SYLLABUS OF WRITTEN TEST FOR RECRUITMENT TO THE POST OF SCIENTIST/ENGINEER 'SC'
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DOMAIN: ATMOSPHERIC SCIENCE AND OCEANOGRAPHY
Post Code – 16

Physical Meteorology

- **Atmospheric composition & vertical structure**; hydrostatic balance, scale height
- **Thermodynamics of moist air**: lapse rates, stability, adiabatic processes, CAPE/CIN
- **Cloud microphysics**: nucleation, condensation/ice processes, precipitation formation
- **Radiation**: solar/terrestrial, radiative transfer basics, greenhouse effect, heating rates
- **Aerosols & air quality basics**: sources, optical properties, role in clouds and climate
- **Boundary layer basics**: turbulence, surface fluxes, inversion, mixed layer

Dynamical Meteorology

- **Forces and equations of motion**: pressure gradient, Coriolis, friction; momentum equations
- **Geostrophic/gradient wind**, thermal wind, vorticity and divergence
- **Large-scale circulation**: Hadley/Ferrel cells, jet streams, Rossby waves
- **Barotropic & baroclinic dynamics**: instability concepts, cyclone development
- **Frontogenesis and synoptic-scale systems**: mid-latitude cyclones, monsoon dynamics
- **Potential vorticity (PV) thinking** for diagnosing atmospheric evolution

Numerical Weather Prediction (NWP)

- **Model equations & discretization**: finite difference/volume/spectral ideas, stability (CFL)
- **Time stepping and filtering**; numerical diffusion and error growth
- **Parameterizations**: PBL/turbulence, convection, microphysics, radiation, land-surface
- **Initialization and lateral boundary conditions**; nesting and regional models (e.g., WRF)
- **Verification**: bias, RMSE, anomaly correlation, ETS; ensemble/uncertainty basics
- **Practical workflows**: running a model, post-processing, interpreting forecast fields

Satellite Meteorology

- **Satellite orbits & sensors**: GEO vs LEO; imagers vs sounders; scan geometry
- **Radiance–BT concepts**; Planck function basics; spectral channels (IR/WV/Vis)
- **Retrieval principles**: forward model, inversion, weighting functions, error sources
- **Key satellite products**: cloud properties, SST/LST, TPW, rainfall, winds (AMVs)

Remote Sensing (Atmosphere-focused)

- **Radiative transfer fundamentals**: absorption/scattering, emissivity, SRF concept
- **Passive vs active sensing**: IR/MW vs radar/lidar; what each measures and limitations
- **Pre-processing**: geolocation, resampling, cloud masking, atmospheric correction
- **Retrieval methods**: regression/ML vs physical retrievals; uncertainty quantification
- **Data fusion**: multi-sensor synergy (e.g., MW+IR, GEO+LEO), reanalysis integration
- **Applications**: aerosols, precipitation, land–atmosphere interaction, climate trends

Physics and Dynamics of Climate

- **Earth's energy balance**: solar forcing, albedo, greenhouse effect, radiative equilibrium
- **Radiative transfer in climate context**: shortwave/longwave, clouds, water vapour feedback
- **Global circulation & heat transport**: Hadley cell, jets, storm tracks; role of eddies
- **Ocean circulation basics**: mixed layer, thermohaline circulation, ENSO and coupled modes
- **Climate variability**: intraseasonal (MJO), interannual (ENSO/IOD), decadal signals
- **Climate feedbacks & sensitivity**: lapse-rate, cloud, ice–albedo, carbon-cycle coupling
- **Climate forcing mechanisms**: GHGs, aerosols, land-use change, volcanic/solar forcing
- **Climate models**: GCM structure, parameterizations, bias sources; scenario simulations
- **Diagnostics and attribution**: trends, extremes, detection/attribution concepts, reanalysis use
- **Monsoon–climate linkages** (especially for India): drivers, teleconnections, predictability limits

Oceanography

- **Physical Oceanography**
  Properties of seawater (Temperature, salinity, density); Equation of state of seawater; Pressure and compressibility; Heat budget of oceans; Light penetration in ocean; Sound propagation in seawater; Water masses (formation & classification); Vertical structure of ocean; Mixed layer, thermocline, deep ocean
- **Dynamical Oceanography**
  Forces acting on ocean water (Pressure gradient force; Coriolis force; Gravity and friction); Equations of motion; geostrophic currents; Gradient currents; Ekman transport & Ekman spiral; Vorticity and circulation; Rossby number & scaling; Boundary layer dynamics
- **Ocean Dynamics**
  General ocean circulation; Wind-driven circulation; Thermohaline circulation; Western boundary currents; Eastern boundary currents; Upwelling and downwelling; Ocean gyres; Role of oceans in climate; Energy transfer in oceans
- **Air–Sea Interaction**
  Heat exchange (sensible & latent heat flux); Momentum transfer (wind stress); Mass exchange (evaporation & precipitation); Formation of waves by wind ; Monsoon–ocean interaction; ENSO (El Niño–Southern Oscillation); Cyclones and ocean response; Feedback mechanisms (ocean ↔ atmosphere)

- **Ocean Circulation**
  Surface circulation patterns; Deep ocean circulation; Thermohaline circulation (global conveyor belt); Major ocean currents (e.g., Gulf Stream type systems); Gyres (subtropical & subpolar); Factors affecting circulation (Wind, Earth rotation, Density differences) Seasonal and regional variations; Circulation in Indian Ocean
- **Satellite oceanography**
  Introduction to satellite oceanography (Principles of remote sensing. Electromagnetic radiation and ocean interaction, Satellite systems and orbits, Polar orbiting satellite, Geostationary satellites); Ocean-observing sensors (Radiometers (IR & microwave), Scatterometers, Altimeters, Synthetic Aperture Radar (SAR).

Physics

- **Mathematical Physics**
  Dimensional Analysis; Vector algebra and Vector calculus: linear vector space: basis, orthogonality and completeness; matrices; similarity transformations, diagonalization, eigenvalues and eigenvectors; linear differential equations: second order linear differential equations and solutions involving special functions; complex analysis: Cauchy-Riemann conditions, Cauchy's theorem, singularities, residue theorem and applications; Fourier Series; Fourier and Laplace transforms; elementary ideas about tensors: covariant and contravariant tensors; Elementary probability theory, random variables, binomial, Poisson and normal distributions. Central limit theorem.
- **Classical Mechanics**
  Newton’s laws; Lagrangian formulation: D'Alembert's principle, Euler-Lagrange equation, Hamilton's principle, calculus of variations; symmetry and conservation laws; central force motion: Kepler problem and Rutherford scattering; small oscillations: coupled oscillations and normal modes; rigid body dynamics: interia tensor, orthogonal transformations, Euler angles, Torque free motion of a symmetric top; Hamiltonian and Hamilton's equations of motion; Liouville's theorem; canonical transformations: action-angle variables, Poisson brackets, Hamilton-Jacobi equation. Special theory of relativity: Lorentz transformations, relativistic kinematics, mass-energy equivalence.
- **Electromagnetic Theory**
  Solutions of electrostatic and magnetostatic problems including boundary value problems; method of images; separation of variables; dielectrics and conductors; magnetic materials; multipole expansion; Maxwell's equations; scalar and vector potentials; Coulomb and Lorentz gauges; electromagnetic waves in free space, non-conducting and conducting media; reflection and transmission at normal and oblique incidences; polarization of electromagnetic waves; Poynting vector, Poynting theorem, energy and momentum of electromagnetic waves; radiation from a moving charge.

- **Thermodynamics and Statistical Physics**
  Laws of thermodynamics; macrostates and microstates; phase space; ensembles; partition function, free energy, calculation of thermodynamic quantities; classical and quantum statistics; degenerate Fermi gas; black body radiation and Planck's distribution law; Bose-Einstein condensation; first and second order phase transitions, phase equilibria, critical point.

- **Atomic and Molecular Physics**
  Spectra of one-and many-electron atoms; spin-orbit interaction: LS and jj couplings; fine and hyperfine structures; Zeeman and Stark effects; electric dipole transitions and selection rules; rotational and vibrational spectra of diatomic molecules; electronic transitions in diatomic molecules, Franck-Condon principle; Raman effect; EPR, NMR, ESR, X-ray spectra; lasers: Einstein coefficients, population inversion, two and three level systems.

Hindi version shall follow.