राष्ट्रीय प्रौद्योगिकी संस्थानश्रीनगर
NATIONAL INSTITUTE OF TECHNOLOGY SRINAGAR
(An autonomous Institute of National Importance under the aegis of Ministry of Education, Govt. of India)
हजरतबल, श्रीनगर, जम्मू-कश्मीर, 190006,भारत
Hazratbal, Srinagar Jammu and Kashmir, 190006, INDIA

SYLLABUS FOR TECHNICAL OFFICER (CRFC)

PART A - CRFC RELATED SYLLABUS [50% Weightage]

Digital Electronics:

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: Microprocessor and microcontroller applications, memory and input-output interfacing; basics of data acquisition systems, basics of distributed control systems (DCS) and programmable logic controllers (PLC).

Measurements:

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, Megohm, Maxwell, Anderson, Schering and Wien for measurement of R, L, Cand 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.

Sensors and Industrial Instrumentation:

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. 4-20 mA two-wire transmitter.

Communication and Optical Instrumentation:

Amplitude- and frequency modulation and demodulation; Shannon's sampling theorem, pulse code modulation; frequency and time division multiplexing, amplitude-, phase-, frequency-, quadrature amplitude, pulse shift keying for digital modulation; 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.

Operation/Maintenance:

Instrumentation knowledge of XRD, SEM, FESEM, EDX, RAMAN Spectroscopy, TGA/DSC, 3-Axis Laser system for surface texturing, Rheometer, Particle size Analyzer, Zeta Potential, TEM, AFM, WDXRF, FTIR, Nano-indenter, Nano-Scratch etc.

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PART B - CORE BARNCH RELATED SYLLABUS [50% Weightage]

(Candidates shall have to attempt the questions from any one of the Sections of PART B as per their eligibility. Questions shall be of B. Tech level for engineering courses and of PG level for Physics)

And

SECTION A : MECHANICAL ENGINEERING

General laboratory knowledge & awareness:

- Practical knowledge in Handling, operation and maintenance of equipment(s) related to Mechanical Engineering Department laboratory.
- General Science (such as Physics, Chemistry, Mathematics & Environment)
- Basic questions related to various laboratory equipment in the Mechanical Engineering Department laboratory, Housekeeping and documentation.
- Troubleshooting all equipment/instrument used on various laboratories of Mechanical Engineering.

Computer Awareness
Basic knowledge of Computer Applications, viz; MS Word, MS Excel, Power Point etc. Internet, MS-DOS, UNIX, Windows, Data Entry, Software knowledge, Networking Platforms, applications of computers in mechanical/Industrial/Production engineering.

Engineering Mechanics:
Laws of Forces, Moment, Friction, Moment of Inertia, Centre of Gravity and Simple Machines.

Mechanics of Solids:
Stresses and Strains, Strain energy, toughness, hardness, fatigue, creep, Bending Moment and Shearing Force Diagrams, Bending Stresses, Columns & Torsion.

Thermodynamics:
Fundamental Concepts, Laws of Perfect Gases, Thermodynamic Processes on Gases, Laws of Thermodynamics, Ideal and Real Gases and Properties of Steam.

Fluid Mechanics:
Type and Properties of Fluids, Pressure and its Measurement, Flow of Fluids and Flow through Pipes.

Theory of Machines:
Simple Mechanisms, Friction, Power Transmission, gyroscope, Flywheel, Governor and Balancing.

Heat-Transfer:
Modes of Heat Transfer, Fourier's Law, Steady State Conduction, Composite Structures, Natural and Forced Convection and Thermal Radiation.

Machining and Machine Tool Operations:

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Cutting Tools and Cutting Materials, Lathe, Drilling, Boring, Shaping and Planing, Broaching, Jigs and Fixtures and Cutting Fluids and Lubricants, Welding, Pattern Making, Metal Forming Processes.

Engineering Materials:
Scope of Material Science, Crystallography, Metals and Alloys, Heat Treatment, Plastics and Advanced Materials.

Machine Design:
Design-Definition, Types of design, necessity of design, Design terminology: stress, strain, factor of safety, factors affecting factor of safety, stress concentration, methods to reduce stress concentration, fatigue, endurance limit, Design Failure, Design of Shaft, Design of Key, Design of Joints, Design of Flange Coupling and Design of Screwed Joints.

Automobile Engineering:
Automobile and its development, Classification of automobiles, Transmission System, Steering System, Braking System, Dynamo and Alternator and Exhaust Emissions.

Computer Integrated Manufacturing:
Introduction to NC, CNC & DNC, Construction and Tooling, Part Programming, System Devices, Problems in CNC Machines, Automation and NC system.

I.C. Engines:
Working principle of two stroke and four stroke cycle, SI engines and CI Engines, Otto cycle, Diesel cycle, Dual cycle, Fuel Supply and Ignition System in Petrol Engine, Fuel System of Diesel Engine, Cooling and Lubrication and Testing of IC Engines.

Metrology and Inspection:
Linear and Angular Measurement, Measurement of Surface Finish and Measurements of Screw threads and Gauges

Refrigeration and air-conditioning:
Fundamentals of Refrigeration, Vapour Compression System, Refrigerants, Air Refrigeration System, Vapour Absorption System and Refrigeration Equipment.

Turbo-machinery:
Introduction to Turbomachines, Classification of Turbomachines, Steam Turbines and Steam Condensers, Gas Turbines and Jet Propulsion

Vibrations:
Types-Longitudinal, Transverse and Torsional vibrations, Dampening of Vibrations, Causes of vibrations in Machines, their Harmful Effects and Remedies.

SECTION B : ELCTRICAL ENGINEERING

Electromagnetic Fields: 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, Magneto-motive force, Reluctance, Magnetic circuits, Self and Mutual inductance of simple configurations.

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Signals and Systems: Representation of continuous and discrete time signals, Shifting and scaling operations, Linear Time Invariant and Causal systems, Fourier series representation of continuous periodic signals, Sampling theorem, Applications of Fourier Transform, Laplace Transform and Z-Transform.

Electrical Machines: Single phase transformer: equivalent circuit, phasor diagram, open circuit and short circuit tests, regulation and efficiency; Three phase transformers: connections, vector groups, parallel operation; Auto-transformer, Electromechanical energy conversion principles, DC machines: separately excited, series and shunt, motoring and generating mode of operation and their characteristics, starting and speed control of DC motors; Single phase induction motor: Operating principle, starting, torque-speed characteristics, speed control; Three phase induction motor: principle of operation, types, performance, torque-speed characteristics, no-load and blocked rotor tests, equivalent circuit, starting and speed control; Synchronous machines: cylindrical and salient pole machines, performance, regulation and parallel operation of generators, starting of synchronous motor, characteristics; Types of losses and efficiency calculations of electric machines.

Power Systems: Power generation concepts, Models and performance of transmission lines and cables, Series and shunt compensation, Electric field distribution and insulators, Sag and tension, Skin effect, Ferranti effect, Distribution systems (AC and DC), Per-unit quantities, Bus admittance matrix, Gauss-Seidel and Newton-Raphson load flow methods, Voltage and frequency control, Power factor correction, Symmetrical components, Symmetrical and unsymmetrical fault analysis, Principles of over-current, differential and distance protection; Circuit breakers, System stability concepts, Equal area criterion, Economic Load Dispatch (with and without considering transmission losses).

Control Systems: Mathematical modelling and representation of systems, Feedback principle, Transfer function, Block diagrams and Signal flow graphs, Transient and Steady-state analysis of linear time invariant systems, Routh-Hurwitz and Nyquist criteria, Bode plots, Root loci, Stability analysis, Lag, Lead and Lead-Lag compensators; P, PI and PID controllers; State space model, State transition matrix.

Electrical and Electronic Measurements: Bridges and Potentiometers, Measurement of voltage, current, power, energy and power factor; Instrument transformers, Digital voltmeters and multimeters, Phase, Time and Frequency measurement; Oscilloscopes, Error analysis.

Analog and Digital Electronics: Characteristics of diodes, BJT, MOSFET; Simple diode circuits: clipping, clamping, rectifiers; Amplifiers: Biasing, Equivalent circuit and Frequency response; Oscillators and Feedback amplifiers; Operational amplifiers: Characteristics and applications; Active and passive filters, Voltage-controlled oscillators, Digital Signal Oscilloscope,Timers, Combinational and Sequential logic circuits, Multiplexer, De-multiplexer, Schmitt trigger, Sample and hold circuits, A/D and D/A converters, 8085Microprocessor: Architecture, Programming and Interfacing.

Power Electronics: Characteristics of power semiconductor devices: Diode, Thyristor, TRIAC, GTO, MOSFET, IGBT; Rectifiers: Uncontrolled, Controlled, Single-phase and Three-phase;DC to DC converter: Buck, Boost and Buck-Boost converters; Inverters: Single phase, Three phase, VSI, CSI and PWM; AC to AC converter: Single phase and Three phase; Line commutated thyristor based converters, Dual Converter, Bidirectional AC to DC voltage source converters, Harmonics, Power factor, Distortion factor.

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SECTION C : ELECTRONICS AND COMMUNICATION ENGINEERING

Networks, Signals, and Systems:

(1) Node and mesh analysis, superposition, Thevenin's theorem, Norton's theorem, reciprocity theorem. Maximum power transfer theorem.
(2) Sinusoidal steady state analysis: phasors, complex power, Time and frequency domain analysis of linear circuits: RL, RC and RLC circuits, solution of network equations using Laplace transform, Linear 2-port network parameters, Y-delta transformation,
(3) Continuous-time signals: Fourier series and Fourier transform, sampling theorem and applications.,
(4) Discrete-time signals: DTFT, DFT, z-transform, discrete-time processing of continuous-time signals. LTI systems: definition and properties, causality, stability, impulse response, convolution, poles and zeros, frequency response, group delay, phase delay.

Electronic Devices and systems

(1) Energy bands in intrinsic and extrinsic semiconductors, equilibrium carrier concentration, direct and indirect band-gap semiconductors,
(2) Carrier Transport Mechanism: diffusion current, drift current, mobility and resistivity, generation and recombination of carriers, Poisson and continuity equations., P-N junction, Zener diode, photo diode, solar cell, BJT, JFET, MOSFET.
(3) Analog Circuits: clipping, clamping and rectifiers, BJT and MOSFET amplifiers: biasing, ac coupling, small signal analysis, frequency response, differential amplifiers, Amplifiers, summers, differentiators, integrators, active filters and oscillators.
(4) Digital Electronics: number systems, binary, octal, hexadecimal and BCD numbers., Boolean algebra, minimization of functions using Boolean identities and Karnaugh map, logic gates, arithmetic circuits, code converters, multiplexers, decoders., latches and flip-flops, counters, shift-registers, propagation delay, ROM, SRAM, DRAM, sample and hold circuits, ADCs and DACs.,
(5) Microprocessors fundamentals; Machine instructions and addressing modes, ALU, data-path and control unit, instruction pipelining.

Control Systems:

(1) Basic control system components; Feedback principle; Transfer function; Block diagram representation; Signal flow graph; Transient and steady-state analysis of LTI systems; Frequency response;
(2) Routh-Hurwitz and Nyquist stability criteria; Bode and root-locus plots; State variable model and solution of state equation of LTI systems.

Communications:

(1) Concept of signal, bandwidth, power spectral density and Autocorrelation, white noise and its properties, filtering of random signals through LTI systems
(2) Amplitude modulation and demodulation, angle modulation and demodulation, spectra of AM and FM signals, superheterodyne receivers, SNR and matched filtering.
(3) Sampling and quantization of signals, PCM, DPCM and ADPCM.

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(4) Digital modulation schemes (ASK, PSK, FSK, QAM), inter-symbol interference, MAP, ML detection and BER, Fundamentals of error detection and correction, Hamming codes, entropy, mutual information and channel capacity theorem.

Electromagnetics:

(1) Maxwell equations, Plane waves and propagations of waves through various media, phase and group velocity, characteristic impedance, poynting vector and skin depth
(2) Wave phenomenon like polarization, scattering, reflection and refraction.
(3) Basic concepts of radiations and antenna, half wave dipole antenna and monopole antennas, linear antenna arrays.

SECTION D : METALLURGICAL & MATERIAL ENGINEERING

Thermodynamics and Rate Processes: Laws of thermodynamics, activity, equilibrium constant, applications to metallurgical systems, solutions, phase equilibria, Ellingham and phase stability diagrams, thermodynamics of surfaces, interfaces and defects, adsorption and segregation; basic kinetic laws, order of reactions, rate constants and rate limiting steps; principles of electro chemistry-single electrode potential, electrochemical cells and polarizations, aqueous corrosion and protection of metals, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, selective leaching, oxidation and high temperature corrosion – characterization and control; heat transfer – conduction, convection and heat transfer coefficient relations, radiation, mass transfer – diffusion and Fick's laws, mass transfer coefficients; momentum transfer – concepts of viscosity, shell balances, Bernoulli's equation, friction factors

Extractive Metallurgy: Minerals of economic importance, comminution techniques, size classification, flotation, gravity and other methods of mineral processing; agglomeration, pyro-, hydro-, and electro-metallurgical processes; material and energy balances; principles and processes for the extraction of non-ferrous metals – aluminium, copper, zinc, lead, magnesium, nickel, titanium and other rare metals; iron and steel making – principles, role structure and properties of slags, metallurgical coke, blast furnace, direct reduction processes, primary and secondary steel making, ladle metallurgy operations including deoxidation, desulphurization, sulphide shape control, inert gas rinsing and vacuum reactors; secondary refining processes including AOD, VAD, VOD, VAR and ESR; ingot and continuous casting; stainless steel making, furnaces and refractories.

Physical Metallurgy: Crystal structure and bonding characteristics of metals, alloys, ceramics and polymers, structure of surfaces and interfaces, nano-crystalline and amorphous structures; solid solutions; solidification; phase transformation and binary phase diagrams; principles of heat treatment of steels, cast iron and aluminium alloys; surface treatments; recovery, recrystallization and grain growth; structure and properties of industrially important ferrous and non-ferrous alloys; elements of X-ray and electron diffraction; principles of optical, scanning and transmission electron microscopy; industrial ceramics, polymers and composites; introduction to electronic basis of thermal, optical, electrical and magnetic properties of materials; introduction to electronic and opto-electronic materials.

Mechanical Metallurgy: Elasticity, yield criteria and plasticity; defects in crystals; elements of dislocation theory – types of dislocations, slip and twinning, source and multiplication of dislocations, stress fields around dislocations, partial dislocations, dislocation interactions and reactions; strengthening mechanisms; tensile, fatigue and creep behaviour; super plasticity; fracture – Griffith theory, basic concepts of linear elastic and elastoplastic fracture mechanics, ductile to brittle

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transition, fracture toughness; failure analysis; mechanical testing – tension, compression, torsion, hardness, impact, creep, fatigue, fracture toughness and formability.

Manufacturing Processes: Metal casting – patterns and moulds including mould design involving feeding, gating and risering, melting, casting practices in sand casting, permanent mould casting, investment casting and shell moulding, casting defects and repair; Hot, warm and cold working of metals; Metal forming – fundamentals of metal forming processes of rolling, forging, extrusion, wire drawing and sheet metal forming, defects in forming; Metal joining – soldering, brazing and welding, common welding processes of shielded metal arc welding, gas metal arc welding, gas tungsten arc welding and submerged arc welding; Welding metallurgy, problems associated with welding of steels and aluminium alloys, defects in welded joints; Powder metallurgy – production of powders, compaction and sintering; NDT using dye-penetrant, ultrasonic, radiography, eddy current, acoustic emission and magnetic particle methods.

SECTION E : COMPUTER SCIENCE ENGINEERING

Digital Logic
Boolean algebra. Combinational and sequential circuits. Minimization. Number representations and computer arithmetic (fixed and floating point).
Computer Organization and Architecture
Machine instructions and addressing modes. ALU, data-path and control unit. Instruction pipelining, pipeline hazards, Memory hierarchy: cache, main memory and secondary storage; I/O interface (interrupt and DMA mode).
Programming, Data Structures and Operating System –
Programming in C. Recursion. Arrays, stacks, queues, linked lists, trees, binary search trees, binary heaps, graphs, System calls, processes, threads, inter-process communication, concurrency and synchronization, Deadlock. CPU and I/O scheduling. Memory management and virtual memory. File systems.
Algorithm: Searching, sorting, hashing. Asymptotic worst case time and space complexity. Algorithm design techniques: greedy, dynamic programming and divide-and-conquer. Graph traversals, minimum spanning trees, shortest paths, Theory of Computation – Regular expressions and finite automata. Context-free grammars and push-down automata. Regular and contex-free languages, pumping lemma. Turing machines, Lexical analysis, parsing, syntax-directed translation. Runtime environments. Intermediate code generation. Local optimisation, Data flow analyses: constant propagation, liveness analysis, common subexpression

Databases: ER-model. Relational model: Relational algebra, tuple calculus, SQL. Integrity constraints, normal forms. File organization, indexing (e.g., B and B+ trees). Transactions and concurrency control.
Computer Networks: OSI and TCP/IP Protocol Stacks, Basics of packet, circuit and virtual circuit-switching; framing, error detection, Medium Access Control, Ethernet bridging; shortest path, flooding, distance vector and link state routing; Fragmentation and IP addressing, IPv4, CIDR notation, Basics of IP support protocols (ARP, DHCP, ICMP), Network Address Translation (NAT); flow control and congestion control, UDP, TCP, sockets; Application layer protocols: DNS, SMTP, HTTP, FTP

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SECTION F : PHYSICS

CLASSICAL MECHANICS

Mechanics of particles and system of particles, conversion law, constraints, degree of freedom, generalized coordinates, D'Alembert's principle, Lagrange's equations of motion from D'Alembert's principle, application of Lagrange's equation of motion to a particle and system of particles, conservation theorem, Hamilton's variational principle, Euler- Lagrange's differential equation. Need of Hamilton's procedure, Legendre's transformation and Hamilton's equation of motion,

ELECTRONICS

Types of power amplifiers-series fed class A amplifier-series fed transformer coupled class B: push pull circuits-harmonic distortion in amplifiers-class C and D amplifiers-design considerations. Differential amplifier-ideal and real op—amp-input and output impedance-frequency response-applications: amplifiers, mathematical operations, active filters, waveform generators-analog computations-Comparators-S and H circuit-voltage regulator.

Optical fibres: graded index step index fibres-refractive index profiles-propagation of optical beams in fibres-mode characteristics and cut off conditions-losses in fibrwes-signal distortion group delaymaterial and wave guide dispersion.

SOLID STATE PHYSICS

Periodic arrays of atoms, Primitive lattice cell, fundamental types of lattices, index system for lattice planes, Simple crystal structure, Atomic radii, coordination number, Cesium chloride structure, Hexagonal Close Packed Structure, Diamond Structure, cubic Zinc Sulphide structure, point group. Diffraction waves by crystals, Braggs law, Scattered wave amplitude, Laue equations, Brillouin zones, reciprocal lattice to SC lattice, B C C lattice, F C C lattice, structure factor of B C C structure, F C C lattice, Atomic form factor.

STATISTICAL PHYSICS

Phase space, relation between eigen states and phase space volume, Liouville's theorem, ensembles, microcanonical, canonical and grand canonical ensembles, Maxwell's Boltzmnn's distribution and Gibb's formulation for canonical and grand canonical ensembles, partition function, their thermodynamic properties, laws of thermodynamics.: Drawbacks of M B distribution, Bose-Einstein's and Fermi-Dirac distribution,

QUANTUM MECHANICS

A brief review of foundations of quantum mechanics, basic postulates of quantum mechanics, uncertainty relations, Schrodinger wave equation, expectation value and Ehrenfest theorem. Relationship between space and momentum representation. Applications: One dimensional potential step, tunneling, Hydrogen atom, particle in a three dimensional box.

NUCLEAR PHYSICS

Nuclear size, nuclear angular momentum (Spin), Nuclear magnetic moments, statistics, Binding energy, Liquid drop model, Shell model, Collective model. – Ground state of deuteron, Low energy neutron-proton scattering and protonproton scattering, Exchange and tensor forces, G.M. Counter, Electron & Proton Synchrotron. Radioactive decay equation equilibrium units, **CONDENSED MATTER PHYSICS**

Defects in crystals: Point defect, Impurities, Vacancies, Frenkel defects, Schottky defects, Intrinsic vacancies, Concentration of Schottky defects, Concentration of frankel defects, extrinsic vacancies, Diffusion, Colour centres, F-Centre, V-Centre, dislocation, Line defects, edge dislocation, screw dislocation, Burger vector. Magnetism: Dia, Para and ferromagnetism,