager, I/O modules, field bus devices (I/O), remote transmission panel (RTP), Ethernet. Electronic device description language (EDDL) and device description (DD). Field bus power supply and its function. Introduction of digital and multi drop communication protocol Vendors. Futures- library, call up, various visualized futures, Reports (alarms, events), history, trading etc

39. Basic hydraulics: principles of Hydraulics. Fluid power and hydraulics, force, weight and mass, pressure, work, power, energy, incompressibility and non-diffusion, hydrostatic pressure, Pascal's law, transmission of fluid power, fluid flow in pipes, Bernoulli's principle, the effect of heat on liquids. A typical hydraulic power system. Hydraulic Fluids. Functions of Hydraulic fluids, physical properties, viscosity, viscosity index, viscosity and pressure, power point, fluid selection, component protections, chemical properties, system contamination, water, dissolve air, foaming, corrosion and rusting, types of hydraulic fluids.

Directional control valves: Directional control valve classification, review of two way valves, 'globe, gauge, plug, needle, ball, automatic two way valves, check valves, pilot operated check valves, spool valves, three ways pool valves, controlling hydraulic motors, NO and NC valves, holding valves, four and five way valves, rotary spool valves, schematic symbols, flow ratings, accessories.

40. Pneumatic principles, mass, pressure, work and energy, compressibility, law of pneumatics, transmission of pneumatic fluid power, pneumatic leverage, air properties, airflow in pipelines viscosity of air pressure, Bernoulli's law, components of pneumatic power system. Primary air treatment. Air treatment, preliminary filtering, relative. Humidity, effects of moisture, water removal, dew point, moisture separators, oil scrubbers, air dryers, (deliquescent and absorption type) air receivers. Secondary air treatment. Methods of treatment, Contaminate separation, contaminate filtration and filter classification and rating, types of media surface filters, depth filters, absorption filters, Lubricating the air.

Piping houses and fittings: Requirement of piping, airflow, piping dimensions and safety factors, piping connections, compressed air piping applications, metallic tubing, tubing bending and tube fitting, tube installation, nonmetallic tube houses, hose fittings and coupling, hose installation.

41. Analytical instruments. Exposure to basic analytical instruments. Types of electrodes used for PH measurements. Relation of PH and mV. PH indicator and controllers. Conductivity meters. Dissolved oxygen meter.

42. **Workshop Science and Calculation :**

- Introduction to Iron and Steel. Differences in Iron & steel.
- Introduction to Property and uses of C.I. and wrought Iron. , Iron and steel properties and uses.
- Properties and uses of plain carbon steel and alloy steel.
- Properties and uses of non ferrous metals and alloys Fraction and decimal - conversion fraction decimal and vice-versa.
- Properties and uses of copper, zinc, lead, tin, aluminum.
- Composition, properties and uses of brass, bronze, solder, bearing material, timber, rubber etc.
- System of units, British, metric and SI units for length, area, volume capacity, weight, time, angle, their conversions. , Effect of alloying elements in the properties of C.I. & steel.
- Unit of temperature for & related problems. Standard & absolute temp.
- Mass, volume, density, weight, sp. Gravity & specific weight. S.I. M.K.S. and F.P.S. units of force, weight etc. their conversion to related problems.
- Inertia, rest and motion, velocity and acceleration.
- Types of forces, its units and Weight calculation.
- Revision & Test , Power and roots Factor, Power base exponents number. Multiplication and division of power and root of a number. Square root of number and problems.
- Heat & temperature, thermometric scales, their conversions.
- Work energy and power, their units and applied problems.
- Percentage, changing percentage to decimal and fraction and vice versa. Applied problems.
- Problem on percentage related to trade.
- Different types of loads, stress, strain, modulus of elasticity. Ultimate strength, different types of stress, factor of safety, examples.
- Ratio & proportion- Ratio, finding forms ratio proportions, direct proportion and indirect proportion. Application of ratio and proportion & related problems.

43. **Engineering Drawing :**

- Engineering Drawing - introduction to Engg. Drawing and its importance.
- Use of drawing instruments –Drawing of straight, inclined and curved lines.
- Exercise on linear and angular measurements.
- Types of lines their meaning & application as per BIS SP: 46-2003.
- Simple conventional symbols for material and parts as per BIS SP: 46-2003. , Geometrical construction of rectangles, square, circles.
- Geometrical construction of polygon and ellipse, parabola & hyperbola.
- Geometrical construction of involutes, oval, and helix.
- Free hand sketching of straight lines, rectangles, circles, square, polygons, ellipse.
- Standard printing style for letters and numbers as per BIS : SP: 46-2003 using stencils
- Free hand sketching of simple geometrical solids, cube, cone, prism, cylinder, sphere, pyramids.

- Scales- Types & its use.
- Revision & Test, Construction of diagonal scale.
- Simple dimensioning technique, size and location, dimensions of parts, holes angles, taper, screw etc. as per BIS SP: 46-2003.
- Transferring measurements for linear, angular, circular dimensions from the given object to the related free hand sketches using different measuring instruments.
- Pictorial drawings, isometric drawings of simple geometrical solids.
- Oblique/orthographic projection of simple geometrical solids.
- Orthographic drawings: Application of both the first angle and third angle. Isometric drawing of simple machined & casting blocks.
- Free hand sketches of trade related hand tools and measuring tools

Note: The above syllabus is indicative and the questions in the test may include similar other topics pertaining to the level and content of essential qualification.