

Syllabus of Written Test for recruitment for the post of **Assistant Engineer (Agri-Electrical)** in the West Bengal Service of Agricultural Engineers under the Water Resources Investigation & Development Department, Govt. of West Bengal

1. MATHEMATICS:

Review of limit, continuity and Partial derivatives, Successive differentiation. Evaluation of definite and improper integrals Applications of definite integrals to evaluate surface areas and volumes of revolutions. Rolle's theorem, Mean value theorem.

Inverse and rank of a matrix, Rank-nullity theorem; System of linear equations; Symmetric, Skew-symmetric and Orthogonal matrices; Determinants; Eigenvalues and Eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem, and Orthogonal transformation.

Fourier series: Half range sine and cosine series,

2. ENGINEERING MECHANICS AND APPLIED MECHANICS:

D. Alembert's principle, Principle of work and energy, Principle of conservation of energy, Power and efficiency, Mass moment of inertia, rotation of rigid bodies, Resolution of forces, Moment, Varignon's theorem, Couple, Resolution of a coplanar force by its equivalent force-couple system, Resultant of forces. Angular momentum and torque, moment of inertia, Parallel and perpendicular axes theorem. Calculation of moment of inertia of some common solids. Rotational dynamics of a rigid body.

Plane curvilinear motion of particles: Rectangular components (Projectile motion); Normal and tangential components (circular motion). Relationship among different elastic constants. Bending moment. Cantilever problems, Elastic, Plastic and Visco-elastic behavior of materials.

Belt, Pulley and chain bodies in rolling contact, Torsion of circular shafts, angle of twist, Torque, power transmission shearing force and bending moment in beams.

3. FIELD THEORY

Electrostatics: Coulomb's law, field intensity, Gauss's law and its application, Electric potential and Potential gradient, Electric displacement, Electric images and inversion, an Electric dipole and flux lines. Energy density in electrostatic field. Polarisation, Divergence theorem (Gauss's law in differential form), Poisson and Laplace's equations in Cartesian, cylindrical and spherical coordinates in 2 and 3 dimensional fields using circular and spherical symmetry, Boundary conditions, Electric stress and mechanical forces on charged conductor surfaces, Electrostatic energy, capacitance calculations, Energy transfer amongst connected capacitance in a system.

Electromagnetics: Magnetic field and intensity, Magnetic scalar and vector potentials, Lorentz force, Faraday's Law, Transformer and motional emf, Displacement current, Maxwell's equations, Time varying Potential, Time harmonic fields, Induced e.m.f in conductor and coils, Force on magnetic material, Biot-savart law, Ampere's circuit law, Magnetic torque and moments, Magnetic boundary condition, Inductor and Inductances, Motoring and Generating principals, Magnetic polarization, Poisson equation and solution.

4. ELECTRIC MACHINE

Electromechanical Energy Conversion Principle, Singly and Doubly Excited Magnetic system. Physical concept of torque production, Distribution factor, Pitch factor. MMF produced by Distributed Windings, MMF of a coil, MMF of single phase distributed Winding.

Machines: EMF generated in the armature. Methods of Excitation, Armature reaction & its effect in the performance, Effect of Brush shift, Commutation process, Torque equation of D.C motor, Operating Characteristics of Shunt, Series & Compound motors, Brushless DC machines, Losses and efficiency of DC machines

3-Phase Induction machine: Construction, Frequency of induced emf, mechanical and electrical angles, Elementary winding configuration of three phase machine, rotating magnetic field, Induction motor as a Transformer, Flux and MMF phasors in Induction motors, Equivalent circuit, Performance equations, Induction motor phasor diagram, slip and slip speed, Torque-slip characteristic, Power slip characteristic, Determination of equivalent circuit parameters, Methods of starting of squirrel Cage, Speed control of Induction motor Polarity Test, Application of Polyphase Induction motor.

Motor power rating: Thermal model of motor for heating and cooling, classes of motor duty, determination of motor rating for continuous, short time and intermittent duty, equivalent current, torque and power methods of determination of rating for fluctuating and intermittent loads. Effect of load inertia & environmental factors. BEE marked energy efficient motors.

Starting of Electric Drives: Effect of starting on Power supply, motor and load. Methods of starting of electric motors. Acceleration time Energy relation during starting, methods to reduce the Energy loss during starting.

Synchronous motor drives: Variable frequency control, Self Control, Voltage source inverter fed synchronous motor drive, Vector control.

Introduction to Solar and Battery Powered Drive, Stepper motor, Switched Reluctance motor drive.

Single Phase Induction Motor: Construction, Double revolving field theory, Cross field theory, Starting methods, Speed-Torque characteristics, Phasor diagram, Condition of Maximum torque, Determination of equivalent circuit parameters, Testing of Single phase motors

3-Phase Transformer: Constructional details, e.m.f equation, core losses and leakage reactance. No-load operation, equivalent circuit, phasor diagram, Determination of polarity and connections (star/star, star/delta, delta/star, star/zigzag, delta/zigzag, open delta), Phasor groups, Effect of unbalanced loading, Production of Harmonics in Transformer and its suppression, Parallel operation of Transformers, Introduction to Tap changing transformer and its function, Special Transformers: Potential transformer, Current transformer, Pulse transformer, Audio frequency transformer, Grounding transformer, Transformer oil, inhibited oil, dry type transformer, Transformer accessories, different types of cooling method, efficiency, all day efficiency, O.C and S.C test, eddy current and hysteresis loss. Single phase auto transformer.

5. POWER SYSTEMS PROTECTION AND SWITCH GEAR

Overhead transmission line: Choice of frequency and voltage, Types of conductors, Inductance and Capacitance of a single phase and three phase symmetrical and unsymmetrical configurations. Bundle conductors. Concept of lump & distributed parameters, Line parameters, Transmission line equation & solutions, Physical significance of solutions, Propagation constants, Characteristic impedance, Wavelength, Velocity of propagation.

Insulators: Types, Voltage distribution across a suspension insulator string, String efficiency, Arching shield & rings, Methods of improving voltage distribution across Insulator strings, Electrical tests on line Insulators.

Cables: Types of cables, cable components, capacitance of single core & three core cables, dielectric stress, optimum cable thickness, grading, dielectric loss and loss angle.

Representation of Power system components: Single-phase representation of balanced three phase networks, the one-line diagram and the impedance or reactance diagram, per unit (PU) system.

Distribution substation: Types of substations, location of substations, substation equipments and accessories, earthing (system & equipment), feeder and distributors, radial and loop systems.

Faults in Electrical systems: Transient on a transmission line, Symmetrical component transformation, sequence impedance and sequence network of power system, synchronous machine, transmission lines and transformers. Symmetrical component analysis of unsymmetrical faults, single line-to-ground fault, line-to-line fault, double line-to-ground fault.

Power system protection: Protective relays- Fundamental principles, block diagrams, basic requirements and type of protection, classification of Electromagnetic relays, basic aspects of static and digital relays, overcurrent, over voltage relays, pilot wire differential protection and wireless pilot. Motor, transformer, feeder, generators -protection & relay protection scheme. Different types of switch gears, circuit breaking transients, transient recovery voltage, current chopping and resistance switching, circuit breaker rating, arc and arc extinction, Different types of circuit breakers, operating mechanism, advantages and disadvantages, Specific uses, Testing of circuit breakers.

6. ELECTRIC POWER UTILISATION

Illumination: Fundamentals of Light Radiation and vision, quantities, units, standards and measurements, Perception of light and color, optical system of human eye, eye as visual processor. Reflection, refraction and other behavior of light.

General classification of lamps, Incandescent, TL, CFL, LED, HID, Metal halide lamps, basic principle of illumination and their operation, The nature of radiation, Polar curve, Law of illumination. Different lighting scheme & their design methods and parameters, Basic luminaries classification and their distribution characteristics, Lighting calculation for indoor application, Flood and Street lighting, basic principle of light control.

Lighting circuits- starters for fluorescent lamps and ignitors of HID lamps, multiple input lamps. Emergency lighting and stand by power sources, Lighting storage batteries.

Electric welding: Types of welding and equipment for such welding.

7. ELECTRICAL & ELECTRONIC MEASUREMENT

Measurements: Method of measurement, Measurement system, Classification of instruments, Definition of accuracy, Precision, Resolution, Speed of response, Error in measurement, Classification of errors, loading effect due to shunt and series connected instruments. Construction, Principle of operation and torque equation of different measuring instruments, Principle of operation of Current & Potential transformer, errors. Measurement of medium, low and high resistances, Megger, Energy meters- construction, theory and application, testing of meters.

Advantages of digital meter over analog meters, Digital voltmeter, Resolution and sensitivity of digital meters, Digital multimeter, sensors & Transducers, Strain gauge, Inductive sensor, LVDT, Proximity sensor, Capacitive, Thermal, Magnetic sensors, Temperature transducers, Flow measurement using magnetic flow measurement.

Radiation sensors: LDR, Photovoltaic cells, photodiodes, photo emissive cell types, materials, construction, response. Geiger counters, Scintillation detectors, Introduction to smart sensors.

8. CIRCUIT THEORY

Review of Laplace transform, concept of complex frequency, circuit elements in transient. Transform equivalent, Laplace transform of impulse and step waveform.

Solutions of RL, RC, LC and RLC circuits in transient with or without stored energy, concept of natural frequency and damping. Fourier series and Fourier Transform

Applications of network theorems in transient domain. Formulation of network equations. Source transformations. Loop variable analysis and mode variable analysis. Millman's theorem and its application in three phase unbalanced circuit analysis

Two port networks, short circuit admittance parameters, open circuit Impedance parameters, series, cascade and parallel connections of two port networks.

9. ELECTRONICS:

Elementary physics of semiconductor materials, p-n junction, semiconductor diode, zener diode, bipolar junction device-transistor, Field effect transistors JFET & MOSFET. Modelling of a semiconductor devices-diode, junction transistors and field effect transistors-hybrid parameters.

Bipolar transistor biasing, common emitter, common base and common collector configurations, low frequency response of RC coupled common emitter amplifiers, FET biasing, MOSFET biasing. Transistor power amplifiers, class A, class B class AB amplifier, complimentary symmetry amplifiers.

Linear microcircuits: Operational amplifiers, offset voltage and currents, bias currents, common-mode rejection ratio, frequency response, slew rate, uses of operational amplifiers as inverting summing amplifier, integrator, non-inverting amplifier. Differential input instrumentation amplifiers and oscillators.

Binary, Octal and Hexadecimal representation and their conversion, BCD, ASCII, EBCDIC, Gray codes and their conversion. Various logic gates and their truth tables and circuits, Adder and subtractor circuit, Circuit of Encoder, Decoder, Comparator, Multiplexer, De-Multiplexer and parity Generator. RAM, ROM, EPROM, EEPROM. Different types of A/D and D/A conversion techniques. TTL, ECL, MOS & CMOS, their operation and specification. Silicon Semiconductor Technology- An Overview, Wafer processing, Oxidation, Epitaxial deposition, Ion-implantation & Diffusion, Cleaning, Etching, Photo-lithography – Positive & Negative photo-resist

10. ELECTRICAL ENGG. MATERIALS

Atomic structure of materials, energy levels and electronic states. Electronic distinction between metals, Insulators and Intrinsic semi-conductors. Interatomic distance, Cohesive forces and energies, Gross electrical and thermal properties of materials in terms of cohesive energies.

States of insulating materials and their applications. Electrical conductivity of metals-Lorentz theory, free electron theory. Alloy-High resistivity alloys, Thermocouple alloys, strain gauge alloys.

Semiconductor: Intrinsic and impurity semiconductors. Acceptors and donor, p-n diodes and transistors. Temperature dependence of p-n junction.

11. POWER PLANNING & DISTRIBUTION: Electricity acts, rules and codes, Standards followed in power supply. Primary and secondary distribution, Types of conductors and insulators in distribution system. Environmental and safety measures. Domestic, commercial and industrial wiring, estimation of main, submain and sub-circuit wiring, installation and testing, fuse, stranded conductors. Disconnecting devices. Lightning arresters. Earthing practices

Power Distribution : Structure of power system, primary and secondary distribution, types of conductors and insulators in distribution system.

12. ENERGY MANAGEMENT & AUDIT

Energy Management & Audit: Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments and intervals of EA regulation. Energy Conservation Act-2001 and related policies, Schemes of Bureau of Energy Efficiency(BEE)-ECBC, Electricity Act 2003, Integrated Energy Policy

Non-Conventional Energy Sources: Concept of renewable Energy and importance, Different types of renewable Energy, Solar energy, Wind energy, Biomass energy, Hydro-energy, Fuel cells, Energy from wastes, Wave, Tidal and geothermal. Concept of energy storing device.

Solar Energy: Solar radiation - beam and diffuse radiation, solar constant, earth sun angles, attenuation and measurement of solar radiation, local solar time, derived solar angles, sunrise, sunset and day length, photo

voltaics - solar cells, different types of PV Cells, Mono-poly Crystalline and amorphous Silicon solar cells. Design of PV array. Efficiency and cost of PV systems & its applications. PV hybrid systems.

Energy Efficient Technologies in Electrical Systems: Maximum demand controllers, Automatic power factor controllers, Energy efficient motors, Soft starters with energy saver, Variable speed drives, Energy efficient transformers, Electronic ballast, Occupancy sensors, Energy efficient lighting controls, Energy saving potential of each technology.

13. NUMERICAL ANALYSIS & COMPUTER PROGRAMMING.

Numerical Analysis: Solution of linear equations, Gauss elimination, Matrix- Inversion using Gauss-Jordan elimination.

Interpolation: Lagrange, Newton's forward, backward and divided difference formulas and errors. Least square curve fitting, Numerical integration using trapezoidal, Simpson's rule.

Programming: basic concepts and technology of computer system and system software, concept of flow chart and algorithm, recursion. Overflow and underflow. Programme in C/C++

14. HYDRAULICS & WATER POWER

Properties of fluids and units, Fluid statics, Fluid Kinetic, Ideal fluid flow, Viscous fluid flow, flow through pipes, flow measurements, momentum equation and fluid dynamics. Fluid machineries: Centrifugal pumps