Annexure-A

Syllabus for the IIRS-JRF Eligibility Test (IIRS-JET)
Indian Institute of Remote Sensing
Indian Space Research Organisation
Dehradun

IIRS-JET is a national level exam conducted by Indian Institute of Remote Sensing (IIRS), ISRO, for the eligibility of the candidates to apply for the post of Junior Research Fellow (JRF) in the area of Remote Sensing (RS), Geographic Information System (GIS) and their Applications.

Scheme of Examination

- Examination will be computer-based having multiple choice type questions.
- Total duration of the Test shall be 120 Minutes (100 Questions).
- There are NO negative marks.
- The paper will be of 100 marks, consisting of 3 sections, namely:
  - Basic Mathematics and Science (25 questions - 25 Marks) - 30 minutes
  - Aptitude and General English (25 questions - 25 Marks) - 30 minutes
  - Subject (Optional Theme*) (one) (50 questions - 50 Marks) - 60 minutes

Note: Candidate can appear for examination for only one of the 10 optional themes.

The cut-off marks for qualifying the Test shall be of 60 marks.

Validity of the Score:

The Score of the Test will be valid for the period of 03 (three) years from the date of declaration of the results and the qualified candidates can apply for the post of JRF at IIRS advertised for recruitment during that period with the above score card.

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Syllabus for the IIRS- JRF Eligibility Test (IIRS-JET)

SECTION-1: SUBJECT (Choose any one of the options) (50 MARKS)

Option-1: Remote Sensing & Geoinformatics

Remote Sensing & Photogrammetry

Physics of Remote Sensing - Definition, Concept & Principles, Electromagnetic Radiation (EMR) and Its Characteristics, Wavelength Regions and their Significance, Interaction of EMR with Atmosphere and Earth's Surface: Absorption, Reflectance and Scattering, Atmospheric Windows, Spectral Signatures & Visual Image Interpretation keys, RS Data Acquisition Mechanisms, EO platforms and sensors, Weather & Communication Satellites, Spectral, Spatial, Temporal and Radiometric resolution. Imaging and Non-Imaging, Active and Passive, Multispectral, hyperspectral sensors. Data Types and Errors, Fundamentals of Digital Image & its Preprocessing(Radiometric & Geometric Correction), Image Enhancement (Radiometric, Spatial and Spectral), Image Classification (Unsupervised & Supervised), Accuracy assessment. Concept of Image fusion and its applications. Concept of Change detection and its applications. Advanced classifiers (ANN, Fuzzy, image segmentation etc.)

Basic concepts of photogrammetry, Basic characteristics of a map, different types of map and scale, Basic Geodesy, Map projections, parallax, relief displacement, stereoscopic measurements, orthoimages, DEM/DTM. Satellite Stereo sensors, Terrain Modelling: Concept and applications of DSM, DTM, DEM, bare earth DEM, DTM derivatives. Introductory concepts of LiDAR Remote sensing. Hyper-spectral Remote Sensing: Basic Principles (including sensors and platforms for data acquisition.

Basic principles of Thermal remote sensing, Thermal Properties of Terrain: Thermal Capacity, Thermal conductivity, Thermal Inertia, Kinetic heat, Temperature, radiant energy and flux, , Thermal Infrared remote sensing applications. Microwave Remote sensing concepts: Backscattering, Range Direction, Azimuth Direction, Incident Angle, Depression Angle, Polarization, Dielectric Properties, Surface Roughness and Interpretation, resolutions Speckle and Its Reduction, Passive and active microwave sensors. SLAR and Scatterometer, Basic concepts of SAR polarimetry. Applications of microwave remote sensing images

GIS

Introduction to GIS, Difference between GIS and other Information Systems, GIS Components, Functions of GIS, Hardware & software requirements for GIS, GIS data sources, Spatial data and attribute data, Geographical data formats (coverage, geodatabase, shapefile, grid, dxf, dwg, geotiff, GML), Attribute types (nominal, ordinal, interval, ratio), Spatial data models (Raster and Vector), comparison of raster and vector data model, Spatial data input techniques and

devices used (resolution, precision), Digitizing, Editing and structuring map data, Concept of Topology, Spaghetti vs. topological vector data, topological relationships, Sources of errors.

Non-spatial data models (Flat file, Hierarchical, Network, Relational and Object Oriented), Overview of DBMS (conceptual, logical and physical models), Advantages of Data Base Management System, ER model, RDBMS, Geodatabases, Database Design using RDBMS, Principal operations in a RDBMS (selection, insertion, updating and deletion), Database normalization rules.

Raster & Vector based spatial analysis, Map overlay, Spatial Join, Buffering analysis. Spatial analysis (raster based): Local, Neighbourhood, Zonal and Global operations. Network analysis. Spatial modelling and multi-criteria analysis. Concept of Web GIS, & Mobile GIS

GNSS

Basic concept of GNSS, Various Global/Regional Satellite constellations, GNSS signals, Pseudo Range Measurement Sources of GNSS errors, DOP. Datum/Ellipsoid (horizontal, vertical) - definition and basic concepts-Global Datum vs. Indian Geodetic Datum, Coordinate Systems. Differential positioning concept, Differential GPS survey Methods. Augmentation Systems (GAGAN, WAAS, LAAS, etc.) & its applications.

OR

Option-2: Earth Observation Applications in Atmospheric Science

Atmospheric composition and thermal structure, interaction of EMR with atmosphere, radiation basic laws, scattering, absorption, Beer-Lambert law. Atmospheric circulation, hydrostatic equation, Equation of continuity, momentum equation, Basic equations and fundamental forces, air pollution, composition. Weather and climate, tropical meteorology, Monsoon system, El Nino Southern Oscillation (ENSO), clouds types, rainfall processes, thermodynamics.

Solar spectral distribution and interaction with atmosphere, Emission and absorption of terrestrial radiation, atmospheric windows, energy balance of earth-atmosphere system, Solar constant and radiative balance at top of the atmosphere, Radiative heating or cooling of atmosphere, terrestrial radiation, Mean heat balance of earth-atmosphere system, atmospheric greenhouse effect, instrumentation and measurement.

Basic concepts of Remote Sensing, GIS & GNSS and its Application in Atmospheric Science

Physics of Remote Sensing - Definition, Concept & Principles, Electromagnetic Radiation (EMR) and Its Characteristics, Wavelength Regions and their Significance, Interaction of EMR with Atmosphere and Earth's Surface: Absorption, Reflectance and Scattering, Atmospheric Windows, Spectral Signatures & Visual Image Interpretation keys, RS Data Acquisition Mechanisms, EO platforms and sensors, Weather & Communication Satellites, Spectral, Spatial, Temporal and Radiometric resolution. Imaging and Non-Imaging, Active and Passive

sensors. Optical, SAR, Thermal Sensors. Fundamentals of Digital Image & its Preprocessing (Radiometric & Geometric Correction), Image Enhancement (Radiometric, Spatial and Spectral), Image Classification (Unsupervised & Supervised), Accuracy assessment

Introduction to GIS, Difference between GIS and other Information Systems, GIS Components, Functions of GIS, Hardware & software requirements for GIS, GIS data sources, Spatial data and attribute data, Geographical data formats (coverage, geodatabase, shapefile, grid, dxf, dwg, geotiff, GML), Attribute types (nominal, ordinal, interval, ratio), Spatial data models (Raster and Vector), comparison of raster and vector data model, Spatial data input techniques and devices used (resolution, precision), Digitizing, Editing and structuring map data, Concept of Topology, Spaghetti vs. topological vector data, topological relationships. Spatial analysis (raster/vector based) Map overlay, Spatial Join, Buffering analysis.

Basic concept of GNSS, Various Global/Regional Satellite constellations.

Meteorological satellite sensors and products, Satellite image interpretation, spectral properties, cloud image interpretation, remote sensing of atmosphere using visible, thermal infrared and microwave radiometer observations, satellite meteorology, scatterometer, atmospheric motion vectors, winds, rainfall, trace gases, aerosols using EO sensors, air pollution, atmospheric sounding: retrieval of temperature and water vapor profiles.

OR

Option-3: Earth Observation Applications in Agriculture

Agricultural Crops and Soil Science

Fundamentals of Agronomy, Crop Production (major kharif and rabi crops), rainfed agriculture, Pest and diseases of field crops and horticultural crops, weather and Climate, measurement of weather parameters, Earth's atmosphere, solar radiation and energy balance, crop physiology, climate change impact on vegetation and agriculture, fundamentals of soil science: physico-chemical properties, soil forming factors and soil forming processes, land evaluation, soils of India: salient characteristics and their land use, environment monitoring and management, ecosystem processes and climate change, ecosystem dynamics, statistical methods.

Soil and Water Conservation

Natural resource management, land degradation processes, soil erosion types and processes, soil hydrological properties and their measurement, soil & water conservation measures, watershed management, watershed morphology, soil hydrology, irrigation & water

management, land degradation types, extent and their characteristics, salt affected soils, soil reclamation measures, soil quality and environmental and soil pollution.

Basic concepts of Remote Sensing, GIS & GNSS and its Application in Agriculture

Physics of Remote Sensing - Definition, Concept & Principles, Electromagnetic Radiation (EMR) and Its Characteristics, Wavelength Regions and their Significance, Interaction of EMR with Atmosphere and Earth's Surface: Absorption, Reflectance and Scattering, Atmospheric Windows, Spectral Signatures & Visual Image Interpretation keys, RS Data Acquisition Mechanisms, EO platforms and sensors, Weather & Communication Satellites, Spectral, Spatial, Temporal and Radiometric resolution. Imaging and Non-Imaging, Active and Passive sensors. Optical, SAR, Thermal Sensors. Fundamentals of Digital Image & its Preprocessing (Radiometric & Geometric Correction), Image Enhancement (Radiometric, Spatial and Spectral), Image Classification (Unsupervised & Supervised), Accuracy assessment

Introduction to GIS, Difference between GIS and other Information Systems, GIS Components, Functions of GIS, Hardware & software requirements for GIS, GIS data sources, Spatial data and attribute data, Geographical data formats (coverage, geodatabase, shapefile, grid, dxf, dwg, geotiff, GML), Attribute types (nominal, ordinal, interval, ratio), Spatial data models (Raster and Vector), comparison of raster and vector data model, Spatial data input techniques and devices used (resolution, precision), Digitizing, Editing and structuring map data, Concept of Topology, Spaghetti vs. topological vector data, topological relationships. Spatial analysis (raster/vector based) Map overlay, Spatial Join, Buffering analysis.

Basic concept of GNSS, Various Global/Regional Satellite constellations

Overview of remote sensing and GIS applications in agriculture and soils; remote sensing data for agriculture and soils, understanding vegetation and soil spectral response curve, basic knowledge of optical, microwave (active and passive) and thermal remote sensing applications in agriculture, microwave remote sensing for kharif crop inventory, crop condition and cropping system analysis, crop management, crop yield models, crop informatics, precision agriculture, satellite agrometerology, agromet variables and parameters, agricultural water and drought management, land surface processes and climate change, soil resource mapping, digital soil mapping techniques, optimal land use planning, digital terrain analysis for watershed characterization, watershed monitoring, soil erosion modelling using GIS, remote sensing in land degradation and desertification characterization and mapping, microwave remote sensing in soil moisture studies

OR

Option-4: Earth Observation Applications in Disaster Management

Definitions of Natural Disasters and Manmade disasters; Various types of Natural disasters and their basic understanding (Floods, Earthquakes, landslides, Tsunamis, Cyclones, droughts etc.); concept of Hazard, vulnerability, susceptibility and risk, Disaster Management cycle; Disaster

risk reduction (DRR), mitigation, preparedness and disaster early warning; Disaster management framework of India and recent initiatives by Govt. of India such as National Disaster Management Act, National Disaster Management Policy, NDMA, NIDM, NDRF, guidelines issued by NDMA for handling various disasters etc.; International Initiatives such as Sendai Framework in the field of Disaster Management.

Drought: its types and impact, soil erosion - causes, types and agents of soil erosion; soil erosion control structures, water harvesting techniques, wind erosion, wind erosion control measures.

Forest fire and environmental hazards: Vegetation types and fire incidences, fire regimes, Types of forest fire, fire triangle. Pollution, particulate emission and their movement.

Geological hazards: Major tectonic features of the Oceanic and Continental crust; Seismic belts of the earth; Environment Impact Assessment; Natural hazards - preventive/precautionary measures - landslides, earthquakes, river and coastal erosion; Landslides - classification, causes and prevention; Slope Stability; Impact assessment of anthropogenic activities such as open cast mining and quarrying, river valley projects, etc.

***Hydrological and coastal Hazards*:** Concept of Hydrology, Hydrological Cycle, Element of Hydrological cycle: Rainfall, interception, infiltration, Soil Moisture, Evapotranspiration etc. Introduction to flood hydrology, flood flow estimation and routing, urban flooding, flood inundation mapping and modeling, GLOF, flood damage assessment, flood hazard and flood risk zone mapping using remote sensing and GIS techniques. Climate change induced disasters (sea level rise, tropical cyclones, etc.). Coastal hazards such as cyclone, storm surges, tsunami, sea-level rise and coastal vulnerability

***Atmospheric Hazards*:** Earth's atmosphere, composition and structure of atmosphere, temperature and pressure variation with altitude, cyclones, anticyclones and general circulation system of earth, types of precipitation, types of monsoon, atmospheric pollution; Global warming – indicator, agent and causes, Global warming and its impacts; Greenhouse gases and effect.

Basic concepts of Remote Sensing, GIS & GNSS and its Application in Disaster Management

Physics of Remote Sensing - Definition, Concept & Principles, Electromagnetic Radiation (EMR) and Its Characteristics, Wavelength Regions and their Significance, Interaction of EMR with Atmosphere and Earth's Surface: Absorption, Reflectance and Scattering, Atmospheric Windows, Spectral Signatures & Visual Image Interpretation keys, RS Data Acquisition Mechanisms, EO platforms and sensors, Weather & Communication Satellites, Spectral, Spatial, Temporal and Radiometric resolution. Imaging and Non-Imaging, Active and Passive sensors. Optical, SAR, Thermal Sensors. Fundamentals of Digital Image & its Preprocessing (Radiometric & Geometric Correction), Image Enhancement (Radiometric, Spatial and Spectral), Image Classification (Unsupervised & Supervised), Accuracy assessment

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Basic concept of GNSS, Various Global/Regional Satellite constellations

Earth observation data for disaster management; Optical, Thermal and microwave remote sensing sensors for Atmospheric, environmental and hydro-meterological and geological hazard monitoring and modeling.

OR

Option-5: Earth Observation Application in Forestry & Environmental Science

Natural resources: Types, distribution and status of vegetation of India and the world; Factors affecting vegetation distribution; Major biomes of the world; Biogeography and life zones; Major systems of plant classification; Plant identification methods; Forest phenology and its drivers; Renewable and non-renewable resources; Social forestry; Agroforestry; Non-timber forest produce

Forest ecology: Definitions; Forest ecosystem structure and functions; Nutrient cycling; Forest productivity estimation; Landscape ecology; Population and community studies; Phytosociology; Ecological succession; Food chains and food webs; Ecological pyramids; Energy flow in ecosystem

Plant physiology: Photosynthesis; Photosynthetic pathways and their significance; Photoperiodism; Transpiration; Plant adaptations

Forest inventory planning: Sampling design; Sampling concepts and methods; Growing stock and biomass estimation; Measures of central tendency; Correlation and regression analysis; Trees outside forests; Forest working plan; Forest mensuration

Conservation and Ecosystem services: Wildlife conservation; Protected areas and their status in India; Wildlife corridors; Biodiversity assessment; Global biodiversity hotspots; Importance of wetlands; Ramsar convention; Wetlands and their conservation; UN Agenda-21 and Aichi Targets; UN Sustainable Development Goals; Assessment and valuation of ecosystem services; Use of plant and plant parts; IUCN; CITES; Rare, endangered and threatened species; Keystone species; Umbrella species; Flagship species

Forest disturbances: Deforestation; Forest degradation; Forest fire - types and its effect on vegetation; Insect pest/diseases; Invasive plants; Threats to wildlife and biodiversity; Habitat fragmentation; Extinction of species

Climate change and Environmental impact assessment: Greenhouse gases; Global warming; Acid rain; Biogeochemical cycles; Forest ecosystem and climate linkages; Climate change impacts on forest ecosystems; IPCC climate change scenarios; Environmental impact assessment – purpose and process; Environmental policy and strategy; Forest, environment and wildlife acts/laws; Kyoto Protocol; $REDD^{+}$, Environmental movements of India;

Environmental pollution: Sources of pollution; Nature of pollutants; Air pollution and its effects; Water pollution and its effects; Eutrophication; Land pollution; Solid wastes; Vehicular pollution; Radiation hazards

Basic concepts of Remote Sensing, GIS & GNSS and its Application in Forestry

Physics of Remote Sensing - Definition, Concept & Principles, Electromagnetic Radiation (EMR) and Its Characteristics, Wavelength Regions and their Significance, Interaction of EMR with Atmosphere and Earth's Surface: Absorption, Reflectance and Scattering, Atmospheric Windows, Spectral Signatures & Visual Image Interpretation keys, RS Data Acquisition Mechanisms, EO platforms and sensors, Weather & Communication Satellites, Spectral, Spatial, Temporal and Radiometric resolution. Imaging and Non-Imaging, Active and Passive sensors. Optical, SAR, Thermal Sensors. Fundamentals of Digital Image & its Preprocessing (Radiometric & Geometric Correction), Image Enhancement (Radiometric, Spatial and Spectral), Image Classification (Unsupervised & Supervised), Accuracy assessment

Introduction to GIS, Difference between GIS and other Information Systems, GIS Components, Functions of GIS, Hardware & software requirements for GIS, GIS data sources, Spatial data and attribute data, Geographical data formats (coverage, geodatabase, shapefile, grid, dxf, dwg, geotiff, GML), Attribute types (nominal, ordinal, interval, ratio), Spatial data models (Raster and Vector), comparison of raster and vector data model, Spatial data input techniques and devices used (resolution, precision), Digitizing, Editing and structuring map data, Concept of Topology, Spaghetti vs. topological vector data, topological relationships. Spatial analysis (raster/vector based) Map overlay, Spatial Join, Buffering analysis.

Basic concept of GNSS, Various Global/Regional Satellite constellations

Applications of remote sensing and GIS in forestry and ecology; National forest cover assessment using satellite data; Vegetation type/land use mapping; Forest cover monitoring. Vegetation Indices.

OR

Option-6: Earth Observation Applications in Geosciences

Earth System Science

Concepts of Earth System Science; Earth and the solar system; Origin and evolution of the Earth; Earth materials, Surface features and processes.

Geomorphic processes and landform evolution; Applied geomorphologic mapping; Geomorphic classification systems; Glacier-climate interaction; glacier dynamics; Periglacial and glacial landforms.

Various mineral resources and their formation process; Prospecting and exploration of economic mineral deposits - sampling, ore reserve estimation; geostatistics; mining methods; various surface indicators for mineral exploration.

Basics of crystallography, mineralogy, geochemistry and petrology.

Basics of structural geology, stratigraphy and geotectonics; Introduction to active tectonics and neotectonics.

Earthquake geology and palaeoseismology; Seismo-Tectonics of the Indian plate; Seismic zones of India vis-à-vis recent earthquakes; Geodynamics of Himalaya.

Groundwater and Engineering Geology:

Basics of hydrogeology; Role of landforms and geological structures in groundwater occurrences; Hydrogeological classification of rocks in India; Groundwater targeting in different geologic terrains using EO data and GIS techniques.

Geophysical methods for groundwater exploration; Groundwater quality and pollution assessment including sea-water intrusion; artificial groundwater recharge methods;

Engineering properties of rocks and soil; Rock mass classification; Construction materials; Mass movement types and classifications of landslides; Landslide characteristics, causes and processes; Remote sensing applications in landslides; dams and reservoirs site selection in different geological settings; Environmental impact assessment of dams and reservoirs.

Basic concepts of Remote Sensing, GIS & GNSS and its Application in Geosciences

Physics of Remote Sensing - Definition, Concept & Principles, Electromagnetic Radiation (EMR) and Its Characteristics, Wavelength Regions and their Significance, Interaction of EMR with Atmosphere and Earth's Surface: Absorption, Reflectance and Scattering, Atmospheric Windows, Spectral Signatures & Visual Image Interpretation keys, RS Data Acquisition Mechanisms, EO platforms and sensors, Weather & Communication Satellites, Spectral, Spatial, Temporal and Radiometric resolution. Imaging and Non-Imaging, Active and Passive sensors. Optical, SAR, Thermal Sensors. Fundamentals of Digital Image & its Preprocessing

(Radiometric & Geometric Correction), Image Enhancement (Radiometric, Spatial and Spectral), Image Classification (Unsupervised & Supervised), Accuracy assessment

Introduction to GIS, Difference between GIS and other Information Systems, GIS Components, Functions of GIS, Hardware & software requirements for GIS, GIS data sources, Spatial data and attribute data, Geographical data formats (coverage, geodatabase, shapefile, grid, dxf, dwg, geotiff, GML), Attribute types (nominal, ordinal, interval, ratio), Spatial data models (Raster and Vector), comparison of raster and vector data model, Spatial data input techniques and devices used (resolution, precision), Digitizing, Editing and structuring map data, Concept of Topology, Spaghetti vs. topological vector data, topological relationships. Spatial analysis (raster/vector based) Map overlay, Spatial Join, Buffering analysis.

Basic concept of GNSS, Various Global/Regional Satellite constellations

Image elements for geological interpretation; Remote sensing applications in interpreting structure & tectonics, lithological mapping, mineral resources, geological hazards, groundwater potentials and environmental monitoring.

Satellites and sensors for terrestrial geosciences

Thermal properties of geological materials; Radar wave properties and interaction with terrain & geology; Spectroscopy of rocks and minerals.

Various methods and applications of Digital Image Processing (DIP) in geology; Basic concepts and principles of multispectral, hyperspectral, thermal Infra-red and microwave data processing and their applications in geology.

Applications of GIS in various geological studies. Geological database creation in GIS; Integrated data analysis; Terrain mapping and analysis

Geophysical methods (electro-magnetic, resistivity, gravity, seismic) of exploration and its integration with remote sensing based information for geoscientific applications.

OR

Option-7: Earth Observation Applications in Ocean Science

Basics of Oceanography: Physical and Chemical properties of Ocean: temperature, salinity, density, pressure, heat budget, Carbon Cycle, Nitrogen Cycle.

Dynamical Oceanography: Equation of motion, Coriolis force, Equation of continuity, Geostrophic flow, Wind-driven circulation, Ekman Transport, upwelling, Buoyancy, Vorticity, Thermohaline circulation, Mixed layer, Waves, Internal waves, Kelvin waves, Rossby waves and Tides.

Marine Biology: Pelagic and Benthic zones of the Ocean, Biotic and Abiotic factor effecting marine life, Planktons, Primary productivity, Food Chain.

Coastal Processes and Marine Ecology: Classification of coasts and the processes of their formations, landforms due to erosional and depositional activities. Climate change and sea level rise. Coastal disasters like tsunami, cyclone, storm surge etc. Basic coastal ecological components like Mangroves, corals and sea grasses. Importance of coast and concept of coastal zone management. Issues pertaining to Indian Coast and their mitigation strategy.

Basic concepts of Remote Sensing, GIS & GNSS and its Application in Ocean Science

Physics of Remote Sensing - Definition, Concept & Principles, Electromagnetic Radiation (EMR) and Its Characteristics, Wavelength Regions and their Significance, Interaction of EMR with Atmosphere and Earth's Surface: Absorption, Reflectance and Scattering, Atmospheric Windows, Spectral Signatures & Visual Image Interpretation keys, RS Data Acquisition Mechanisms, EO platforms and sensors, Weather & Communication Satellites, Spectral, Spatial, Temporal and Radiometric resolution. Imaging and Non-Imaging, Active and Passive sensors. Optical, SAR, Thermal Sensors. Fundamentals of Digital Image & its Preprocessing (Radiometric & Geometric Correction), Image Enhancement (Radiometric, Spatial and Spectral), Image Classification (Unsupervised & Supervised), Accuracy assessment

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Basic concept of GNSS, Various Global/Regional Satellite constellations

Applications in Oceanography: Passive and Active sensors for Oceanographic study: Optical sensors, Thermal sensors, Passive microwave sensors, Active microwave sensors (Altimeter, Scatterometer, Synthetic Aperture Radar). Retrieval of Oceanographic parameters from satellite sensors: Phytoplankton concentration, Suspended Sediment Concentration, Diffused attenuation coefficient, Sea Surface Temperature, Sea Surface Salinity, Sea Surface Height, Significant Wave Height, Wind speed over ocean, Geostrophic Current, Wave spectrum, Estimation of column primary productivity, Coastal Bathymetry, Identification of Potential Fishing Zone (PFZ).

Applications in Coastal Processes and Marine Ecology: Remote sensing and GIS applications for coastal study. Study of coastal hazards/disasters using geospatial techniques, Study of Coastal ecological components from space-borne sensors. Use of Remote sensing and GIS for Coastal zone management. Parameters retrieved using RS techniques for coastal zone study. Gap areas and future sensor requirement for coastal zone studies and management.

OR

Option-8: Earth Observation Applications in Urban & Regional Planning

Urbanization in India, definition of urban and regional areas, census classification of urban areas, trends in urban population, urban sprawl: causes and effects, population trend in India, types of urban densities, migration, land-man ratio, household size, terminology and concepts of urban and regional planning, Guidelines for Urban and Regional Planning (URDPFI Guidelines), urban and regional planning models, characteristics of development/ master/ zonal plans, urban growth models, Regional studies: concepts, resource regions in India, Decentralized planning, Base maps characteristics and scales, urban land use/ land cover classification system and mapping, concepts of Smart Cities and AMRUT, basics of urban hydrology, urban flooding and urban drainage planning, classification of urban roads, types of parking, various types of road and traffic surveys, weather and climate, urban climate, urban heat island, urban pollution, urban multi-hazards, risk and vulnerability assessment, types and sources of renewable energy. Basic statistical techniques and their interpretation, spatial metrics, population projection techniques. Overview of Sustainable Development Goals.

Basic concepts of Remote Sensing, GIS & GNSS and its Application in Urban & Regional Planning

Physics of Remote Sensing - Definition, Concept & Principles, Electromagnetic Radiation (EMR) and its Characteristics, Wavelength Regions and their Significance, Interaction of EMR with Atmosphere and Earth's Surface: Absorption, Reflectance and Scattering, Atmospheric Windows, Spectral Signatures & Visual Image Interpretation keys, RS Data Acquisition Mechanisms, EO platforms and sensors, Weather & Communication Satellites, Spectral, Spatial, Temporal and Radiometric resolution. Imaging and Non-Imaging, Active and Passive sensors. Optical, SAR, Thermal Sensors. Fundamentals of Digital Image & its Preprocessing (Radiometric & Geometric Correction), Image Enhancement (Radiometric, Spatial and Spectral), Image Classification (Unsupervised & Supervised), Accuracy assessment.

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Application of remote sensing data [Optical (MX/stereo), Microwave, LiDAR, Hyperspectral and Thermal] for urban and regional area analysis, planning and governance; urban features

extraction, material characterization; base maps, urban sprawl and growth modeling, prediction of future growth pattern using CA-ANN, MCE-CA Models; use of Night-Time Light Data in urban studies; 3D modeling techniques and visualization for urban surface profiling; DEM/DSM Generation for urban areas; urban climate, pollution, flooding and hazard, urban utilities and infrastructure management, GPR applications in utility mapping, urban heritage; property tax assessment; tourism resources, urban green spaces, land suitability analysis, slums mapping, solid waste management, renewable energy harnessing.

OR

Option-9: Earth Observation Applications in Water Resources

Basics of Hydrology and water cycle: Introduction to hydrological cycle and its components (Precipitation, Interception, Infiltration, ET, Runoff etc.); Concept of the basin/watershed; Water resources of India; Water availability and use in Indian river basins; Water quality.

Basics of surface, snow and ground water hydrology and hydraulics: Concepts and measurements of precipitation, surface runoff, infiltration, evapotranspiration; Hydrograph; Snow & Glacier hydrology; Watershed hydrology; Soil erosion; Fundamentals of open channel flow and flow in porous media; flow routing, discharge measurement; Basics of open channel and ground water hydraulics

Concepts of Flood and Drought Assessment and Management: Flood peak estimation; Flood routing; 1D/2D flow simulations; Dam break; Flood inundation modelling; Drought indices; Flood and Drought information systems.

Concepts of Water Resources Planning and Management: Reservoir and canal design; Site suitability and EIA of water resources projects; Basic concepts of irrigation water management; Concept of impact of climate change on hydrological cycle components and water sector Conjunctive use of surface and ground water.

Basic concepts of Remote Sensing, GIS & GNSS and its Application in Water Resources

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Introduction to GIS, Difference between GIS and other Information Systems, GIS Components, Functions of GIS, Hardware & software requirements for GIS, GIS data sources, Spatial data

and attribute data, Geographical data formats (coverage, geodatabase, shapefile, grid, dxf, dwg, geotiff, GML), Attribute types (nominal, ordinal, interval, ratio), Spatial data models (Raster and Vector), comparison of raster and vector data model, Spatial data input techniques and devices used (resolution, precision), Digitizing, Editing and structuring map data, Concept of Topology, Spaghetti vs. topological vector data, topological relationships. Spatial analysis (raster/vector based) Map overlay, Spatial Join, Buffering analysis.

Basic concept of GNSS, Various Global/Regional Satellite constellations

Overview of remote sensing and GIS applications in hydrology; Hydrological cycle parameters (Precipitation, ET, soil moisture, etc.) retrieval using satellite data; surface water, snow, ice sheet and glacier mapping using remote sensing, rainfall-runoff modelling using GIS, watershed characterization using digital elevation models, flood mapping and irrigation studies using remote sensing.

OR

Option-10: Programming for Geospatial Analysis & Modelling

Basic concepts of remote sensing, GIS & GNSS

Physics of Remote Sensing - Definition, Concept & Principles, Electromagnetic Radiation (EMR) and Its Characteristics, Wavelength Regions and their Significance, Interaction of EMR with Atmosphere and Earth's Surface: Absorption, Reflectance and Scattering, Atmospheric Windows, Spectral Signatures & Visual Image Interpretation keys, RS Data Acquisition Mechanisms, EO platforms and sensors, Weather & Communication Satellites, Spectral, Spatial, Temporal and Radiometric resolution. Imaging and Non-Imaging, Active and Passive sensors. Optical, SAR, Thermal Sensors. Fundamentals of Digital Image & its Preprocessing (Radiometric & Geometric Correction), Image Enhancement (Radiometric, Spatial and Spectral), Image Classification (Unsupervised & Supervised), Accuracy assessment

Introduction to GIS, Difference between GIS and other Information Systems, GIS Components, Functions of GIS, Hardware & software requirements for GIS, GIS data sources, Spatial data and attribute data, Geographical data formats (coverage, geodatabase, shapefile, grid, dxf, dwg, geotiff, GML), Attribute types (nominal, ordinal, interval, ratio), Spatial data models (Raster and Vector), comparison of raster and vector data model, Spatial data input techniques and devices used (resolution, precision), Digitizing, Editing and structuring map data, Concept of Topology, Spaghetti vs. topological vector data, topological relationships. Spatial analysis (raster/vector based) Map overlay, Spatial Join, Buffering analysis.

Basic concept of GNSS, Various Global/Regional Satellite constellations

Programming for Geospatial Analysis & Modelling

Programming Language Concepts

- Variables, Constants & Data Structures

- Expressions (Logical, Boolean, Arithmetic and Algebraic) and Statements
- Decision/Control Structures
- Iteration/Repetition Structures
- Functions, Modules & Recursion
- Array and strings processing

Data Handling

- Console input-output handling (Simple and Parameterized)
- File data handling (input and output)
- Database handling

Programming language platforms

- Desktop based
- Web based
- Mobile Based
- Hybrid

Coding Practices

- Object Oriented Programming
- Programming frameworks
- Batch Processing
- Debugging and Exception Handling
- Code Optimization and
- Handling memory leaks

Advanced Topics

- Parsing and scrapping
- Semantic Web
- Natural Language Processing (NLP)
- External Libraries and Modules
- Programming for cluster computation e.g. MPI etc.
- Image Processing
- Big Data Handling
- Artificial Intelligence ,Machine Learning and Deep Learning

Architecture

- Procedural pattern
- Client Server
- Master Slave

- Distributed architecture
- Model-view-controller pattern
- Service Oriented Architecture(Web 2.0)

Programming/Scripting Languages

- Python, Java, FORTRAN, etc.
- PHP, Javascript, XML,HTML etc.

SECTION-2: BASIC MATHEMATICS AND SCIENCE (25 MARKS)

2.1 BASIC MATHEMATICS

Number Systems

Real Numbers: Euclid's division lemma, Fundamental Theorem of Arithmetic - statements after reviewing work done earlier and after illustrating and motivating through examples, Proofs of irrationality of $\sqrt{2}$, $\sqrt{3}$, $\sqrt{5}$, Decimal representation of rational numbers in terms of terminating/non-terminating recurring decimals.

Algebra

***Polynomials*:** Zeros of a polynomial. Relationship between zeros and coefficients of quadratic polynomials. Statement and simple problems on division algorithm for polynomials with real coefficients.

Pair of Linear Equations in Two Variables: Pair of linear equations in two variables and graphical method of their solution, consistency/inconsistency. Algebraic conditions for number of solutions. Solution of a pair of linear equations in two variables algebraically – by substitution, by elimination and by cross multiplication method. Simple situational problems. Simple problems on equations reducible to linear equations.

Quadratic Equations: Standard form of a quadratic equation $ax^2 + bx + c = 0$, $(a \neq 0)$. Solutions of quadratic equations (only real roots) by factorization, and by using quadratic formula. Relationship between discriminant and nature of roots. Situational problems based on quadratic equations related to day to day activities to be incorporated.

Arithmetic Progressions: Motivation for studying Arithmetic Progression Derivation of the n^{th} term and sum of the first n-terms of an A.P. and their application in solving daily life problems.

Coordinate Geometry

Lines (In two-dimensions): Concepts of coordinate geometry, graphs of linear equations. Distance formula. Division of a line segment in a given ratio (internally).

Geometry

Triangles: Definitions, types, area calculation in different type of triangle, counter examples of similar triangles and related problems.

Circles: **Definition,** Tangent to a circle at point of contact and from a point outside, equations, radius and circumference, Construction of a triangle similar to a given triangle, and related problems.

Trigonometry

Introduction to Trigonometry: Trigonometric ratios of an acute angle of a right-angled triangle. Proof of their existence (well defined); motivate the ratios whichever are defined at 0^o and 90^o. Values (with proofs) of the trigonometric ratios of 30^o, 45^o and 60^o. Relationships between the ratios.

Trigonometric Identities: Proof and applications of the identity $\sin^2 A + \cos^2 A = 1$. Only simple identities to be given. Trigonometric ratios of complementary angles.

Heights and Distances (Angle of elevation, Angle of Depression): Simple problems on heights and distances. Problems should not involve more than two right triangles. Angles of elevation / depression should be only 30^o, 45^o, and 60^o.

Mensuration

Areas Related to Circles: Motivate the area of a circle; area of sectors and segments of a circle. Problems based on areas and perimeter / circumference of the above said plane figures. (In calculating area of segment of a circle, problems should be restricted to central angle of 60°, 90° and 120° only. Plane figures involving triangles, simple quadrilaterals and circle should be taken)

Surface Areas and Volumes:

- Surface areas and volumes of combinations of any two of the following: cubes, cuboids, spheres, hemispheres and right circular cylinders/cones. Frustum of a cone.
- Problems involving converting one type of metallic solid into another and other mixed problems. (Problems with combination of not more than two different solids be taken).

Statistics and Probability

Statistics: **Statistical parameters estimation (**Mean, median and mode) of grouped and ungrouped data. Cumulative frequency graph, distributions.

Probability: Classical definition of probability, different types of events, simple problems on probability theory.

2.2 BASIC SCIENCE

Chemistry

Matter Theory: Solid, liquid and gas; change of state - melting (absorption of heat), freezing, evaporation (Cooling by evaporation), condensation, sublimation Elements, compounds and mixtures. Atoms and molecules, Atomic and molecular masses, Valency. Chemical formulae of common compounds. Electrons, protons and neutrons; isotopes and isobars.

Chemical reactions and equations: Chemical reactions- types of chemical reactions, displacement reactions, redox reactions, combination and decomposition of reactions, Chemical Equations.

Acids, bases and salts: Introduction of acids and bases, properties of acids and bases, concept of pH scale, pH scale and its importance, important chemical compounds,

Metals and non-metals: Physical properties of metals and non-metals, chemical properties of metals, metals in nature, electrovalent bonding of metals, formation and properties of ionic compounds.

Carbon and its compounds: Covalent bonding in non-metals, carbon compounds, introduction to hydrocarbons, properties of hydrocarbons, nomenclature of organic compounds, alcohols and carboxylic acids.

Periodic classification of elements: Classification of elements, similarities of element's properties, modern periodic table of elements.

Physics

Distance and displacement, velocity; uniform and non-uniform motion along a straight line; acceleration. Force and motion, Newton's laws of motion, inertia of a body, inertia and mass, momentum, force and acceleration. Elementary idea of conservation of momentum, action and reaction forces. Gravitation; universal law of gravitation, force of gravitation of the earth (gravity), acceleration due to gravity; mass and weight; free fall. Thrust and pressure. Archimedes' principle, buoyancy, elementary idea of relative density. Work, power, Sound**,** Different forms of energy, conventional and non-conventional sources of energy: fossil fuels, solar energy; biogas; wind, water and tidal energy; nuclear energy. Renewable versus non-renewable sources.

Electromagnetic Theory

Basics of Electromagnetic theory

Electromagnetic Waves: Basic idea of displacement current, Electromagnetic waves, their characteristics, their Transverse nature (qualitative ideas only). Electromagnetic spectrum (radio waves, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays) including elementary facts about their uses.

Dual Nature of Radiation and Matter

Dual Nature of Radiation and Matter: Dual nature of radiation, Photoelectric effect, Hertz and Lenard's observations; Einstein's photoelectric equation-particle nature of light. Matter waves-wave nature of particles, de-Broglie relation, Davisson-Germer experiment (experimental details should be omitted; only conclusion should be explained).

Atoms and Nuclei

Atoms: Alpha-particle scattering experiment; Rutherford's model of atom; Bohr model, energy levels, hydrogen spectrum.

Nuclei: Composition and size of nucleus, Radioactivity, alpha, beta and gamma particles/rays and their properties; radioactive decay law. Mass-energy relation, mass defect; binding energy per nucleon and its variation with mass number; nuclear fission, nuclear fusion.

Optics

Ray Optics and Optical Instruments: *Ray Optics:* Reflection of light, spherical mirrors, mirror formula, refraction of light, total internal reflection and its applications, optical fibers, refraction at spherical surfaces, lenses, thin lens formula, lensmaker's formula, magnification, power of a lens, combination of thin lenses in contact, refraction of light through a prism. Scattering of light - blue colour of sky and reddish appearance of the sun at sunrise and sunset. *Optical instruments:* Microscopes and astronomical telescopes (reflecting and refracting) and their magnifying powers.

Wave Optics: Wave front and Huygen's principle, reflection and refraction of plane wave at a plane surface using wave fronts. Proof of laws of reflection and refraction using Huygen's principle. Interference, Young's double slit experiment and expression for fringe width, coherent sources and sustained interference of light, diffraction due to a single slit, width of central maximum, resolving power of microscope and astronomical telescope, polarization, plane polarized light, Brewster's law, uses of plane polarized light and Polaroids.

SECTION-3: APTITUDE AND GENERAL ENGLISH (25 MARKS)

3.1 Aptitude

Problems on basic arithmetic and reasoning viz numbers, percentage, area, volume, profit & loss, distance, velocity, time & work, clocks & calendars, permutation & combination, compound interest, simple interest, H.C.F. & L.C.M., odd man out, analogy, similarities & differences, classification, series completion, coding and decoding, statement conclusion, spatial visualization, spatial orientation, discrimination, observation, relationship concepts, judgment and arithmetical reasoning.

3.2 General English

Questions in this component will be designed to test the candidate's understanding and knowledge of English language and will be based on error recognition, fill in the blanks (using verbs, preposition, articles, etc.), vocabulary, grammar, sentence structure, synonyms, antonyms, sentence completion, phrases and idioms and comprehension.

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