Syllabus for descriptive **Subject Aptitude Test (SAT)** for recruitment to the **post of Assistant Director of Factories, Class-I (Gazetted)**in the Department of Labour & Employment, H.P.The descriptive SAT paper shall have two parts i.e. Part-I and Part-II and cover the following topics of B.Tech (Mechanical Engineering) level. The SAT shall be of 03 hours duration having 120 Marks.

PART-I (60 MARKS)

1.1 Engineering Physics

Semiconductor materials,p-type, and n-type semiconductors; Fermi level in semiconductors; Current conduction in semiconductors, I-V characteristics of p-n junction diode, Some special p-n diodes: Zener diode, Tunnel diode, Photo diode, and Light emitting diode. Einstein's theory of matter radiation interaction and A and B coefficients; amplification of light by population inversion, different types of lasers: gas lasers (He-Ne, CO2), solid-state lasers (ruby, Neodymium), dye lasers; Properties of laser beams: mono-chromaticity, coherence, directionality and brightness, laser speckles, applications of lasers in science, engineering and medicine. Introduction to fibre optics, Acceptance Angle, Numerical Aperture, Normalized frequency, Modes of propagation, material dispersion & pulse broadening in optical fibres, fibre connectors, splices and couplers, Applications of optical fibres. Electromagnetic waves & Dielectrics, Physical significance of Gradient, Divergence & Curl, Relationship between Electric Field & Potential, Dielectric polarization, Displacement current, Maxwell's Equations, electromagnetic wave propagation in free space and isotropic dielectric medium, Poynting vector, Electromagnetic Spectrum (Basic ideas of different region). Magnetic Materials & Superconductivity, Basic ideas of Dia, Para, Ferro & Ferrimagnetic materials, Ferrites, Hysteresis loop, Magnetic Anisotropy, Superconductivity, Superconductors as ideal diamagnetic materials, Signatures of Superconducting state, Meissner Effect, Type I & Type II superconductors, Applications of superconductivity.

1.2 Basic Electrical and Electronics Engineering

DC Circuits covering Ohm's Law and Kirchhoff's Laws; Analysis of series, parallel and series-parallel circuits excited by independent voltage sources; Power and energy; Electromagnetism covering, Faradays Laws, Lenz's Law, Fleming's Rules, Statically and dynamically induced EMF; Concepts of self-inductance, mutual inductance and coefficient of coupling; Energy stored in magnetic fields; Single Phase AC Circuits covering generation of sinusoidal voltage, average value, root mean square value, form factor and peak factor of sinusoidal voltage and current, phasor representation of alternating quantities; Analysis

with phasor diagrams of R, L, C, RL, RC and RLC circuits; Real power, reactive power, apparent power and power factor, series, parallel and series- parallel circuits; Balanced and unbalanced 3 -phase circuit - voltage, current and power relations, 3-phase power measurement,Comparison of single phase and three phase supply Constructional features of a single phase transformer, its operating principle and applications, equivalent circuit, phasor analysis and calculation of performance indices. DC Motors and Generators, Number System and LogicDesign, Conversions and code, conversion of bases (decimal, binary, octal and hexadecimal numbers), addition and subtraction, Boolean algebra, logic gates (AND, OR, NAND, NOR, XOR, XNOR), concept of universal gate, Operation of CRO and its applications, Signal Generator, measurement of voltage, phase and frequency using CRO.

1.3 Engineering Mathematics

Linear Algebra: Matrix algebra, systems of linear equations, eigen values and eigen vectors. **Calculus**: Functions of single variable, limit, continuity and differentiability, mean value theorems, indeterminate forms; evaluation of definite and improper integrals; double and triple integrals; partial derivatives, total derivative, Taylor series (in one and two variables), maxima and minima, Fourier series; gradient, divergence and curl, vector identities, directional derivatives, line, surface and volume integrals, applications of Gauss, Stokes and Green's theorems. **Differential Equations:** First order equations (linear and nonlinear); higher order linear differential equations with constant coefficients; Euler-Cauchy equation; initial and boundary value problems; Laplace transforms; solutions of heat, wave and Laplace's equations. **Complex Variables:** Analytic functions; Cauchy-Riemann equations; Cauchy's integral theorem and integral formula; Taylor and Laurent series. **Probability and Statistics:** Definitions of probability, sampling theorems, conditional probability; mean, median, mode and standard deviation; random variables, binomial, Poisson and normal distributions. **Numerical Methods:** Numerical solutions of linear and non-linear algebraic equations; integration by trapezoidal and Simpson's rules; single and multi-step methods for differential equations.

1.4 Engineering Chemistry, Energy and Environment: -

Engineering Chemistry: Sources of water, common impurities, Hardness, water quality parameters and their analysis, Water Softening process, Drinking water purification and domestic water purifiers, basic concepts of electrochemistry, Construction and working of Batteries-Lead acid storage battery, Ni-Cd Storage cell, Lithium batteries, fuel cell and Solar cell,Introduction to corrosion science, Chemical and Electrochemical Corrosion, Theory of electrochemical corrosion, Types of Electrochemical Corrosion, Factors affecting rate of corrosion-Related to metal & related to environment, Control of corrosion,

Applications of various Spectroscopy Techniques,Classification, Synthesis, properties and applications of Engineering Materials Polymers, Introduction to conducting polymers, applications, Mechanism of conduction in poly acetylene, Nano-Material,Properties of nano materials, Graphene, Fullerenes,Carbon nano tubes, nano wires, nano cones, Application of nano-materials.

Energy and Environment: Structure and function of an ecosystem; Conventions on Climate Change**;**Air, Water, Noise and Nuclear Pollution**,** theirOrigin, sources, adverse effects and preventive measures; Important environmental protection acts in India– water, air (prevention and control of pollution) act, wild life conservation and forest act.Various Renewable and non-renewable resourcesi.e. Coal, Petroleum, Solar energy, wind energy, hydrothermal energy, nuclear energy, Tidal energy, Bio energy etc., National green hydrogen mission. Principles of Disaster Management, National policy on disaster Management.

1.5 Strength of Materials

Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for plane stress and plane strain; thin and thick cylinders; shear force and bending moment diagrams; bending and shear stresses; concept of shear centre; deflection of beams; torsion of circular shafts; Theories of Failure; Euler's theory of columns; energy methods; thermal stresses; strain gauges and rosettes; Stresses in closed and open coiled helical springs subjected to axialloadsandtwisting couples.Leafsprings,flatspiralsprings.Stresses and strains in (i) rotating rims,neglectingtheeffectof spokes,(ii)rotatingdiscs,includingdiscofuniformstrengthanddiscshrunkonhub(iii)rotating cylinders(solid&hollow). testing of materials with universal testing machine; testing of hardness and impact strength.

1.6 Engineering Mechanics & Theory of Machines

Engineering Mechanics: Free-body diagrams and equilibrium; friction and its applications including rolling friction, belt-pulley, brakes, clutches, screw jack, wedge, vehicles, etc.; trusses and frames; virtual work; kinematics and dynamics of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations; Lagrange's equation.

Theory of Machines: Displacement, velocity and acceleration analysis of plane mechanisms; dynamic analysis of linkages; cams; gears and gear trains; flywheels and governors; balancing of reciprocating and rotating masses; gyroscope.

1.7 Machine Design and Vibrations

Machine Design: Design for static and dynamic loading; failure theories; fatigue strength and the S-N diagram; principles of the design of machine elements such as bolted, riveted and welded joints; shafts, gears, rolling and sliding contact bearings, brakes and clutches, springs.

Vibrations: Free and forced vibration of single degree of freedom systems, effect of damping; vibration isolation; resonance; critical speeds of shafts. Case studies on automobile suspensions, automatic transmissions, material conveyor systems, construction machinery.

PART-II (60 MARKS)

2.1 Fluid Mechanics & Hydraulic Machinery

Fluid Mechanics: Fluid properties; fluid statics, forces on submerged bodies, stability of floating bodies; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation; dimensional analysis; viscous flow of incompressible fluids, boundary layer, elementary turbulent flow, flow through pipes, head losses in pipes, bends and fittings; basics of compressible fluid flow, Impact of jet on flat and curved plates.

Hydraulic Machinery: Classification of water turbines, heads and efficiencies, Impulse and reaction principles, velocity diagrams, Pelton-wheel, Francis and Kaplan turbines-working, design principles and applications.

2.2 Heat Transfer

Modes of heat transfer; one dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction, lumped parameter system, Heisler's charts; thermal boundary layer, dimensionless parameters in free and forced convective heat transfer, heat transfer correlations for flow over flat plates and through pipes, effect of turbulence; heat exchanger performance, LMTD and NTU methods; radiative heat transfer, Stefan- Boltzmann law, Wien's displacement law, black and grey surfaces, view factors, radiation network analysis

2.3 Engineering Thermodynamics

Thermodynamic systems and processes; properties of pure substances, behaviour of ideal and real gases; zeroth and first laws of thermodynamics, calculation of work and heat in various processes; second law of thermodynamics; thermodynamic property charts and tables, availability and irreversibility; thermodynamic relations.

Applications: Power Engineering: Air and gas compressors; vapour and gas power cycles, concepts of regeneration and reheat. I.C. Engines: Air-standard Otto, Diesel and dual cycles. Refrigeration and air-conditioning: Vapour and gas refrigeration and heat pump cycles; properties of moist air, psychrometric chart, basic psychrometric processes, Steam Boilers, boilermountingsandaccessories,HeatBalanceSheet, Flow Through Nozzles and Steam Turbines.

2.4 Materials, Manufacturing and Industrial Engineering

Engineering Materials: Structure and properties of engineering materials, phase diagrams, heat treatment, stress-strain diagrams for engineering materials.

Casting, Forming and Joining Processes: Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering and adhesive bonding.

Machining and Machine Tool Operations: Mechanics of machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, tool life and wear; Lathe, milling, drilling and shaping machines – construction and kinematics; economics of machining; principles of non-traditional machining processes, principles of work holding, jigs and fixtures; abrasive machining processes; NC/CNC machines and CNC programming.

Metrology and Inspection: Accuracy and precision; Types of errors; Limits, fits and tolerances; linear and angular measurements; comparators; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly; Inspection of screw threads and gears; Surface roughness measurement by contact and non-contact methods, concepts of coordinate-measuring machine (CMM).

Computer Integrated Manufacturing: Basic concepts of CAD/CAM and their integration tools; Geometric modeling, CNC; Automation in Manufacturing, additive manufacturing, Industrial Robots – configurations, drives and controls.

Production Planning and Control: Forecasting models, aggregate production planning, scheduling, materials requirement planning; lean manufacturing. Inventory Control: Deterministic models; safety stock inventory control systems.

Operations Research: Linear programming, simplex method, transportation, assignment, network flow models, simple queuing models, PERT and CPM.

Automobile Engineering: Classification, components, requirementsof automobile body, vehicle frame. types, front engine rear drive & frontenginefront drive vehicles, four-wheel drivevehicles, Clutches, Power Transmission, SuspensionSystems, SteeringSystem, AutomotiveBrakes,Tyres&Wheels, AutomotiveElectricals.

Industrial Economics and Management: EngineeringEconomics, Supply and Demand, NationalIncome Concepts, Value Analysis, Human Resource Management, Financial Management, Marketing Management, ProjectManagement, TQMprinciples, tools&techniques, QualityManagementSystem&QualityAudit.

2.5 Mechatronics, Industrial Automation and Robotics

Basics of mechatronics, a measurementsystemwithitsconstituentelements,openandclosedloopsystem,DigitalLogicand ProgrammableLogicController, Microprocessor and Input/Output System, Basic principles of automation, Hard automation, flexible automationextending the capabilities of conventional machines through improveddevices and manipulators, classification and specification of robots, laws of robotics,elementsofrobotanatomy,hydraulic,pneumaticandelectricalmanipulators,end-effectors and theirdesign, Roboticmanipulation, Directkinematics, Inverse Kinematics, Performance analysis of industrial robots: Performance Analysis andtheirmanufacturing applications, Economicsof robotics.