Indian Institute of Space Science and Technology

Department of Space, Govt. of India

Thiruvananthapuram

Curriculum and Syllabus for

B.TECH Physical Sciences- 2011

Semester I

Code	Course Title	L	T	P	C
MA111	Calculus	2	1	0	3
PH111	Physics I	3	1	0	4
CH111	Chemistry	2	1	0	3
AE111	Basic Mechanical Engineering	2	1	0	3
AV111	Basic Electrical Engineering	2	1	0	3
HS111	Communication Skills I	1	0	0	1
PH131	Physics Lab I	0	0	3	1
CH131	Chemistry Lab	0	0	3	1
AE131	Basic Engineering Lab	0	0	3	1
HS131	Communication Skills Lab I	0	0	3	1
	Total	12	5	12	21

Semester II

Code	Course Title	L	T	P	C
MA121	Vector Calculus and Differential Equations	2	1	0	3
PH121	Physics II	3	1	0	4
CH121	Materials Science	2	1	0	3
AE121	Engineering Mechanics	2	1	0	3
AV121	Basic Electronics Engineering	2	1	0	3
HS121	Communication Skills II	1	0	0	1
PH141	Physics Lab II	0	0	3	1
CH141	Materials Science Lab	0	0	3	1
AE141	Engineering Graphics	1	0	3	2
AV141	Basic Electrical and Electronics Engineering Lab	0	0	3	1
HS141	Communication Skills Lab II	0	0	3	1
	Total	13	5	15	23

Semester III

Code	Course Title	L	T	P	C
MA211	Linear Algebra, Numerical Analysis and Transforms	2	1	0	3
PH211	Optics and Electromagnetic Waves	3	1	0	4
PH212	Mathematical Physics	3	1	0	4
RS211	Remote Sensing and Applications	3	0	0	3
AV215	Computer Organization and DBMS	3	0	0	3
HS211	Introduction to Economics	2	0	0	2
MA231	C Programming Lab	0	0	3	1
PH231	Optics Lab I	0	0	3	1
RS231	Remote Sensing Lab	0	0	3	1
	Total	16	2	9	22

Semester IV

Code	Course Title	L	T	P	C
MA221	Partial Differential Equations, Calculus of Variations and Complex Analysis	2	1	0	3
PH221	Modern Optics	3	0	0	3
PH222	Classical Mechanics	3	1	0	4
ES221	Earth System Science	3	0	0	3
AV225	Measurement and Instrumentation	3	0	0	3
HS221	Introduction to Social Science and Ethics	2	0	0	2
PH241	Optics Lab II	0	0	3	1
ES241	Earth System Science Lab	0	0	3	1
AV245	Measurement and Instrumentation Lab	0	0	3	1
	Total	17	1	9	21

Semester V

Code	Course Title	L	T	P	C
MA311	Probability and Statistics	3	0	0	3
PH311	Quantum Mechanics	3	1	0	4
ES311	Atmospheric and Ocean Sciences	3	0	0	3
AP311	Introduction to Astronomy and Astrophysics	3	0	0	3
AV311	Digital Signal Processing	3	0	0	3
CH311	Environmental Science and Engineering	2	0	0	2
PH331	Computational Physics Lab	0	0	3	1
AV331	Digital Signal Processing Lab	0	0	3	1
	Total	17	1	6	20

Semester VI

Code	**Course Title**	**L**	**T**	**P**	**C**
PH321	Statistical Mechanics	3	0	0	3
PH322	Atomic, Molecular and Nuclear Physics	3	0	0	3
RS321	Pattern Recognition	3	1	0	4
ES321	Introduction to Space Vehicles	2	0	0	2
E01	Elective I	3	0	0	3
E02	Elective II	3	0	0	3
E03	Elective III	3	0	0	3
PH341	Modern Physics Lab	0	0	3	1
ES341	Astronomy Lab	0	0	3	1
	Total	20	1	6	23

PS451 : Summer Internship and Training : 3 Credits

Semester VII

Code	Course Title	L	T	P	C
HS411	Principles of Management Systems	3	0	0	3
E04	Elective IV	3	0	0	3
E05	Elective V	3	0	0	3
E06	Elective VI	3	0	0	3
I01	Institute Elective	3	0	0	3
ES431	Earth and Space Science Lab	0	0	3	1
PS452	Comprehensive Viva-Voce I	0	0	0	2
	Total	15	0	3	21

Semester VIII

Code	**Course Title**	**L**	**T**	**P**	**C**
PS453	Comprehensive Viva-Voce	0	0	0	3
PS454	Project Work	0	0	0	12
	Total	0	0	0	15

Abbreviations

MA – Mathematics; PH – Physics; CH – Chemistry; HS – Humanities; AE – Aerospace Engineering; AV – Avionics; L – Lecture; T – Tutorial; P – Practical; C – Credits.

Sl. No	Course Code	Course Title	Earth System Science	Astrophysics and Planetary Sciences	Remote Sensing
1	ES461	Atmospheric Structure, Dynamics and Air-Sea Interaction	√	-	-
2	ES462	Solid Earth and its Dynamics	√	-	-
3	ES463	Biosphere and Hydrosphere	√	-	-
4	ES464	Gas Dynamics	√	√	-
5	ES465	Numerical Weather Prediction and Modeling	√	-	-
6	ES466	Earth Observation from Space	√	-	-
7	ES467	Solar Terrestrial Relations	√	-	-
8	ES468	Estimation and Stochastic Process	√	√	√
9	ES469	Astronomical Techniques	-	√	-
10	ES470	Radiation Process in Astrophysics	-	√	-
11	ES471	Structure and Evolution of Stars	-	√	-
12	ES472	Cosmology and Astro Biology	-	√	-
13	ES473	Diffused Matter in Space	-	√	-
14	ES474	High Energy Astrophysics	-	√	-
15	ES475	Galaxies (Structure, Dynamics and Evolution)	-	√	-
16	ES476	Solar System Science	-	√	-
17	ES477	Image Interpretation and Digital Image Processing	-	-	√
18	ES478	Optical Sensors	-	-	√
19	ES479	Geographic Information System	-	-	√
20	ES480	Introduction to Photogrammetry	-	-	√
21	ES481	Microwave Remote Sensing	-	-	√
22	ES482	Cartography and Navigation	-	-	√
23	ES483	Data Archival and Mining	-	-	√
24	ES484	Quantitative Methods in Remote Sensing	-	-	√
25	ES485	Physics of Stars	-	√	-
26	ES486	Planetary Geosciences	√	-	-
27	ES487	LIDAR Remote Sensing	-	-	√
28	ES488	Climate Change	√	-	-
29	ES489	Tropical Meteorology	√	-	-
30	ES490	Universe in a Nutshell	-	√	-
31	ES491	Introduction to Planetary Geoscience	-	√	-
32	ES492	Processing of Satellite Remote Sensing Data	-	-	√
33	ES493	Hyperspectral Remote Sensing	-	-	√
34	ES494	General Relativity and Cosmology	-	√	-

SEMESTER I

MA111 CALCULUS (2 - 1 - 0) 3 credits

Sequence and series of real numbers: (4 lectures) Sequence, convergence, limit of sequence, non-decreasing sequence theorem, Sandwich Theorem(applications), L'Hospital's rule, Infinite series, convergence, geometric series, Tests of convergence (nth term test, integral test, comparison test, Ratio and root test), Alternating Series and conditional convergence, Power series.
Differential Calculus: (14 lectures) Functions of one variable –Limits, continuity and derivatives – Taylor's theorem – Applications of derivatives – Curvature and Asymptotes – Functions of two variables – Limits and continuity – Partial derivatives – Differentiability, Linearization and differentials – Extremum of functions – Lagrange multipliers.
Integral Calculus: (13 lectures) Lower and upper integral – Riemann integral and its properties – the fundamental theorem of integral calculus – mean value theorems – differentiation under integral sign – Numerical Integration- double and triple integrals – change of variable in double integrals – polar and spherical transforms – Jacobian of transformations.
Textbooks:
1. Stewart, J., Calculus: Early Transcendentals, 5th ed., Brooks/Cole (2007).
2. Jain, R. K. and Iyengar, S. R. K., Advanced Engineering Mathematics, Narosa (2005).

References:
1. Greenberg, M. D., Advanced Engineering Mathematics, Pearson Education (2007).
2. James, G., Advanced Modern Engineering Mathematics, Pearson Education (2004).
3. Kreyszig, E., Advanced Engineering Mathematics, 9th ed., John Wiley (2005).
4. Thomas, G. B. and Finney, R. L., Calculus and Analytic Geometry, 9th ed., Pearson Education (2003).

PH111 PHYSICS I (3 - 1 - 0) 4 credits

PHYSICS 101 (3-1-0-4)

MECHANICS & THERMODYNAMICS

Mechanics

Vectors and Kinematics:

Vectors, linear independence, completeness, basis, dimensionality,inner products, orthogonality. Displacement, derivatives of a vector. Velocity, acceleration. Kinematic equations, motion in plane polar coordinates

Newtonian Mechanics:

Momentum, Force, Newton's Laws, Applications. Dynamics of a system of particles, conservation of momentum, impulse, center of mass

Work and Energy:

Integration of the equation of motion, Work energy theorem, applications. Gradient operator - potential energy and force - interpretation. Energydiagrams. Non conservative forces. Law of conservation of energy,power, particle collisions.

Rotations:

Angular momentum - torque on a single particle. Moment of inertia. Angular momentum of a system of particles. Pure rotation about an axis – the physical pendulum

Central Force Motion:

Central force motion of two bodies. Relative coordinates - reduction to one dimensional problem.Spherical symmetry and conservation of angular momentum - consequences. Planetary motion and Kepler's laws.

Harmonic Oscillator:

1-D harmonic oscillator. Damped and forced harmonic oscillators - solutions

Thermodynamics

Zeroth law of thermodynamics - Temperature - measurement and scales - Thermal expansion - Heat and work - First law of thermodynamics - Heat transfer mechanisms - Irreversible processes and Entropy - Change in Entropy - Second law of thermodynamics - Heat engines

Textbooks:

An Introduction to Mechanics - D. Kleppner and R. J. Kolenkow- Cambridge University Press (2010)

Heat and Thermodynamics - M. W. Zemansky - McGraw Hill Pub.(1997)

CH111 CHEMISTRY (2 - 1 - 0) 3 credits

Chemical Kinetics: Basic concepts of chemical kinetics; reaction stoichiometry, empirical rate equations, elementary reactions, order and molecularity – composite reactions: reversible reactions, chain reactions, reaction mechanisms – effect of temperature on reaction rates: Arrhenius equation – catalysis; different types of catalysts, enzyme catalysis, inhibition – dynamics of chemical processes; theories of reaction rates.

Electrochemical Systems: Introduction to electrochemical cells; EMF, applications of EMF measurements, thermodynamic data – electrolytic conductance; Kohlrausch's law, Arrhenius theory, Ostwald's dilution law, transport number, electrochemical series, concentration cell.

Polymer Chemistry: Basic concepts; molecular weights and distributions, thermal transitions, morphology – classification of polymers: methods of polymerization – copolymers – polymers for space applications – polymer degradation.

Propellants and Explosives: Basics of explosives and propellants; classification of explosives and propellants, initiators, detonators – explosion, detonation, RDX, HMX, plastic bonded explosives, explosive polymers – different types of propellants; calorific value, efficiency factor – composite propellants.

Textbooks:

1. Jain, P. C. and Jain, M., Engineering Chemistry, 15th ed., Dhanpat Rai Pub. Company (2007).
2. Krishnamurthy, N., Vallinayagam, P., and Madhavan, D., Engineering Chemistry, Prentice Hall of India (2007).

References:

1. Atkins, P. and de Paula, J., Atkins' Physical Chemistry, 8th ed., Oxford Univ. Press (2007).
2. Laidler, K. J., Chemical Kinetics, 3rd ed., Pearson Education (2005).
3. Young, R. J. and Lovell, P. A., Introduction to Polymers, 2nd ed., CRC Press (2000).
4. Dryden's Outlines of Chemical Technology, 3rd ed., Affiliated East-West Press (1997).
5. Urbenskey, T., Chemistry and Technology of Explosives, vol.2, vol.3 and vol.4, Pergamon Press (1988).
6. Bailey, A. and Murray, S. G., Explosives, Propellants & Pyrotechnics, 2nd ed., Brassey's (2001).

AE111 BASIC MECHANICAL ENGINEERING (2-1-0) 3 credits

Introduction to mechanical engineering – role of mechanical engineers – engineering thermodynamics; basic laws and thermal engineering applications – introduction to engineering materials and manufacturing processes – introduction to mechanisms – introduction to measurement system and data analysis.

Textbooks:

1. Agrawal, B. and Agrawal, C. M., Basic Mechanical Engineering, Wiley India (2008).
2. Lecture notes.

References:

1. Shanmugham, G., Introduction to Mechanical Engineering, Tata McGraw-Hill (2007).
2. Çengel, Y. A. and Boles, M. A., Thermodynamics - An Engineering Approach, 5th ed., Tata McGraw-Hill (2006).
3. Kalpakjian, S. and Schmidt, S. R., Manufacturing Engineering and Technology, 4th ed., Prentice Hall (2001).
4. Holman, J. P., Experimental Methods for Engineers, 7th ed., Tata McGraw-Hill (2004).

AV111 BASIC ELECTRICAL ENGINEERING (2-1-0) 3 credits

Circuit analysis, Kirchoff's law, mesh and nodal methods – transient analysis for RLC circuit – alternating current theory – resonance, Q factor and power measurement by two wattmeter circuits – network theorems – magnetic circuit, principles of magnetic circuits – DC and AC excitation – hysteresis loop, BH curve – losses, energy, and force production – electrical machines – power electronics, SCR, TRIAC, DIAC, and UJT; application in DC-DC converter and inverter circuit – introduction to transducer – storage batteries, different technologies,

specification, maintenance and usage in aerospace applications.

Textbooks:

1. Hughes, E., Electrical and Electronic Technology, Pearson Education (2002).
2. Deltoro, V., Principles of Electrical Engineering, 2nd ed., Prentice Hall (1986).
3. H. Cotton, Principles of Electrical Engineering, Sir Isaac Pitman & Sons (1967).

References:

1. Hayt, W. H. and Kemmerley, J. E., Engineering Circuit Analysis, 4th ed., McGraw-Hill (1986).
2. Murthy, K. V. V. and Kamath, M. S., Basic Circuit Analysis, 1st ed., Reprinted, Jaico Publishing (1998).
3. Kothari, D. P. and Nagrath, I. J., Theory and Problems of Basic Electrical Engineering, Prentice Hall (2000).
4. Pal, M. A., Introduction to Electrical Circuits and Machines, Affiliated East-West Press (1975).

HS111 COMMUNICATION SKILLS I (1-0-0) 1 credit

PH131 PHYSICS LAB I (0-0-3) 1 credit

- Properties of Matter and Thermal Physics
    1. Determination of Young's modulus
    2. Determination of rigidity modulus
    3. Determination of viscosity of liquid - constant and variable pressure head
    4. Determination of surface tension - capillary rise method
    5. Thermal conductivity of a bad conductor - Lee's disc method
    6. Determination of specific heat of a liquid using steam
- Mechanics and Sound
    1. Determination of moment of inertia - flywheel
    2. Determination of 'g' using compound pendulum
    3. Keter's pendulum - precise setting and analysis
    4. Frequency of tuning fork - sonometer
- Optics
    1. Focal length - convex and concave lens
    2. Refractive index - spectrometer i-d curve
    3. Refractive index - small angle prism
    4. Spectrometer grating - wave length of spectral lines
    5. Grating - minimum deviation, oblique incidence

CH131 CHEMISTRY LAB (0-0-3) 1 credit

- Inorganic Chemistry
    1. Acidimetry and alkalimetry
    2. Permanganometry
    3. Dichrometry
    4. Iodometry and iodimetry
- Physical Chemistry
    1. Chemical kinetics
    2. Viscosity of sugar solution
    3. Potentiometry
    4. Conductometry
- Organic Chemistry
    1. Determination of purity of phenol
    2. Preparation of simple organic compounds
    3. Synthesis of polymers

AE131 BASIC ENGINEERING LAB (0 - 0 - 3) 1 credit

1. Study of lathe and accessories
2. Turning practice – taper turning and thread cutting
3. Study of shaping machine and slotting machine
4. Machining practice using shaping machine
5. Study of milling machine
6. Machining practice using milling machine – gear cutting
7. Welding – demonstration of gas welding, brazing, TIG, and MIG welding
8. SMAW practice
9. Practice on CNC lathe
10. Practice on CNC milling machine

HS131 COMMUNICATION SKILLS LAB (0 - 0 - 3) 1 credit

1. Listening drills
2. Pronunciation drills
3. Practice special communication situations
4. Vocabulary exercises and group discussions
5. Functional grammar exercises
6. Technical writing tips (engineering and scientific papers)
7. Technical guide lines for seminar presentation
8. Neuro-linguistic programming
9. Passage comprehension
10. Metronome practice with the help of mnemonics

Note: Language Lab employs multimedia teaching materials to enhance speaking, listening, reading, and writing skills. This course also includes neuro-linguistic programming to develop language competency.

Textbooks:

1. Huxley, Brave New World, Chatto and Windus, 1932.
2. M. Padmanabhan, Harvest Kali for Women, 2008.

References:

1. A. Baker and S. Goldstein, Pronunciation Pairs, Cambridge Univ. Press, 2002.
2. S. Brown and D. Smith, Active Listening, Cambridge Univ. Press, 2004.
3. T. Buzan, Use Your Head, Guild Publishing, 1974.
4. G. Maugur, The English Language Laboratory Drills for Students of Science and Technology, Oxford Univ. Press, 2005.
5. G. Orwell, Nineteen Eighty Four, Secker and Warburg, 1949.

SEMESTER II

MA121	VECTOR CALCULUS AND DIFFERENTIAL EQUATIONS	(2 - 1 - 0) 3 credits

Vector Calculus: (11 Lectures) Scalar and vector fields – level surfaces – directional derivatives, gradient, curl, divergence – Laplacian – line and surface integrals – theorems of Green, Gauss, and Stokes

Sequences and Series of functions: (5 Lectures) Complex sequences – sequences of functions – uniform convergence of series – test for convergence – uniform convergence for series of functions.

Differential Equations: (15 Lectures) First order ordinary differential equations – classification of differential equations – existence and uniqueness of solutions of initial value problem – higher order linear differential equations with constant coefficients – method of variation of parameters and method of undetermined coefficients – power series solutions – regular singular point – Frobenius method to solve variable coefficient differential equations – special functions: Legendre polynomials, Bessel's function, gamma function, and their properties – Sturm-Liouville problems.

Textbooks:

1. Ross, S. L., Differential Equations, Blaisedell (1995).
2. Kreyszig, E., Advanced Engineering Mathematics, 9th ed., John Wiley (2005).
3. Stewart, J., Calculus: Early Transcendentals, 5th ed., Brooks/Cole (2007).

References:

1. Greenberg, M. D., Advanced Engineering Mathematics, Pearson Education (2007).
2. Jain, R. K. and Iyengar, S. R. K., Advanced Engineering Mathematics, Narosa (2005

PH121	PHYSICS II	(3 - 1 - 0) 4 credits

Optics, Electricity & Magnetism

1. Curvilinear coordinates - Conservative vector fields and their potential functions – Gauss' theorem, Stokes' theorem – physical applications in electrostatics - Electrostatic potential and field due to discrete and continuous charge distributions - Dipole and quadrupole moments - Energy density in an electric field - Dielectric polarization - Conductors and capacitors - Electric displacement vector - dielectric susceptibility.

2. Biot-Savart's law and Ampere's law in magnetostatics - Magnetic induction due to configurations of current-carrying conductors - Magnetization and surface currents - Energy density in a magnetic field - Magnetic permeability and susceptibility - Force on a charged particle in electric and magnetic fields - Electromotive force, Faradays' law of electromagnetic induction. Self and mutual inductance, Displacement current.

3. Nature of light – Ray approximation in Geometrical Optics- Reflection- Refraction- Fermat's principle- Dispersion- Mirrors and Lenses – Aberrations- Interference- diffraction- polarization - Lasers(to be decided)

Text books:

1. Introduction to Electrodynamics - 3rd Edition - D. J. Griffiths, Prentice Hall (1999)

2. Optics by E. Hecht, Fourth Edition, Pearson Education

CH121 MATERIALS SCIENCE (2 - 1 - 0) 3 credits

Corrosion Science: Introduction to corrosion; electrochemical mechanisms, theories of corrosion, factors influencing corrosion – testing and measurement of corrosion – protection against corrosion.

Introduction to Ceramic and Composite Materials: General characteristics – applications of composites materials – classification of composites; fibers, matrices, factors influencing composite properties, mechanical properties of fibers – ceramic materials; bonding in ceramics, structure of glasses and silicates, processing of ceramics, properties of ceramics.

Material Characterization: Spectroscopic techniques; basics of IR and UV – thermal characterization; TGA, DSC, DTA.

Textbook:

- Callister Jr., W. D., Materials Science and Engineering: An Introduction, 7th ed., John Wiley (2006).

References:

1. Revie, R. W. and Uhlig, H. H., Corrosion and Corrosion Control - An Introduction to Corrosion Science and Engineering, 4th ed., Wiley (2008).
2. Bockris, J. O'M. and Reddy, A. K. N., Modern Electrochemistry 1: Ionics, Springer (1998).
3. Reed, J. S., Principles of Ceramics Processing, 2nd ed., Wiley-Interscience (1995).
4. Kemp, W., Organic Spectroscopy, 3rd ed., Palgrave (2007).
5. James, W. D. and Kenneth, H. T., Thermal Methods, John Wiley (1987).
6. Skoog, D. A., West, D. M., and Holler, F. J., Fundamentals of Analytical Chemistry, 8th ed., Thomson Brooks/Cole (2004).

AE121 ENGINEERING MECHANICS (2- 1 - 0) 3 credits

Basics of statics – fundamental principles and concepts – analysis of structures – trusses, frames, machines, beams, cables – friction – center of mass and area moments of inertia – mass moment of inertia – virtual work and energy method – applications of energy method for equilibrium – stability of equilibrium – review of particle dynamics – plane kinematics of rigid bodies, rotation – plane kinetics of rigid bodies – introduction to vibration.

Textbooks:

1. Meriam, J. L. and Kraige, L. G., Engineering Mechanics: Statics (vol.1), Dynamics (vol.2), 5th ed., Wiley (2002).
2. Beer, F. B. and Johnston, E. R., Vector Mechanics for Engineers: Statics (vol.1), Dynamics (vol.2), 8th ed., Tata McGraw-Hill (2007).

References:

1. Timoshenko, S. and Young, D. H., Engineering Mechanics, 4th ed., Tata McGraw-Hill (2007).
2. Hibbeler, R. C., Principles of Statics and Dynamics, 10th ed., Prentice Hall (2006).
3. Shames, I. H., Engineering Mechanics: Statics and Dynamics, 4th ed., Prentice Hall (1996).

AV121 BASIC ELECTRONICS ENGINEERING (2 - 1 - 0) 3 credits

Semiconductor diodes: characteristics, applications in rectifiers and power supplies – BJT characteristics, biasing circuit – small signal and low frequency transistors – field effect devices: JFET/HFET, MOSFET operation, characteristics and small signal models – amplifiers and oscillators – operational amplifiers: parameters and characteristics, application-active filters – digital circuits: basic logic gates-combinational circuit, flip flops-applications, memories.

Principles of Communication: Basic block diagram – modulation, types – overview of satellite communication.

M**icroprocessor and Computer Architecture:** 8 bit microprocessor-architecture, assembly language program – functional block diagram of computer architecture – introduction to computers, microcomputers and its functional block diagram.

Textbooks:

1. Boylsted, R. L. and Nashelsky, L., Electronic Device and Circuits, Pearson Education (2003).
2. Floyd, T. L., Electronic Device, Pearson Education, 8th ed. (2007).
3. Tomazi, W., Electronic Communication Systems: Fundamentals Through Advanced, Pearson Education (2005).

References:

1. Mottershed, A., Electronic Devices and Circuits: An Introduction, EEE Publication, 12th Indian ed. (1989).
2. Bapat, Y. N., Electronic Devices and Circuits, Tata McGraw-Hill, 9th ed. (1989).
3. Malvino, A. P., Electronic Principles, 12th ed., 3rd TMH ed., Tata McGraw-Hill (1989).
4. Jain, R. P., Modern Digital Electronics, McGraw-Hill (2004).
5. Mano, M. M., Digital Design, Prentice Hall (2002).
6. Gaonkar, R. S., Microprocessor Architecture, Programming, and Applications with the 8085, 5th ed., Penram International Pub. India Ltd. (2007).
7. J. G. Kassakian, M. F. Schlecht, and G. C. Verghese, Principles of Power Electronics, Addison-Wesley Series in Electrical Engineering, 1991.
8. R. W. Erickson, Fundamentals of Power Electronics, Chapman & Hall, 1997.
9. N. Mohan, T. Undeland, and W. Robbins, Power Electronics: Converters, Applications, and Design, 2nd ed., John Wiley, 1995.

HS121 COMMUNICATION SKILLS II (1 - 0 - 0) 1 credit

PH141	PHYSICS LAB II	(0 - 0 - 3) 1 credit

PHYSICS LAB II

Electricity and magnetism

1. Series and parallel resonant circuits-Frequency response using CRO
2. To measure the capacitance as a function of area of plates, determine the capacitance of plate capacitor by charge measurement
3. Comparison of magnetic moments-Box and Searle's vibration magnetometer
4. Hysteresis- magnetometer

Basic Electronics

1. Single stage C.E. transistor amplifier-frequency response, amplifier parameters
2. Full wave rectifier with junction diodes
3. Operational amplifier-astable multivibtrator

Optics

1. Diffraction at straight edge
2. Refractive index of glass-Newton's rings
3. Beam profile measurement of He-Ne laser
4. To observe the rotation of the plane of polarization of light using sugar solution.
5. To determine *Planck's* constant using interference filters

CHEMISTRY LAB II

1. Cryoscopy
2. Separation techniques
3. Synthesis/Characterization of polymer composite matrices
4. Critical solution temperature
5. Transition temperature of solids
6. Synthesis and characterization of ceramic materials

Text

Laboratory Manual

References

1. A.I.Vogel, A Text book of Qunatitative Organic Analysis, ELBS, London
2. D.P. Shoe maker and C.W.Garland, Experiments in Physical Chemistry, McGraw-Hill London
3. A.I.Vogel, A Text book of Qunatitative Inorganic Analysis, ELBS, London
4. H.H.Willard, L.L.Merritt and J.A.Deen-Instrumental methods of Analysis-Affiliated East-West press

CH141	MATERIAL SCIENCE LAB	(0 - 0 - 3) 1 credit

AE141 ENGINEERING GRAPHICS (1 - 0 - 3) 2 credits

Geometrical construction of simple plane figures – free hand sketching – drawing scales – graphical communication through multiple projections – first angle and third angle projections – simple projection of points, lines and planes – projection of simple solids in simple positions (orthographic and isometric) – solid sections – intersection of solids – development of surfaces – introduction to CAD – creation of simple drawing – solid modeling – auxiliary projection – section views.

Textbook:

- Bethune, J. D., Engineering Graphics with Auto CAD, Prentice Hall (2007).

References:

1. Venugopal, K., Engineering Drawing and Graphics, 2nd ed., New Age International (1994).
2. Luzadder, W. J. and Duff, J. M., Fundamentals of Engineering Drawing, 11th ed., Prentice Hall (1995).

AV141 BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LAB (0 - 0 -3) 1 credit

HS141 COMMUNICATIONS SKILLS LAB II (0 - 0 - 3) 1 credit

SEMESTER III

MA211	LINEAR ALGEBRA, NUMERICAL ANALYSIS AND TRANSFORMS	(2 - 1 - 0) 3 credits

Linear Algebra: Matrices; solution space of system of equations $Ax = b$, eigenvalues and eigenvectors, Cayley-Hamilton theorem – Definition of Group, ring field – Vector spaces over real field, subspaces, linear dependence, independence, basis, dimension – inner product – Gram-Schmidt orthogonalization process – linear transformation; null space and nullity, range and rank of a linear transformation.
Numerical Methods: Solution of algebraic and transcendental equations – solution of system of linear equations – numerical integration – interpolation – solution of ordinary differential equations.
Transforms: Fourier series expansion of periodic functions with period two – Fourier series of even and odd functions – half-range series – Fourier series of functions with arbitrary period – conditions of convergence of Fourier series. Fourier integral – the Fourier transform pair – algebraic properties of Fourier transform – convolution, modulation, and translation – transforms of derivatives and derivatives of transform – inversion theory. Laplace transforms of elementary functions – inverse Laplace transforms – linearity property – first and second shifting theorem – Laplace transforms of derivatives and integrals – Laplace transform of Dirac delta function – applications of Laplace transform in solving ordinary differential equations.
Textbooks:
1. Kreyszig, E., Advanced Engineering Mathematics, 9th ed., John Wiley (2005).
2. Jain, M. K., Iyangar, S. R. K., and Jain, R. K., Numerical Methods for Scientific and Engineering Computation, New Age International (2003).

References:
1. Greenberg, M. D., Advanced Engineering Mathematics, Pearson Education (2007).
2. Samuel D. Conte, Carl de Boor, Elementary Numerical Analysis, Third Edition, McGraw-Hill
3. E.V. Krishnamurthy, Numerical Algorithms, Affiliated East-West Press, 1986
4. Jain, R. K. and Iyengar, S. R. K., Advanced Engineering Mathematics, Narosa (2005

PH211	OPTICS AND ELECTROMAGNETIC WAVES	(3 - 1 - 0) 4 credits

OPTICS

Matrix methods in paraxial optics: Introduction, Matrix method, Unit planes, Nodal planes, A system of two thin lenses
Aberrations: Introduction, spherical aberration, coma, astigmatism, curvature, distortion and chromatic aberration
Basics of optical coherence and interference: Introduction, spatial and temporal coherence, complex degree of coherence and fringe visibility, interference by division of wavefront, interference by division of amplitude, multiple beam interference and interferometers
Diffraction: Introduction to Fresnel and Fraunhoffer diffraction patterns using, single and multiple slits, circular aperture diffraction, diffraction grating, Fraunhoffer approximation and its relation with Fourier optics, Zone plate 5. Polarization
Polarized light concepts, phenomenon of double refraction, quarter and half-wave plates, optical activity, Faraday rotation, Jones calculus.

E.M WAVES

Introduction - Propagation of electromagnetic waves, Reflection/Refraction of electromagnetic waves at normal incidence/oblique incidence and problems, Guided electromagnetic waves, TE/TM waves, Characteristics of TE/TM waves, Attenuation of TEM/TE/TM waves, Transmission lines, lossless, distortion less medium, radio and ultra high frequency lines and problems, rectangular and cylindrical waveguides, Retarded potentials, Hertzian dipole radiation, Half wave dipole radiation, Circular loop antenna or magnetic dipole radiation, problems based on this chapter.

Text and Reference books

1. Hecht , Optics, Pearson Education, Pearson Education.
2. Ajoy Ghatak, Optics , McGraw-Hill.
3. Sadiku, Electromagnetics, Oxford University Press.
4. Jordan and Balmain, Electromagnetic waves and radiation systems, PHI.

PH212 MATHEMATICAL PHYSICS (3 - 1 - 0) 4 credits

Curvilinear Co-ordinates and Matrices, Orthogonal coordinates, cylindrical coordinatesystems, Spherical polar coordinate systems, orthogonal matrices, Hermiatian matrices and unitary matrices.
Vector spacesTensors, function spaces, Hilbert spaces, orthogonal expansions, operators in infinite dimensional spaces.
Fourier Series and Fourier Transform, Properties, advantages and uses of Fourier series, applications, Gibbs phenomenon, discrete Fourier Transform, transform theorems, momentum representation.
Functions, Dirac-Delta function, legendre functions, Bessel Functions, Laguerre functions, Hermite functions.
Groups and their Representations - Discrete groups, Lie groups and Lie algebra and applications

Text and Reference books

- G B Arfken and H J Weber, Mathematical methods in physics, Academic Press, 2001

RS211 REMOTE SENSING AND APPLICATIONS (3 - 0 - 0) 3 credits

Physics of Remote Sensing: Introduction – Electromagnetic Spectrum – Effects of Atmosphere – Fundamentals of Radiometry – Spectral Reflectance - Physical basis of signatures.
Data Acquisition: Remote sensors – Optical-infrared sensors – Microwave systems – Platforms (Aerial and Space).
Data Products and Analysis: Data reception – Data Products - Resolution – Visual and Digital Interpretation – Geometric Correction – Radiometric Correction – Image enhancement – Image Classification - Basics of Photogrammetry.
Remote Sensing Applications: Agriculture – forestry – land use / land cover mapping – water resources – snow and glacier – wetland management – coastal zone management – marine fisheries – earth science.

Geographical Information System: Components of GIS – Map Projections – Spatial and Non-Spatial data – Data model and input – data analysis and output – spatial modelling – case studies

Text Book

- Joseph G., Fundamentals of Remote Sensing, Second Edition, Universities Press, 2005

References:

1. Lillesand T.M., Kiefer R.W. and Chipman J.W., Remote Sensing and Image Interpretation, Fifth Edition, John Wiley & Sons, 2004.
2. Campbell J.B., Introduction to Remote Sensing, Fourth Edition, The Guilford Press, 2008.
3. Lo C.P. and Yeung A.K.W., Concepts and Techniques of Geographic Information Systems, Second Edition, Prentice Hall, 2006.

AV215 COMPUTER ORGANIZATION AND DBMS (3 - 0 - 0) 3 credits

Overview: functions of Operating systems, layered architecture; basic concept; interrupt architecture, system calls and notion of a process and threads; synchronization and protection issues; scheduling; memory management including virtual memory management including virtual memory and paging techniques; i/o architecture and device management; file systems; distributed file systems; Case studies of Unix , Windows NT Introduction to computer organization: Structure and function of a computer - Processing unit: Characteristics of CISC and RISC processors - Performance of a processing unit. Memory subsystem : Memory hierarchy - Main memory unit - Internal organization of a memory chip - Organization of a main memory unit - Error correction memories - Interleaved memory units - Cache memory unit - Concept of cache memory - Mapping functions - organization of a cache memory unit - Fetch and Write mechanisms - Memory management unit - Concept of virtual memory - Address translation - hardware support for memory management. Input / Output subsystem: Access of I/O devices - I/O ports. - I/O control mechanisms - Program controlled I/O - Interrupt controlled I/O - DMA controlled I/O - I/O interfaces - System buses - peripherals - Terminals - Video displays - Magnetic storage disks - magnetic tapes - CD ROMs. High-Performance processors: Instruction pipe lining - Pipe line - Hazards - Super scalar processors - Performance considerations. Multi processor systems: Shared memory systems - Interconnection networks - Caches in multi processor systems.

Textbooks:

- Abraham Silberschatz, Peter Baer Galvin and Greg Gagne Operating System Concepts, 7th Edition, Wiley publications, 2005.

References:

1. Tanenbaum A.S., Operating systems:Design and implementation, Prentice Hall, 1992.
2. Tanenbaum A.S., Structured computer organization, 4th edition, PHI, 1999.
3. Stallings W, Operating systems, second edition, prentice Hall, 1995.
4. Hayes, J.P, Computer architecture and Organisation, McGraw Hill, 1998.

HS211 INTRODUCTION TO ECONOMICS (2 - 0 - 0) 2 credits

Exploring the subject matter of Economics: why we study economics – types - definitions – economic systems – economics as a science.

Principles and Concepts of Micro Economics: demand – supply – production – costs – markets – equilibrium.

Basics of Macro Economics: role of government – national income concepts – inflation concepts – classical vs. Keynesianism.

Economic Problems and Policies: meaning of development – problems of growth – population – agriculture and industry – balance of payments – planning – study report related to economics of space program.

Textbooks:

1. Samuelson, Paul A. and William D. Nordhaus, Economics, 17th ed., McGraw-Hill (2005).
2. Dewett, K. K., Modern Economic Theory, 22nd ed., S. Chand & Co.
3. Thirlwall, A. P., Growth and Development with Special Reference to Developing Economies, Palgrave (2003).

References:

1. Gardner, A., Macroeconomic Theory, Surjeet Publications (1998).
2. Koutsoyiannis, A., Modern Microeconomics, 2nd ed., Palgrave Macmillan (2003).
3. Black, J., A Dictionary of Economics, Oxford Univ. Press (2003).
4. Meir, J. M. and Rauch, J. E., Leading Issues in Economic Development, 7th ed., Oxford Univ. Press (2005).
5. Todaro, M. P. and Smith, S. C., Economic Development, 8th ed., Pearson Education Ltd. (2008).
6. Economic Survey 2008, Government of India, Ministry of Finance.
7. O'Connor, D. E., The Basics of Economics, Greenwood Press (2004).

MA231 C PROGRAMMING LAB (0 - 0 - 3) 1 credit

PH231 OPTICS LAB I (0 - 0 - 3) 1 credit

1. Beam profile analysis of He-Ne laser.
2. Finding the band gap energy of Light Emitting diodes using Newton's Rings.
3. Finding wavelength of light using Fresnel's Biprism.
4. Matrix Methods using lenses.
5. Find the thickness of glass plate using Michelson's Interfereometer.
6. To find wave length of given light source using Michelson's Interfereometer.
7. To find wave length of given light source using Fabry-Perot interferometer.
8. To determine the slit width and thickness of thin wires from the study of Fraunhoffer diffraction pattern.
9. To find the radius of a pinhole using Fraunhoffer diffraction pattern.

10. To measure wavelength of He-Ne laser using vernier caliper.
11. To find the optical rotation of sugar solution using polarimeter.

RS231	REMOTE SENSING LAB	(0 - 0 - 3) 1 credit

1. Introduction to toposheet and remotely sensed images
2. Making measurements with spectroradiometer
3. Visual Interpretation of satellite image
4. Radiometric correction of satellite image
5. Geometric correction of satellite image
6. Contrast enhancement of satellite image
7. Filters and Color transforms
8. Unsupervised classification of satellite image
9. Supervised classification of satellite image
10. Introduction to GIS
11. Basic functions in GIS

SEMESTER IV

MA221 PARTIAL DIFFERENTIAL EQUATIONS, CALCULUS OF VARIATIONS AND COMPLEX ANALYSIS (2 - 1 - 0) 3 credits

Partial Differential Equations: Introduction to PDEs – modeling Problems related and general second order PDE – classification of PDE: hyperbolic, elliptic and parabolic PDEs – canonical form – scalar first order PDEs – method of characteristics – Charpits method – quasi-linear first order equations – shocks and rarefactions – solution of heat, wave, and Laplace equations, using separable variable techniques and Fourier series..

Calculus of Variations: Optimization of functional, Euler - Lagranges equations, First Variation, Isoperimetric Problems, Rayleigh-Ritz method.

Complex Variable: Complex numbers and their geometrical representation – functions of complex variable – limit, continuity and derivative of functions of complex variable – analytical functions and applications – harmonic functions – transformations and conformal mappings – bilinear transformation – contour integration and Cauchy's theorem – convergent series of analytic functions – Laurent and Taylor series – zeroes and singularities – calculation of residues – residue theorem and applications.

Textbooks:

1. Kreyszig, E., Advanced Engineering Mathematics, 9th ed., John Wiley (2005).
2. Mathews, J. H. and Howell, R., Complex Analysis for Mathematics and Engineering, Narosa (2005).

References:

1. Churchill, R. V. and Brown, J. W., Complex Variables and Applications, 6th ed., McGraw-Hill (2004).
2. Wylie, C. R. and Barrett, L. C., Advanced Engineering Mathematics, McGraw-Hill (2002).
3. Greenberg, M. D., Advanced Engineering Mathematics, Pearson Education (2007).
4. James, G., Advanced Modern Engineering Mathematics, Pearson Education (2004).
5. Sneddon, I. N., Elements of Partial Differential Equations, McGraw-Hill (1986).
6. Renardy, M. and Rogers, R. C., An Introduction to Partial Differential Equations, 2nd ed., Springer-Verlag (2004).
7. McOwen, R. C., Partial Differential Equations – Methods and Applications, 2nd ed., Pearson Education (2003).

PH221 MODERN OPTICS (3 - 0 - 0) 3 credits

Rigorous diffraction theory, diffraction of a Gaussian beam, applications of Fresnel and Fraunhofer diffraction, Fourier optics, Fourier transforming property of a thin lens, spatial frequency filtering and its applications, OTF, MTF

Coherence theory, partial coherence, holography, construction and reconstruction of hologram

Light quanta and their origin, thermal equilibrium of radiation, Einstein's coefficients, metastable states, population inversion, optical pumping, spontaneous and stimulated emission, Lasers - working principle, threshold condition for lasing, resonant cavities, two-level and three-level lasers, Ruby, He-Ne, carbon dioxide lasers

Theory of optical fibers and wave guides, scalar wave equation, modes of a fiber and planar

wave guides, periodic media, Bragg diffraction and Bragg devices

Elements of non-linear optics, higher harmonic generation, optical phase conjugation, optical bistability, solitons, self and cross phase modulations, optical Bloch equation, Stimulated Raman Scattering

Electro-optic effects in different crystals, acousto-optic effects, Raman-Nath diffraction and acousto-optic devices

Text / Reference books:

1. Ghatak, A. K. and Thyagarajan, K – Optical Electronics, Cambridge University Press, 2009.
2. Born. M and E. Wolf, Principles of Optics, Seventh edition, Cambridge University Press, 2006.
3. Baha E. A., Saleh and M. C. Teich - Fundamentals of Photonics, John Wiley and Sons, 1991.
4. Goodman, J. W - Introduction to Fourier Optics, Third Edition, Viva Books Private Limited, 2007.
5. Boyd, R. W - Nonlinear Optics, Second Edition, Academic Press, 2003
6. Keiser, G - Optical Fiber Communications, Fourth Edition, Tata McGraw Hill, 2008.
7. Laud, B.B. - Lasers and Nonlinear Optics, New Age International (P) Limited, 1991.

PH222 CLASSICAL MECHANICS (3 - 1 - 0) 4 credits

Brief survey of the Newtonian mechanics of a particle and systems of particles; Constraints , generalised coordinates, D'Alembert's principle and Lagrange's equation, velocity dependent potential and dissipation function.

Variational principles and Lagrange's equations, Lagrange multipliers, conservation theorems and symmetry properties; Central force motion, Kepler's laws , orbital dynamics , stability of circular orbits , precession of equinoxes and of satellite orbits ;

Rigid body motion, Euler angles, inertia tensor and moment of inertia.

Euler's equations of motion, free motion of rigid bodies, motion of symmetric top.

Hamiltonian's canonical equations of motion, Routh's procedure; Principle of least action; Small oscillations, normal coordinates and normal mode frequencies.

Canonical transformations, equations of canonical transformations, symplectic approach.

Poisson Brackets (PB) and canonical invariants , infinitesimal canonical transformations , Noether's theorem conservation laws in the PB formulation , angular momentum PB relations

Hamiltonian-Jacobi theory of linear oscillatory systems, Hamiltonian's principal and characteristic functions, separation of variables, action-angle variables; Hamilton-Jacobi theory, geometrical optics and wave mechanics.

Dynamical systems: First order autonomous systems, basic theory and examples, Area preserving transformations, Transformations with dilation, Second order autonomous systems, fixed points equilibrium and stability, separation of variables, classification and determination

of fixed points, limit cycles.

Text book

1. Goldstein, H - Classical Mechanics, Addison Wesley, 2nd ed., 1980.
2. Biswas, S. N - Classical Mechanics, Books and Allied, 1998.

References

1. Rana, N. C and P. S. Jog - Classical Mechanics, Tata McGraw Hill, 1991.
2. Arnold,V. I - Mathematical Methods of Classical Mechanics, Springer Verlag, 1981.
3. Hand, L. N and J. D. Finch - Analytical Mechanics, Cambridge University Press, 1998.
4. L. Breklhovskikh, L and V. Gancharov - Mechanics of Continua and Wave dynamics, Springer Verlag, 1985.
5. Lai, W. M D. Rubin and E. Krempl - Introduction to Continuum Mechanics, Pergamon Press, 1978.
6. Sommerfeld, A - Mechanics Academic Press, 1952.
7. Percival, I and S. Richards - Introduction to Dynamics Cambridge University Press, 1982.
8. Landau, L. D and E. M. Lifshitz - Mechanics, Pergamon Press, 1960.

ES221 EARTH SYSTEM SCIENCE (3 - 0 - 0) 3 credits

- Introduction, Earth System, Components of Earth System – Atmosphere, Hydrosphere, Cryosphere, Lithosphere, Biosphere, Earth crust and Mantle. Vertical thermal structure of the atmosphere – vertical variation of pressure, temperature and density in the atmosphere; Major and Minor constituents of the earth's atmosphere and their role in earth's climate; Aerosols.
- Thermal classification of atmospheric layers: troposphere, stratosphere, mesosphere, and thermosphere; Introduction to the structure of Earth's ionosphere and magnetosphere.
- Spectra of solar and terrestrial radiation; Absorption and scattering of solar and terrestrial radiation in the atmosphere; Radiation and energy budget of the earth-atmospheric system; Greenhouse effect.
- Climate System – Roles of various components of the Earth System in determining Climate. Feedback processes in Climate System – concept of feedback, applications of feedback to the climate system.
- Hydrological Cycle in the Earth System; Carbon Cycle in the Earth System; Oxygen in the Earth System
- Climate Variability- Milankovich cycle, Internally generated climate variability, coupled climate variability, Anthropogenic forcing of climate change; El Nino Southern Oscillation.

Solid Earth Component

- Introduction to the components of the earth system
- Internal structure of the earth: crust, mantle and core
- Formation of minerals and Rocks:General physical, chemical and optical properties of common rock forming minerals; Igneous, sedimentary and metamorphic processes;

genesis of common, igneous, metamorphic and sedimentary rocks.

- Geologic work of natural agents- atmosphere, wind, water and glaciers
- Isostasy, Sea floor spreading, Continental Drift and Plate tectonics
- Formation, classification and genetic mechanisms of Volcanoes, earthquakes and other mass movements

Text / Reference Books:

1. J.M. Wallace and P.V. Hobbs, Atmospheric Science, An Introductory Survey, International Geophysical Series, 2006.
2. J.P. Pexioto and A.H. Oort, Physics of climate, Springer.
3. Dynamic and Physical Meteorology, S. L. Haltiner and F. L. Martin
4. Introduction to Theoretical Meteorology, S. Hess
5. The Physics of Atmosphere, John Houghton
6. IPCC Report, 2007. "Climate Change 2007", Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. (Or the latest IPCC report available at any point of time)
7. "Engineering and General Geology" by Parbin Singh

AV225	MEASUREMENT AND INSTRUMENTATION	(3 - 0 - 0) 3 credits

Introduction to measurement, error analysis, Static and dynamic performance characteristics of instruments. Basic voltmeter and Ammeter wattmeter and energy meter design, Electronic voltmeter, Digital Measurement systems (DMM, Frequency, A/D and D/A), spectrum analyzer, filter design, Hall effect devices. DC bridges for resistance measurements. A.C. Bridges-Measurement of inductance and capacitance, Earth resistance measurements. Frequency and Power factor meters, Potential and Current Transformers, D.C. and A.C. potentiometer, Instrumentation amplifiers. Transducers - strain gauges, inductive and capacitive transducers, piezoelectric and Hall-effect transducers, Temperature sensors, photo-diodes & transistors, digital transducers, signal conditioning and telemetry, introduction to smart sensors and MEMS, Data Acquisition Systems.

Textbooks

- A.K. Sawhney, A course in Electrical and Electronics Measurements and Instrumentation, Dhanpat Rai and Sons, New Delhi, 2006.

References

1. Doebelin, E.O., Measurement systems: Application and Design, 5th ed., McGraw hill, 2003.
2. Golding E.W. and Widdis F.E., Electrical measurements and measuring instruments, Sir Issac Pitman and Sons pvt ltd, 1995.
3. Albert D. Helfrick, William D. Cooper, Modern Electronic Instrumentation and

Measurement Techniques., Prentice Hall of India Private Limited.

HS221 INTRODUCTION TO SOCIAL SCIENCE AND ETHICS (2-0-0) 2 credits

Social Science : Introduction to sociology, anthropology – social science research design and sampling.

Ethics : Professional and personal ethics – values and norms and human rights.

Text books

Lecture notes

References :

1. Perry, J. and Perry, Contemporary Society : An Introduction to Social Science, 11th ed., Allyn & Bacon 2005.
2. Giddensl A., Sociology, 5th ed. Wiley (2006).
3. Flyberg, B, Making Social Science Matter, Cambridge University Press (2001)
4. Singer, P., A Companion to Ethics, Wiley-Blackwell (1993)

PH241 OPTICS LAB II (0 - 0 - 3) 1 credit

ES241 EARTH SYSTEM SCIENCE LAB (0 - 0 - 3) 1 credit

eteorological Sensors to measure air temperature, air humidity, pressure, wind direction an peed, and precipitation

ephigram – From a given radiosonde sounding determine
(i) LCL, (ii) LFC (iii) CAPE, (iv) CIN, (v) Showalter Index
(ii) Obtain potential temperature and equivalent potential temperature

eteorological Surface Chart and its Analysis - Meteorological Upper Air Chart and its Analysis

odeling: Solving simple equations such as

1. Lorenz equations for understanding Chaos
2. Linear nondivergent barotropic vorticity equation as applied to a symmetric vortex in a plane
3. Linear nondivergent barotropic vorticity equation as applied to a symmetric vortex in a plane
4. Nonlinear nondivergent barotropic vorticity equation as applied to a symmetric vortex
5. Linear Shallow Water Equations
6. Nonlinear Shallow Water Equations

AV245	MEASUREMENT AND INSTRUMENTATION LAB	(0 - 0 - 3) 1 credit

SEMESTER V

MA311	PROBABILITY AND STATISTICS	(3 - 0 - 0) 3 credits

Probability distributions: binomial distribution, hyper geometric distribution, Poisson approximation to the binomial, geometric distribution, normal distribution, normal approximation to the binomial distribution, uniform distribution, gamma distribution, beta distribution, and Weibull distribution – mathematical expectation and moments: mean, variance, moment generating function, and characteristic function. Random Variable: discrete and continuous random variables.
Sampling Distributions and Inference Concerning Means: Population and samples – central limit theorem – sampling distributions of mean and variance – point estimation – confidence interval for mean, variance and proportions – tests of hypotheses: the null hypotheses and the significance tests – control charts for variables and attributes – acceptance sampling by attributes – simple, double and sequential sampling plans – design of experiments.
Correlation and Regression Analysis: Curve fitting by the method of least squares – chi-square test of goodness of fit – contingency tables – inference based on the least square estimators – regression – correlation – inference concerning correlation coefficient.

Textbook:
1. Walpole, Myers, Myers, Ye, Probability & Statistics for Engineers & Scientists, 8th ed., Pearson.

References:
1. Johnson, R. A., Miller & Freund's Probability and Statistics for Engineers, 6th ed., Prentice Hall (2000).
2. Levin, R. I. and Rubin, D. S., Statistics for Management, 7th ed., Prentice Hall (1998).
3. Milton, J. S. and Arnold, J. C., Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences, McGraw-Hill (2002).
4. Ross, S. M., Introduction to Probability and Statistics for Engineers and Scientists, 3rd ed., Academic Press (2004).
5. Feller, W., An Introduction to Probability Theory and Its Applications, vol.1 & vol.2, John Wiley (1968).
6. Hogg, R. V., Craig, T., and McKean, J. W., Introduction to Mathematical Statistics, 6th ed., Prentice Hall (2004).
7. Hogg, R. V. and Tanis, E. A., Probability and Statistical Inference, 7th ed., Prentice Hall (2005).
8. Larsen, R. J. and Marx, M. L., An Introduction to Mathematical Statistics and Its Applications, 4th ed., Prentice Hall (2005).
9. Mendenhall, W., Wackerly, D., and Scheaffer, R. L., Mathematical Statistics with Applications, 7th ed., Duxbury Press (2007).

PH311	QUANTUM MECHANICS	(3 - 1 - 0) 4 credits

Towards quantum mechanics (review)-relevant experiments, wave particle duality , uncertainty principle, the quantum concept, postulates of quantum mechanics , Schrodinger equation, probability interpretation, simple one-dimensional potential problems.
Operators and operator algebra, eigenfunctions and eigenvalues, expectation values, Dirac bra-kets, Hilbert space of state vectors, unitary transformations.
Angular momentum, rigid rotator, the Hydrogen atom isotropic oscillator, Stern-Gerlach experiment and spin, spin-half particle in a magnetic field, the harmonic oscillator.
Addition of angular moment, CG coefficients, Wigner-Eckart theorem.
Approximate methods-time independent perturbation theory, variational method , WKB

approximation.
Quantum Information: Why quantum computing, Qubits, simple algorithms.

Text and Reference books

1. Harry Paul, Int. to Quantum Theory, Camb. Uni. Press (2008)
2. J. J. Sakurai, Modern Quantum Mechanics, Addison Wesley (1993)

ES311 Atmospheric and Ocean Sciences (3-0-0) 3 credits

Atmospheric Thermodynamics – Gas laws, Virtual temperature, Hydrostatic balance, Geopotential, Scale Height, Hypsometric Equation, First Law of Thermodynamics- Dry Adiabatic Lapse Rate, Potential Temperature, Water vapor in air, Saturated Adiabatic Lapse Rate, Static Stability, Second Law of Thermodynamics, Heat Balance of earth Atmosphere system.

Atmospheric Dynamics – Coriolis Force, Pressure gradient force, Friction, Equations of motion in the atmosphere; Equation of Continuity, Hydrostatic balance; Geostrophic Wind, Gradient Wind, Thermal Wind, Isobaric coordinate system.

General circulation of the atmosphere: Hadley, Ferrel and Polar Cells; Inter Tropical Convergent Zone and its annual migration; Monsoons.

Fronts, Thunderstorms, Tornadoes, Lows, Depressions and Tropical Cyclones.

Oceans – General Introduction, dimensions of the oceans, geographical features, physical properties of sea water, density of sea water, distribution of temperature, salinity and density in space and time. Heat budget of the oceans, Bowen ratio, sea level variation, acoustical and optical properties of sea water, Formation and classification of water masses, T-S diagram, Water masses of the ocean with special reference to Indian Ocean.

Circulation, Currents in the Ocean, upwelling and sinking with special reference to the Indian Ocean.

General aspects of ocean waves, their generation and propagation, storm surges and tsunamis; Tides and tide generating forces.

Text Books:

1. J. M. Wallace and P.V. Hobbs, Atmospheric Science – An Introductory Survey, International Geophysical Series, 2006.
2. Introduction to Dynamic Meteorology, J. R. Holton, Academic Books
3. Dynamic and Physical Meteorology, S. L. Haltiner and F. L. Martin
4. R H. Stewart, Introduction to Physical Oceanography.

AP311	INTRODUCTION TO ASTRONOMY AND ASTROPHYSICS	(3 - 0 - 0) 3 credits

Descriptive introduction to the contents of the universe: solar system, planets, satellites, comets and asteroids, exoplanets, types and population of stars, color-magnitude diagram and the main sequence, different types of galaxies and their contents, clusters of galaxies, need for dark matter, hot gaseous nebulae, dust clouds, Scales: Mass, distance and luminosity scales, Astronomers' units Source of information in Astronomy: Radiation from astronomical sources, primary continuum and spectral line processes, propagation effects, telescopes and detectors at various wavelengths, Astronomy from Space Dynamics: Primacy of Gravity, Introduction to General Relativity, Effective potential in Schwarzschild metric, Black Holes, Orbital precession, gravitational lensing, gravitational waves, Virial theorem and gravitational collapse. Thermodynamics: Heating and Cooling of gas, Ionization and Thermal equilibrium, diffuse matter, HII regions, shock-heated gas, non-thermal distribution of particles and radiation from them Combined Thermal, Mechanical and Radiative Equilibrium: Equations of stellar structure, Dimensional study stellar properties, Mass-Radius and Mass-Luminosity relations, HR diagram, Degenerate matter Equation of State, introduction to Mass limits of degenerate stars, Nucleosynthesis stages, qualitative description of stellar evolution. Evolution of the Universe: Hubble's law, Concept of Big Bang, Evolution of scale factor, density and temperature, primordial nucleosynthesis and cosmic background radiation, qualitative description of structure formation, formation of stars and galaxies, reionization of the universe, expansion history, need for Dark Energy.

Text / References:

1. BW Carroll & DA Ostlie, An Introduction to Modern Astrophysics, Latest Edition, Addison-Wesley.
2. Frank Shu, The Physical Universe, Latest Edition, University Science Books
3. Martin Harwit, Astrophysical Concepts, Latest Edition, Springer.
4. T. Padmanabhan, Invitation to Astrophysics, Latest Edition, World Scientific Publishing Co.
5. T. Padmanabhan, Theoretical Astrophysics vols 1-3, Latest Edition, Cambridge University Press.
6. Malcolm Longair, High Energy Astrophysics, vols 1-2, Latest Edition, Cambridge University Press.
7. Sparke and Gallaghar, Galaxies in the Universe: An Introduction, Latest Edition, Cambridge University Press.
8. Dina Prialnik: An Introduction to the Theory of Stellar

AV311	DIGITAL SIGNAL PROCESSING	(3 - 0 - 0) 3 credits

Discrete time signals and systems- DFS, DTFT, DFT – FFT computations using DIT and DIF algorithms Infinite Impuse Response Digital Filters, Finite Impulse Response Digital filters, Finite Word length effect, Introduction to Multirate Signal Processing, Introduction to programmable DSPs-Architecture of TMS 320C5X.

Textbook:

1. John G Proakis, Dimtris G Manolakis, Digital Signal Processing Principles, Algorithms and Application, PHI, 3rd Edition, 2000.
2. B.Venkataramani & M. Bhaskar, Digital Signal Processor Architecture, Programming

and Application, TMH 2002.

References:

1. Alan V Oppenheim, Ronald W Schafer, John R Back, Discrete Time Signal Processing, PHI, 2nd Edition 2000
2. Avtar singh, S.Srinivasan, DSP Implementation using DSP microprocessor with Examples from TMS32C54XX, Thamson / Brooks cole Publishers, 2003
3. S.Salivahanan, A.Vallavaraj, Gnanapriya, Digital Signal Processing, McGraw-Hill / TMH, 2000.
4. Johny R.Johnson, Introduction to Digital Signal Processing, Prentice Hall, 1984.
5. S.K.Mitra, Digital Signal Processing- A Computer based approach, Tata McGraw-Hill, 1998, New Delhi.

CH311 ENVIRONMENTAL SCIENCE AND ENGINEERING (2-0-0) 2 credits

Awareness of the impact of environment on quality of life – natural resources – biological systems – bio-geo chemical cycles – chemical processes; water treatment operations, water sampling, storage, quality measurement – oxygen demand – detection of pollutants – current environmental issues; pollutants, global warming, causes and consequences, air pollution, organic and inorganic air pollutants, smog-acid mine drainage, accumulation of salts in water – soil formation; micro and macro nutrients in soil, pollutants in soil – green chemistry: an alternative tool for reducing pollution – engineering interventions; flow sheets, waste minimization, e-waste management, ASP, reverse osmosis, trickling filter – environmental management; solid, liquid waste management, hazardous wastes, ISO standards – Kyoto protocol, Montreal protocol, Euro norms.

Textbook

Rao, V., Textbook of Environmental Engineering, Prentice Hall of India (2002).

References:

1. Baird, C. and Cann, M., Environmental Chemistry, 3rd ed., W. H. Freeman and Company (2005).
2. Manual on Water Supply and Treatment, CPHEEO, Ministry of Urban Development, GOI (1999).
3. Manual on Sewerage and Sewage Development, CPHEEO, Ministry of Urban Development, GOI (1993).
4. Hauser, B. A., Practical Hydraulics Hand Book, Lewis Publishers (1991).
5. Hammer, M. J., Water and Wastewater Technology, Regents/Prentice Hall (1991).
6. Sharma, J. P., Comprehensive Environmental Studies, Laxmi Publications (2004).
7. Garg, S. K., Environmental Engineering (vol. 1 and 2), Khanna Publishers (2004).
8. Kiely, G., Environmental Engineering, McGraw-Hill (1997).
9. Bharucha, E., Textbook of Environmental Studies, University Grants Commission

(2004).

Vanloon, G. W. and Duffy, S. J., Environmental Chemistry: A Global Perspective, Oxford Univ. Press (2000

PH331	**COMPUTATIONAL PHYSICS LAB**	(0 - 0 - 3) 1 credit

AV331	**DIGITAL SIGNAL PROCESSING LAB**	(0 - 0 - 3) 1 credit

SEMESTER VI

PH321 STATISTICAL MECHANICS (3 - 0 - 0) 3 credits

Preliminary concepts, probability theory, random walk problem, Laws of thermodynamics and their consequences.

Phase space, Liouville's theorem and its consequences, Statistical description of system of particles, microstates, ensembles, basic postulates, density of state for ideal gas in classical limit, thermal and mechanical interactions, quasi-static process.

Microcanonical ensembles and their equivalence, canonical ensembles, partition functions, ideal gas, Gibbs paradox, equipartition theorem, M-B gas velocity and speed distribution, chemical potential, free energy and connection with thermodynamic variables, 1st and 2nd order phase transition.

Statistical thermodynamics, irreversibility and attainment of equilibrium, reversible and irreversible processes, approach to thermal equilibrium, statistical calculation of thermodynamic variables.

Thermodynamics of black body radiation, Stefan-Boltzmann law, Wien's displacement law, Einstein and Debye's theories of specific heat of solids.

Maxwell, Boltzmann, Bose-Einstein, Fermi-Dirac gases, statistics of occupation numbers, evaluation of partition functions, ideal gases in the classical limit, Ideal Bose system, Bose-Einstein condensation.

Formulation of quantum statistics, density matrix, ensembles in quantum statistical mechanics, simple application of density matrix

Texts / Reference books:

1. Pathria, R. K - Statistical Mechanics Pergamon Press, Oxford.
2. Huang, K - Statistical Mechanics, 2nd Ed, John Wiley.
3. Laud, B. B - Fundamentals of Statistical Mechanics, New Age.
4. Greiner - Thermodynamics and Statistical Mechanics, Springer Verlag.
5. Liboff, R. L - Kinetic Theory, Classical, Quantum, and Relativistic Descriptions, Prentice Hall, 1990.
6. Kubo, R, M. Toda and N. Hashitsume - Statistical Physics Vol. II, Non Equilibrium Statistical Mechanics Springer Verlag, 1985.
7. Yeomans, J. M - Statistical Mechanics of Phase Transitions, Clarendon Press, 1994
8. Boon, J. P & S Yip - Molecular Hydrodynamics, Dover Pub. 1991.
9. Salinas, S. R. A - Introduction to statistical physics, Springer 2001.

PH322 ATOMIC, MOLECULAR AND NUCLEAR PHYSICS (3 - 0 - 0) 3 credits

Spectra of alkali atoms, vector atom model, LS and JJ couplings, doublet fine structure, two electron atom, Zeeman and Paschen-Back effect, normal and anomalous Zeeman effect, Stark effect.

Symmetric and antisymmetric wave functions, Slater determinants, constant field approximation, Hartree-Fock method, Born-Oppenheimer approximation.

Fine structure of spectral lines, nuclear spin and hyperfine structure, spectra of diatomic molecules, polyatomic molecules.

X-ray spectra, general factors influencing spectral line widths and line intensities, molecular

symmetry, irreducible representation, rotational and vibrational spectra of diatomic molecules

Electronic spectra, Franck-Condon principle, bond dissociation energies, molecular orbitals and models, fluorescence and phosphorescence.

FTIR and Laser Raman spectroscopy, magnetic resonance, ESR and MNR spectra, lasers, interaction of laser with atoms.

Nuclear physics - Nuclear radius, mass, binding energy, nucleon separation energy, liquid drop model, semi empirical mass formula, mass parabolas, beta stability line, angular momentum, parity, electromagnetic moments, excited states.

Radioactivity - radioactive decay law, alpha decay - nuclear stability, theory of alpha particle emission, beta decay - energetics, angular momentum and parity selection rules, Fermi and Gamow - Teller transition probabilities, Kurie plot and mass of a neutrino, gamma decay - energetics, mossbauer effect.

Text and Reference books:

1. Herzberg, G - Molecular Spectroscopy and Molecular Structure, Vols. I, II and III, Van Nostrand, 1945.
2. Bates, D and I. Estermann, Advances in Atomic and Molecular Physics, Academic Press, 1965.
3. Cohen, B. L - Concepts of Nuclear Physics, McGraw Hill, revised ed. 1988.
4. Cagnac, B and J. C. Pabey-Payroula - Modern Atomic Physics Vol. I and II McMillan, 1975.
5. Barrow, G. M - Introduction to Molecular Spectroscopy, Benjamin, 1964
6. Fano, U and L. Fano - Physics of atoms and molecules: An Introduction to Structure of Matter, Univ. of Chicago Press, 1972.
7. Enge, H. A - Introduction to Nuclear Physics, Addison-Wesley, 1971.
8. Wong, S. S. M - Introductory Nuclear Physics, Prentice Hall, 1990.
9. Preston, M. A and R. K. Bhaduri, Structure of the Nucleus, Addison- Wesley, 1975.
10. Pal, M. K - Theory of Nuclear Structure, Affiliated East West Press, 1982.

RS321 PATTERN RECOGNITION (3 - 1 - 0) 4 credits

PR overview-Feature extraction-Statistical Pattern Recognition-Supervised Learning-Parametric methods-Non parametric methods; ML estimation-Bayes estimation-k nn approaches-Linear discriminat functions-Unsupervised learning and clustering-Syntactic Pattern recognition-Graphical approaches to PR-Neural PR-Content addressable memory.

Texts / Reference books:

1. Roberrt Schalkoff , Pattern Recognition: Statistical, Structural And Neural Approaches, John Wiley & Sons, 1991.
2. Richard O. Duda, Peter E. Hart, David G. Stork, Pattern Classification, 2nd Edition, Wiley, 2000.

ES321 INTRODUCTION TO SPACE VEHICLES (2-0-0) 2 credits

Coordinate Frames: Heliocentric inertial, Geocentric inertial, topo centric and body centric frames

Space Propulsion: Thrust Equation, Specific Impulse, Rocket Equation, propulsion options and

advanced propulsion concepts

Basics of Space vehicle Design: Rocket Performance and staging, subsystems of launch vehicle and space crafts, Atmospheric drag ; Force and moments during atmospheric phase, aerodynamic disturbance on vehicle, Equations of motion of ascent flight and spacecraft

Basic Orbital Maneuvers: Single Impulse and two impulse coplanar transfers, combined maneuvers, Hohmann transfer , sphere of influence, Application of Hohmann transfer concept to Lunar and Interplanetary missions

Basics of Time Systems (Solar, Sidereal, Atomic, UT) , Co-ordinate Transformation (Euler angles, Direction cosine, Quaternion), Importance of time systems in co-ordinate transformation

Introduction to Navigation Guidance and Control, Basics of Inertial (Gimballed platform INS, Strapdown INS), Non-inertial and Integrated navigation systems

Inertial Sensors (Accelerometers and Gyroscopes (Basic Principles)) and Star sensors for interplanetary missions

Text Book:

Michael D. Griffin and James R.French , ` Space Vehicle design ` , AIAA Education Series, 2004

Vallado, David A, `Fundamentals of astrodynamics and applications', Microcosm Press (California), 2001

Modern inertial technology navigation, guidance and control by Lawrence, Anthony
Publication: New York Springer 1998

E01	**ELECTIVE I**	**(3-0-0) 3 credits**
E02	**ELECTIVE II**	**(3-0-0) 3 credits**
E03	**ELECTIVE III**	**(3-0-0) 3 credits**
PH341	MODERN PHYSICS LAB	(0 - 0 - 3) 1 credit
ES341	ASTRONOMY LAB	(0 - 0 - 3) 1 credit

VII SEMESTER

HS411	PRINCIPLES OF MANAGEMENT SYSTEMS	(3 - 0 - 0) 3 credits

Personnel Management: Introduction – changing role of personnel manager – new people management – manpower planning – recruitment and selection – performance appraisal – workers participation in management – grievance handling.

Industrial Management: Management Functions – organization – principles of planning – management by objectives – organization structures – principles of organizing – span of control – delegation, leadership, directing, and controlling.

Project Management: Development of project network – project representation – project scheduling – linear time-cost trade-offs in projects: a heuristic approach – project monitoring and control with PERT.

References:

1. Koontz H., O'Donnel, C., and Weihrich, H., Essentials of Management, McGraw-Hill (1990).
2. Venkataratnam, C. S. and Srivastava, B. K., Personnel Management and Human Resources, Tata McGraw-Hill (1991).
3. Mazda F., Engineering Management, Prentice Hall (1997).
4. Gido, J. and Clements, J. P., Successful Project Management, 2nd ed., South-Western College Publishing (2003).
5. Khanna, O. P., Industrial Engineering and Management, Dhanpat Rai Publications (P) Ltd. (2003).
6. Memoria, C. B. and Gankar, S. V., Personnel Management - Text and Cases, Himalaya Publishing House (2007).

E04	**ELECTIVE IV**	(3 - 0 - 0) 3 credits
E05	**ELECTIVE V**	(3 - 0 - 0) 3 credits
E06	**ELECTIVE VI**	(3 - 0 - 0) 3 credits
I01	**INSTITUTE ELECTIVE**	(3 - 0 - 0) 3 credits
ES431	**EARTH AND SPACE SCIENCE LAB**	(0 - 0 - 3) 1 credit
PS452	**COMPREHENSIVE VIVA-VOCE I**	(0 - 0 - 0) 2 credits

SEMESTER VIII

PS 453	COMPREHENSIVE VIVA VOCE	(0-0-0)	3 credits
PS 454	PROJECT WORK	(0-0-0)	12 credits

ELECTIVE COURSES

ES 461 ATMOSPHERIC STRUCTURE, DYNAMICS AND AIR-SEA INTERACTION (3-0-0) 3 credits

Atmospheric Structure:

Atmospheric Structure -*Standard Atmosphere, composition, Layers of the Atmosphere, Atmospheric boundary layer; Exosphere; Radiosonde;* Weather and Climate - *A Satellite's View of the Weather Storms of All Sizes, A Look at a Weather Map, Weather Symbols and the Station Model.*

Dynamic Meteorology:

Dynamics: Newton's Second Law of Motion - *Lagrangian Momentum budget, Eulerian Momentum budget*; Equations of Motion; Height Contours on Isobaric Surfaces; Winds - Geostrophic wind, Gradient wind*; Cyclostrophic wind*; Scale analysis of the equations of motion; Mass Conservation - *Continuity Equation, Incompressible continuity Equation, , Altitude profile of wind in the Boundary-Layer;* Circulation Theorem (non-rotating and rotating), Baratropic and Baroclinic atmosphere.

Global Circulation: Differential Heating - *Latitude variation of radiation balance - Meridional Temperature Gradient; Meridional Heat transport through atmosphere and ocean*; *Thermal Wind*; Jet Stream - *Baroclinicity, Angular momentum*; Vorticity - *Relative Vorticity, Absolute Vorticity, Potential Vorticity, Isentropic Potential Vorticity*; Instability - *Barotropic Instability & Rossby Waves, Baroclinic Instability & Planetary Waves*; Global Winds - *General Circulation of the Atmosphere, Single-cell Model, Three-Cell Model, ITCZ; Westerly Winds and the Jet Streams*, Quasi-Biennial Oscillations, Equatorial waves, Tides and gravity waves

Air-Sea Interaction:

Physical interaction between the Ocean and Atmosphere, Radiation - *Solar radiation, Long-wave radiation;* Heat exchange through latent and sensible heat*;* The Oceanic heat balance; Oceanic forcing by air-sea exchange of moisture and heat - *Moisture exchange,* Air-Sea Momentum transfer and drag - *Charnock's Law, Sea Surface Roughness*, Wind-driven circulation of the Ocean – Ocean Gyres, *Ekman flow, Coastal upwelling, The tropical surface circulation, The Indian Ocean monsoonal circulation,* Thermohaline circulation.

Large-scale Air-Sea interaction: Ocean-Atmosphere interaction in the tropics, Genesis and characteristics of ENSO; ENSO and air - sea coupling, Global impact of ENSO, ENSO and the Indian Monsoon.

Text Books:

1. J.M. Wallace and P.V. Hobbs, Atmospheric Science – An Introductory Survey, International Geophysical Series, 2006
2. J.R. Holton, An Introduction to Dynamic Meteorology.
3. R H. Stewart, Introduction to Physical Oceanography.
4. Dynamic and Physical Meteorology, S. L. Haltiner and F. L. Martin
5. Introduction to Theoretical Meteorology, S. Hess

ES462 SOLID EARTH AND ITS DYNAMICS (3-0-0) 3 credits

History of the Earth: Planetary Perspective - Origin & Early History -Comparative Planetology - Building blocks of planets (composition of terrestrial planets).

Structure of the Earth : Earthquake and Seismology - Velocity structure of the earth – Isostasy - The Crust and Upper Mantle - The Lower Mantle and Core - Seismic Tomography - Mantle heterogeneity - Shape of the Earth (geodetic datums, geometric earth models, reference ellipses &earth surfaces).

The Dynamic Earth: - Fluid Mechanics and Earth Rheology - Heat Flow and Mantle convection - Plate Tectonics - Mantle melting and Volcanism -Folding and Diapirism - Faulting and earthquake mechanism – Mountain building processes - Magneto hydrodynamics and core dynamics -Geomagnetism and Paleomagnetism.

Mineral Physics: Elasticity and solid state geophysics - Anisotropy: fabric of mantle - Phase changes and mantle mineralogy.

Sampling the Earth: Application of trace elements and isotopes to mantle studies - Radioactivity and Geochronology - Magmas and xenoliths: Windows to mantle - Chemical composition of mantle.

Origin and Evolution of Layers and Blobs: The Upper mantle - The nature andcause of mantle heterogeneity - Crystallization of the mantle

TextBooks

1. New Theory of the Earth: by Don L. Anderson, Cambridge University Press; 2nd edition
2. Geodynamics: by Donald L. Turcotte& Gerald Schubert, Cambridge University Press;
3. 2nd edition
4. Physics of the Earth: by Frank D. Stacey & Paul M. Davis, Cambridge University Press; 4rth edition

Reference Books

1. The Solid Earth: An Introduction to Global Geophysics: by C. M. R.Fowler, Cambridge University Press; 2nd edition
2. Global Tectonics: by Philip Kearey, Keith A. Klepeis, Frederick J. Vine, Wiley-Blackwell; 3rd edition
3. An Introduction to Seismology, Earthquakes and Earth Structure: by Seth Stein & Michael Wysession, Wiley-Blackwell; 1st edition

ES463 BIOSPHERE AND HYDROSPHERE (3-0-0) 3 credits

ES464 GAS DYNAMICS (3-0-0) 3 credits

Conservation laws – Euler's Equations – Common Equations of State – Hydrostatic Equiibrium – Isothermal sphere – Virial Theorem – linear perturbation theory – acoustic waves – Jeans' instability – Rayleigh Taylor instability – de Laval nozzle - Parker wind solution – Bondi accretion – Shock waves– Sedov solution – elements of plasma physics - Debye screening – orbit theory - elements of MHD – flux freezing – Alfven waves - Langmuir oscillations – dispersion relation of electromagnetic waves propagating in plasmas- plasma instabilities - transport phenomena

Text/ Reference:
1. F.H. Shu, The Physics of Astrophysics vol II: Gasdynamics, University Science Books.
2. M.J. Thompson, An Introduction to Astrophysical Fluid Dynamics, Imperial College Press.
3. Arnab Rai Choudhuri, The Physics of Fluids and Plasmas, Cambridge University Press.
4. Francis F Chen , Introduction to Plasma Physics and Controlled Fusion, Springer

ES465 NUMERICAL WEATHER PREDICTION AND MODELING (3-0-0) 3 credits

Introduction: Numerical Weather Prediction as an Initial Value Problem, Filtering Problem, Finite Difference Techniques, Explicit, Implicit, and semi-implicit Schemes. Spectral Technique, Galerkin methods, CFL conditions and stability analysis, Staggered grid, Nonlinear Instability and Aliasing.

Introduction: Basic of atmospheric models, types of model (physical, stastistical, etc)

Introduction to Hierarchy of Numerical Models: Barotropic Model, Equivalent Barotropic Model, Two level Baroclinic Model, Shallow Water Equation Model, Primitive Equation Models.

Discussion of the governing laws of primitive equation models (no need of derivations as that was done in the previous semesters).

Numerical representation of atmospheric and oceanic equations (Finite-difference versus spectral models; Time-stepping and numerical stability; Staggered grids and other grids)

Parameterization of small-scale processes: Physical Process, Parameterized processes, Parameterization of sub grid scale process, Parameterization of Convection, Clouds, and Micro Physics, and overview of the parameterization of other physical processes (surface fluxes, boundary layer, radiation, land surface, sea-ice and snow)

High Resolution Modeling: Basic, Capabilities, Limitations, and Interpretation

Resolution, Accuracy, Efficiency, and Computational Cost

Climate Simulation and Climate Drift

Verification and Validation of Climate Model

Text and Reference Books:

1. An Introduction To Three-Dimensional Climate Modeling, By Warren M. Washington, Claire L. Parkinson
2. An introduction to Numerical Weather Prediction Techniques, By T. N. Krishnamurti and L. Bounoua
3. Climate Change and Climate Modeling, By J. David Neelin

ES466 EARTH OBSERVATION FROM SPACE (3-0-0) 3 credits

Fundamentals of Earth Observation from Space - Satellite payloads and imagery, satellite orbits, platforms, imaging techniques, Field of view, pixel, spatial resolution, scan line, navigation, registration, revisit time. Rayleigh and Mie scattering of solar radiation in the earth's atmosphere; Spectral dependence of surface reflectance in different surface types (e.g., ocean, thick vegetation, desert, ice) in the visible and near-IR.

Fundamental radiation transfer equations: For satellite-measured radiance due to scattered and reflected solar radiation from the earth-atmosphere system; emitted radiation from earth's surface.

Characteristics of the passive and active remote sensing techniques: Techniques and ideal spectral bands for passive remote sensing of surface types, vegetation, ocean surface temperature and chlorophyll, and atmospheric constituents (minor constituents, aerosols, and clouds) using visible and IR radiometry. Inversion techniques for retrieval of geophysical parameters from satellite data.

Remote sensing and tracking of weather systems using satellite observations: Fog, convective systems, lows, depressions, cyclones Microwave remote sensing of surface and atmospheric parameters Active remote sensing of clouds and surface winds using microwave radars Atmosphere Soundings – Temperature, Humidity

Physical Oceanography : Sea surface heights, currents, waves. Cryosphere – Polar Science (surface extent, snow height, glacier, snow water equivalence, seasonal snow cover)
Hydrosphere : Precipitation, Soil Moisture Calibration and validation techniques (CAL/VAL)

Case study: Tracking of a cyclone using visible and IR remote sensing data obtained from geostationary satellite.

ES467 SOLAR TERRESTRIAL RELATIONS (3-0-0) 3 credits

ES468 ESTIMATION AND STOCHASTIC PROCESS (3-0-0) 3 credits

Elements of probability theory - random variables-Gaussian distribution-stochastic processes-characterizations and properties-Gauss-Markov processes-Brownian motion process-Gauss-Markov models - Optimal estimation for discrete-time systems - fundamental theorem of estimation-optimal prediction.
Optimal filtering - Weiner approach-continuous time Kalman Filter-properties and implementation- steady-state Kalman Filter-discrete-time Kalman Filter-implementation-sub-optimal steady-state Kalman Filter-Extended Kalman Filter-practical applications.
Optimal smoothing - 0ptimal fixed-interval smoothing optimal fixed-point smoothing-optimal fixed-lag smoothing-stability-performance evaluation.

ES469 ASTRONOMICAL TECHNIQUES (3-0-0) 3 credits

Telescopes and Detectors – optical, infrared, radio, x-rays, gamma-rays, neutrinos and cosmic rays; Gravitational radiation; Detection of dark matter and Dark Energy Astronomy from Space; Imaging – focal plane imagers, PSF and deconvolution, interferometry Photometry, Spectroscopy, Polarimetry, Astrometry; Solar telescopes; Surveys, Astronomical databases, Virtual Observatory
Text/ Reference Books
1.C.R. Kitchin, Astrophysical Techniques, CRC press.
2.M. Longair, High Energy Astrophysics vol 1, Cambridge University Press.

ES470 RADIATION PROCESSES IN ASTROPHYSICS (3-0-0) 3 credits

Concepts of Radiative Transfer – special relativity – Maxwell's equations – Wave equation – retarded potentials – radiation field – Poynting vector – radiation from accelerated charge – bremsstrahlung – Thomson and Compton scattering – synchrotron radiation – thermal and non-thermal distribution of radiating particles – non-thermal synchrotron radiation – self-absorption – synchrotron and Compton cooling – Inverse Compton catastrophe and brightness temperature limit – propagation effects: dispersion, faraday rotation, depolarization – Atomic and molecular spectra – fine structure and hyperfine transition

Text/ Reference Books

1.G.B. Rybicki and A.P. Lightman, Radiative Processes in Astrophysics, Wiley.
2. F.H. Shu, The Physics of Astrophysics vol I: Radiative Processes, University Science Books.
3. W.H. Tucker, Radiation Processes in Astrophysics.

ES471 STRUCTURE AND EVOLUTION OF STARS (3-0-0) 3 credits

Mechanical, Thermal and Nuclear time scales – Hydrostatic equilibrium (Newtonian and Relativistic) – Polytropic Equation of State – Lane Emden Equation – Degenerte matter Equation of State – White Dwafs and Chandrasekhar limit – Virial Theorem - Radiative Equilibrium – Schwarzschild convection criterion – nuclear energy generation – stages of nuclear burning – full set of stellar structure equations – example solutions – HR diagram and the main sequence – Schonberg-Chandrasekhar limit – post- main sequence evolution – Hayashi tracks – Horizontal branch – giant and asymptotic giant branches – planetary nebula formation – supernovae – compact objects.

Text/ Reference Books

1.R. Kippenhahn and A. Weigert, Stellar Structure and Evolution, Springer.
2. A. Weiss et al, Cox and Giuli's Principles of Stellar Evolution, Cambridge Scientific Publishers.
3. Dina Prialnik, An introduction to the theory of stellar structure and evolution, Cambridge University Press.
4. S. Chandrasekhar, An introduction to the Study of Stellar Structure, Dover.

ES472 COSMOLOGY AND ASTRO BIOLOGY (3-0-0) 3 credits

Universe at large scales – Homogeneity and Isotropy – Distance ladder – Expansion and redshift, Hubble's law – Newtonian cosmology – modifications due to relativity – equation of state of radiation, matter and dark energy – dark matter and the evidence of its existence – different eras of expansion – thermodynamics of the universe – primordial nucleosynthesis – cosmic background radiation – growth of density perturbations in dark matter and baryonic matter – struncture formation – imprints on CMB – description and interpretation of CMB observations – Supernova Ia distance-redshift data – evidence
of dark energy – future of the universe

Origin of life – prebiotic molecules and development of life forms – habitable zone – Mars and life – Icy bodies (Europa and others) – Titan's atmosphere – detection of exoplanets – search for extraterrestrial life.

Text/ Reference Books

1.J.V. Narlikar, An introduction to Cosmology, Cambridge University Press.
2.J.A. Peacock, Cosmological Physics, Cambridge Univrsity Press.
3.T. Padmanabhan, Course on Theoretical Astrophysics, vol. 3, Cambridge University Press.
4. I. Gilmour and M.A. Sephton, An introduction to Astrobiology, Cambridge University Press.

ES 473 DIFFUSED MATTER IN SPACE (3-0-0) 3 credits

Occurrence and state of cosmic diffuse matter – ionized, atomic, molecular gas and dust – heating and cooling, equilibrium phases – probes of diffuse matter (line and continuum radiations at various

wavelengths) – Thermal and ionization equilibrium of HII regions – UV shielding in molecular gas – extinction/reddening/polarization due to dust – dust heating and IR emission – star forming regions - cosmic rays and non-thermal synchrotron emission – recombination and re-ionization of IGM – Lyman alpha forest, Mg absorption systems – Gunn Peterson effect – Heating of intracluster gas – Sunyaev- Zeldovich effect – excess entropy problem and possible resolution

Text/ Reference Books

1.M.A. Dopita and R.S. Sutherland, Diffuse Matter in the Universe, Springer.
2. D.E. Osterbrock and G.E. Ferland, Astrophysics of Gaseous Nebulae and Active Galactic Nuclei,
University Science Books.
3. L. Spitzer, Physical Processes in the Interstellar Medium, Wiley.
4. D. Mihalas and J. Binney, Galactic Astronomy, Princeton University Press .
5. J.E. Dyson and D.A. Williams, The Physics of the Interstellar Medium, IOP publishing.

ES474 HIGH ENERGY ASTROPHYSICS (3-0-0) 3 credits

Radiation-matter interaction – Sources of high energy (UV-gamma rays) radiation in the universe - Detectors for high energy particles, X-rays, gamma rays and neutrinos – Space astronomy - Elements of General Relativity - compact stars – magnetospheric processes around neutron stars (pulsars and magnetars) – interacting binaries – Roche potential and accretion – Shkura-Sunyaev thin disk model – accretion phenomenology around compact objects – stellar mass black holes vs supermassive black holes – AGN phenomenology and unified scheme – Jet production and superluminal motion – Supernova remnants and shock acceleration of relativistic particles – Gamma Ray Bursts

Text/ Reference Books

1.M. Longair, High Energy Astrophysics, vol. 1 and 2, Cambridge University Press
2. F. Melia, High Energy Astrophysics, Princeton University Press
3. Ya B. Zeldovich and I.D. Novikov, Relativistic Astrophysics, vol. I, Stars and Relativity

ES475 GALAXIES (STRUCTURE, DYNAMICS AND EVOLUTION) (3-0-0) 3 credits

Classification of galaxies – contents and dimensions – collisionless stellar dynamics – relaxation time, dynamical friction, violent relaxation – galactic potential and orbits – spiral density wave and Lindblad resonance – rotation curves – Tully-Fisher relation – Central Black

Holes and fundamental plane relationship – Mass and Luminosity function – Press Schechter formalism – Star formation history and chemical evolution – active galaxies and activity duty cycle – galaxies at high redshift - clusters and groups – evidence of dark matter

Text/ Reference Books

1.L.S. Sparke and J.S. Gallagher, Galaxies in the Universe, Cambridge University Press.
2. J. Binney and S. Tremaine, Galactic Dynamics, Princeton University Press.
3. J. Binney and M. Merrifield, Galactic Astronomy, Princeton University Press.
4.A.K. Kembhavi and J.V. Narlikar, Quasars and Active Galactic Nuclei: An Introduction, Cambridge
University Press.

ES476 SOLAR SYSTEM SCIENCE (3-0-0) 3 credits

Origin of the Solar System; Solar system objects (Sun, planets, satellites, dwarf planets, comets, asteroids) Age of the solar system - Nucleosynthesis-Abundance of the elements and Distribution in the solar system Sun-Solar activity- solar wind- solar flare - Solar wind interaction with interplanetary medium - solar system bodies. Tides and tidal dissipation:

The Roche Limit Origin of the earth-moon system Radioactive decay – internal heating of solar system objects – radionuclide dating methods- time scales of formation of solar system objects .Remote sensing of surface of solar system bodies – evolution of solar system bodies . Interiors of the terrestrial planets - Atmospheres of the terrestrial planets –comparative . Planetology (Mercury, Venus, Earth and Mars) The gas giants: chemical and physical make-up – The gas giants: thermal balance and atmospheres - Physics of ice, icy satellites and ring systems - Comets and their significance: the Oort cloud and the Kuiper Belt - Asteroids: their Origin, composition and distribution in time and space -Meteors and meteorites Fate of the Sun and Solar System- Red Giant.

Text Book :

Physics and Chemistry of the Solar System, JS Lewis, Academic Press, Rev Ed.

References:

1.Moons and Planets, W.K. Houtmann, Wadsworth Publishing Company 4th Ed.
2.Planet Earth, C Emiliani, Cambridge University Press
3.Planetary Sciences, Imke de Pater and Jack J Lissauer, Cambridge University Press

ES477 IMAGE INTERPRETATION AND DIGITAL IMAGE PROCESSING (3 - 0 - 0) 3 credits

Principles of visual interpretation – Visual interpretation keys; Digital image data collection, data formats, storage considerations; Characteristics of remotely sensed data;
Image Pre-processing – Radiometric errors – sources and correction. Geometric error – sources and correction – Image registration;
Image enhancement – Spatial Domain – Frequency Domain;
Image Compression - Multispectral transformations - Principal component analysis – Band ratio – vegetation indices – tasseled cap transformations; Univariate and multivariate statistics Classification – unsupervised classification- clustering – segmentation- supervised classification – maximum likelihood – minimum distance to mean- parallelepiped- accuracy assessment;
Advanced data processing – contextual classification –support vector classification – neural network – sub pixel analysis – Object oriented classification - hyperspectral image processing –multisensor fusion;

Textbook :

Richards J.A. and Jia.X, Remote sensing digital image analysis: an introduction, Birkhäuser, 2006

References:

1. Mather P.M. , Computer Processing of Remotely sensed Images 3rd edition, John Wiley and Sons 2008
2. Jensen J.R., Introductory digital image processing: a remote sensing perspective (3rd edition), Prentice Hall series in geographic information science, 2005
3. González R.C. and Woods R.E., Digital image processing (3rd edition), Prentice Hall,2008
4. Schowengerdt R.A., Remote sensing: models and methods for image processing (3rd edition), Academic Press, 2007.

ES478 OPTICAL SENSORS (3-0-0) 3 credits

ES479 GEOGRAPHIC INFORMATION SYSTEM (3 - 0 - 0) 3 credits

Introduction to Geographic Information System (GIS) – Hardware – Software – Data types and models – Input / output techniques in GIS (spatial and non-spatial) – Digitizing – Editing – Topology creation – Non-spatial database creation – Spatial analysis (vector and raster) – Overlay analysis - Buffer analysis – Network analysis – DEM – 3D analysis – Visualization – Global Positioning System (GPS) – National Spatial Data Infrastructure (NSDI) – Decision support systems – WebGIS – Enterprise GIS.

Text Books:

1. Lo C.P. and Yeung A.K.W., Concepts and Techniques of Geographic Information Systems, Second Edition, Prentice Hall, 2006.
2. Burrough P.A. and McDonnell R.A., Principles of Geographical Information Systems, Oxford University Press, 1998
3. DeMers M.N. , Fundamentals of geographic information systems (4th edition, Wiley,2008.
4. Wilson J.(ed) , The Handbook of Geographic Information Science, Wiley-Blackwell, 2007.

ES480 INTRODUCTION TO PHOTOGRAMMETRY (3 - 0 - 0) 3 credits

Basics of cameras, films, filters, projection, scale, parallax – Surveying concepts and instruments – Mathematical photogrammetric principles (Orientation : Interior Orientation / Exterior Orientation / Relative Orientation / Absolute Orientation) – Analog vs Analytical vs Digital Photogrammetry - Photogrammetric camera and calibration – Collinearity and coplanarity – Analytical model creation - Numerical methods and least square adjustment – Triangulation – Image blocks – Image model and simulation – Satellite based digital photogrammetry – Stereo coverage – Linear array sensors – Push broom – Three line scanners – Panoramic linear array – Orbital parameters – Modelling – Stereogenerator – Control equipment for satellite triangulation – Hardware and software packages for satellite photogrammetry.

ES481 MICROWAVE REMOTE SENSING (3 - 0 - 0) 3 credits

Basics of Microwave Remote Sensing – Passive and active microwave sensors – Basic principles of RADAR observation; Imaging Radar Systems: SLAR – SAR – Geometric characteristics of RADAR – Radar image interpretation – Interferometric RADAR – Radargrammetry – Polarisation – Polarimetric SAR.

ES482 CARTOGRAPHY AND NAVIGATION (3 - 0 - 0) 3 credits

Principles of cartography - Geographic phenomena – Map projections and visualization - Mapping Standards - Hardware and software for Data Capture and Analysis -Thematic maps – Symbology– Scale and Generalization - Mapping points, Lines, areas and Volume– Map composition, Design and Compilation – Digital Maps - Webcartography - Cybercartography – Future Trends

Global Navigation Satellite Systems (GNSS) – Satellite Geodesy and Surveying - GPS, GLONASS, Galileo, IRNSS - Signal Acquisition and Tracking – Estimating Position, Velocity and Time – Sources of Error - Differential GNSS - Indoor and Weak Signal Navigation- Navigation Receivers and Software - Integration of GNSS and INS – Future Navigation systems

Text Books:

1. Slocum T.A., McMaster R.B., Kessler F.C. and Howard H.H., Thematic Cartography and Geovisualization (3rd Edition), Prentice Hall, 2008.
2. Robert G Cromley, Digital Cartography, Prentice Hall, Eaglewood Cliffs, New Jersey, 1992.
3. Robinson A.H., Morrison J.L., Muehrcke P.C., Kimerling A.J. and Guptill S.C., Elements of Cartography (6th edition), Wiley, 1995.
4. Bernhard Hofmann-Wellenhof, Global Navigation Satellite Systems: GPS, GLONASS, Galileo, and more , Springer, First Edition, 2007
5. Scott Gleason and Demoz Gebre-Egziabher (Eds), GNSS Applications and Methods, Artech House, 2009
6. Ahmed El-Rabbany, Introduction to GPS -The Global Positioning System, Artech House, 2002
7. Elliott D. Kaplan , Understanding GPS: Principles and Applications, Second Edition, Artech House, 2005

ES483 DATA ARCHIVAL AND MINING (3 - 0 - 0) 3 credits

Data flood, knowledge discovery, Machine learning, Learning as search, Decision trees, Rules, Rules involving relations, Instance based representation, Classification, Information gain and gain ratio, Dealing with missing values, Trees to rules, Evaluation and credibility, Cost sensitive learning, Clustering, Visualization, Data mining, Society privacy issues. Ontologies, Information Retrieval.

Books:

1. A.K. Pujari, *Data Mining Techniques,* Universities Press, 2010.

2. Han and Kamber, *Data Mining : Concepts and Techniques, 2nd Edition, Morgan Kaufmann, 2006.*

ES484 QUANTITATIVE METHODS IN REMOTE SENSING (3 - 0 - 0) 3 credits

Modelling and analysis of the following areas and topics: Leaf area retrieval -Net Primary Productivity (NPP) Calculation - Soil moisture estimation - Snow melt runoff prediction - Soil erosion and runoff modeling - Reflectance retrieval - Ocean chlorophyll and productivity - Land subsidence modeling - Seismic microzonation; Risk and vulnerability assessment - Forest growing stock estimation - Landscape matrix ecology - LST / SST / Wave and wind calculation - Gravity and sea-surface height anomaly

ES485 PHYSICS OF STARS (3 - 0 - 0) 3 credits

ES486 PLANETARY GEOSCIENCES (3-0-0) 3 credits

Solar System: majorconcepts, planets, satellites, asteroids, meteorites and comets; formation and internal differentiation of the planets; general features of Terrestrial and Jovian planets.

Planetary atmospheres; exo- and endogenic processes associated with origin and internal evolution of planets-planetary volcanism, craters, impactcratering processes, elemental composition; mineralogy and petrology; thermal, seismic and magnetic properties, and chronological techniques.

Earth as a reference material; geology and geophysics of terrestrial planets: mars, venus and mercury; comparative planetology of Jupiter, Uranus and Saturn and their satellites; physical properties, composition, mineralogy and petrology of the airlessrocky bodies: the Moon and its Terrestrial Analogues, Io, Phobos and Deimos, minor bodies such as asteroids, comets, meteor, meteoroid and meteorites.

Past, Present and future planetary exploration mission

RecommendedBooks(Text/References)

1. Taylor, S.R., McLennan. S.M., Planetary Crusts: Their Composition, Origin and Evolution, Cambridge University Press
2. Kelly Beatty, J., Petersen, C.C., Chaikin, A., The New Solar System, Cambridge University Press
3. Lewis, J.S., Physics and Chemistry ofthe Solar System, Academic Press
4. Hartmann, W.K., Moons &Planets, Wadsworth Publishing Company

ES 487 LIDAR REMOTE SENSING (3-0-0) 3 credits

LIDAR remote sensing - introduction to lasers and LIDAR, history of LIDAR development, LIDAR system components, characteristics of LIDAR data, LIDAR systems in development

LIDAR remote sensing platforms-airborne platforms, spaceborne platforms, ground-based platforms, bathymetric mapping systems

Georeferencing and calibration of LIDAR data - geodesy, datums, and coordinate systems, direct georeferencing technology, boresight calibration, LIDAR data preprocessing, quality control, LIDAR error budget, noise removal

Automated classification- layer extraction, automated filtering, manual editing and product generation- surface editing, hydrologic enforcement, Lidargrammetry, terrain data products

Quality assurance, quality control, and accuracy assessment- data validation, quantitative assessment, qualitative assessment, accuracy standards

LIDAR applications: topographic analysis- contour mapping, slope, aspect and hillshade, flood inundation analysis, line-of-sight analysis, Forestry- LIDAR and forests, measuring forests with LIDAR, basic forest metrics, 3D urban modeling-photogrammetry and LIDAR, terrestrial and airborne LIDAR fusion, mobile LIDAR mapping.

Textbooks Recommended:

Shan, J. and C. Toth, 2008. Topographic Laser Ranging and Scanning, Principles and Processing. Boca Raton, FL. Taylor & Francis Group. ISBN 9781420051421.
Maune, D. F., ed. 2007. Digital Elevation Model Technologies and Applications: The DEM Users Manual, 2nd edition. Bethesda, MD. American Society for Photogrammetry and Remote Sensing. ISBN 1-57083-082-7.

ES488 CLIMATE CHANGE (3-0-0) 3 credits

Fundamentals of Climate & Climate Change Science: Weather vs Climate, Environmental change concepts, Natural Climate Variations (slow and quick); Unnatural Changes (Ozone depletion and Global Warming); Over view of Climate and Twentieth Century Climate Change; Physics of the Greenhouse Effect and Global Radiation Budget; Greenhouse Effect of Trace Gases; Atmospheric Radiative Transfer - Albedo, Radiative forcing and climate Feedbacks, Aerosols, Clouds, Radiation interactions, Atmospheric Pollution and Visibility; Urban heat island effect and Urban Climate change; Hydrological cycle, Carbon cycle.

Twentieth Century Climate Changes: Science controversies past and present, The IPCC-AR Findings and their significance; The Strengths and Weaknesses of the AR conclusions; Global Dimming and its Masking Effect on Global Warming; Global Dimming and Brightening; The Atmospheric Temperature Trend Controversy & its Significance to the Climate Change problem; The water vapor feedback Controversy and how was it settled?; Rainfall trends and AR models failure to simulate the trends; Retreat of Glaciers - why are these so important, the melting Himalaya glaciers controversy; How unusual is the observed warming compared with past climates; Extreme weather events.

Impact: Potential impact on agriculture, coral reefs, health and on policy; Disaster Management and Technology, Extreme weather events, adaptability; Economics of climate change; Emission Trading; Monitoring and assessment of emissions; Requirements for planning India's national climate change policies

What can we do about Climate Change?: Past and future Policies and Protocols, Need for gloal cooperation; IPCC and UNFCC; Energy consumption & Limitations of "renewable energy"; Stabilization Wedges for CO_2; Geo-Engineering and problems with "geo-engineering"; Moral and Ethical Dilemmas.

Suggested reading

Frontiers of Climate Modeling, 2006; J.T. Kiehl and V. Ramanathan, Cambridge University press.
Global Physical Climatology, 1994. D. L. Hartmann
An Introduction to Solar radiation, Muhammad Iqbal, 1983.
An Introduction to atmospheric radiation, K.N. Liou.
IPCC-AR4 report

ES489 TROPICAL METEOROLOGY (3-0-0) 3 credits

Introduction and Overview

Energy and global climate, definition of the tropics, energy balance and role of the tropics – surface energy budget, meridional energy transport, vertical energy transport, vertical

structure of the tropical atmosphere – T, Q, MSE, P, Trade wind inversion, role of the tropics in momentum balance.

Tropical circulation: atmospheric component – Brewer Dobson circulation, Quasi-biennial oscillation, oceanic component (upper and deep ocean circulation)

Response to Equatorial Heating

Spatial Distributions of Moisture and Precipitation

Tropical Climate Variability: Diurnal Varibility, Intra-seasonal Variability (Equatorial Waves and MJO), Seasonal Variability, Inter Annual Variability, and Decadal Variability.

Monsoons (Indian, Australian, African, American)

Tropical Cyclones (Genesis, Intensification, Evolution, Dissipation, Structure, Motion, and forecasts)

Observation, Analysis, and Prediction: Challenges of tropical weather prediction, Weather Analysis,

Forecast Verification and Validation

Reference Study Materials:

1. Tropical Meteorology (Vol I and II), G. C. Asnani
2. Introduction to Dynamic Meteorology, J. R. Holton, Academic Books
3. Atmospheric Science – An Introductory Survey, J. M. Wallace and P. V. Hobbs
4. The Physics of Atmosphere, John Houghton
5. A collection of refereed research papers will be provided during the course.

ES490 UNIVERSE IN A NUTSHELL (3-0-0) 3 credits

Understanding the Night Sky: celestial coordinates (alt-azimuth, right ascension-declination), celestial time keeping - annual path of the Sun in the sky, annual motion of stars in the sky, equinoxes and solstices, lunar cycle.

Stars & Stellar Evolution: Sun from core to corona, solar activity cycle, solar weather, stars as blackbodies, stellar luminosity, stellar surface temperatures, stellar masses, distances to stars (parallax, inverse square law), magnitude system, color & temperature, star formation, energy generation in stars, stellar nucleosynthesis, evolution of low mass and high mass stars, planetary nebulae - white dwarfs, supernova - neutron stars, black

Milky Way & Beyond: Galactic structure & components, kinematics of the Galaxy, determining our location in the Galaxy, the SMBH at the Galactic center, estimating the mass of Sgr A*. Galaxy morphologies, Hubble classification scheme and general trends (stellar population, star formation rate, gas and dust content). Dynamics of spiral galaxies, rotation curves, dark matter, dynamics of elliptical galaxies.

Cosmology & Large Scale Structure: Galaxy groups, clusters, dynamical mass of clusters, dark matter, gravitational lensing as a probe of cluster mass, morphological evolution of galaxies, active galaxies, large scale structure of the universe. Expansion of the universe, Hubble's law, cosmological redshift, cosmic microwave background (observations & basic measurements), dark energy, early universe and primordial nucleosynthesis.

Extrasolar planets [optional]: Detection techniques for extrasolar planets, properties of

extrasolar planet, detection of exoplanet atmospheres, biomarkers, Drake equation & life elsewhere

[1] An Introduction to Modern Astrophysics, Bradley W. Carroll & Dale A. Ostlie, Addison-Wesley, 2006, ISBN-10: 0805304029

[2] Astrophysics for Physicists, Arnab Rai Choudhuri, Cambridge University Press, 2010, ISBN-10: 0521815533

ES491 INTRODUCTION TO PLANETARY GEOCSCIENCE (3-0-0) 3 credits

Solar System: major concepts, planets, satellites, asteroids, meteorites and comets; Formation and internal differentiation of the planets; general features of Terrestrial and Jovian planets.

Planetary atmospheres; exo-and endogenic processes associated with origin and internal evolution of planets- planetary volcanism, craters, impact cratering processes, elemental composition; mineralogy and petrology; thermal, seismic and magnetic properties, and chronological techniques.

Earth as a reference material; geology and geophysics of terrestrial planets: mars, venus and mercury; comparative planetology of Jupiter, Uranus and Saturn and their satellites; physical properties, composition, mineralogy and petrology of the airless rocky bodies: the Moon and its Terrestrial Analogues, Io, Phobos and Deimos, minor bodies such as asteroids, comets, meteor and meteoroid.

Recommended Books (Text/References)

1. Taylor, S.R., McLennan. S.M., Planetary Crusts: Their Composition, Origin and Evolution, Cambridge University Press

2. Kelly Beatty, J., Petersen, C.C., Chaikin, A., The New Solar System, Cambridge University Press

3. Lewis, J.S., Physics and Chemistry of the Solar System, Academic Press

4. Hartmann, W.K., Moons & Planets, Wadsworth Publishing Company

ES492 PROCESSING OF SATELLITE REMOTE SENSING DATA (3 - 0 - 0) 3 credits

Concept of Signatures; Remote Sensing systems; Data acquisition from space; Raw data and the associated errors; Examples of Satellite raw data; Satellite Data Processing – definition, need; Data after different stages of processing (2)
Satellite orbits – Kepler's Laws of Planetary motion – Orbital elements- Conversion of orbital elements to inertial coordinates and vice versa;Shape of the Earth; Actual gravitational field of earth; concept of Julian time, sidereal angle, geodetic coordinates; (3)
Equations of motion – inertial system of coordinates – Orbit determination done at the ground station- Concept of subsatellite point and ground trace (2)

Basic Numerical Analysis for solution of Systems of Differential Equations – Runge Kutta Method – Propagation of state vector from epoch to any desired time (1)
Concept of Attitude of Satellite- impact of positive and negative roll, pitch and yaw on the image
Different types of sensors used - Pushbroom, whiskbroom, 2 D array, mirror scan - Concept of integration time, instantaneous Field of View, Quantisation - Resolution – spatial, temporal, radiometric and spectral; (3)
Choice of orbits – low earth orbiting – sun synchronous – definition – need and how to achieve the same - Geostationary orbits leads to Geosynchronous orbits- exact choice of orbit is determined by sensor characteristics like integration time, focal length etc – difference in the ground trace of sun synchronous orbits, geostationary and geosynchronous orbits - Use of STK to visualise all these cases (4)
Basics of Image Processing - What is an image; gray level; Histogram of image,enhancement of images; (1)
Fourier Transforms - Nyquist sampling theorem- Resampling techniques - different types of Resampling kernels – Digital implementation of Resampling techniques -Transformation of images – zooming, rotation, etc. (8)
Radiometric Calibration – Radiometric errors - Striping - reason for the same; how they are corrected (1)
Geometric errors- meaning – source of geometric and imaging errors- depends on the payload (imaging mechanism)/satellite characteristic -Earth rotation error– panoramic distortion error-servo error-stagger error; attitude related error (1)
Basic philosophy of geometric correction - Earth Rotation Correction, Attitude correction, stagger correction

Mathematical Modelling involved in Geometric Correction; Look Point Equation-
3 D Geometry - Planes, lines, angle bisectors etc. (2)
Case study of IRS payloads and INSAT payloads - LISS geometry and scan mirror geometry. (4)
Other ancillary information needed with the products like sun azimuth, Elevation, satellite azimuth, elevation – define and how to calculate them – (develop software for them) (1)

Map Projections – need and why so many? - (develop software for some simple projections) (2)
Generation of tick marks
Validating products - Define Ground Control Points GCPs – check accuracy of products with Ground Control points (2)
Use of GCPs for generating corrected products from radiometrically corrected data – Automatic matching of ground control points using the method of correlation – Sum of squares of deviation - warping of images – least squares method; Goshtasby transformation (develop software)
Mosaicing of images – radiometric normalisation; location of tie points; establishing the geometrical transformation; generation of seamless mosaic image (4) Overlay of continental boundaries - rasterisation of the vector data (develop software)(2)
Formats of finished products – geotiff, hdf, buffer (2)

REFERENCES:

1. Remote Sensing Models - A Schowengerdt
2. Remote Sensing of the Environment An Earth Resource Perspective – Jensen
3. Introduction to Remote Sensing – George Joseph
4. Manual of Remote Sensing
5. Orbital Mechanics – Escobal
6. Image Processing – Gonzales and Wintz

ES493 HYPERSPECTRAL REMOTE SENSING (3 – 0 -0) 3 credits

Examination of popular multispectral sensors' bandwidths and comparison with spectral signatures of typical surface features, development of hyperspectral remote sensing, AVIRIS,

CASI, DIAS, Hyperion, Proba-1 etc., reflectance spectrometry, field and lab spectroradiometers,
pre-processing of hyperspectral imagery: atmospheric calibration/correction, spectral correlation
and data redundancy, dimensionality reduction and feature selection, endmember extraction – PPI, N-FINDR, hyperspectral band ratios and vegetation indices, hyperspectral image classification methods: spectral angle mapper, spectral information divergence, constrained energy minimization, spectral feature fitting, band depth analysis, support vector machines, applications of hyperspectral remote sensing: vegetation biophysical and biochemical parameters, soil properties, mineral identification, water quality assessment, material identification and mapping, anomaly detection, reference spectral libraries- USGS, and ASTER spectral libraries.

Textbook:

1. Hyperspectral Remote Sensing: Principles and Applications by Marcus Borengasser, William S. Hungate, and Russell Watkins, CRC Press.
2. Techniques and Applications of Hyperspectral Image Analysis by Hans F. Grahn and Paul Geladi, Wiley & Sons Ltd.
3. Hyperspectral remote sensing of tropical and sub-tropical forests by Margaret Kalacska and G. Arturo Sanchez-Azofeifa., published by CRC Press.
4. Hyperspectral data exploitation: theory and applications by Chein-I Chang,Wiley & Sons Ltd.

ES 494 GENERAL RELATIVITY AND COSMOLOGY (3-0-0) 3credits

Principles of Relativity:

Overview of Special Relativity, spacetime interval and Lorentz metric, propertime, action for free particle, relativistic dynamics, four vectors, electrodynamics in 4 dimensional language. Introduction to general relativity (GR), equivalence principle, gravitation as a manifestation of the curvature of spacetime.

Geometrical Framework of General Relativity:

Curved spaces, tensor algebra, dynamics of particles and affine connection, covariant derivatives and parallel transport, Physics in curved spacetime, Curvature - Riemann tensor,Bianchi identities, Action Principle, Einstein's field equations, Energy momentum tensors,Spacetime symmetries and Killing vectors, energy-momentum tensor for a perfect fluid,connection with Newton's theory.

Solutions to Einstein's Equations and their Properties:

Spherical symmetry, derivation of the Schwarzschild solution, test particle orbits for massive and massless particles. The three classical tests of GR, Black holes.

Cosmological Models:

Universe at large scales – Homogeneity and isotropy – distance ladder – expansion and redshift - Cosmological Principle - Robertson-Walker metric - Hubble's law- Observable quantities – luminosity and angular diameter distances, Dynamics of Friedman- Robertson-Walker models: Solutions of Einstein's equations for sources with p = □ and w = −1, 0, 1/3, discussion of closed, open and flat Universes.

Physical Cosmology and Early Universe:

Thermal History of the Universe, distribution functions in the early Universe – relativistic and non-relativistic limits; Decoupling of neutrinos and the relic neutrino background; Nucleosynthesis; Decoupling of matter and radiation ; Cosmic microwave background radiation

(CMB); Inflation – Origin and growth of Density Perturbations; Formation of galaxies and large scale structures; Anisotropies in CMB; The Intergalactic medium and reionization.

Text Books:

1. Cosmological Physics, Cambridge University Press, J . A. Peacock
2. An Introduction to Relativity, J. V. Narlikar, Cambridge University Press, 2010 (For the lectures on General Relativity and Cosmology).
3. Theoretical Astrophysics, Volume III: Galaxies and Cosmology, T. Padmanabhan,Cambridge University Press, 2002 (for lectures on Cosmology)

References:

1. Classical Theory of Fields, Vol. 2, L. D. Landau and E. M. Lifshitz, Oxford : Pergamon Press, 1994 (For more material on General Relativity).
2. Introduction to Cosmology, J. V. Narlikar, Cambridge University Press, 1993 (For the lectures on Cosmology).
3. First course in general relativity, B. F. Schutz, Cambridge university press, 1985 (For material on General Relativity).
4. Structure Formation in the Universe. T. Padmanabhan, Cambridge University Press, 1995 (for material on Cosmology and Structure formation).