Detailed syllabus for the post of Assistant Engineer (Instrumentation) in Universities in Kerala Category No.069/2024

Module 1: Engineering Mathematics (5 Marks)

Linear Algebra: Matrix algebra, systems of linear equations, consistency and rank, Eigenvalue and Eigenvectors.

Calculus: Mean value theorems, theorems of integral calculus, partial derivatives, maxima and minima, multiple integrals, Fourier series, vector identities, line, surface and volume integrals, Stokes, Gauss and Green's theorems.

Differential Equations: First-order equations (linear and nonlinear), second-order linear differential equations with constant coefficients, method of variation of parameters, Cauchy's and Euler's equations, initial and boundary value problems, solution of partial differential equations: variable separable method.

Analysis of Complex Variables: Analytic functions, Cauchy's integral theorem and integral formula, Taylor's and Laurent's series, residue theorem, solution of integrals.

Probability and Statistics: Sampling theorems, conditional probability, mean, median, mode, standard deviation and variance; random variables: discrete and continuous distributions: normal, Poisson and binomial distributions.

Numerical Methods: Matrix inversion, solutions of non-linear algebraic equations, iterative methods for solving differential equations, numerical integration, regression and correlation analysis.

Module 2: Electricity and Magnetism (5 Marks)

Coulomb's Law, Electric Field Intensity, Electric Flux Density, Gauss's Law, Divergence, Electric field and potential due to point, line, plane and spherical charge distributions, Effect of dielectric medium, Capacitance of simple configurations, Biot-Savart's law, Ampere's law, Curl, Faraday's law, Lorentz force, Inductance, Magnetomotive force, Reluctance, Magnetic circuits, Self and Mutual inductance of simple configurations.

Module 3: Electrical Circuits and Machines (10 Marks)

Voltage and Current Sources: Independent, dependent, ideal and practical; V-I relationships of resistor, inductor, mutual inductance and capacitor; transient analysis of RLC circuits with dc excitation.

Kirchhoff's laws, mesh and nodal analysis, superposition, Thevenin, Norton, maximum power transfer and reciprocity theorems.

Peak-, average- and rms values of AC quantities; apparent-, active- and reactive powers; phasor analysis, impedance and admittance; series and parallel resonance, locus diagrams,

realization of basic filters with R, L and C elements. Transient analysis of RLC circuits with ac excitation.

One-port and two-port networks, driving point impedance and admittance, open-, and short circuit parameters.

Single Phase Transformer: Equivalent circuit, phasor diagram, open circuit and short circuit tests, regulation and efficiency; Three phase induction motors: principle of operation, types, performance, torque-speed characteristics, no-load and blocked rotor tests, equivalent circuit, starting and speed control; Types of losses and efficiency calculations of electric machines.

Module 4: Signals and Systems (10 Marks)

Introduction to signals and systems, Linear Time-invariant (LTI systems): definitions and properties, causality, stability, impulse response and convolution, continuous-time and discrete-time Fourier series, continuous-time and discrete-time Fourier Transform Z-transform: definition, properties and inverse, stability analysis using pole-zero plot, difference equation solution using unilateral Z-transform, DFT and its properties, FFT: radix 2 FFT algorithms, realization of IIR and FIR structures – parallel and cascade structure, frequency response, group delay and phase delay, basics of IIR and FIR filters, finite word length effects.

Module 5: Control Systems and Process Control (15 Marks)

Open loop and closed loop system: Transfer function, force-voltage & force-current analogy, block diagrams, signal flow graphs – Mason's gain formula – characteristic equation, time domain analysis – transient & steady state responses – time domain specifications & steady state error.

Concept of stability – Routh's stability criterion – Root locus – effect of addition of poles and zeros. Frequency domain analysis – Nyquist & Bode plots, gain margins and phase margin, lag, lead and lag-lead compensators and their design using Bode plot.

State space analysis of system: State space models, state transition matrix, relationship between state equations and transfer function, controllability and observability.

Process Control: Block diagram, Process characteristics, Process parameters, Discontinuous controller modes, continuous controller modes, pneumatic controllers – proportional controller – PI controller – PD controller – PID controller, tuning of PID controllers.

Final Control Element and Control Valves: Pneumatic, electric and hydraulic actuators, air-to-open and air-to-close control valves, direct-acting & reverse-acting Control valves. Different valve plugs, control valve characteristics, valve positioner, sizing of control valves, motion transmitter, limit switch, air pressure regulator & I/P converter.

Process Control Strategies: Single variable, Independent variable, Interactive variable, compound variable and multivariable control, Feedback control system, Feed forward control system, Cascade control system – Ratio control system – Adaptive control system –

Split Range Control System, Adjustment and Tuning of controllers, Data loggers, Data acquisition system, Supervisory control, Direct Digital control, DCS, PLC, SCADA system for industrial automation.

Module 6: Analog Electronics (12 Marks)

Characteristics and applications of diode, Zener diode, BJT and MOSFET; small signal analysis of transistor circuits, feedback amplifiers. Characteristics of ideal and practical operational amplifiers; applications of op-amps: adder, subtractor, integrator, differentiator, difference amplifier, instrumentation amplifier, precision rectifier, active filters, oscillators, signal generators, voltage-controlled oscillators and phase locked loop, sources and effects of noise and interference in electronic circuits.

Module 7: Digital Electronics and Microprocessors (13 Marks)

Combinational logic circuits, minimization of Boolean functions. IC families: TTL and CMOS. Arithmetic circuits, comparators, Schmitt trigger, multi-vibrators, sequential circuits, flipflops, shift registers, timers and counters; sample-and-hold circuit, multiplexer, analog-to-digital (successive approximation, integrating, flash and sigma-delta) and digital-to-analog converters (weighted R, R-2R ladder and current steering logic). Characteristics of ADC and DAC (resolution, quantization, significant bits, conversion/settling time); basics of number systems.

Embedded Systems: Architecture and programming 8085 and 8086 Microprocessors, 8051 Microcontroller. Microprocessor and microcontroller applications, memory and input-output interfacing.

Module 8: Measurements (10 Marks)

SI units, standards (R, L, C, voltage, current and frequency), systematic and random errors in measurement, expression of uncertainty - accuracy and precision, propagation of errors, linear and weighted regression.

Bridges: Wheatstone, Kelvin, Maxwell, Anderson, Schering and Wien bridges for measurement of R, L, C and frequency, Q-meter.

Measurement of voltage, current and power in single and three-phase circuits; ac and dc current probes; true rms meters, voltage and current scaling, instrument transformers, timer/counter, time, phase and frequency measurements, digital voltmeter, digital multimeter; oscilloscope, shielding and grounding.

Module 9: Sensors and Industrial Instrumentation (15 Marks)

Resistive, capacitive, inductive, piezoelectric, Hall effect sensors and associated signal conditioning circuits; transducers for industrial instrumentation: displacement (linear and angular), velocity, acceleration, force, torque, vibration, shock, pressure (including low pressure), flow (variable head, variable area, electromagnetic, ultrasonic, turbine and open

channel flow meters) temperature (thermocouple, bolometer, RTD (3/4 wire), thermistor, pyrometer and semiconductor); liquid level, pH, conductivity and viscosity measurement.

Module 10: Communication and Optical Instrumentation (5 Marks)

Analog communication systems: amplitude and angle modulation and demodulation systems, Shannon's sampling theorem, Digital communication systems: pulse code modulation (PCM), differential pulse code modulation (DPCM), digital modulation schemes: amplitude, phase and frequency shift keying schemes,optical sources and detectors: LED, laser, photo-diode, light dependent resistor, square law detectors and their characteristics; interferometer: applications in metrology; basics of fiber optic sensing. UV-VIS Spectrophotometers, Mass spectrometer.

NOTE: - It may be noted that apart from the topics detailed above, questions from other topics prescribed for the educational qualification of the post may also appear in the question paper. There is no undertaking that all the topics above may be covered in the question paper.