National Institute of Technology Calicut

NITC Campus P.O, Kozhikode – 673601, Kerala, India

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Syllabus for Written Test for the post of Assistant Professor Grade II (Pay Level -10)

DEPARTMENT OF MECHANICAL ENGINEERING

Module 1: Mathematics

Limit, continuity, differentiability, mean value theorems, higher order and partial derivatives, sequences and series, convergence, multiple integrals, vector field: divergence and curl, integral theorems, Linear algebra: solution of a system of linear equations, vector spaces, rank and determinant, eigenvalue problems, Ordinary Differential Equations (ODE): solution of first order ODE, solution of second order non-homogeneous ODE with constant coefficients, Probability distributions and random variables, statistics: population and sampling, tests of hypothesis, analysis of variance, curve fitting, Partial differential equations (PDE), First order and second order PDEs, complex numbers and functions.

Module 2: Industrial Engineering and Management stream

Decision modelling: Formulation and solution of linear programming problems, primal-dual relationships, sensitivity analysis, formulation and solution of integer programming problems, Network models and solutions, unconstrained and constrained optimization.

Statistics: Numerical description of data, Discrete and continuous probability distributions, confidence interval estimation for the mean and proportion, hypothesis testing for single populations about a population mean, Chi-Square goodness of fit test.

Supply chain management: Supply chain drivers, performance measures, models for facility location and capacity allocation, vehicle routing in transportation.

Inventory control: Single period inventory models, periodic review and continuous review policies, deterministic and probabilistic inventory models, selective control of inventories.

Manufacturing planning and control: Demand forecasting, aggregate production planning, master production scheduling, material requirements planning, flow shop scheduling, job shop scheduling.

Work systems design: Method study, time study, productivity measurement.

Statistical quality control: Control charts for variables and attributes, process capability, acceptance sampling.

Marketing management: Consumer behaviour, marketing research, new product development, market segmentation, pricing.

Module 3: Mechanics and Machine Design stream

Engineering Mechanics: Force and moment, resultant of a force system, equations of equilibrium, free-body diagram, static indeterminacy, laws of Coulomb friction, properties of surfaces: first and second moments of area, transfer theorems, polar moment of area, principal axes, particle kinematics: velocity and acceleration calculations in rectangular and polar coordinates, particle dynamics: Newton's laws, energy and momentum methods, moment-of-momentum equation for a particle.

Solid Mechanics: Definition of stress, deformation and strain, Hooke's Law, various elastic constants, shear force and bending moment diagrams, stress and deformation analysis of structural elements like rods, beams, shafts, etc., buckling analysis of columns, plane stress and plane strain problems, stress tensor, stress transformation, principal stresses and planes, Mohr's circle, strain tensor, equations of elasticity: equations of equilibrium, strain-displacement relations, compatibility conditions and constitutive equations, boundary conditions.

Mechanics of Machinery and Vibrations: Mechanisms and machines, kinematics of mechanisms, degrees of freedom, position, displacement, velocity and acceleration analysis, cams and gears: cam design, law of gearing, types of cams and gears, gear trains, kinematic synthesis, static and dynamic force analysis of machines, balancing, vibration analysis of single DoF systems: free and forced vibration, undamped and damped systems, Introduction to multiple DoF and continuous systems.

Machine Design: The design process, design factors, selection of materials, statistical considerations in design, stress concentration, theories of failure, design for impact and fatigue loads, consideration of creep and thermal stresses in design, design of various types of joints like threaded joints, welded joints, and joints with keys and pins, design of machine elements like springs and power shafting, design of clutches, brakes, belts and chain drives, design of gears, lubrication and journal bearing design, rolling contact bearings and their selection, concepts of product design, design for manufacturability, reliability, failure Analysis: sources of failure, methodology of failure analysis.

Module 4: Manufacturing and Material Science stream

Machining Science: Mechanics of metal cutting, cutting tool geometries, tool materials, tool wear, micromachining, additive manufacturing.

Metrology: Computation of Measurement Uncertainty according to GUM, Geometric Dimensioning and Tolerancing, Coordinate Measuring Machines, Surface Finish Measurement, Machine Vision.

Modern machining processes: Abrasive Jet machining, Ultrasonic machining, Chemical and electrochemical machining, electro-discharge machining, wire EDM, Electron beam machining, Laser beam machining, etc.

Machine Tool Design and Computer Numerical Control: Design of Metal cutting machine tools, kinematics, layouts. CNC Machine tools - Design, mechatronic elements, CNC programming

Materials Science:

Mechanical behavior of materials: Slip systems, dislocation interactions, grain size. Fracture: Brittle and ductile fracture, Fatigue, creep and stress rupture. Tension tests, hardness tests.

Ferrous and non-ferrous metallurgy: Melting units, solidification. Cast irons - types, effect of elements, defects. Steel and non-ferrous metallurgy - Iron carbon diagrams, heat treatment, modification.

Metal casting and joining: Solidification, casting processes, design of castings, inspection. Joining processes - Arc welding, laser beam, ultrasonic, etc. Adhesive bonding. Heat affected Zone.

Module 5: Thermo-fluid and Energy stream

Fluid statics: manometer, forces on bodies in fluid; Fluid kinematics: Deformation of a fluid element, strain rates- velocity relations; Fluid dynamics: Integral and differential forms of continuity and momentum equations. Euler's equation; Bernoulli's equation, velocity and discharge measuring devices. Prandtl's boundary layer equations, Integral momentum equation. Solutions to Plane Couette and Poiseuille flows. Dynamic action of fluid on flat and curved surfaces: Force, work done and efficiency; Classification and performance analysis of hydraulic turbines and pumps.

Basic terminology in thermodynamics; forms of energy; Energy interactions; First law of thermodynamics applied to non-flow and flow processes; Pure substances; Second law of thermodynamics applied to cycles; Entropy: entropy change of pure substances, entropy principle; Exergy: balance, applied to state and process; Thermodynamic property relations; Non-reactive gas mixtures, Gibbs phase rule; Introduction to irreversible thermodynamics, Onsager's reciprocity theorem.

Basic modes of heat transfer, Differential energy equations of heat conduction in different geometry and its boundary conditions: method of separation of variables, method of superposition; steady one dimensional heat conduction in fins of different profiles; Convection heat transfer: Concept of bulk mean temperature, differential and integral energy equations for steady laminar forced/natural convection boundary layer over flat plate and its analytical solution, steady laminar forced convection in tubes and ducts: analytical solution for hydrodynamically developed and thermally developing/developed flow problems; Heat exchangers; Thermal radiation: concepts of black and grey bodies, diffuse and specular surfaces, radiation intensity, emissive power, irradiation, radiosity; Radiant energy exchange between two surfaces, radiation shape factor, its properties and algebra; Radiation shield; Radiant energy exchange in enclosures: Electric network analogy.

Analysis of gas power cycles: Otto cycle, Diesel cycle, dual combustion cycle, Analysis of actual

cycles. Four stroke and Two stroke engines, valve timing and port timing diagrams: Engine systems: Fuel systems, cooling system, lubrication system, ignition system. Combustion in IC engines: Stages of combustion, ignition lag, flame propagation, knocking in SI and CI engines, pre-ignition, octane number, cetane number, ignition delay. IC Engine performance; Brayton cycle: Regeneration, reheat and inter cooled cycles, ideal jet propulsion cycles, turbojet engines.

Properties of steam and atmospheric air, psychrometry, Carnot vapour cycle, Rankine cycle, inter-cooling, reheat and regeneration, binary and combined power cycles, dual pressure cycle, co-generation; Vapour compression refrigeration cycle, refrigeration system components; Coal and other fossil fuels, combustion calculations; Steam generators, Steam nozzles, choking, design for throat and exit areas; Steam turbines, impulse and reaction turbines, velocity diagram calculations, turbine performance, compounding of steam turbines; Condensers, cooling towers, waste heat recovery techniques.