DRDO SET Syllabus

Chemical Engineering – CH

Process Calculations and Thermodynamics:

Laws of conservation of mass and energy
use of tie components
recycle, bypass and purge calculations
degree of freedom analysis
First and Second laws of thermodynamics
First law application to close and open systems
Second law and Entropy Thermodynamic properties of pure substances
equation of state and departure function, properties of mixtures
partial molar properties, fugacity, excess properties and activity coefficients
phase equilibria: predicting VLE of systems
chemical reaction equilibria.

Fluid Mechanics and Mechanical Operations:

Fluid statics
Newtonian and non-Newtonian fluids
Bernoulli equation
Macroscopic friction factors
energy balance
dimensional analysis
shell balances
flow through pipeline systems
flow meters, pumps and compressors
packed and fluidized beds
elementary boundary layer theory
size reduction and size separation
free and hindered settling; centrifuge and cyclones
thickening and classification
filtration, mixing and agitation
Conveying of solids.

Heat Transfer:

Conduction
convection and radiation
heat transfer coefficients
steady and unsteady heat conduction
boiling
condensation and evaporation

types of heat exchangers and evaporators and their design

Mass Transfer:

Fick's laws
molecular diffusion in fluids
mass transfer coefficients
film, penetration and surface renewal theories
momentum
heat and mass transfer analogies
stagewise and continuous contacting and stage efficiencies
HTU & NTU concepts design and operation of equipment for distillation
absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification and adsorption

Chemical Reaction Engineering:

Theories of reaction rates
kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors, non-ideal reactors
residence time distribution, single parameter model
non-isothermal reactors
kinetics of heterogeneous catalytic reactions
diffusion effects in catalysis

Instrumentation and Process Control:

Measurement of process variables
sensors, transducers and their dynamics
transfer functions and dynamic responses of simple systems, process reaction curve
controller modes (P, PI, and PID)
control valves
analysis of closed loop systems including stability
frequency response and controller tuning, cascade, feed forward control

Plant Design and Economics:

Process design and sizing of chemical engineering equipment such as compressors
heat exchangers
multistage contactors
principles of process economics and cost estimation including total annualized cost, cost indexes
rate of return, payback period
Discounted cash flow, optimization in design.

Chemical Technology:

Inorganic chemical industries
sulfuric acid, NaOH, fertilizers (Ammonia, Urea, SSP and TSP)
natural products industries (Pulp and Paper, Sugar, Oil, and Fats)

petroleum refining and petrochemicals
polymerization industries; polyethylene, polypropylene, PVC and polyester synthetic fibers.

Computer Science and Engineering – CS

Theory of Computation:

Regular languages and finite automata
Context free languages and Push-down automata, Recursively enumerable sets and Turing machines
Undecidability; NP-completeness.

Digital Logic:

Logic functions, Minimization
Design and synthesis of combinational and sequential circuits
Number representation and computer arithmetic (fixed and floating point).

Computer Organization and Architecture:

Machine instructions and addressing modes
ALU and data-path, CPU control design, Memory interface
I/O interface (Interrupt and DMA mode)
Instruction pipelining
Cache and main memory, Secondary storage

Programming and Data Structures:

Programming in C
Functions, Recursion, Parameter passing, Scope, Binding
Abstract data types, Arrays, Stacks, Queues, Linked Lists
Trees, Binary search trees, Binary heaps
Algorithms
Analysis, Asymptotic notation, Notions of space and time complexity, Worst and average case analysis
Design: Greedy approach, Dynamic programming, Divide-and-conquer
Tree and graph traversals, Connected components, Spanning trees, Shortest paths
Hashing, Sorting, Searching.
Compiler Design: Lexical analysis, Parsing, Syntax directed translation, Runtime environments, Intermediate and target code generation, Basics of code optimization.

Operating System:

Processes, Threads, Inter-process communication
Concurrency, Synchronization, Deadlock, CPU scheduling
Memory management and virtual memory
File systems, I/O systems, Protection and security.

Databases:

ER-model, Relational model (relational algebra, tuple calculus)
Database design (integrity constraints, normal forms)
Query languages (SQL)
File structures (sequential files, indexing, B and B+ trees)
Transactions and concurrency control

Computer Networks:

ISO/OSI stack, LAN technologies (Ethernet, Token ring)
Flow and error control techniques
Routing algorithms, Congestion control, TCP/UDP and sockets
IP(v4), Application layer protocols (icmp, dns, smtp, pop, ftp, http)
Basic concepts of hubs, switches, gateways, and routers.

Electronics and Communication Engineering – EC

Networks:

Network graphs: matrices associated with graphs
incidence, fundamental cut set and fundamental circuit matrices
Solution methods: nodal and mesh analysis
Network theorems: superposition, Thevenin and Norton's maximum power transfer, Wye-Delta transformation
Steady state sinusoidal analysis using phasors
Linear constant coefficient differential equations
time domain analysis of simple RLC circuits
Solution of network equations using Laplace transform: frequency domain analysis of RLC circuit s. 2-port network parameters: driving point and transfer functions
State equations for networks.

Electronic Devices:

Energy bands in silicon, intrinsic and extrinsic silicon
Carrier transport in silicon: diffusion current, drift current, mobility, and resistivity
Generation and recombination of carriers. p-n junction diode
Zener diode, tunnel diode, BJT, JFET, MOS capacitor, MOSFET, LED
p-I-n and avalanche photo diode, Basics of LASERs
Device technology: integrated circuits fabrication process, oxidation, diffusion, ion implantation, photolithography, n-tub, p-tub and twin-tub CMOS process.

Analog Circuits:

Small Signal Equivalent circuits of diodes, BJTs, MOSFETs and analog CMOS
Simple diode circuits, clipping, clamping, rectifier
Biasing and bias stability of transistor and FET amplifiers
Amplifiers: single-and multi-stage, differential and operational, feedback, and power. Frequency response of amplifiers.

Simple op-amp circuits
Filters
Sinusoidal oscillators; criterion for oscillation; single-transistor and op-amp configurations
Function generators and wave-shaping circuits, 555 Timers
Power supplies.

Digital Circuits:

Boolean algebra, minimization of Boolean functions
logic gates
digital IC families (DTL, TTL, ECL, MOS, CMOS)
Combinatorial circuits: arithmetic circuits, code converters, multiplexers, decoders, PROMs and PLAs
Sequential circuits: latches and flip-flops, counters and shift-registers
Sample and hold circuits, ADCs, DACs
Semiconductor memories
Microprocessor(8085): architecture, programming, memory and I/O interfacing

Signals and Systems:

Definitions and properties of Laplace transform
continuous-time and discrete-time Fourier series
continuous-time and discrete-time Fourier Transform
DFT and FFT, z-transform
Sampling theorem
Linear Time-Invariant (LTI) Systems: definitions and properties
causality, stability, impulse response, convolution, poles and zeros
parallel and cascade structure, frequency response
group delay, phase delay
Signal transmission through LTI systems.

Control Systems:

Basic control system components
block diagrammatic description, reduction of block diagrams
Open loop and closed loop (feedback) systems and stability analysis of these systems
Signal flow graphs and their use in determining transfer functions of systems
Transient and steady state analysis of LTI control systems and frequency response
Tools and techniques for LTI control system analysis: root loci, Routh-Hurwitz criterion, Bode and Nyquist plots
Control system compensators: elements of lead and lag compensation, elements of Proportional-Integral-Derivative (PID) control
State variable representation and solution of state equation of LTI control systems.

Communications:

Random signals and noise: probability, random variables, probability density function, autocorrelation, power spectral density

Analog communication systems: amplitude and angle modulation and demodulation systems, spectral analysis of these operations, superheterodyne receivers
elements of hardware, realizations of analog communication systems
signal-to-noise ratio (SNR) calculations for amplitude modulation (AM) and frequency modulation (FM) for low noise conditions
Fundamentals of information theory and channel capacity theorem
Digital communication systems: pulse code modulation (PCM), differential pulse code modulation (DPCM)
digital modulation schemes: amplitude, phase and frequency shift keying schemes (ASK, PSK, FSK), matched filter receivers, bandwidth consideration and probability of error calculations for these schemes
Basics of TDMA, FDMA and CDMA and GSM.

Electromagnetics:

Elements of vector calculus: divergence and curl
Gauss' and Stokes' theorems, Maxwell's equations: differential and integral forms
Wave equation, Poynting vector. Plane waves: propagation through various media
reflection and refraction
phase and group velocity
skin depth. Transmission lines: characteristic impedance
impedance transformation
Smith chart
impedance matching
S parameters, pulse excitation
Waveguides: modes in rectangular waveguides; boundary conditions
cut-off frequencies; dispersion relations
Basics of propagation in dielectric waveguide and optical fibers
Basics of Antennas: Dipole antennas
radiation pattern
antenna gain

Electrical Engineering – EE

Electric Circuits and Fields: Network graph, KCL, KVL, node and mesh analysis, transient response of dc and ac networks
sinusoidal steady-state analysis, resonance, basic filter concepts
ideal current and voltage sources, Thevenin's, Norton's and Superposition and Maximum Power Transfer theorems, two-port networks, three phase circuits
Gauss Theorem, electric field and potential due to point, line, plane and spherical charge distributions
Ampere's and Biot-Savart's laws
inductance
dielectrics; capacitance

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
Fourier, Laplace and Z transforms

Electrical Machines:

Single phase transformer –equivalent circuit, phasor diagram, tests, regulation and efficiency
three phase transformers – connections, parallel operation
auto-transformer
energy conversion principles
DC machines – types, windings, generator characteristics, armature reaction and commutation, starting and speed control of motors
Three phase induction motors – principles, types, performance characteristics, starting and speed control
single phase induction motors
Synchronous machines – performance, regulation and parallel operation of generators, motor starting, characteristics and applications; servo and stepper motors.

Power Systems:

Basic power generation concepts
transmission line models and performance
cable performance, insulation
corona and radio interference
distribution systems
per-unit quantities
bus impedance and admittance matrices
load flow
voltage control
power factor correction
economic operation
symmetrical components
fault analysis
principles of over-current, differential and distance protection
solid state relays and digital protection
circuit breakers
system stability concepts, swing curves and equal area criterion
HVDC transmission and FACTS concepts.

Control Systems:

Principles of feedback
transfer function
block diagrams; steady-state errors
Routh and Niquist techniques
Bode plots
root loci
lag, lead and lead-lag compensation

state space model
state transition matrix, controllability and observability
Electrical and Electronic Measurements: Bridges and potentiometers
PMMC, moving iron, dynamometer and induction type instruments
measurement of voltage, current, power, energy and power factor
instrument transformers
digital voltmeters and multimeters
phase, time and frequency measurement
Q-meters
oscilloscopes
potentiometric recorders; error analysis.

Analog and Digital Electronics:

Characteristics of diodes, BJT, FET; amplifiers – biasing, equivalent circuit and frequency response
oscillators and feedback amplifiers; operational amplifiers – characteristics and applications
simple active filters; VCOs and timers
combinational and sequential logic circuits; multiplexer
Schmitt trigger
multi-vibrators
sample and hold circuits
A/D and D/A converters; 8-bit microprocessor basics, architecture, programming and interfacing.

Power Electronics and Drives:

Semiconductor power diodes, transistors, thyristors, triacs, GTOs, MOSFETs and IGBTs – static characteristics and principles of operation
triggering circuits
phase control rectifiers
bridge converters – fully controlled and half controlled
Principles of choppers and inverters; basis concepts of adjustable speed dc and ac drives.

Mechanical Engineering – ME

Engineering Mechanics:

Free body diagrams and equilibrium
trusses and frames
virtual work
kinematics and dynamics of particles and of rigid bodies in plane motion, including impulse and momentum (linear and angular) and energy formulations; impact.

Strength of Materials:

Stress and strain, stress-strain relationship and elastic constants, Mohr's circle for

plane stress and plane strain, thin cylinders
shear force and bending moment diagrams
bending and shear stresses
deflection of beams
torsion of circular shafts
Euler's theory of columns
strain energy methods
thermal stresses.

Theory of Machines:

Displacement, velocity and acceleration analysis of plane mechanisms
dynamic analysis of slider-crank mechanism
gear trains
flywheels

Vibrations:

Free and forced vibration of single degree of freedom systems
effect of damping
vibration isolation
resonance, critical speeds of shafts

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, spur gears, rolling and sliding contact bearings, brakes and clutches.

Fluid Mechanics:

Fluid properties
fluid statics, manometry, buoyancy
control-volume analysis of mass, momentum and energy
fluid acceleration
differential equations of continuity and momentum
Bernoulli's equation
viscous flow of incompressible fluids
boundary layer
elementary turbulent flow
flow through pipes, head losses in pipes, bends etc.

Heat-Transfer:

Modes of heat transfer
one dimensional heat conduction, resistance concept, electrical analogy, unsteady

heat conduction, fins
dimensionless parameters in free and forced convective heat transfer, various correlations for heat transfer in flow over flat plates and through pipes; thermal boundary layer
effect of turbulence
radiative heat transfer, black and grey surfaces, shape factors, network analysis
heat exchanger performance, LMTD and NTU methods.

Thermodynamics:

Zeroth, First and Second laws of thermodynamics
thermodynamic system and processes; Carnot cycle
irreversibility and availability
behaviour of ideal and real gases, properties of pure substances, calculation of work and heat in ideal processes
analysis of thermodynamic cycles related to energy conversion.

Applications:

- **Power Engineering:** Steam Tables, Rankine, Brayton cycles with regeneration and reheat
- **C. Engines:** air-standard Otto, Diesel cycles
- Refrigeration and air-conditioning: Vapour refrigeration cycle, heat pumps, gas refrigeration, Reverse Brayton cycle
- **moist air:** psychrometric chart, basic psychrometric processes
- **Turbomachinery:** Pelton-wheel, Francis and Kaplan turbines — impulse and reaction principles, velocity diagrams.

Engineering Materials:

- Structure and properties of engineering materials
- heat treatment, stress-strain diagrams for engineering materials.

Metal Casting:

- Design of patterns, moulds and cores
- solidification and cooling; riser and gating design, design considerations.

Forming:

- 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.

Joining:

- Physics of welding, brazing and soldering
- adhesive bonding
- Design considerations in welding.

Machining and Machine Tool Operations:

- Mechanics of machining, single and multi-point cutting tools, tool geometry and materials, tool life and wear
- economics of machining
- principles of non-traditional machining processes
- principles of work holding, principles of design of jigs and fixtures Metrology and Inspection: Limits, fits and tolerances
- linear and angular measurements; comparators
- gauge design; interferometry
- form and finish measurement
- alignment and testing methods; tolerance analysis in manufacturing and assembly.

Computer Integrated Manufacturing:

- Basic concepts of CAD/CAM and their integration tools.

Production Planning and Control:

- Forecasting models, aggregate production planning
- scheduling, materials requirement planning.

Inventory Control:

- Deterministic and probabilistic models
- safety stock inventory control systems.

Operations Research:

- Linear programming, simplex and duplex method, transportation, assignment, network flow models, simple queuing models, PERT and CPM.