

**CURRICULUM OF
SPACE SCIENCE**

FOR

**B.S.
M.S.**

(Revised 2004)



HIGHER EDUCATION COMMISSION, ISLAMABAD

CURRICULUM DIVISION, HEC

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PREFACE

Curriculum of a subject is said to be the throbbing pulse of a nation. By looking at the curriculum of a subject, one can judge the state of intellectual development and the state of progress of a nation. The world has turned into a global village, new ideas and information are pouring in a constant stream. It is, therefore, imperative to update our curricula by introducing the recent developments in the relevant fields of knowledge.

In exercise of the powers conferred by Sub-section (1) of Section 3 of the Federal Supervision of Curricula Textbooks and Maintenance of Standards of Education Act 1976, the Federal Government vide Notification No.D773/76-JEA (Cur.), dated December 4, 1976, appointed Higher Education Commission as the Competent Authority to look after the Curriculum Revision Work beyond Class XII at Bachelor level and onwards to all Degrees, Certificates and Diplomas awarded by Degree Colleges, Universities and other Institutions of higher education.

In pursuance of the above decisions and directives, the Commission is continually performing curriculum revision in collaboration with the Universities. According to the decision of the special meeting of Vice-Chancellors' Committee, curriculum of a subject must be reviewed after every 3 years. For the purpose, various Committees are constituted at the national level comprising senior teachers nominated by the Universities. Teachers from local degree colleges and experts from user organizations, where required, are also included in these Committees.

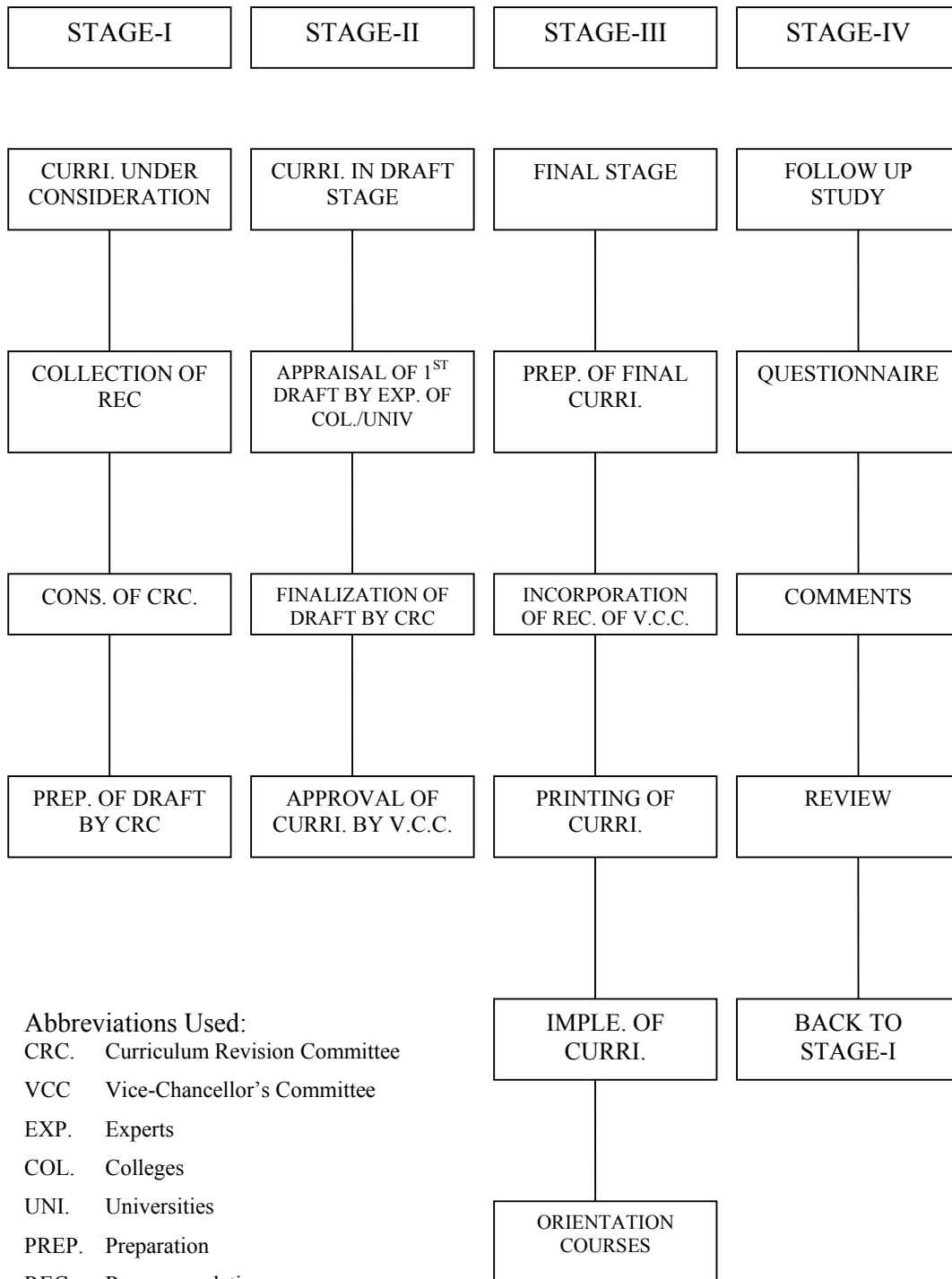
The National Curriculum Revision Committee on **Space Science** in its meeting held in May 2004 at the HEC Regional Centre, Karachi finalized the draft curriculum after due consideration of the comments and suggestions received from the Universities and Colleges where the subject under consideration is taught.

The Final draft prepared by the Curriculum Revision Committee duly approved by Competent Authority is being circulated for implementation by the Universities.

(PROF. DR. ALTAF ALI G. SHAIKH)
Adviser (HRD)

August 2004

CURRICULUM DEVELOPMENT



INTRODUCTION

A final meeting of the National Curriculum Revision Committee pertaining to the development of curricula for Space Science at under-graduate and graduate levels was held on May 10-12, 2004 at Higher Education Commission, Regional Centre, Karachi. The participants were from different public sector universities and organizations of Pakistan working in the field of space science.

A list of attendees is given below:

1. Dr. Muhammad Ayub Khan Yousufzai, Convener
Chairman,
Department of Applied Physics
Visiting Professor,
Institute of Space Science & Planetary Atmosphere,
University of Karachi, Karachi.
2. Mr. Muhammad Amjed Siddique Almas Secretary
Manager (Tech.),
National Development Complex (NDC),
National Engineering & Scientific Commission (NESCOM),
Islamabad.
3. Dr. Sabir Hussain Usmani Member
Chairman,
Department of Electronic Engineering,
Balochistan University of Information,
Jinnah Town Samungli Road, Quetta.
4. Dr. Badar Ghauri Member
Deputy Chief Manager,
Space and Upper Atmosphere Research Commission (SUPARCO),
Karachi.
5. Prof. Dr. Muhammad Ali Member
Chairman,
Department of Space Science,
University of the Punjab, Lahore.
6. Dr. Mohsin Jamil Butt Member
Assistant Professor,
Department of Space Science,
University of the Punjab, Lahore.
7. Prof. Dr. Rashid Kamal Ansari Member
Chairman,
Department of Mathematical Sciences,
Federal Urdu University of Arts, Science and Technology,
Karachi

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|---|--------|
| 8. Mr. Muhammad Ashiq
General Manager,
Space & Upper Atmosphere Research Commission (SUPARCO),
Karachi. | Member |
| 9. Mr. Muhammad Shahid Qureshi
Project Director,
Institute of Space Science & Planetary Astrophysics (ISPA),
University of Karachi, Karachi. | Member |
| 10. Dr. Muhammad Ishaq Mirza
Ex-Member Space Research,
Space and Upper Atmosphere Research Commission (SUPARCO),
Karachi. | Member |
| 11. Mr. Muhammad Javed Iqbal
Assistant Professor,
Department of Mathematics,
University of Karachi, Karachi | Member |

The meeting commenced with the recitation of holy verses from the Holy Quran. Dr. Altaf Ali G. Shaikh, Adviser, (HRD), HEC Islamabad inaugurated the meeting and welcomed the participants on behalf of the Chairman, Higher Education Commission. He gave a small briefing to the participants on the objectives and the role of National Curriculum Revision Committee. It was emphasized that the Space Science curricula should be in compliance with international standards, emerging technologies, and to meet the indigenous requirements of Pakistan. In addition, he emphasized that the Space Science curricula should ensure the quality trends and the development of dynamic professional human resources.

He further added that HEC is providing all the available resources to enhance the quality of education in our universities nationwide. He then introduced all participants of the meeting. He requested Dr. Muhammad Ayub Khan Yousufzai to act as Convener and Mr. M. Amjed S. Almas as Secretary for all the technical sessions of the meeting.

Prof. Dr. Altaf requested the participants to set up an agenda of items of discussion for the three days meeting in order to achieve the desired objectives of the programme. The participants proposed the following agenda of items.

1. Significance and objectives of Space Science
2. Nomenclature of Degree Programmes
3. B.S. (Space Science)
4. M.S. (Space Science)
5. Recommendations/Suggestions

1. Significance and objectives of Space Science

Rapidly growing subjects of space science in the present era of information technology are in process of evolution from the state of infancy to the advanced levels at academic and research institutions. The significant subjects falling under the umbrella of Space Science comprise Remote Sensing and Satellite Applications. Remote Sensing is inter-disciplinary in nature and encompasses

subjects of physical sciences (physics, mathematics and statistics); engineering and technology (surveying, cartography, photogrammetry, civil engineering and computer technology); natural sciences (environmental sciences, agriculture, forestry) and earth sciences (geology, geodesy, geography, cartography, geophysics). The space science uses new space-age technologies like data visualizations, spatial data management analysis tools, and remotely-sensed imaging and satellite photography to greatly advance scientific understanding of Earth and its systems. With the launch of Earth resources satellites in polar and geostationary orbits around the Earth, the decade of 90's has witnessed a wide spectrum of applications in disparate fields subject to the need and quality of imagery datasets acquired from the Earth orbiting satellites. The advances in computer technology have also contributed a lot in the development of more sophisticated than ever sensors capable of imaging the earth in hyper-spectral, multi-resolution and multi-temporal modes. Digital image processing and Geographic Information Systems (GIS) are the new subjects having direct relevance to Remote Sensing Technology.

2. Nomenclature of the Degree Programmes in Space Science

To develop and streamline the degree programmes in Space Science in the Public sector universities. HEC recommends the following nomenclature:

1. BS (Space Science) – Four Years Programme
2. MS (Space Science) – Two Years Programme

It is recommended that all public sector universities should follow the above nomenclature.

Duration: 4 years 8 semesters

Eligibility Criteria

- *Intermediate with Physics and Mathematics from any recognized Board/ University*
- *A-level (Physics and Mathematics) or any other equivalent certificate from a recognized Board/University.*

Committee proposed the following Schemes of Study for B.S. programme.

SCHEME OF STUDIES FOR BS (SPACE SCIENCE)

Semester-I

CH (Theory+Lab.)

1. Islamic Studies **(GC)** (2+0)
2. English Grammar and Composition **(GC)** (3+0)
3. Physics-I (Mechanics & Thermodynamics) **(SC)** (3+0)
4. Calculus & Geometry **(SC)** (3+0)
5. Introduction to Computers **(GC)** (0+2)
6. Physics and Chemistry of the Upper Atmosphere **(CC)** (3+0)

Sub-Total: 16

Semester-II

1. English (Communication Skills) **(GC)** (3+0)
2. Spectroscopy **(SC)** (3+0)
3. Physics-II (Waves & Oscillations and Statistical Mechanics) **(SC)** (2+1)
4. Advanced Calculus **(SC)** (3+0)
5. Computer Programming (e.g., C++) **(GC)** (2+1)
6. Astronomy-II (Spherical Astronomy) **(CC)** (2+1)

Sub-Total: 18

Semester-III

1. Pakistan Studies **(GC)** (2+0)
2. Psychology **(GC)** (2+0)
3. Physics-III (Electricity & Magnetism, Modern Physics) **(SC)** (3+1)
4. Differential Equations & Linear Algebra **(SC)** (3+0)
5. Statistics and Probability **(SC)** (3+0)
6. Astronomy-I (General Astronomy) **(CC)** (3+0)

Sub-Total: 17

Semester-IV

1. Digital Electronics **(SC)** (3+1)
2. Mathematical Methods **(SC)** (3+0)
3. Celestial Mechanics **(CC)** (3+1)
4. Atmospheric Science & Meteorology **(CC)** (3+0)
5. Fundamentals of Rocket **(CC)** (3+0)

Sub-Total: 17

Semester-V

1. Numerical Methods **(SC)** (3+1)
2. Classical Mechanics & Electrodynamics **(SC)** (3+0)
3. Aerospace Systems **(CC)** (3+0)
4. Remote Sensing **(CC)** (3+0)

5. Ionospheric Physics & Radio wave Propagation **(CC)** (3+0)

Sub-Total: 16

Semester-VI

1. Foreign Language (French, German etc.) **(GC)** (2+1)

2. Quantum Mechanics **(SC)** (3+0)

3. Special Theory of Relativity **(SC)** (3+0)

4. Image Processing & GIS **(CC)** (3+1)

5. Communication Systems **(CC)** (3+1)

Sub-Total: 17

Semester-VII

1. Stellar & Galactic Astronomy **(CC)** (3+0)

2. Weather Analysis and Forecasting **(CC)** (3+0)

3. Gravitational Physics **(CC)** (3+0)

4. Remote Sensing Applications **(CC)** (3+1)

5. Research Methodology **(GC)** (2+0)

6. Thesis/Elective **(CC)** (3+0)

Sub-Total: 18

Semester-VIII

1. Data Communication **(CC)** (3+0)

2. Cosmology **(CC)** (3+0)

3. Geodesy **(CC)** (3+0)

4. Seminar (Presentation Approach) **(GC)** (1+0)

5. Project/Thesis **(CC)** (3+0)

Sub-Total: 13

Total Number of Courses: 44

Total Credit Hours: 132

Core Courses (CC) - [20-Courses] 64

Supporting Courses (SC) - [14-Courses] 45

General Courses (GS) - [10-Courses] 23

Note: Thesis (6 CH) will be offered to the student having outstanding record/ performance in lieu of one elective course (Semester-VII, 3 CH) and the Project (Semester-VIII, 3 CH).

DETAILED OUTLINE OF COURSES FOR BS

Semester-I

16-CH

1. Islamic Studies/Ethics

(2+0)-CH

Islamic Studies

Fundamental of Islam, Tauheed: Arguments for the oneness of God, impact of Tauheed on human life. Place of man in the universe, purpose of creation, textual study of Surah al-Rahman and Surah al-Furqan, Prophethood, need for prophet, characteristics of a prophet, finality of prophethood, seerat life of the prophet as embodiment of Islamic ideology, faith in the Hereafter (aakhrat), effects of the belief on worldly life. Ibadah: Concept of Ibadah, major Ibadah, Salat, Saom, Zakat, Hajj and Jihad. Basic Sources of Shariah: The Holy Quran: Its revelation and compilation, The authenticity of the text. Hadith: Its need, authenticity and importance. Consensus (Ijma), analogy (Qiyas). Sources of Knowledge: Islamic approach to institution, Reason and experience. Revelation (Wahi) as source of knowledge. Moral and social philosophy of Islam: The concept of good and evil, Akhlaq-e-Hasna with special reference to Surah Al-Hujrat. Professional Ethics Kasb-e-Halal. Islamic Political Principles: Salient features of the Islamic State, Madina character, Responsibilities of the Head of the State, Rights and Duties of citizens. Economics order of Islam: Right to property, System of Taxation, Distribution of Wealth, Zakat and Ushr, Interest-Free Economy, Shirakat and Muzarabat. Islam as Living Force: Application of Islamic Teaching to Socio-Economic Development in the 20th Century.

Ethics

Nature, Scope and methods of Ethics, Ethics and Religion, Ethical teachings of world religions. Basic moral concepts, Rights and wrong, Good and evil, An outline of Ethical systems in philosophy, Heonism, Utilitarianism, Rationalism and Kant. Self-Realization Theories, Intuitionism, Islamic moral theory: Ethics of Quran and its philosophical basis. Ethical precepts from Quran and hadith and promotion of moral values in society.

2. English Grammar and Composition

(3+0)-CH

The course description is the same as recommended in the equivalent undergraduate courses in Computer Science, Computer Engineering etc.

3. Physics-I (Mechanics & Thermodynamics)

(3+0)- CH

Mechanics

Vector and scalar triple product, Divergence Theorem, Stokes Theorem. Particle Dynamics: Effect of drag forces on motion: Applications of Newton's Laws. Non-inertial frames and Pseudo forces. Centrifugal force as an example of pseudo force. Systems of Particles: Two particle systems and generalization to many particle systems: Centre of mass: its position velocity and equation of motion. Calculation of centre of mass using integral calculus. Elastics and Inelastic Collisions. Conservation of momentum. Rotational Dynamics: Kinetic energy of rotation; Moment of inertia. Parallel axis theorem, perpendicular axis. Determination of moment of inertia of various shapes. Angular Momentum: Angular Velocity, Gravitation: Universal Gravitational Law, Radial and

transversal velocity and acceleration. Motion of planets and Kepler's Laws (Derivation and explanation), Motion of Satellites. Energy considerations in planetary and satellite motion, qualitative discussion on application of gravitational laws to the Galaxy.

Thermodynamics

Review of previous concepts. First law of Thermodynamics and its applications to adiabatic, isothermal, cyclic and free expansion. Reversible and irreversible processes. Second law of thermodynamics, Carnot Theorem, Carnot engines. Heat engine. Thermodynamic temperature scale. Entropy in reversible process. Entropy in irreversible process. Thermodynamic functions. Thermodynamic functions (Internal energy, Enthalpy, Gibbs functions). Maxwell relations, Tds equations, energy equations and their applications. Low Temperature Physics. Thermoelectricity, Thermocouple, Seebeck's effect, Thomson effect.

Books Recommended:

- Resnick H and Krane P, (2002), 5th Edition "Physics" Vol. I, John Wiley, New York.
- Sears, Zemansky and Young, (2000), 8th Ed., "University Physics", Addison-Wesley, Reading 8th Edition, USA.
- Alonso and Finn, (1999), "Physics", Addison-Wesley, Reading, USA

4. Calculus & Geometry

(3+0) CH

Calculus

Rational & Irrational Numbers, Bounded Set of Real Numbers, Infimum & Supremum, Infinite Sequence & its Convergence, Sum & Product, Recurrence Relations of Sequence & Convergence, Applications, Real Valued Functions, Limits of Functions, Limits of Functions Via Sequence, Continuity & Discontinuity, Intermediate Value Theorem and its Consequences, Derivative of a Function, Derivative of Some Special Functions, Extreme Values, Their Evaluation & Application.

Geometry

Survey of Euclidean Geometry (Revision), The Axioms, Theorems of Plane Figures, Some Constructions, Symmetries, The General Equation of Conics, Tangent, Normal and Asymptotes. Vectors: Inner Products, Direct Line, Orthogonal Projections, Equation of Line in Symmetric Forms, Direction Ratios and Direction Cosine, Plane: The Normal Form, The General Form of Equation, Distance of a Point from a Plane, Angle between Two Planes, The Line of Intersection of Two Planes, The Parametric Equation, Surfaces: Equation of surface, Space Curves, Plane Sections, Surfaces of Revolutions, Symmetries, Lines on Cylinders, Tangents Lines, Planes: Quadric Surfaces: Sphere, Ellipsoids, Quadric Cones, Hyperboloids, Paraboloids, Cylinders, Spherical Coordinates: Azimuth and Elevation, Other Spherical Coordinates, Matrices of Planer Rotations, Stabilization of Coordinates.

Books Recommended:

- George B, Thomas and Ross B.F, (2001), "Calculus and Analytic Geometry", Addison. Wesley, USA. Also Published by National Book Foundation.
- Abraham S, (2000), "Analytic Geometry", Addison Wesley, USA.

- Charles W, (1998), “Analytic Geometry a Vector Approach”, Wiley, New York.
- Filler S & Parker C, (2000), “Analytic Geometry & Calculus”, Addison Wesley, USA.

5. Introduction to Computers

(0+2) CH

Brief history of computers and their applications. Major components of a computer. Computer and Society. The social impact of computer age. Computers in offices, industry and education. Office automation tools; Word processing, Graphic packages, Databases and Spreadsheets. Current trends, research and future prospects. Legal and moral aspects of Computer Science. Using Internet.

6. Physics and Chemistry of the Upper Atmosphere

(3+0) CH

The Atmosphere, Thermal structure of the Upper atmosphere, Variation of pressure with height in the atmosphere, Large-scale motion in the atmosphere, Temperature and water vapors, Composition of the atmosphere, Radiative equilibrium model, Diffusion Separation, Photochemical processes, Cloud Formation, Atmospheric Waves, Sound and Gravity waves, and Rossby Waves, Turbulence, Solar and Terrestrial Radiation, Energy balance for earth and the atmosphere, Solar variability, Spatial and temporal scales of atmospheric processes, Derivation of the Geostrophic Wind-speed, Atmospheric residence time, Atmospheric composition. Sulfur-containing compounds, Carbonyl Sulfide, Nitrogen-containing compounds, Nitrous Oxide, Nitrogen oxide, Ammonia, Carbon-containing compounds, Methane, Volatile Organic Compounds, Halogen-containing compounds, Atmospheric Ozone, Ozone flux from the Stratosphere to the Troposphere, Stratospheric Aerosol, Biomass Burning.

Books Recommended

- Brasseur, G, and Solomon, S, (2001), “Aeronomy of the middle and upper atmosphere”, Reidel, Dordrecht. The Netherland.
- 2. Crutzen, P J, (1996), Ed. “Ozone in the stratosphere and troposphere, in composition, Chemistry and Climate of the atmosphere”, H. B. Singh, V. N. Reinhold, New York.
- Seinfeld J H, and Pandis N S, (1998), “Atmospheric Physics and Chemistry,” Wiley, New York.
- Wayne R P, (1991), “Chemistry of the Atmosphere”, Oxford University Press, UK.
- Houghton J T, (1989), “The Physics of the Atmosphere”, Oxford, New York.

Semester-II

18-CH

1. English (Communication Skills)

(3+0)-CH

The course description is the same as recommended in the equivalent undergraduate courses in Computer Science, Computer Engineering etc.

2. Spectroscopy

(3+0)-CH

Introduction to Spectroscopy, Theory and Instrumentation. Application of UV-visible spectra to transition metal ions and organic molecules. I.R. spectra and their use in structural elucidation for organic, organo-metallic and inorganic systems. Solutions to Schrodinger Equation for one-electron atom, Corrections to the one-electron atom, Many-electron atoms, Molecules and the Born-Oppenheimer approximation, Molecular spectra: Rotation and Vibration, Interaction of atoms with EM radiation, Selection Rules, Line Shapes and Widths.

Books Recommended

- Bransden B H & Joachain C J, (1983), "Physics of Atoms and Molecules", Longman, New York.
- Francis M & Mirabella K, (1998), "Modern Techniques in Applied Molecular Spectroscopy", Wiley-Interscience, New York.

3. Physics-II (Waves & Oscillations and Statistical Mechanics) (2+1)-CH

Waves & Oscillations

Waves in Physical Media: Mechanical waves, Travelling waves, Phase velocity of travelling waves; Sinusoidal waves; Group speed and dispersion. Waves speed, Mechanical analysis, principle of superposition (basic ideas). Sound: Beats Phenomenon, Analytical treatment. Light: path difference, phase difference etc. Interference: Coherence of sources; Double slit interference, analytical treatment. Fresnel's Biprism and its use. Diffraction: Diffraction at single slit, analytical treatment using addition of waves. Double slit interference and diffraction combined. Diffraction grating. Dispersion and resolving power of gratings. Polarization: Polarization by polarizing sheets, by reflection, by double reflection and double scattering. Linear, circular, elliptic polarization. Specific rotation of plane of polarization. Use of Polarimeter. Harmonic Oscillations: SHM and uniform circular motion, combinations of Harmonic motions: Lissajous patterns. Damped Harmonic Motion. Forced Oscillations and resonances.

Statistical Mechanics

Statistical Distribution and Mean values: Mean free path and microscopic calculations of mean free path. Distribution of Molecular speeds, Distribution of energies: Maxwell distribution; Maxwell-Boltzmann energy distribution; Internal energy of an ideal gas. Brownian motion, Qualitative description. Diffusion, Conduction and Viscosity.

Books Recommended

- Sears K, Zemansky B & Young C, (2000), 5th Ed., "College Physics", Wiley, New York.
- Giancoli E, Serway, (1998), "Physics", Oxford University Press, UK.
- Corson D R & Loran.P, (1989), "Introduction to Electromagnetic Field and Waves," Toppan Co. Tokyo.
- Rafique A, (2000), "Mechanics", National Book Foundation, Lahore.

4. Advanced Calculus

(3+0)-CH

Riemann Integrals and their Properties, Fundamental Theorems of Calculus, Application to Area, Fluid Pressure etc. Real Functions of Several Variables and

Directional Derivatives. Differentiability. Tangent Plane, Chain Rule, Extreme Values and its Evaluations, Sketching Graphs of Functions of Two Variables and Applications. Multiple Integrals, Volume of a Solid Surface. Polar and Cylindrical Coordinates. Infinite Series, Test For its Convergence, Root and Ratio Test, Gauss and Integral Test and its Application.

Book Recommended:

- George B.T & Ross L.F, (2001), "Calculus and Analytical Geometry," Addison Wesley, USA.

5. Computer Programming

(2+1)-CH

Introduction to operating System, Exploring print (), C building blocks, variables, input/output, operators, loops: for loops, while loop, do while loop, decisions, if statement, if else statement, else if construct switch statement, conditional statement, function, function that return a value using argument to pass data to a function, external variable, arrays and strings, pointers, structure, files and introduction to C++ concepts

Books Recommended

- Lafore R (1990), C Programming Using Turbo C, Howard and W Sams
- Microsoft Disk Operating System Manual
- Shildt H, Turbo C/C++
- Bloom E P, Turbo C++
- Hein J L (1996), Theory of Computation: An Introduction, 1/e, Jones and Bartlett, Boston

6. Astronomy-I (Spherical Astronomy)

(2+1)-CH

Introduction, The great and small circles, spherical angle and spherical triangle, applications to the Earth, longitude and latitude, basics of spherical trigonometry, the celestial sphere, horizontal and equatorial systems of coordinates, observer's meridian and diurnal motion, circumpolar stars, right ascension, the equation of time. Elements of spherical Astronomy, The celestial sphere, Parallax, Aberration and Precession.

Books Recommended

- Wooland E. W. & Clemence G. M. (1966), "Spherical Astronomy", Academic Press, Boston
- Smart W. M. (1977), "Text book on Spherical Astronomy", Cambridge University Press, Cambridge

1. Pakistan Studies**(2+0)-CH**

Historical background of Pakistan: Muslim society in Indo-Pakistan, the movement led by the societies, The downfall of Islamic society, The establishment of British Raj — Causes and consequences. Political evolution of Muslims in the twentieth century: Sir Syed Ahmed Khan; Muslim League; Nehru; Allama Iqbal: Independence Movement; Lahore Resolution; Creation of Pakistan and transfer of power. Pakistan culture and society, Constitutional and Administrative issues, Pakistan and its geo-political dimension, Pakistan and International Affairs, Pakistan and the challenges ahead.

Books Recommended

- Chaudary M A, (1967), "The Emergence of Pakistan"
- Aziz K K,(1976), "The making of Pakistan"

2. Psychology**(2+0)-CH**

Introduction to Psychology: (a) Nature and application of Psychology in Pakistan (with special reference to world today). (b) Brief historical backgrounds and schools of Psychology. Methods of Psychology: Observation (Naturalistic and Field study), Case – history, Experimentation, Survey, Interview, Statistical Method. Biological Basis of Behaviour, Sensation, Perception and Attention. Factors of Perception. Motives, Emotion. Learning Memory. Thinking. Personality: Definition and nature, Theories of Personality, Psychoanalytical theory of Freud, Phenomological theory of Carl Roger.

Recommended Books

- Hilgard E R, Atkinson R C, Rita L. & Atkinson, (2000), "Introduction to Psychology", Wiley, New York.
- Ruch & Zimbardo, (1999), "Psychology and Life", Academic Press, Boston
- Lindzey, Hall & Thompson, (1987), "Psychology", Academic Press, Boston
- John M Darley, Sam Glucksberg, Ronald A Kinchla, (2000), "Psychology", McGraw-Hill
- Lyle E Bourne, Jr. Bruce& Ekstrand R, (1986), "Psychology, its principles", McGraw-Hill.
- Papalia D & Old S W, (1998), "Psychology", McGraw-Hill.

3. Physics-III (Electricity & Magnetism, Modern Physics)**(3+1)-CH****Electricity & Magnetism**

Electric field of continuous charge distributions, dipole in an electric field, Application of Gauss' law, calculating the field from the potential, capacitor with dielectric, electric current density and Ohm's law, semiconductors and superconductors, magnetic force on a charged particle, magnetic force on a current, torque on a current loop, magnetic dipole, Biot-Savart Law, Ampere's law, Faraday's law, Lens's Law, motional EMF, induced electric fields, Gauss' law for magnetism, origin of atomic and nuclear magnetism, magnetization, magnetic materials, induced magnetic fields and displacement current,

Maxwell's equations, generating and electro-magnetic wave, travelling waves and Maxwell's equations, energy transport and the Pointing vector.

Modern Physics

Bohr's theory (review) Franck. Hertz experiment, energy level of electrons, Atomic spectrum, Angular momentum of electrons, vector atom model, orbital angular momentum. Spin quantization, Bohr's Magnetron. X-ray spectrum, (Continuous and discrete) Moseley's law, Pauli Exclusion Principle table and its use in developing the periodic table.

Books Recommended:

- Resnick H and Krane P, (2002), 5th Edition "Physics" Vol. I, John Wiley, New York.
- Sears, Zemansky and Young, (2000), 8th Ed., "University Physics", Addison-Wesley, Reading 8th Edition, USA.
- Alonso and Finn, (1999), "Physics", Addison-Wesley, Reading, USA.
- Resnick, Halliday & Crane, (1999), 5th Ed., "Fundamental of Physics", Wiley, New York.

4. Differential Equations & Linear Algebra

(3+0)-CH

Differential Equations

Differential equations: types and their formation. Different methods of solving first order ordinary differential equations and their applications. The Bernoulli, Ricatti and Clairaut equations. Families of curves Orthogonal trajectories. Initial and boundary value problems. Second and higher order linear differential equations with constant coefficients, their methods of solution and applications.

Linear Algebra

Fields. Vector spaces and subspaces with their examples. Linear dependence and independence. Bases and dimensions of finitely spanned vector spaces. Linear transformation of vector spaces. Kernel space, image space, and the relation between their dimensions. Matrix algebra.

Recommended Books

- * Edwards C H & Penny D E, (2004), "Elementary Linear Algebra" Prentice-Hall, Canada.
- Hadley G (2004), "Linear Algebra", Addison-Wesley, Readings, USA.

5. Statistics & Probability

(3+0)-CH

Statistical measure, statistical description and graphical representation of data set, introduction to probability theory, permutation and combinations, random variables, probability distributions, mean, standard deviation, variance, expectation, Expectation Binomial, Poisson, hyper-geometric and normal distributions, conditional and joint distribution. Sampling analysis, inferential statistics for one and two population mean, hypothesis testing for one sample and two samples, Chi-square distribution, test of normality: Chi-square test and Kolmogorov test, test of randomization, test of homogeneity. Regression

analysis, correlation analysis, inferential method in regression and correlation, analysis of variance.

Recommended Books

- Ross S, (1989), 4th Ed., “Introduction to Probability Models”, Academic, New York.
- Cowan G (1998), “Statistical Data Analysis”, Clarendon, Oxford.
- Stark H and Woods J W, (1986), “Probability, Random Processes and Estimation”, Prentice-Hall, Englewood Cliffs, New Jersey.
- Stirzaker D (1994), “Elementary Probability”, University Press, Cambridge.
- Krzanowski W J (1998), “Statistical Data Analysis”, Arnold, London.
- Larson H J and Shubert B O (1979), “Probabilistic Models in Engineering Sciences” Wiley, New York.
- Thomas J B (1981), “An Introduction to Applied Probability and Random Processes”, Wiley, New York.

6. Astronomy-II (General Astronomy)

(3+0)-CH

Solar system, Planets and minor objects, Planetary data, Nature of radiations from cosmos, Interaction of light with matter, Stellar structure and evolution, Protostars, pre-main-sequence and main-sequence stars, Sources of stellar energy, The Sun and solar neutrino puzzle, Stellar magnitudes, Colours and temperatures, H-R diagrams, Binary stars, Visual, spectroscopic and eclipsing binaries, Variable stars, Compact stars, White dwarfs and neutron stars, Pulsars, quasars, galaxies and their types, Active galaxies.

Recommended Books

- Knox R (1979), “Foundation of Astronomy From Big Bang to Black Holes”, David & Charles, London.
- Allen C W (1973), 3rd Ed., “Astrophysical Quantities”, Athlone London.
- Kuiper G P & Middlehurst B M (ed.), (1966), “The Solar Systems”, Vols.1-5, Chichago University Press, USA.
- Kuiper G P & Middlehurst B M (ed.), (1974), “Stars and Stellar Systems”, Vols. 1-9, Chicago University Press, USA.
- Abell G O (1975), 3rd Ed., “Exploration of the Universe”, Holt, Rinehart & Winston, New York.

Semester-IV

17-CH

1. Digital Electronics

(3+1)-CH

Different number systems and their inter-conversions, different codes. Basic Logic Gates, Boolean algebra, Truth Tables, Karnaugh Map Minimization, Combinational Logic devices. Combinational Logic Devices: Adder, Subtractor, Decoders, Encoders and Multiplexers – Demultiplexers, Flip Flops, Sequential logic circuits (Registers Counters, A to D and D to A converters), Programmable Logic Devices.

Recommended Books

- Thomas L. Floyd, (1997), "Digital Fundamentals" Collier Macmillan, Canada.
- Tocci, (2001), "Digital Electronics", McGraw-Hill, USA
- Tokheim L R, (1985), "Digital Electronics", McGraw-Hill, USA
- James B & Robert D, (1985), "Digital Fundamentals", Delwar Pub. Inc.

2. Mathematical Methods

(3+0)-CH

Spherical and Cylindrical Co-ordinates, Co-ordinate Transformations, Functions of Complex Variables, Analytic Functions, Cauchy's Theorem, Cauchy's Integral Formula, Taylor and Laurent Series, Linear Differential Equations, Power Series Solution, Frobenius Method, Partial Differential Equations, The Stretched String Wave Equation, Laplace Equation, Heat Equation, Boundary Value Problems, Bessel and Legendre Functions, Calculus of Variation Euler Lagrange Equation, Brachistochrone Problems, Fourier Series, Fourier Transforms and Laplace Transforms.

Recommended Books

- Butkov E, (2001), "Mathematical Physics" Addison-Wesley, USA.
- Arfken, G, (1998), "Mathematical Methods for Physicists", Academic Press.
- Pipes L A, Harvill R, (2000), "Applied Mathematics for Engineers and Physicists", McGraw-Hill, USA.
- Potter M C & Goldberg J, (1998), 2nd. Ed., "Mathematical Methods", Prentice Hall, New Jersey.
- Gupta B D, (1998), 2nd Ed., "Mathematical Physics", Vikas Publishing House, New Delhi.
- Kreyszig & Don Ford, (2000), 6th Ed., "Advanced Engineering Mathematics", Wiley, USA.

3. Celestial Mechanics

(3+1)-CH

Central Force Motion: Energy and Angular Momentum, Central Force Motion: Stability of Circular Orbits, Central Force Motion: Gravity, The Two-Body Problem: Orbital Elements, The Three Dimensional Orbit, The Orbit in Time, Additional Problems in 2-Body Motion, The N-Body Problem, The 3-Body Problem: Jacobi's Integral, Tisserand's Criterion, The 3-Body Problem: Zero Velocity Curves, Capture and Escape, The 3-Body Problem: Lagrangian Points, Horseshoe and Tadpole Orbits, 2-Body and 3-Body Examples, The Lagrange Equilibrium Points, Stability of the Lagrange Equilibrium Points, The Perturbation Equations of Celestial Mechanics, Drag Forces and Tidal Evolution, Tidal Evolution and Planetary Oblateness, Perturbation from a Constant Force (Radiation Pressure), Other Perturbations. Planet-Planet Interactions: The Disturbing Function, Planetary Perturbations: Resonances. Planetary Perturbations: Secular Effects, Spin-Orbit Resonances.

Recommended Books

- John P Vinti, Gim J Der, Nino L. Bonavito, (1998), "Orbital and Celestial Mechanics", American Institute of Aeronautics and Astronautics.

- Danby J M A, (1988), 2nd.Ed. “Fundamentals of Celestial Mechanics”, Wiley, USA.

4. Atmospheric Science & Meteorology

(3+0)-CH

Atmospheric evolution, theories of planetary atmosphere development, chemical cycles, natural green house effect, the structure of the atmosphere, Atmospheric chemistry (composition Basic photochemical cycles of NO_2 , O_3 , NO), radiative fluxes and radiation balance, net radiation and the energy transfer within the atmosphere and at the earth's surface, light scattering by aerosols and clouds, radiative effects of atm., visibility degradation, energy transfer within the troposphere and their influence on the atmospheric stability tendencies, the hydrostatic equilibrium, the hydrostatic equation and its use, clausius clayron equation and its use, the potential temperature, atmospheric electricity (intracloud {IC}, cloud to ground {CG}).

The Earth's Atmosphere, Stratospheric Ozone Depletion, Energy and Radiation, Sun Angle and Seasons, Solar Radiation in the Atmosphere, Radiation Balances, Energy and Temperature, Daily Temperature Variations, Global Temperature Controls, Atmospheric Optics, Atmospheric Humidity, Cooling Processes, Condensation, Lifting Mechanisms, Static Stability, Inversions, Cloud Types, Cloud Droplets Precipitation Processes, Precipitation Types, Atmospheric Pressure, Horizontal Flow Aloft, Geostrophic Winds, Rotating Motion, Coriolis Force, Types of Vortices, Surface Flows, Atmospheric General Circulation, Tropical Hadley Circulation, Midlatitude, General Circulation, Thermal Winds, Thermally Direct Circulations, Down slope Winds, Air Masses and Fronts, Polar Front Theory, Vorticity, Rossby Waves Dynamics, Thunderstorm Environments, Tornadoes, Tropical Cyclones, Hurricanes, Meteorological Instruments, Surface and Upper Air Weather Charts, Satellite Meteorology, Radar Meteorology, Weather Symbols, Weather Forecasting

Recommended Books

- Josph M M, (1997), “The atmosphere and science of weather” Prentice Hall, New Jersey.
- Donald A C, (2001), “An introduction to weather climate and environment”, Prentice Hall, New Jersey.
- Deneil Botkin & Edward Keller, (1995), “Environmental science, earth as a living planet”, Wiley, USA.
- George L (1974), “Your guide to weather” Prentice Hall, New Jersey.
- Barry R, (1987), “Atmosphere weather and climate”, Wiley, USA.
- John T H (1987), “Climate change causes effects and solutions by Atmospheric change”, Prentice Hall, New Jersey.
- Macintosh D H & Thom S A, (1993) “Essentials of Meteorology”, Wiley, USA.

5. Fundamentals of Rocket

(3+0)-CH

History of rockets, Rocket Equation, Thrust, Exhaust Velocity, Multi Stage Rocket, Ideal Rocket, Nozzle Alignment, Flight performance Effect of Propulsion system on vehicle performance, Space Flight, Flight Manoeuvres, Liquid Propellant Rocket Engine Fundamentals Propellants, Propellant Tanks, Tank Pressurization, Flow and Pressure Balance, Valves and Pipe Lines, Liquid

Propellants Propellant Properties, Liquid Oxidizers, Liquid Fuels, Liquid Monopropellants, Liquid Propellant Rocket Engines The basic configuration of the Liquid Propellant Engine, The Performance of Liquid fuelled rocket engines, Thrust Chambers Combustion and Nozzle, Starting and Ignition, Combustion of Solid Propellants Physical and Chemical Processes, Ignition Process, Nozzle of Solid Rockets, Solid Propellant Rocket Motors Basic configuration, Propellant Composition, The Thermal Rocket Engine The Basic configuration, The development of thrust and the effect of the atmosphere.

Recommended Books

- George P S, & Oscar B, "Rocket Propulsion Elements", (2001), 7th Ed., Wiley-Interscience Publication, New York.
- Martin J L Turner, "Rocket and Spacecraft Propulsion Principles: Practice and New Developments", Praxis Publishing, Chichester, UK.
- Wilbur L P, Henrig G S, Robert A N, (2000), 1st Ed., "Satellite Communication System Engineering", Prentice Hall, New Jersey.

Semester-V

16-CH

1. Numerical Methods

(3+1)-CH

Error analysis: round-off error; absolute, relative and percentage error; significant digits; propagated error; error in original data, etc. Truncation errors. Solution of non-linear equations, approximation of functions, bisection method, linear interpolation, newton's method, quasi-linearisation. Solving system of linear equations, gaussian elimination, crout's decomposition scheme, qd-algorithm, efficient computation and use of determinants; matrix inversion; iterative methods. System of nonlinear equations interpolation: interpolating polynomials; extrapolation; divided differences and finite differences of various orders, difference tables, forward, backward and central differences. Symbolic derivatives. Interpolation with unequal intervals. Inverse interpolation. Curve fitting by various methods: splines, cubic spline curves; least squares approximation. Numerical differentiation, higher order numerical derivatives. Numerical integration, Simpson's rule. Numerical solution of ordinary differential equations: initial value problem; solving ordinary differential equations, various order runge-kutta methods. Boundary value problems.

Recommended Books

- Bowers R L (1991), "Numerical Modelling in Applied Physics and Astrophysics", Wiley, USA.
- Burden R L and Faires J D, (1999), 5th. Ed., "Numerical Analysis", PWS, Boston.
- Gerald C F & Wheatley Patrick O, (1999), 6th Ed., "Applied Numerical Analysis", Addison-Wesley.
- Atkinson K E (1989), "An Introduction to Numerical Analysis", Wiley, New York.
- James M L, Smith G M, & Wolford J C (1977), "Applied Numerical Methods for Digital Computers", Harper and Row Ltd., San Francisco.

2. Classical Mechanics & Electrodynamics

(3+0)-CH

Classical Mechanics

Elementary Principles: Brief survey of Newtonian mechanics of a system of particles, constraints, D'Alembert's principle. Lagrange's equation and its applications. Variational Principles: Calculus of variation and Hamilton's principle, Derivation of Lagrange's equation from Hamilton's principle. Two body Central Force Problem: Two body problem and its reduction to one body problem, Equation of motion and solution for one body problem, Kepler's laws laboratory and centre of mass system, Rutherford scattering. Rigid Body Equation of Motion: Angular momentum, Tensors and dydics, moment of inertia, Rigid body problems and Euler's equations. Hamilton Equation of Motion: Legendre transformation and Hamilton equations of motion, Conservation theorems, principles of least actions. Canonical Transformations: Examples of canonical transformations, Lagrange and Poisson brackets, Liouville's theorem.

Electrodynamics

Electrostatic Field, Dielectric Material, Electric Polarization, Charge Density, Current Density, Electric Potential, Magnetic Induction, Vector Potential and its Application, Gauss's Law, Ampere's Law and Faraday's Law of Magnetic Induction, Four-Dimensional Operator (\square), The Conservation of Electric Charge, Differential and Integral forms of Maxwell's Equations, Characteristics of Electromagnetic Waves, Covariant form of Maxwell's Equations, Wave Equations in terms of Electromagnetic Potential and their Solutions, Plane Electromagnetic Waves in Free Space and their Solution, Propagation of Electromagnetic Waves in Conducting and Non-Conducting Media, Modes of Propagation, Poynting Theorem, Plane Wave Between Two Parallel Conducting Plates, TE-Mode, TM-Mode, TEM-Mode.

Recommended Books

- Fawwaz. J Ulaby, (1997), "Fundamentals of Applied Electromagnetic", Prentice Hall, USA.
- John. Reitz, Fredeick J Milford, (1990), 6th Ed., "Foundations of Electromagnetic Theory" Narosa Publishing House, New Delhi.
- Edward E Jorden & Keith B, (1991), 2nd Ed., "Electromagnetic Waves and Radiating System" Prentice Hall of India.
- Paul L & Dal C, (1986), "Electromagnetic Fields and Waves", CBS Publishers and Distributors, Dehli.
- Peter W Milonni, & Joseph H. Eberly (1991), "Lasers" John Wiley, USA.
- Parsad, K D, (1996), 3rd Ed., "Antenna and Wave propagation", Tech India Publications.
- Jackson J D, Damodaran V R, (1999), 3rd Ed., "Classical Electrodynamics", Wiley Eastern Ltd.

3. Aerospace Systems

(3+0)-CH

Aerospace Systems, System evolution, System Overview, System configuration, System Programme, The Space segment, Composition and structure, System aspects, Post Launch Requirements, Satellite composition, Critical constructional Phases, Major Constructional Phases, Mission Control activities, Post-launch Earth segment, Pre-Launch activities, Pre-launch Earth segment, System control, Interfaces and configuration, Inter-segment control

interfaces, Telemetry interface functions, Telecomm and Interface functions, Tracking Interface functions, Executive Control configuration, System executive, Man and machine, operational Software, Pre-launch executive, Pre-and Post-launch comparison, Pre-launch developments, Comprehensive rationalization, Evolving systems, Retaining control, System expansions, Standardisation for operations, Packet Standards, Evolving operational methodologies, Advanced aerospace systems, Space probes, Satellites, Space stations, Space Shuttles, Strategic Defence Initiative(SDI), Star wars, Anti-satellite weapon system, Global Positioning System (GPS).

Recommended Books

- John T Garner & Malcolm Jones, (2002), "Satellite Operations-System Approach to design and control", Ellis Horwood Limited, West Sussex, England.
- Wilburl, L Pritchard, Henri G Suyderhoud and Robert A Nelson, (1998), "Satellite Communication Systems Engineering", Wiley, New York.

4. Remote Sensing

(3+0)-CH

Introduction to Remote Sensing, Remote Sensing and its Physical Principles, Electromagnetic Radiation, EM Spectrum, Interaction of Electromagnetic Radiation with Atmosphere and with the Earth's Surface, Atmospheric Windows, Signatures in Remote Sensing, Significance of Multi Spectral Imagery, Spectral, Spatial, Temporal and Radiometric Resolutions, Colours and Human Vision, Colour Models, Types of Photographic Films, Data Acquisition in Remote Sensing, Framing and Scanning Systems, Aerial and Satellite Sensors, Aerial Photography, Flight Planning Parameters, Concepts of Stereoscopy, Parallax and Photogrammetric Measurements, Microwave Remote Sensing, Radar Equation, Different Types of Radar, Concepts of Slant Range, Ground Range, Remote Sensing Platforms and Sensors, Earth Resources Satellite Systems, SPOT Satellite System, SPOT System Orbital Elements, SPOT Satellite Sensors, LANDSAT System Orbital Elements, LANDSAT Sensors, IKONOS Satellite, Quick Bird Satellite, Hyper Spectral Sensors, Image Formats, Atmospheric Remote Sensing, Recent Development in Remote Sensing.

Recommended Books

- Thomas D Rabenhorst & Paul D McDermott, (1989), "Introduction to Remote Sensing", Merrill Publishing Co.
- Lillesand & Kiefer, (1987), 2nd Ed., "Remote Sensing and Image Interpretation", John Wiley, USA.
- Floyd F Sabins Jr., (1996), "Remote Sensing, Principles and Interpretation", W H Freeman Electronic Publishing Centre, San Francisco.
- Paul J Curran, (1985), "Principles of Remote Sensing", Longman Inc., New York.
- Gibson Paul J (2000), "Introductory Remote Sensing: Principles and Concepts", Routledge, USA.
- Patel, Surindra S, (1992), 2nd Ed., "Principles of Remote Sensing", World Scientific, Singapore.
- Rees W G, (2001), 2nd Ed., "Physical Principles of Remote Sensing", Cambridge University Press.

5. Ionospheric Physics & Radio wave propagation

(3+0)-CH

Ionospheric Physics

Ionospheric Regions and Parameters, Ionospheric Anomalies, Applications of Ionosphere, Chemistry of Ionosphere, Refractive Index of Ionosphere, RI of Ionosphere in the presence of Magnetic Field i.e., Appleton Hartree Formula, Sudden Ionospheric Disturbances.

Radio wave propagation

Radio wave propagation in a homogeneous ionized gas media, The phase and group velocities in an ionized gas, Radio wave propagation in a homogeneous ionized gas in the presence of a permanent magnetic field, Refraction and reflection of radio waves in the ionosphere, Physical processes in the propagation of magneto-hydrodynamic waves, Physical processes in the propagation of long and very long waves, Physical processes in the propagation of Medium waves and short waves, variations in the medium and short waves propagation, calculation of the sky wave signals in the long waves, medium wave and short waves (bands), calculation of the Short wave, radio circuits, Short waves echoes and their fading, the effects of geomagnetic disturbances on short wave propagation, the sunspot variation in the short wave signal field strength.

Recommended Books

- Armel, P (1986), "Radio Wave Propagation", Macmillan UK.
- Collin E R, (1995), "Antennas and Radio wave Propagation", McGraw-Hill, New York.
- Budden K, (1989), "Radio waves in the Ionosphere", Elsevier Publishing Company, New York.
- Fawwad T U, (2001), "Fundamentals of Applied Electromagnetics", Prentice-Hall International, New Jersey.
- Kennedy G (2002), "Electronic Communication", McGraw-Hill, New York.
- Burrows C R, and Attwood S S, (2000), "Radio Wave Propagation", Academic Press, New York.
- Kerr D E, (1989), "Propagation of Short Waves", McGraw-Hill, New York.
- Wait J R, (1997), "Electromagnetic Waves in Stratified Media", Pergamon Press, New York.
- K D Parsad, K D, (1996), 3rd Ed., "Antenna and Wave propagation" Tech India Publications, New Delhi.
- Judd, F C, (1987), "Radio Propagation", Wiley, New York.

Semester-VI

17-CH

1. Foreign Language (French, German, etc.)

(2+1)-CH

The course description is the same as recommended in the equivalent undergraduate courses in Arts and Humanities.

2. Quantum Mechanics

(3+0)-CH

Schrödinger Equation and its Applications, Potential Step, Potential Well and Potential Barrier Problems, Harmonic Oscillator, Hydrogen-Like Atoms, Uncertainty Principle, Expectation Values, Equation of Continuity, Angular Momentum, The Eigen Values and Eigen Function of L^2 and L_z , Spin Angular Momentum, Pauli's Matrices, Total Angular Momentum, Magnetic Moment, Zeeman Effect, Time Independent Perturbation Theory for Non-Degenerate Case, First and Second Order Corrections to Eigen Values and Eigen Functions.

Recommended Books

- Eugene Merzbacher, (1987), 2nd Ed., "Quantum Mechanics", Wiley, USA.
- John L Powell & Crasemann B, (1990), 2nd Ed., "Quantum Mechanics", Narosa Publishing House.
- Linus P, Bright E, Wilson A, (2001), "Introduction to Quantum Mechanics", McGraw-Hill, USA.
- Davies P C W, (1999), "Quantum Mechanics", McGraw-Hill, USA.
- Bransden B H, & Joachain C J, (2000), "Introduction to Quantum Mechanics", John Wiley, New York.

3. Special Theory of Relativity

(3+0)-CH

Four-vectors, Minkowski Space and light cone, Position 4-vector and 4-velocity, 4-momentum, 4-force and equation of motion, Motion under a constant force, Equivalence of mass and energy with practical manifestations, Particles of zero rest mass, Compton effect, Emission of a photon from an excited nucleus, Doppler effect, Aberration of light, Tachyons.

Recommended Books

- Saleem M & Rafique M, (1992), "Special Relativity", Ellis Horwood, London.

4. Image Processing and GIS

(3+1)-CH

Image Processing

Digital Image Processing, Geometric Correction, Radiometric Correction, Restoration Techniques, Image Enhancement Techniques, Contrast Enhancement, Histogram Stretch, Special Stretching, Digital Image Filtering, Concepts of Convolution and Kernel Operation, Scaling Factor, Image Ratioing, Digital Image Classification, Supervised Classification, Un-Supervised Classification, Terrain Analysis, Soils, Origin, Drainage Patterns, Soil Erosion, Drainage Classes, SRS Applications, Land-Use, Land Cover Phenomenon,

Land-Use in Remote Sensing, Advantages of Satellite Remote Sensing in Land-Use and Land Cover Categorization, Geological Phenomenon, Wetland Mapping, Coastal Mapping, Forestry, Defence Application, DEM/DTM. Ground Truth: Physical Field Surveys and Ground Truthing, Landuse and Landcover Maps, Landuse & Landcover Change Detection Maps, Sea Surface Temperature Maps, Coastal Landform.

Geographic Information Systems (GIS)

Introduction to Geographic Information System (GIS), Elements of GIS, Early Developments in GIS, Evolution of GIS, From the Real World to GIS, Real World Model, Data Model, Characteristics of Geographic Data in GIS, Representation of Data, Sources of Data, Spatial and Non Spatial Data, Typical GIS Data, Data Collections and Quality, Mapping with GIS, Map Concepts, Map Elements, Spatial Relationship, Coordinate System, Projection Systems. Raster Based GIS, Vector Based GIS, Automatic Conversion between Vector and Raster Models, Vector Versus Raster Models, Hardware Components of a GIS, Computers, Networks, Displays, Quantizers, Plotters and other Output Devices, Software Components of a GIS, Introduction to Cartography Techniques, GIS Database Development, Data Management Software, Data Display Software, Digital Surface Modelling in GIS, Applications of GIS for Land Resource Management, Regional Planning and Land Use Change Analysis, Errors in GIS, Advanced Concepts of GIS.

Recommended Books

- Jensen J R, (1996), "Introductory Digital Image Processing – A Remote Sensing Perspective", Prentice Hall, New Jersey
- Lillesand & Kiefer, (2000), "Remote Sensing and Image Interpretation", Wiley, New York.
- Jensen J R, (1998), 3rd Ed., "Manual of Remote Sensing, Principles and Applications of Imaging Radar", Wiley, USA.
- Jensen J R, (2003), 3rd Ed., "Introductory Digital Image Processing", Prentice Hall, New Jersey.
- Rafael C, Gonzalez, Richard E W, (2001), 2nd Ed., "Digital Image Processing", Addison-Wesley, USA.
- Paul A, Longley, Michael F, Goodchild, David J, David W, (2002), "Geographic Information Systems and Science", Wiley, USA.
- Michael N & DeMers, G, (2001), "GIS Modelling in Raster", Wiley, USA.
- Philippe Rigaux, Michel O, Scholl, Agnes V, Morgan K, (2001), 1st Ed., "Spatial Databases: with Application to GIS", Wiley, USA.

5. Communications Systems

(3+1)-CH

Introduction: the basic diagram of a communication system, channel characteristics, Probabilistic approaches to system optimization. Signal and linear system analysis: signal models, signal classification, Fourier series, Power spectral density and correlation, signals and linear systems. Basic Modulation Techniques: Linear modulation, angle modulation, amplitude modulation, frequency modulation, phase modulation, feedback demodulators, analogue pulse modulation, Delta modulation, and multiplexing. Probability and random signals, noise in modulation system, narrowband noise, signal-to-noise ratios, noise in angle modulation, noise in pulse code modulation, information

and channel capacity, base band data transmission, analogue signal transmission, noise in analogue communication systems, digital carrier modulation schemes, error control coding. Introduction to communication network, the way network works.

Recommended Books

- Lathi B P, (1998), "Modern Digital and Analogue Communications Systems", Oxford University Press.
- William T, Shanmugan K, Theodore R, & Kurt K, (2004), "Principles of Communication Systems Simulation with Wireless Applications", Wiley, USA.
- Ziemer R E, Tranter W H, (2002), 5th Ed., "Principles of Communications: systems modulation and noise", Wiley, USA.
- Ziemer R E, (2002), "Principles of Communications", Wiley, New York
- Haykin S, (2000), "Communication Systems", Wiley, New York
- Walrand J, (2002), "Communication Networks", McGraw-Hill, New York.

Semester-VII

18-CH

1. Stellar & Galactic Astronomy

(3+0)-CH

Astrometry; stellar distances, masses and luminosities. Theory of stellar models. Stellar evolution. Nucleosynthesis. Binaries, pulsars and neutron stars. Interstellar medium. Milkyway galaxy. Structure and dynamics of galactic systems. Radioastronomical studies.

Observed data on galaxies. Cosmological distance scale. Large scale distribution of galaxies and quasars. Cosmic rays. Clusters of galaxies. Intergalactic medium. Formation and evolution of galaxies in various cosmological models

Recommended Books

- Knox R (1979), "Undation of Astronomy From Big Bang to Black Holes", David & Charles, London
- Allen C W (1973), 3rd Ed., "Strophysical Quantities", Athlone London.
- Kuiper G P & Middlehurst B M (ed.), (1966), "The Solar Systems", Vols.1-5, Chichago University Press, USA.
- Kuiper G P & Middlehurst B M (ed.), (1974), "Stars and Stellar Systems", Vols. 1-9, Chicago University Press, USA
- Abell G O (1975), 3rd Ed., "Exploration of the Universe", Holt, Rinehart & Winston, New York

2. Weather Analysis and Forecasting

(3+0)-CH

Tropical Meteorology, Meteorological Elements, Seasons and Circulations, Solar Radiations, Characteristics of terrestrial Radiations and its absorption and Transmission, Simpson's Computation of Terrestrial Radiation transfer, Heat balance, Cloud Physics, Aviation Meteorology. Weather Charts – Development and Analysis, T-Phi-Gram, Weather forecasting.

Recommended Books

- Petterson S, (2003), "Weather Analysis and Forecasting", Wiley, USA.
- London. H M S O, (2001), "Handbook of Weather Forecasting", McGraw-Hill.
- Riehl K, (2000), "Tropical Meteorology", Wiley, USA.

3. Gravitation Physics

(3+0)-CH

Riemannian Geometry, Tensor algebra, Covariant differentiation, Principles of Gravitation Physics, energy momentum tensor, Einstein Field equations, Schwarzschild solution, Experimental test of Gravitation Physics.

Recommended Books

- Msner C W, Thorne K S & Wheeler J A, (1973), "Gravitation", W H Freeman, San Francisco.
- Stephani H, (1982), "General Relativity and Introduction to Gravitation Fields", Cambridge Press.
- Feinstein A, & Ibanes J, (1992), "Recent Development in Gravitation", World Scientific, Singapore.

4. Remote Sensing Applications

(3+1)-CH

Introduction. Geo-stationary weather monitoring. Cartography and mapping. Natural resource management. Mineral exploration. Disaster management: fire, earth quakes etc., Impact assessment, three broad categories of applications: Measurement analysis-measurement of feature or phenomena, Classification analysis-classification of land cover into categories. Estimation analysis-appraisal of quantities for units or specific land-use. Geological mapping. Environmental applications: pollution monitoring, slope analyses, visibility analyses, rainfall/ runoff measurements, flood plain analyses and area-wide drainage and management studies. Land use planning, zoning. Cadastral mapping.

Recommended Books

- Thomas M Lillis and Ralph W Kiefer. (1998), 4th Ed., "Remote Sensing and Image Interpretation", Wiley, New York,
- Ghassem Asrar, (1998), "Theory and Applications of Optical Remote Sensing" Wiley, New York.
- Henk J Buiten, Jan G P W Clevers, (1994), "Land Observation by Remote Sensing: Theory and Applications", Wiley, New York.
- Johnson A I, Pettersson, C B, (1990), "Geotechnical Applications of Remote Sensing and Remote Data Transmission", Wiley, New York.

5. Research Methodology

(2+0)-CH

Introduction to Research, Types of Research, Research Problem, Review of Related Literature, Research Hypothesis or Questions, Sampling, Research Instruments, Research Types (Detail Description), Collection and Analysis of Data, Statistics in Science, Writing Research Proposals and Reports, Evaluation Criteria.

Recommended Books

- Manian L & Cohen S, (1994), "Research methods in education", Oxford University Press, UK.

- Saleem M, Rafique M, (1992), “Special Relativity” Ellis Horwood, London, Redwood Press Melksham.
- Kaufmann W J, (1985), “Universe” W. H. Freeman San Francisco.
- Zeilik M, & Gaustad J, (1990), “Astronomy: The Cosmic Perspective”, Wiley, USA.
- Kuhn K F, & Koupelis T, (2001), 3rd Ed., “In Quest of the Universe” Jones and Bartlett Publishers.
- Contopoulos G, & Kotsakis D, (1987), 2nd Ed, “Cosmology – The Structure and Evolution of the Universe”, Springer-Verlag, New York
- Kaufmann W J, (1997), 4th Ed., “Discovering the Universe”, W H Freeman, New York.
- Michael Zeilik, (2002), 9th Ed., “Astronomy – The Evolving Universe”, Cambridge University Press.

3. Geodesy

(3+0)-CH

Fundamental concepts, definitions and basic aims of geodesy. The Geodetic model of the Earth. Newtonian gravitation. Gravity. Earth rotation. Potential theory. Laplace equation and solutions. Spherical harmonics. The normal field. Gravimetry. Disturbing potential and gravity anomalies. Gravity reductions. Isostasy. Geoid calculations. Bruns’s equation. Stokes integration. Gravity satellite missions. Calculations in the ellipsoid. Transmission of geodesic coordinates. Satellite-based positioning, global positioning system (GPS), satellite laser ranging (SLR) and radar altimetry. Astronomic positioning, very long baseline interferometry (VLBI). Vertical positioning and height systems. Concepts of kinematic positioning, inertial techniques, multi-sensor systems. Realisation of planar and height control network projects: planning, form of the network, marking, measurement, computation, analyses and evaluation, and report writing.

Recommended Books

- Gunter Seeber, (2003), 2nd Ed., “Satellite Geodesy”, de Gruyter Inc.
- Torge W, (2001), 3rd, “Geodesy: The Concepts”, Elsevier.
- William M K, (2000), “Theory of Satellite Geodesy” Dover Publishing Co.
- Schwarz K P, (1999), “Fundamentals of Geodesy” UCGE Report No. 10014, Department of Geometrics Engineering, University of Calgary, Canada.
- James R S (1997), “Introduction to Geodesy: The History and Concepts of Modern Geodesy”, Wiley, Inter-science; New York.
- Lambeck, K, (1988), “Geophysical Geodesy”, Clarendon Press, Oxford,
- Vanicek, P, Krakiwsky, E, (1986), “Geodesy — The concepts”, North-Holland Pub. Amsterdam.
- Moritz, H, Sammlung W K, Neue F B, (1980), “Advanced Physical Geodesy”, Prentice-Hall., New Jersey.
- Heiskanen, W A, & Moritz, H, (1967), “Physical Geodesy”, W H Freeman Co., San Francisco and London

4. Seminar (Presentation Approach)

(1+0)-CH

5. Project/Thesis

(3+0)-CH

MS (Space Science)

Duration: 2-years (4-semesters)

Eligibility Criteria

- B.S. (Space Science) from any recognized university;
- M.Sc. (Space Science) with deficiency courses, if any;
- M.Sc. Physics/ Maths/ Geography or any other equivalent having 16-year education with deficiency courses;
- B.Sc. (Hon) in Space Science having 15-year education has to complete a minimum of 120 Credit Hours along with deficiency courses if required.

Credit Hours

Committee proposes 30-36 Credit Hours for the award of M.S. (Space Science) degree.

SCHEME OF STUDIES FOR M.S.

Core: Minimum 9 Credit Hours – including n Mandatory Course on Modelling Techniques

Elective: Minimum 9 Credit Hours

Thesis: 09 Credit Hours

Core Courses: (3 Credit hours each)

1. Modelling Techniques
2. Advance Remote Sensing
3. Astrodynamics
4. Astrophysical Techniques
5. Telecommunication
6. Meteorology and Climatology

Elective Courses: (3 Credit hours each)

Module A. Specialization in Advance Remote Sensing

- i. Image Analysis and interpretation
- ii. Land-use/Land-cover studies
- iii. Geological Studies

Module B. Specialization in Astrodynamics

- i. Orbital Mechanics and GPS System
- ii. Flight Dynamics and Control
- iii. Flight Structure

Module C. Specialization in Meteorology and Climatology

- i. Environmental Science
- ii. Climatic Modelling
- iii. Synoptic Climatology

Module D. Specialization in Telecommunication

- i. Digital Signal Processing
- ii. Cellular and Satellite Communication
- iii. Optical Communications

Module E. Specialization in Astrophysical Techniques

- i. Advance Cosmology
- ii. Gravitational Physics
- iii. Galactic and extra-galactic Astronomy

University may extend and develop the elective course module according to facilities and resource persons.

Semester-I: (3 Credit hours each)

Modelling Techniques

At least two courses from the following:

- 1. Advance Remote Sensing
- 2. Astrodynamics
- 3. Astrophysical Techniques
- 4. Telecommunication
- 5. Meteorology and Climatology

Semester-II

One of the Modules of the given Elective Subjects

Semester-III & IV

Topic of Special Interest (3-CH)

Thesis (9-CH)

A course on "Topic of Special Interest" will be offered by the teacher to thesis student.

DETAILED OUTLINE OF COURSES OF M.S.

1. Modelling Techniques

Modelling: Fundamental principles, deterministic vs. stochastic models, interpretation of results. Simulation of stochastic processes. General Theory of Stochastic Processes: filtrations; stopping times; martingales and convergence; elementary applications. The research problem and preparations of the research proposal, Review of the related literature, organization and identification of the literature, data collection, sampling and their methods, qualitative data analysis and their interpretation and validation, quantitative data analysis, modern computational aids, language of the computer, interpretation of the results, formulation of conclusions and generalization, statistical methods, descriptive statistics, inferential statistics, statistical inference based on parametric tests and non-parametric test, general format of the research report, style and format of writing, typing of the research report, proof reading of the final draft of the research report, theoretical and experimental research.

Books Recommended

- Banker D, Robbert L, (1993), "International Product Research", American Book Co., New York.
- Buch M B ed., (1991), "Fourth Survey of Research in Education", NCERT, New Delhi
- Koul, L, (1995), "Choosing an appropriate statistical technique for analysis of data in experimental research" Tata McGraw-Hill, New Delhi.
- Koul, L, (2000), "Methodology of Education Research", Vikas Publishing House Delhi.
- Yadav, R K, (1991), "Research in Comparative Education", NCERT, New Delhi.

2. Advanced Remote Sensing

Review of physical principles, including governing equations, interaction of solar radiation with the atmosphere, lithosphere, hydrosphere, and biosphere. Imaging system geometrics; data products, and applications. Radar and thermal remote sensing. Digital image processing. Transformations, Band ratios, Principal Components. Image classification: collection and processing of field data to coordinate with remotely sensed imagery. Classification schemes, development of a classification scheme, developing training field statistics, polygon training field selection, seed pixels, feature space selection, evaluating training field statistics, separability analysis, divergence, transformed divergence, contingency matrix, ellipse diagrams. Unsupervised and supervised algorithms, decision tree analysis, textural, neural network. Accuracy assessment, the error or confusion matrix, errors of omission, errors of commission, class accuracy, overall accuracy assessment. Advanced techniques for analysis and interpretation of remotely sensed imagery. Data correction and analysis. Digital terrain analysis: theoretical and technical issues of collection, management, analysis, and display of terrain data. Application of photogrammetry, geographic information systems, and cartography. Theory and techniques for statistical analysis of point patterns, spatially continuous data, and data in spatial zones, scale and resolution effects, spatial heterogeneity metrics. Fractal analysis, geo-statistics, an introduction to digital image

processing (IP) and computer vision (CV) concepts, use IP/CV software with emphasis on remote-sensing applications and problem solving.

Books Recommended

- Jensen, John R, (1996), 2nd Ed. "Introductory Digital Image Processing", A Remote Sensing Perspective, Prentice Hall Series in Geographic Information Science, New York.
- Matter, P M (1999), "Computer Processing of Remotely Sensed Images", Macmillan, New Jersey.
- Dansan and Plummer, (1995), "Advances in environmental remote sensing", Wiley, New York.
- Avery, Thomas E and Graydon L, (2003), 5th Ed., "Fundamentals of Remote Sensing", Riverside, Publishing Company, Berlin.
- Campbell N and James B, (2001) third Ed., "Introduction to Remote Sensing", Guilford Press, UK.
- Elachi and Charles, (1987), "Introduction to the physics and techniques of remote sensing", John Wiley, New York.
- Lillesand and Kieffer, (1998), 3rd Ed. "Remote sensing and image interpretation", John Wiley, New York.
- Sabins M H, (1999), 4th ed., "Remote Sensing", Principles and Interpretation, Freeman, San Francisco.

3. Astrodynamics

Two-body problem in three dimensions, orbital elements, orbit types (circular, elliptical, hyperbolic), reference frames and time-keeping, orbit determination, position and velocity, introduction to three-body problem. Earth Orbits: orbital perturbations (earth, environment, third-body effects), orbit lifetime, ballistic trajectories, types and uses of orbits (low, mid, high, sun-synchronous, geosynchronous). Mission Analysis: basic orbital manoeuvring, delta-V considerations, interplanetary transfer and rendezvous, method of patched conics. Space-Vehicle Attitude Dynamics: rigid-body motion, typical configurations (non-spinning, spinning, momentum-bias), applications. Space-Vehicle Attitude Control: typical sensor and actuator devices, strategies for attitude control, application of classical control. Launch Vehicle Considerations: various rocket configurations, staging, ascent to orbit. Additional topics may be covered as time permits.

Books Recommended

- Moulton S, (2000), "Introduction to Celestial Mechanics", Wiley, New York.
- William M K, (2001), "Introduction to Satellite Geodesy", Wiley, New York.
- James R. Wertz (1997), 3rd Ed., "Space Mission Analysis and Design" Mcmillan, UK.
- David A Valado, (2003), 2nd. Ed., "Fundamentals of Astrodynamics and Applications", Wiley, New York.
- Thomas P Sarafin, (2002), "Spacecraft Structures and Mechanisms from Concept to Launch", McGraw-Hill, New York.

4. Astrophysical Techniques

Positional astronomy: coordinate systems, spherical geometry, precession, time. Statistics: sample and parent population, mean and variance, binomial, Poisson and Gaussian distributions, regression, correlation, chi-squared, non-parametric statistics. Optics: geometric optics, telescope design, aberrations, physical optics. Atmosphere: refraction, seeing, adaptive optics, observatory sites, atmospheric extinction and emission. Detectors: semiconductors, dark current, Johnson noise, photodiodes, bolometers, CCDs, infrared arrays. Data processing: introduction to IDL. Photometry: photometric and radiometric concepts, magnitudes, photometric systems, absolute calibration, signal to noise, practical considerations. Spectroscopy: typical slit spectrometer, prisms, gratings, practical considerations. Radio astronomy: single aperture radio telescopes, brightness and antenna temperatures, interferometry, aperture synthesis. Space astronomy: why do it, technical considerations, residual atmosphere, attitude control & determination. X-ray astronomy: interaction of X-rays with matter, X-ray optics, X-ray detectors. Neutrino astronomy. Gravitational wave astronomy.

Books Recommended

- C R Kitchin, (2003), 4th Ed., “Astrophysical Techniques” Institute of Physics Publishing, UK
- Seth Shostak, et al, (2003) “Arising the Universe: Perspectives on Extraterrestrial Life”, Wiley, New York.
- Leo Sartori and Donald D, (1987), “Principles of Stellar Evolution and Nucleosynthesis”, Wiley, New York.
- Charles K, Herbert K, (1994), 2nd Ed. “Thermal Physics”, Wiley, New York.

Telecommunications

Transmission channels, Linear modulation, Exponential modulation, Noise in analogue carrier wave transmission, Carrier wave systems, Base-band digital transmission, Sampling and pulse coded modulation, Band-pass digital transmission, Error control coding, Information theory, Advanced system applications: Sampling, interpolation, and aliasing, Pulse Code Modulation, Performance of digital communication, Description of ASK, PSK, FSK, QPSK, and QAM. Representation of Noise, Performance (Signal to Noise Ratio).

Modulation Communication Networks, Definition and Role of layered approach, SI and TCP/IP models, Physical layer: Digital transmission Systems. Data Link layer. Local Area Networks (Aloha, slotted Aloha, CSMA), Network layer: Packet Switching and routing.

Principles of Satellite Communication, Electromagnetic Spectrum, Interactions of Microwaves with Atmosphere, Communication Satellite System and Sub-Systems (Attitude and orbit control system), Telemetry, Tracking and Command (TT&C) Power Sub-System, Communication Sub-Systems, Spacecraft Antenna, Satellite Link Design (Basic transmission theory, RF Links, Optimisation of RF Link, System Noise Temperature, Noise Figure, G/T Ratio, Down/Uplink Design and Complete Link Budget), Earth Station Parameters, Base Band Formation, Multiple Access Techniques.

Special Purpose Communication Satellites (DBS, INMARSAT, VSAT, SARSAT and LEO Satellites etc.).

Books Recommended

- Timothy Pratt, (1986), "Satellite Communication" John Wiley, New York.
- Frenzal K, (1999), 3rd Ed., "Communication Electronics" McGraw-Hill, New York.
- D C Agarwal, (1999), "Satellite Communication", McGraw-Hill, New York.
- Brain Ackroyd, (2002), "Satellite Communication", World Satellite Communication.
- Dennis Roddy, 1991), 3rd Ed., "Electronic Communication", Prentice Hall, India.
- John M, (1993), "Satellite Communication", Prentice Hall, New York.
- Ryder J D (1976), "Electronic Circuits and System", Prentice Hall, New York.
- Umesh S, Sumitra SMT, (1992), 2nd Ed. "Antenna and Wave Propagation", Prentice Hall, New York.
- Zeimer R, (1999), "Principles of Communication", McGraw-Hill, New York.
- Maral G, (1993), 4th Ed., "Satellite Communication", John Wiley, New York.
- Bruce E, Lee SW and Lo. Y T, (2001), "Satellite Communication Ground Segment and Earth Station", John Wiley, New York.

4. Meteorology and Climatology

Meteorology

The Composition and Structure of Earth's Atmosphere, Hydrostatic Equation and its Applications, The Clausius-Clapeyron Equation, The Poisson's Equation, Adiabatic Processes, Parcel Concepts, Stability in the Atmosphere, Moisture in the Atmosphere, The Tephigram, Skew-T Log-P Diagram, Solar and Terrestrial Radiation, The Greenhouse Effect, Energy Balance at the Earth's Surface, Net Radiation, Free and Forced Convection, Temperature Inversions.

Cloud Formation, Cloud Classification, Precipitation Processes, Forms of Precipitation, Thunderstorms, Tornadoes, Hurricanes, Tropical Cyclones, Cyclones and Anti-Cyclones, Pressure Gradient Force, Coriolis Force, Friction, Geostrophic Wind, Gradient Wind, Thermal Wind, Land-Sea and Mountain-Valley Breezes, Chinook and Katabatic Winds, Jet Streams, Air Masses, Weather Fronts, Meteorological Satellites, Interpretation of Weather Satellite Imagery, Automatic Weather Stations, Weather Maps.

Climatology

The Climate System, Variations of Climate Over the Past Millennium, The Ice Ages, Koppen's Climate Classification, Influence of the Ocean Boundary, Human Influences on Climate, The Enhanced Greenhouse Effect, Feedback Processes, Climate Predictions, Climate Models, Climate Change and Global Warming, Modelling the Climate Change, The Impacts of Climate Change, Observations of Climate, Dynamic Response to External Forcing, El-Nino,

Southern Oscillations, La-Nina, Satellite Clouds Climatologies, Recent Developments.

Books Recommended

- Andrews, D G (2000), 1st Ed., “An Introduction to Atmospheric Physics” Cambridge University Press, Cambridge.
- Tsonis, A A (2002), 1st Ed., “An Introduction to Atmospheric Thermodynamics”, Cambridge University Press, Cambridge.
- Donald, A C (2000), Sixth Ed. “Meteorology Today” Bruce Cole, New York.
- Barry, R G and Chorley, R J, (1987), 5th Ed., “Atmosphere, Weather and Climate”, Methuen, London.
- Houghton, J (2002), 1st Ed., “The Physics of Atmospheres”, Cambridge University Press, Cambridge.

Detail of Modules:

The detail of these courses may please be developed subject to the availability of Lab. facilities and resource persons.

Recommendations/Suggestions

National Curriculum Revision Committee (NCRC) of the Higher Education Commission in Space Science recommended the following suggestions for creating general awareness and developing technical and professional manpower in the field of Space Science to cater for the current/future needs of the academic and research institutions of the country.

- The Committee recommends a National Institute of Space Science and Technology be established to cater the future needs of the county.
- The information on current trends of research in Space Science be disseminated to the public sector universities.
- Interaction/collaboration between universities and the relevant research & development organizations like, SUPARCO, NESCOM, PTA, AMASTRO-PAK, WAPDA, IWASRI, EPA, SSOP, OGDCL, GSP, etc. for arranging the workshops/seminars/lectures on current topics of Space Science.
- It is also recommended that in under-graduate courses of computer discipline basic knowledge of space science may also be imparted to broaden their field of specialization.
- Computer scientists be encouraged to teach basic courses in Space Science for their special applications in Robotics and related Micro-processor control applications.
- Universities be equipped with Astronomical observatories and other related space science laboratory facilities for fulfilling the teaching/research requirements.

- Public awareness programmes like Sky-watch/Star-gazing shows be initiated by utilization of existing facilities/planetaria and by arranging space days/weeks/quizzes.
- University teachers be trained on various software tools that are in-use in different fields of Space Science, by providing them hands-on training.
- Fundamental topics in space science be taught at Matric and Inter levels.
- The committee recommends the inclusion of the basic knowledge of Astronomy in the curriculum of Madrassas.

SUGGESTIONS

Scientific Software and Hands-on Training

GIS and Image-processing Software are recommended to be incorporated in under-graduate and graduate courses in space science. Syllabi for imparting hands-on training on image processing operations, transformations, filters, digital classification, compilation of classification results and developing thematic layers of geographic information corresponding to various applications. ArcView, ArcGIS, ER-Mapper and Erdas Imagine are some commonly available software in the market for developing highly professional remote sensing and GIS-related applications both in academic and non-academic institutions.

Suggestions for Starting New Programs in Space Science

In addition to the already running courses in Space science, new programs are suggested be initiated including Remote Sensing/Digital Image Processing, Photogrammetry & Digital Cartography, Astronomy/Astrophysics and Satellite Communications at post graduate level. The specialization in the aforesaid subjects would enable the graduates to understand the core subject matter and to implement the modern techniques for research, analysis and effective resource management.

Coordination between Educational Institutions and S&T Organizations

Invited lectures on different topics should be held at regular basis in the department/faculty levels to introduce to the concerned students about the practical utility of the subject. This can only be made possible by mutual collaboration of the educational institutions and S&T organizations.

Teachers' Training

To enact education of modern subjects at post-graduate levels, teaching staff of the Universities/Colleges should be given opportunities to get training in the respective fields, so that state-of-the-art manpower could be produced. Training opportunities could be sought from both in-side the country and/or abroad.

Class Demonstration/Introduction of Software Tools

The present age of information technology, computers are becoming endemic in research, development and production setups. There are numerous softwares available in the indigenous and international markets that are of real help in solving intricate problems of applied sciences with precision and accuracy, saving lot of time and manual efforts. Keeping the significance of computer technology in view, it is suggested that software be included in the curriculum. For instance for Remote Sensing and GIS Solutions, Erdas Imagine, ER-Mapper, Idrisi, Arcview, ArcGIS, PCI-Geomatica can be used in RS/GIS laboratories for the training of students.

Research Projects and Presentations

The modern-day commercial, academic and research studies demand for developing the relevant projects comprising introduction to the specific approach to be followed and methodology to be adopted for achieving desired results. This approach places a strong emphasis upon designing a course where students should learn the development and management of projects, oral presentation, and report writing skills.

Research Thesis

Students should be encouraged to opt for thesis instead of a special paper. The thesis work is always helpful for strengthening researching and writing skills in the students. Moreover, research students learn to develop a complete layout of the thesis on an assigned topic and this practice leads to building up confidence in them for their future career. Emphasis should be placed on selecting more demanding and technically sound thesis topics than the theoretical ones so that practically efficient and professional graduates could be produced.

From societal progress to effective resource development, space science education is essential for enhancing our decision making capabilities regarding the planning and management of our national resources.