Space Sci.

DEPARTMENT OF PHYSICS, EELCTRONICS & SPACE SCIENCES
GUJARAT UNIVERSITY, AHMEDABAD 380009
GUJARAT

Advanced P.G. Diploma in Space Science and Its Applications

(Effective from June 2005)

FIRST SEMESTER (600 MARKS)

Paper	Subject	Internal Exam	External exam	Total marks
1.	Solar Terrestrial Physics and Space Plasma Physics	30	70	100
2.	Atmospheric Physics	30	70	100
3.	Microcontroller	30	70	100
4.	Microwaves	30	70	100
5.	Programming in C++ and Numerical Methods	30	70	100
	Practicals	30	70	100
	+ Total Marks			600

SECOND SEMESTER (600 MARKS)

Paper	Subject	Internal Exam	External exam	Total marks
6.	Fundamentals of Remote Sensing	30	70	100
7.	Satellite Systems, Orbits and Control	30	70	100
8.	Digital Signal Processing	30	70	100
9.	Satellite Communication	30	70	100
10.	Communication and Remote Sensing Applications	30	70	100
	Project	30	70	100
	Total marks			600
	Grand Total marks			1200

Paper I

Solar Terrestrial Physics and Space Plasma Physics

UNIT - I

The neutral atmosphere:

Vertical structure : Nomenclature, hydrostatic equilibrium. exosphere, heat balance and vertical temperature profile, composition.

Winds and tides :

Propagating waves in neutral atmosphere : Acoustic gravity waves.

Atmospheric chemistry: Composition and chemistry of middle atmosphere and thermosphere.

The solar wind and magnetosphere :

Solar radiations : Solar electromagnetic radiation. Solar flare. radio emissions from sun. solar activity cycles.

Solar wind : Discovery. theory of solar wind, properties of solar wind. IMF

Geomagnetic cavity : Geomagnetic field, magnetopause.

UNIT - II

Principles of ionosphere at middle and low latitudes :

Physical aeronomy : Principles, Chapman production function, ionization by energetic particles, principles of chemical recombination, vertical transport.

Chemical aeronomy : E and F1 regions, F2 region and protonosphere, D region.

Principles of airglow.

Charged particle motion and electrical conductivity : Particle motion in a magnetic filed in presence of collisions, response to neutral air wind, conductivity.

UNIT - III

Ionospheric phenomena at middle and low latitudes :

Observed behavior of the midlatitude ionosphere : E region and sporadic E, F1 region. F2 region and its anomalies, D region, effects of solar flare, variation with sunspot cycle, eclipse effects

Ionospheric current system : Generation of global ionospheric currents, Sq current system. F-region drifts, ion drag effects

Peculiarities of the low latitude ionosphere :

Storms : Magnetic storms and Dst index, F region ionospheric storms, D region storms, winter anomaly of radio absorption

Irregularities : Scintillations, scintillation drifts, spread-F bubbles and F-region irregularities at low latitudes, irregularities in the equatorial electrojet, TID

UNIT-IV

Observational techniques :

Direct sensing of gaseous medium : Direct measurements of neutral atmosphere, Langmuir probe, impedance and resonance probe, mass spectrometers.

Remote sensing by radiowaves : Ionospheric sounding, Trans-ionospheric propagation, VLF propagation, whistlers, partial reflections

Scatter radar techniques : Volume scattering, coherence, coherent scatter radar, incoherent scatter radar, MST radar, Lidar

Airglow studies : photometry, imaging and spectrometry

UNIT – V

Space plasma Physics :

Plasma Probes : Techniques of plasma diagnostics, magnetic and electron probes a probe in plasma, formation of sheath and the Debye length. The Langmuir-Child law, the electrostatic (Langmuir) probe, probe theory for a collisionless non magnetized plasma, the probe characteristic (I-V curve) and measurement of plasma parameters. Applications of a.c. techniques to the Langmuir probe, the floating double probe and its approximation to the Langumir probe, effect of collisions and magnetic fields.

Impedance probes and resonance probes, probes in the laboratory plasma and probes in space.

Optical methods of plasma studies (introductory)

References :

Hargreaves J.K., The solar-terrestrial Environment, Cambridge Univ. Press, 1992

Ratcliff J.A., Introduction of ionsosphere and magnetosphere, Cambridge Univ. Press

Rishbeth and Garriot, Introduction to ionospheric physics, Academic press, 1969

Giraud A. and Petit M., Ionospheric techniques and phenomena, Riedel, 1978

Rees M.J., Chemistry of upper atmosphere, Academic Press

Degaonker S.S., Introduction to space physics, Gujarat University Press, 1972

Langmuire C.L., Elementary plasma physics, Wiley Eastern

Chen F.F., Introduction to plasma physics, Plenum Press

Uman K.A., Introduction to plasma physics, MGH

Paper II

Atmospheric Physics

UNIT – I

Atmospheric structure, composition and thermodynamics :
Vertical profile of pressure and density, atmospheric composition as a function of height. temperature distribution, Virtual temperature, Hydrostatic equation and its applications, Adiabatic process, Water vapor in air, Concept of static stability, Second law of thermodynamics and entropy, T-Φ gram.

UNIT – II

Atmospheric aerosol and cloud physics:
Atmospheric aerosol, Nucleation of water vapor condensation, Growth of cloud droplets in warm clouds, Microphysics of cold clouds
Clouds and storms : Cloud morphology, Air-mass thunderstorm, Hurricanes, Extra tropical cyclonic storms, Artificial modification of clouds and precipitation

UNIT –III

Weather elements and synoptic scale systems :
Surface weather elements:
Synoptic charts : surface synoptic charts, time series representation, upper level synoptic charts, vertical soundings
Tropical systems : ITCZ, monsoon, tropical cyclones, western disturbances

UNIT IV

Atmospheric dynamics : Coordinate systems, Apparent forces in coordinate systems, Real forces, Horizontal equation of motion, Vertical equation of motion, Thermal wind, Thermodynamic energy equation, Continuity equation, Primitive equations.

UNIT V

General circulation :

Thermally driven circulation in the absence of rotation, Influence of planetary rotation upon thermally driven circulations, Thermally driven circulations in the tropics, Baroclinic disturbances, Dissipation of Kinetic energy, Kinetic energy cycle. Atmospheric transport of energy, Atmosphere as heat engine.

References :

Wallace J.M and Hobbs P.V., Atmospheric science – an introductory survey, Academic Press, 1977

Jacobson M.Z., Fundamentals of atmospheric modeling, Cambridge Univ. Press, 1999

Andrues D.G., Introduction of atmospheric physics, 1997

Salbay M.L., Fundamentals of atmospheric physics. 1996

Houghton J.T., Physics of Atmosphere, 2002

Holton J.R., Introduction to dynamic meteorology, Academic press, 1972

Hess S.L., Introduction to theoretical meteorology, Holt-Rinehart Winston

Ayode J.O., Introduction to climatology of the tropics, John Wiley, 1983.

Paper III

Microcontroller

UNIT – I

Microprocessors and microcontrollers : Microcontroller survey, 8051 microcontroller hardware, I/O pins, ports and circuits, external memory, counters and timers, serial data, I/O interrupts, introduction to 8051 assembly programming.

UNIT - II

Moving data : Addressing modes, external data moves, code memory, read only data moves, push and pop opcodes, data exchange, example programs
Logical operations : Byte level logical operations, bit-level logical operations, rotate and swap operations, example programs.
Arithmetic operations : Flags, incrementing and decrementing, addition, subtraction. Multiplication, and division, decimal arithmetic, example programs.
Single-bit instructions.

UNIT - III

Jump and call instructions : The jump and call program range, jumps, calls and subroutines, interrupts and returns, more details on interrupts, example programs.
8051-microcontroller design : Specifications, design, testing, timing subroutines, look-up table, serial data transmission.
Timer-counter programming.

UNIT – IV

8051 serial communication : Network configuration, 8051 data communication modes (mode 0, mode 1, mode 2, mode 3), example programs
Interrupts programming : 8051 interrupts, programming timer interrupts, programming external hardware interrupts, programming the serial communication interrupt, interrupt priority in 8051.

UNIT - V

Applications :
Keyboards : human factors, key switch factors, key configurations, programs for keyboards, a scanning program for small keyboard, interrupt driven programs for small keyboards, program for matrix keyboard.
Displays : Interfacing of seven-segment display and LCD with 8051.
Interfacing of ADC and DAC.
Interfacing of stepper motor.

Reference Books:

1. Ayala K.J. 8051 Microcontroller, Penram International .
2. Mazidi and Mazidi, 8051 Microcontroller and embedded system. Pearson Education.
3. Myke Prdko, Programming and customizing the 8051 Microcontroller.

Paper IV

Microwaves

UNIT – I

Transmission Line and matching :
Normalized impedance, Smith impedance chart and admittance chart, single stub matching, double stub matching, quarter wave transformer, half wave transformer, taper, shunt-susceptance matching

UNIT – II

Microwave cavity resonators :
Coaxial resonators, waveguide cavity resonators (rectangular cavity and circular cavity), cavity excitation and tuning, Q-factor of microwave cavities (unloaded Qo, Q factor of a transmission line, unloaded Q factor of coaxial cavity), loaded and external Q, coupled cavities (reflection type and transmission type).

UNIT - III

Microwave transistors :
Microwave bipolar transistors (physical structure, configuration, principle of operation, amplification phenomenon, power frequency limitations). Microwave field effect transistors (physical structure, principle of operation, small signal equivalent circuit, drain current, cutoff frequency and maximum oscillation frequency). High mobility transistors, HEMTS (physical structure, operational mechanism, performance characteristics, electronic applications).

UNIT – IV

Microwave integrated circuits :
Microstrip lines, parallel strip lines, coplanar strip lines, shielded strip lines, MMIC (materials, growth). Thin film formation (planar resistor film, planar inductor film, planar capacitor film).

UNIT – V

Antennas :

Slot, horn and complimentary antennas (slot antenna, patterns of slot antenna in flat sheet. Babinet's principle and complementary antenna, the impedance of slot antenna. Horn antennas, rectangular horn antenna, beamwidth comparison, conical horn antennas. ridge hones. septum horns, corrugated horns), antenna measurement.

References:

Samual Y. Liao. Microwave Devices and circuits. PHI.
Annpurna Das and Sisir Das. Microwave engineering, TMH.
John D. Krauss, Antennas. McGraw Hill.

Paper V

Programming in C++ and Numerical Methods

UNIT - 1

Object oriented programming: Basic concepts, benefits, objected oriented languages, applications
Tokens, expressions and control structures : Declaration of variables, dynamic initialization of variables, reference variables, operators in c++, scope resolution operator, memory management operators, manipulators, operator overloading,
Functions : Inline functions, default arguments, function overloading,

UNIT – II

Classes and Objects : Specifying a class, defining member functions, making an outside function inline, nesting of member functions, private member functions, arrays within a class, memory allocation for objects, static data members, static member functions, arrays of objects, object as function arguments, friendly functions, returning objects, pointers to members, local classes.
Constructors and destructors : Constructors, parameterized constructors, multiple constructors in a class, constructors with default arguments, dynamic initialization of objects, copy constructor, dynamic constructors, constructing two-dimensional arrays, destructors.

UNIT – III

Operator overloading and type conversions : defining operator overloading, overloading unary operators, overloading binary operators, overloading binary operators using friends, manipulation of strings using operators, rules for overloading operators, type conversions
Inheritance : defining derived classes, single inheritance, making a private member inheritable, multilevel inheritance, multiple inheritance, hierarchical inheritance, hybrid inheritance, virtual base classes, constructors and derived classes, member classes: nesting of lasses.
Pointers, virtual functions and polymorphism : pointers to objects, this pointer, pointers to derived classes, virtual functions, pure virtual functions,

UNIT – IV

Roots of quadratic equation: Method of bisection, Newton-Raphson method.
Solutions of simultaneous algebraic equations : Gauss elimination method, Gauss-Seidel method.
Interpolation : Langrage interpolation, interpolation using differences

UNIT – V

Differentiation : Langrage interpolation, Newton's divided difference interpolation
Integration : Trapezoidal rule, Simpson's rule
Numerical solutions of differential equations : Euler's method, Runga-Kutta method.

Reference Books:

1. **Balagurusamy E., Programming in ANSI C (IInd Ed.), TMH Pub.**
2. **Balagurusamy E., Object Oriented Programming in C++, (II edition), TMH Pub.**
3. Kochan S.G., Programming in C, CBS Pub.
4. Gottfried B.S., Programming with C
5. Kenetker Y., Let us C, BPB Pub.
6. Kernighan B.W. and Ritchie D.K., C Programming language, PH Pub.
7. **Rajaraman V., Computer oriented numerical methods, PHI, 1980**
8. **Grewer, Numerical methods for engineers and scientists, Khanna Publ.**
9. Suresh Chandra, Computer applications in Physics, Narosa, 2003

Paper VI

Fundamentals of Remote Sensing

UNIT – I

Radiative transfer :
The spectrum of radiation, absorption and emission of radiation by molecules, quantitative description of radiation, blackbody radiation, absorptivity and emissivity, atmospheric absorption of solar radiation, atmospheric absorption and emission of IR radiation, scattering of solar radiation, role of radiative transfer in the global energy balance.
Remote sensing system, Measurement geometry, Radiometric quantities, Surface characteristics of radiometric measurements, Observation geometry in remote sensing, Radiometric measurement.

UNIT - II

Physical basis of signatures:
Signature in the reflective OIR region: vegetation, soil, water bodies/ocean, snow, Thermal Infrared region, Microwave region: microwave emission, microwave scattering.

UNIT - III

Remote sensors:
Classification of remote sensors, Selection of sensor parameters, Resolutions: spectral, spectral, radiometric, temporal resolution.

Optical IR sensors :
Quality of image in optical systems, Imaging mode, Photographic camera and films, TV cameras, Opto-mechanical scanners, Opto-mecahnical scanners operated from satellites, Push-broom cameras, Hyper-spectral imager, Measuring third dimension, Image quality aspects

UNIT - IV

Microwave sensors:
Passive microwave sensors : Dicke radiometer, satellite born microwave radiometers, push-broom and synthetic aperture radiometer, Active microwave sensors: altimeters, Side looking radar: real aperture radar, synthetic aperture radar, image quality in radar imagery, Space-born SAR systems, scatterometer,

UNIT – V

Data reception and data products:
Data formats, Ground segment organization, Data product generation, Referencing scheme, Data products output medium.
Special processing : contrast enhancement, enhancement by color coding, spatial filtering, image transforms
Data analysis :
Visual image analysis, Digital classification : optimum band selection for digital classification, supervised classification, unsupervised classification, Classification accuracy.

Reference

George Joseph, Fundamentals of Remote Sensing, University Press, 2003
Wallace J.M and Hobbs P.V., Atmospheric science – an introductory survey, Academic Press, 1977
B.C. Panda, Remote Sensing – principles and applications, Viva Books, N. Delhi, 2005
Lillesand T.M. and Kiefer R.W., Remote sensing and image interpretation, John Wiley & Sons, 2002 (4th edition)
Rees W.G., Physical principles of remote sensing, Cambridge Univ. Press, 1990
Colwell R.N. (Ed), Manual of remote sensing, American Society of Photogrammetry, 1983.
Sabins F.F, Remote sensing : Principles and interpretation, Freeman and Co., 1987
Slater, P.N., Remote sensing : optics and optical systems, Addison-Wesley Pub., 1980
Ulaby et al , Microwave remote sensing – active and passive, , 1981
Campbell J.B., Introduction to remote sensing, Taylor & Francies, 1996
Jenson J.R., Remote sensing environment : An earth resource perspective, Prentice Hall, 2000
Kidder S.Q. and Vonder Harr T.H., Satellite meteorology – an introduction, Academic press, 1995

Paper VII

Satellite systems, orbits and control

UNIT – I

Communication satellite subsystems : Power supply, attitude orbit control, propulsion subsystem, repeaters, antenna subsystem, telemetry tracking and command subsystem, thermal control subsystem, structure subsystem. Reliability of subsystems

UNIT-II

Satellite earth station : Earth station design requirement, earth station subsystems, monitoring and control, frequency coordination, small earth stations, VSAT, mobile and transportable earth stations.

UNIT -III

Satellite orbits : Solar system, celestial sphere, spherical triangle, horizontal equatorial ecliptic and galactic coordinate systems, circumpolar stars, sidereal time

UNIT - IV

Many body problem, integrals of many body problem, formulation of two body problems, ecliptic orbit, solution of Kepler's equation by different methods, parabolic orbit, numerical problems related to the motion of artificial satellite and heavenly bodies, orbital elements, determination of orbital elements from position and velocity, theory of perturbation, perturbation due to (ta) third body (b) atmospheric drag, asphericity of the primary body with particular reference to artificial earth satellite

UNIT - V

Principle of De-Level nozzle, propellants, multistage rockets for satellite launching, sequence in launching a satellite into orbit, space shuttle, principle of ballistic missile, Indian program for satellite launching.

Reference Books :

Agarwal D.C., Satellite communication, Khanna publishers, 2000

Paper VIII

Digital Signal Processing (DSP)

UNIT – I

Introduction to DSP : Comparison between ASP and DSP, applications of DSP, classification of signals, characteristics of continuous time signal and discrete time signal.
Discrete time signals and systems: Discrete time signals, operating upon the signal ie. Shifting, folding, advance, addition, subtraction, multiplication, etc., symbols used in discrete time system, classification of discrete time systems, analysis of discrete time liner time invariant system.

UNIT – II

Z-transform : Definition of Z-transform, region of convergence, properties of Z-transform, relationship of FT and ZT, pole-zero plot.
Inverse Z-transform : Power series method, partial fraction expansion method, residue method. One-sided Z-transform and its properties, solution of difference equations.

UNIT – III

Discrete Fourier Transform (DFT) : Definition, inverse discrete Fourier transform, properties of DFT, relationship of DFT to other transforms, DFT as linear transformation, linear filtering using DFT.

UNIT – IV

Flowgraph and filter structure : FIR structures (direct form, cascade form, frequency sampling, lattice, linear phase structures), IIR structures : Direct form, cascade form, parallel form, lattice structure), signal flowgraph presentation.

UNIT – V

Design of digital IIR filters : Impulse invariant method, bilinear and transformation method.
Analog filters for designing digital filter : Butterworth, Chebyshev.
Design of digital FIR filters: Fouerier series method, windowing technique, DFT method, frequency sampling method.

Reference Books :

1. Proakis and Manolakis, Digital signal processing, PHI
2. Nair B.S., Digital signal processing, PHI
3. Sarkar N., Digital signal processing, Khanna Publ.
4. Oppenhein and Schafer, Discrete-time signal processing, PHI

Paper IX

Satellite communication

UNIT – I

Satellite systems :
Communication satellite systems, Communication satellites, orbiting satellite, satellite frequency bands, satellite multiple access formats
Modulation, encoding and decoding :
Analog modulation, Analog FM carrier, digital coding, spectral shaping, digital decoding, error correction encoding, block waveform encoding, digital throughput

UNIT – II

The satellite channel :
Electromagnetic field propagation, antennas, atmospheric losses, receiver power, carrier-to-nose ratio, satellite link analysis, frequency re-use by dual polarization, spot beams in satellite downlinks

UNIT – III

Satellite transponder :
Transponder model, satellite front end, RF filtering of digital carriers, satellite signal processing, transponder limiting, nonlinear satellite amplifiers, effect of nonlinear amplification on digital carrier

Frequency division multiple accessing:
FDMA system, nonlinear amplification with multiple FDMA carriers, FDMA nonlinear analysis, FDMA canalization, AM/PM conversion with FDMA, Satellite switched FDMA

Time division multiple accessing :
TDMA system, preamble design, satellite effects of TDMA performance, network synchronization, SS-TDMA

UNIT – IV

Code division multiple accessing :
Direct sequence CDMA systems, performance of DS-CDMA satellite systems, Frequency-hopped CDMA, Antijam advantages of spectral coding
Code acquisition and tracking

UNIT – V

Phase coherency in satellite systems :
Carrier phase noise, frequency generators, multipliers and synthesizers, phase error in carrier referencing, satellite link phase coherency, pilot tone frequency corrections, satellite link phase coherency

Reference books :

Gagliardi R.M., Satellite communications, Lifetime learning publication, 1984
Agarwal D.C., Satellite communication, Khanna publishers, 2000
Pratt T and Bostian C.W., satellite communications, John Wiley and sons, 1986
Martin J., Communications satellite systems, Prentice Hall, 1978