Space and Atmospheric Sciences

Education Curriculum

Physical Research Laboratory
Ahmedabad

January 2008

INDEX

Contents

Annexures

MODIFIED CURRICULUM FOR CSSTEAP POST GRADUATE COURSE ON SPACE AND ATMOSPHERIC SCIENCES

Preface

Space technology has given new dimensions to the understanding of earth's processes, which has proved to be a means for improvement of quality of life of the people, and preserving the ecological balance the same time. All countries should have access to space technology and must share the benefits. An essential pre-requisite to partaking in these opportunities is the building of various indigenous capabilities for the development and utilization of space science and technology. In recognition of such a pre-requisite, a consensus has emerged within the international community that if effective assimilation and appropriate application of space technology are to succeed in the developing countries, devoted efforts must be made at the local level, for the development of necessary expertise in space technology fields. Towards this end, the United Nations General Assembly has called for the establishment of Centres of Space Science and Technology Education at the regional level in the developing countries.

The Centre for Space Science and Technology Education for Asia and the Pacific (CSSTEAP), affiliated to the United Nations, was established in India in November 1995. The principal goal of the centre is the development of skills and knowledge of university educators and research and application scientists, through rigorous theory, research, applications, field exercises and pilot projects in those aspects of space science and technology that can enhance social and economic development in each country. The Post Graduate course in Space and Atmospheric Sciences is one of the four post graduate courses run by the Centre. The CSSTEAP Post Graduate Course in Space and Atmospheric Sciences is being conducted once in two years at the Physical Research Laboratory (PRL), Ahmedabad. So far five courses have been conducted and 51 participants from 14 countries benefited by these education programs. Out of these 14 countries 13 are from Asia-Pacific region, and one from outside. (Table-1)

The Education programme in Space and Atmospheric Sciences is organized in two phases, Phase I and Phase II. The phase I, which is of nine month duration is conducted at CSSTEAP centre, and consists of 5 modules. While modules 1 and 3 deal with theory, modules 2 and 4 include various laboratory experiments. Module 5 consists of a pilot project to give the participants hands on experience on problems of interest to their respective countries.

The structure of the syllabus of the course has been prepared by UN – OOSA. The draft syllabus has been prepared by CSSTEAP in India and ratified by UN-OOSA. With passage of time, importance of different sections of the course has changed and some chapters need to be strengthened and some others need to be dealt with lesser stress. While the overall course curriculum remains same as established by UN, a Board of Studies (BOS) consisting of experts from the relevant field, reviews the course content, at the end of each course, taking into account student and faculty feed back as well. Based on the recommendation of the BOS, the syllabus is fine tuned for each subsequent course. Curriculum development is a continuous process that should take into account, among other things, various technological development, new emerging application scenario and feedback received from the faculty and students.

A special committee has, therefore, been constituted by the Director CSSTEAP to look in to the syllabus and suggest suitable modifications so that the syllabus could take into account the advancement in the field and the regional requirement. (Annexure II)

REPORT OF THE COMMITTEE APPOINTED BY THE DIRECTOR CSSTEAP TO REVIEW THE CURRICULUM FOR THE PG COURSE ON SPACE AND ATMOSPHERIC SCIENCES

1. Introduction

Since the dawn of civilization man has been curious about the cosmos and his own place in the universe. Looking at the bright Sun during the day and Moon and other shining objects in the night sky, he has wondered what they are, how far they are, how did they come into existence and from where do they get energy to shine continuously. Similarly man has always been curious about the origin, age and atmosphere of his home planet namely the Earth. Till as recently as 200 years ago, man's knowledge of the universe was limited to that of nearby planets of the solar system and stars in our own Milky Way. There was no understanding about the interior of the earth, its composition, age and nature of its atmosphere. The extent of the observable universe was confined to our Milky Way. Invention of telescope, spectrometers and other measuring instruments, has brought about a revolution in the last two hundred years in our understanding of the Earth, Moon, Planets, stars and other heavenly bodies. Discovery by Edwin Hubble in the early part of the twentieth century that many of the fuzzy nebular objects in the sky are Galaxies like our own that are receding with high velocity, immediately suggested that the universe is expanding and that it was born in a cosmic explosion many billions years ago. Accidental discovery of the Cosmic Microwave Background (CMB) that has a Black Body like spectrum with temperature of 2.73 K, in mid sixties provided a strong observational support for the origin of the Universe in a Big Bang about 13 billion years ago. This was further reinforced by precise measurement of the temperature of the CMB by space experiments flown on COBE (Cosmic Microwave Background Explorer) and WMAP (Wilkinson Microwave Anisotropy Probe) satellites.

Advent of space age made it possible for the mankind to send satellites and space probes outside the earth's atmosphere to remotely probe all the parts of our own planet Earth and farthest regions of the cosmos. Till 1950 most of this knowledge was derived from the earth based observations made in the visible band. Discovery of radio emission from cosmic sources opened up the invisible window of Radio waves to study the universe. Launching of space based instruments led to the birth of Space Astronomy and its various disciplines like Infrared astronomy, Ultraviolet astronomy, X-ray astronomy and Gamma –ray astronomy which are inaccessible from the earth due to the opaqueness of atmosphere to the radiation at these wavelengths. For the first time man could explore the mysteries of the Invisible Universe and study the birth, evolution and death of the stars and galaxies from observatories orbiting the earth. Infrared window enabled study of stars at their birth and in their infancy. Normal and active Galaxies located at cosmological distances i.e. close to the time of the birth of the universe, appear brightest in the infrared as the enormous speed with which they are moving away shifts their light to longer wavelengths. Center of our Milky Way and other regions obscured due to dimming of visible light by the dust and gas, are made visible by infrared sensitive instruments in space. Glimpse of the high energy universe with new radiation processes and violent events that occur in the nearby and farthest parts of the cosmos, is best obtained with X-ray and Gamma-ray telescopes. Credible evidence for the existence of exotic objects like the Black Holes and Neutron stars has been provided by space observatories with X-ray and Gamma-ray sensitive instruments. The most energetic explosions in the universe known as Gamma-ray Bursts, were discovered by chance from satellites meant for detecting man made nuclear explosions on the earth. Discovery of Quasars, Radio Galaxies, Far-off Normal Galaxies etc that have very high Red Shift ie.

the wavelength of their radiation has shifted to very long wavelengths, has enabled astronomers to probe most distant parts of the universe that corresponds to the time close to the birth of the universe. Hubble Space Telescope orbiting the earth has made major contributions to the study of the distant and early universe.

Earth orbiting satellites with highly sensitive detectors of visible, near-infrared and microwave radiation , are continuously staring at all parts of the earth's surface and its atmosphere and measuring their various characteristics in all the three dimensions. Satellite-borne magnetic sensors and charged particle detectors have mapped precisely the magnetic field of the earth and distribution of the charged particles trapped by it leading to a vastly improved understanding of the radiation environment of the earth and its vicinity. Major advances in the knowledge and understanding of the geology and geophysics of the earth have resulted from the space observations. The structure and composition of the earth's atmosphere, its major and minor constituents, their variation with time due to natural and man made activities , have been derived from the satellite based studies. Ozone is an important constituent of the atmosphere that absorbs the solar ultraviolet rays thus shielding life on the earth from its harmful effects. Discovery of severe depletion in the abundance of ozone over the Antarctic zone (known as Ozone Hole) due to release of huge quantities of man made halogen containing gases like Freon etc. was made from space observations. This alerted the mankind about the dangers posed to its existence by chemical pollution created by it and resulted in the initiation of measures for preventing release of ozone damaging chemicals. Satellites are providing the most reliable data on the abundances of Carbon-di-oxide (CO_2), methane , nitrogen dioxide and other molecules that are thought to be responsible for the heating of the atmosphere and are known as 'Greenhouse gases'. Space studies have thus vastly advanced the frontiers of fundamental knowledge about the earth and atmospheric sciences.

Solar X-rays and Ultraviolet radiation falling on the upper layers of the atmosphere, break-up the molecules and atoms in the atmosphere i.e ionize them, producing what is known as Ionosphere that is important for communication through the radio waves. Extent of the Ionosphere and its characteristics like electron density, temperature etc varies with the solar activity which in turn affects radio communication. Earth's magnetic field is contained in a spherical cavity known as Magnetosphere. It was discovered from early satellite measurements that a stream of plasma known as 'Solar Wind", largely consisting of protons and electrons , is blowing away at a speed of several hundred km. per second from the Sun and is impinging on the magnetosphere. This drags away part of the magnetosphere that is on the opposite side of the Sun creating a Geotail. Solar flares and Coronal Mass Ejections (CMEs) also occur sporadically on the Sun producing huge flux of charged particles. When these arrive near the earth, they cause geomagnetic storms, precipitation of the particles from the Radiation Belts and profoundly change the characteristics of the ionosphere. This results in 'Radio Blackout' and disruption of radio communication on the earth. Satellites in earth orbits are also some time crippled by severe solar storms due to radiation damage to their instruments. Even power stations on the earth are some times knocked out by very big flares on the Sun. A new discipline of "Space Weather" has come into existence that aims at monitoring and understanding of radiation and magnetic environment in the interplanetary space and magnetospheric region. Understanding of Space Weather and its prediction is important to take suitable measures for the prevention of damage to the satellite systems.

Studies of the various disciplines of Space Sciences, including astronomy and astrophysics, in the training program and in graduate studies curriculum is thus very important for generating human resource for research as well as technical work in various spheres of human activities.

2. Importance of Space Sciences Studies for Developing Countries:

Application of knowledge derived from space platforms has made major contributions to the welfare of mankind. Earth observing satellites have provided the most accurate topographical maps of the earth, the oceans and the various geological features. The most precise estimates of the earth's resources, its forest cover, water bodies etc have been derived from maps obtained from remote sensing satellites. Changes in the forest cover and their degradation, use of land and water resources, estimates of production of various grains etc. are today routinely derived from space imagery. At the time of natural calamities like floods, cyclones, earthquakes, volcano eruptions, forest fires etc. the satellite images provide an accurate estimation of the affected areas and population to plan appropriate relief measures. In the urban planning and optimal use of resources the remote sensing data are of crucial importance. Communication satellites in the geostationary orbits have revolutionized the broadcasting and television services as well as voice communication. This has made education accessible to people located in remote areas as well as spread knowledge and awareness about hygiene, environment, health and nutrition to socially and educationally disadvantaged groups. Global Positioning Satellites (GPS) system has made a tremendous impact in almost all spheres of human life. Global Warming is a topic of great concern to the entire mankind and space observations and measurements are crucial to assess its near and long term impact. Prediction of near term weather is critically dependent on the data from weather satellites. Thus there is hardly any sphere of human activity that has not been touched by space science.

Astronomy and Astrophysics is also an integral part of space science as discussed earlier. Study of this is important as it addresses some of the most basic and profound questions like the origin of the universe ,its evolution and ultimate fate, origin and formation of the solar system including the earth; origin of the life on the earth and is there life elsewhere in the universe. Answering these questions is a great intellectual challenge to the entire human race and it is only appropriate that all the nations participate in this exciting adventure.

Exposure and knowledge of space science, including astronomy, trains one to handle different kinds of scientific and technological problems that one encounters in many spheres of human activity.

3. Considerations in Revision of the Curriculum for the Sixth Course:

The following considerations have gone into revising the curriculum for the Sixth Course in Space and Atmospheric Science (SAS):

(1) It should be kept in mind that the course is of 9 month duration and students with varying background and different level of knowledge of Physics are enrolled in the course. Stress should therefore, be laid on topics related to space science and these should be covered to provide a broad perspective of the subjects.

(2) The main objective of the course is to impart a broad knowledge of different subjects and disciplines of the SAS. The course should emphasize basic knowledge of the subject being taught, required theoretical tools, present status of the field emphasizing recent developments, experimental techniques used to obtain the data, methodology of observation and data analysis methods for deriving the results. Rather than giving an in depth exposure of any topic, the course should provide a broad knowledge of the theoretical and experimental aspects of different topics without too much technical details, so that the student wishing to pursue further deeper study or

research in any topic, is well equipped to take it up by building upon the knowledge acquired in the course work.

(3) Students should be given adequate exercises in the course work so that they develop problem solving skills by applying the theoretical knowledge acquired in the course.

(4) Opportunities should be provided to the students to gain hands on experience of the excitement of different fields by active participation in experimental work or theoretical computational work. This will provide better understanding of the physical phenomenon or topic than only the class room teaching.

(5) Experiments should be so devised that, as far as possible, students are able to make observations themselves and have a proper understanding of the underlying principle of the experiment, methodology employed, data analysis tools and sources of errors.

(6) The course should be so structured that various topics covered under a paper have a coherence and connectivity. Following broad exposure of a topic and its scope, the essential theory of the subject should be taught, without too much detailed technical treatment, to familiarize the students with the essential physical principles of the subject.

(7) In paper 1 (SAS.101) the time allotted to different modules has been revised. A new module titled 'Aerosols, Greenhouse Gases and their effects on Radiation Budget' has been introduced and allotted 10 hours. This was considered necessary as this is a topic of great current interest and has strong link to Global Warming.

(8) Module dealing with 'Propagation of Electromagnetic Waves' has been shifted from paper 3 (SAS.103) in earlier curriculum and added to Paper 2 (SAS.102). The topic of Airglow has been shifted from Paper 2 to Paper 3. The time allotted for different modules of Paper 2 has been revised.

(9) The committee felt that one paper be devoted entirely to cover all aspects of experimental techniques employed in atmospheric science, ionospheric physics, airglow studies, plasma science, methodology of data analysis, statistical treatment of data and error analysis. Syllabus for Paper 3 with the title of "Measurement and Data Analysis Techniques" has been drafted by adding all the experimental techniques of papers 1, 2 and 4. Instruments and Techniques employed in Astronomy observations are generally of different type and will be taught as part of paper 6.

(10) It was noted that in the previous syllabus of Paper on Space Technology, a significant part of the course hours was devoted to the launch vehicles, spacecraft design and associated sub-system technologies. It is felt that this paper should emphasize Space Technology and Space Instrumentation from the view point of imparting knowledge for designing and building of space–borne instruments. Therefore too many technical details of the launch vehicles, building of spacecrafts and associated sub-systems need not be covered in the paper. A broad exposure to the different types of launch vehicles, different types of spacecraft designs and buses should be adequate. A major part of this paper should be devoted to the design considerations for payloads, the selection of materials and components for the space instruments, their test and qualification procedures etc. A major revision has been made in the syllabus of this paper.

(11) In Paper 6 (SAS.202) a new module entitled 'Solar System Exploration' with 5 hours of teaching time has been introduced to familiarize the students with the recent advances in exploration of planets and satellites with the space probes. The time allotted to different modules has been revised.

4. PROPOSED SYLLABUS STRUCTURE FOR SIXTH COURSE

4.1 Outline of the 6th Course

Paper Title	Topic	Contact hours
I Semester		
Theory		
SAS.101	Structure, Composition and Dynamics of Planetary Atmospheres	50
SAS.102	Ionospheric Physics	50
SAS.103	Measurement & Data Analysis Techniques	50
SAS.104	Basics of Space Technology and Space Instrumentation	50
Practicals		
SAS.105	Practical I	90
SAS.106	Seminar I	30
II Semester		
Theory		
SAS.201	Introduction to Solar Physics, Magnetospheric Physics and Space Weather	50
SAS.202	Astronomy & Astrophysics	50
SAS.203	Pilot Project	300
Practicals		
SAS. 204	Practical II	90
SAS. 205	Seminar II	30

Semester III and IV

Phase-II - Project Work and Dissertation (at home country)

4.2 Details of the Curriculum Contents

(Numbers in parentheses indicate number of periods of 60 minute duration

Semester I: 20 Weeks, 4 papers 100 Marks each

Paper 1 SAS .101 Structure, Composition and Dynamics of Planetary Atmospheres (50)

1.1 Basic concepts of Earth's Atmosphere (10)

Basic Structure of Atmosphere - Hydrostatic Equilibrium - Scale Height - Geopotential Height Thermodynamic Considerations – Elementary Chemical Kinetics – Composition and Chemistry of Lower, Middle and Upper Atmosphere - Thermal Balance in Thermosphere .

1.2 Solar Radiation and its Effects on Atmosphere (5)

Solar Radiation at the Top of the Atmosphere – Attenuation of Solar Radiation in the Atmosphere – Radiative Transfer – Thermal Effects of Radiation – Photochemical Effects of Radiation

1.3 Aerosols, Greenhouse Gases and their effects on Radiation Budget (15)

Aerosols & Radiation Budget - Long Term Climate Impact - Black Carbon & Dust- Greenhouse Gases - Carbon monoxide - Carbon dioxide - Oxides of Nitrogen - Methane – Atmospheric Ozone – Ozone Chemistry – Ozone Hole .

1.4 Dynamics of Earth's Atmosphere (10)

Equation of Motion of Neutral Atmosphere – Thermal Wind Equation – Elements of Planetary Waves – Internal Gravity Waves and Atmospheric Tides – Fundamental Description of Atmospheric Dynamics and Effects of Dynamics on Chemical Species

1.5 Atmospheres of other Planets and Satellites (10)

Inner and Outer Planets – Characteristics of Atmospheric Structure and Composition of Jupiter, Mars, Venus and Saturn and their Important Satellites.

Paper 2 SAS .102 Ionospheric Physics (50)

2.1 Structure and Variability of Earth's Ionosphere (15)

Introduction - Chapman's Theory of photo-ionization – Continuity equation and photo-chemical equilibrium – Loss processes - α and β Chapman layers - Chemistry of E and F1 regions - D region chemistry – Water cluster ions and their significance - Electron attachment and negative ions in the D region - F region processes – F layer splitting - Vertical transport - Ambipolar diffusion and F2 peak - Topside ionosphere – Diffusion between ionosphere and protonosphere - Morphology – diurnal, seasonal and solar cycle variations of ionospheric regions - F- region anomalies - SIDs

2.2 Ionospheric Plasma Dynamics (15)

Properties of magneto plasma – Gyro frequency - Plasma frequency - Debye length and Frozen in field - Basic fluid equation - Steady state plasma motions due to applied forces - Electrical conductivity of the ionosphere - Generation of electric field and electric field mapping - Ionospheric dynamo - Ionospheric irregularities – Equatorial Spread F and Equatorial Electrojet (linear theories) - Mid-latitude ionospheric irregularities – Sporadic E

2.3 Electromagnetic Wave Propagation in Ionosphere (15)

Theory of Wave propagation - Properties of plane waves in isotropic and anisotropic media - Group propagation - Ray and group velocities - Radio waves in ionized media – Propagation in isotropic plasma and refractive index - Concepts of critical frequency and virtual height - Magnetoionic theory – Appleton-Hartree formula for refractive index - Ordinary and extraordinary waves - Reflection conditions - Deviative and nondeviative absorption formulas - Oblique incidence propagation – MUF and skip distance.

2.4 Ionospheres of other Planets and Satellites (5)

Ionospheres of Mars, Venus, Jupiter, Saturn and Titan

Paper 3 SAS.103 Measurement and Data Analysis Techniques (50)

3.1 Radio Frequency Techniques (15)

EM radiation - Small dipoles and Loops - Half wave dipole - Antenna Arrays - Reflector Antenna – Applications for Radio Astronomy - Transmission lines and Impedance Matching Techniques - Receivers and Transmitters - Ionospheric Absorption Techniques - Ionosonde - HF and VHF Radars – Coherent and Incoherent Scatter Radars (HF, VHF and MST) - Radio Beacon Techniques - Global Positioning System (GPS),

3.2 Optical Techniques and Airglow (15)

Photomultipliers Tubes - Image Intensifiers – Lasers - Semiconductor Photonic Devices - Photo diodes - Avalanche diodes - Laser diodes - CCD & CMOS imaging detectors -– Imagers - Interference Filters and Etalons – Fabry Perot Interferometer - Filter Photometers – Lidar - Airglow – Oxygen green and red line emission - Nightglow – Dayglow – Twilight Glow –– Applications of Airglow Measurements for Ionospheric Dynamics

3.3 In Situ Techniques on Space Platforms (10)

Langmuir Probe – Electric Field Probe – Ion Drift Meter – Retarding Potential Analyzers – Mass Spectrometers and Magnetometers – Satellite based temperature measurement - Satellite Drag for Neutral Densities - Measurement of Aerosols, Trace Gases and Ozone

3.4 Data Analysis Techniques (10)

Error analysis - Time series – Fourier Transform – DFT – FFT –Least Square Method – Linear Fitting – Statistical test of Significance – Correlation – Chi Square Test.

Paper 4 SAS.104 Basics of Space Technology(50)

4.1 Launch Vehicles, Satellites and their Orbits (5)

Principles of Rocketry - Rocket Motors - Solid and Liquid Fuel Rockets - Sounding Rockets - Cryogenic engines - Multistage Rockets - Satellite Launch Vehicles - Basics of Satellite orbits-Kepler's Laws – Sub-satellite Point – Orbital Parameters – Sun-synchronous and geosynchronous Orbits – Low-Earth Orbits

4.2 Attitude Control, Power and Thermal systems of Spacecrafts (15)

Attitude Sensors – Sun Sensors – Star Sensors – Earth Sensors – Magnetic Aspect Sensors- Accuracy – Spin Stabilization and Gyros – Control of Flight-path – Close-loop Guidance, Spacecraft Power System –Solar Cells and Panels – Primary and Secondary Batteries–– Special Power Sources – Radioactive Thermoelectric Generators (RTG) , Spacecraft thermal control techniques

4.3 Selection of Materials for Space –borne payloads (10)

Behavior of Materials in Space (Temperature, Pressure and Radiation) – Outgassing ––Corona Discharge–– Coating and Coating-compounds – Radiation Damage –,Mounting of Subsystems – Structural and Mass Limitations – Carbon Fiber Reinforced Plastic (CFRP) - Honeycomb Structures ––Effects of Vibrations and Shocks on Spacecraft Structures – Spacecraft Thermal Environments – Thermal Paints and Surface Finish .

4.4 Reliability, Tests and Qualification of Payloads for Space Experiments (5)

Fabrication of Electronics – Subassemblies- Electromagnetic Compatibility—Checkout, Reliability Considerations and derating - Test and Evaluation - Thermovac tests - Vibration and shock tests

4.5 Telemetry, Tracking , Command (TTC) and Data Handling System (5)

Telemetry System – Signal Conditioner, Onboard Data Recorder, Telecommand – Encoder—Decoder—Pulse and Data Commands - RF Systems – Receivers, Transmitters and Antenna— Ground Segments – Real-time and Off-line — Tracking

4.61 Examples of Remote Sensing, Weather and Communication satellites (4)

Discussion of some Indian and foreign operating remote sensing satellites and their instruments - Vital instrument parameters and sensitivity of instruments - Examples of communication satellites and their instruments - limitations and sensitivity of instruments

4.62 Science Satellites (6)

Discussion of instruments and their capabilities on Atmospheric Science satellites like ENVISAT, Megha-Tropique - Instruments and sensitivities of Astronomy satellites – Hubble Space Telescope, Spitzer Observatory - Chandra X-ray Observatory, Rossi X-ray Timing explorer - Astrosat and Swift mission

Semester II: 19 Weeks, 100 Marks each 2 papers and Pilot Project

Paper 5 SAS.201 Introduction to Solar Physics , Magnetospheric Physics and Space Weather (50)

5.1 Origin of Magnetic Field of Earth and Other Planets (10)

Dipole Description of Geomagnetic Field –Local elements and their determination - Secular and Diurnal Variation of Geomagnetic Field – Determination of Geomagnetic Coordinates of Station — Magnetic Fields of Other Planets.

5.2 Elements of Solar Physics (15)

Sun and its Atmosphere – Solar Magnetic field - Sunspots and Solar Cycles – Solar Flares , Coronal Mass Ejections (CME) and Solar Wind

5.3 Magnetosphere of Earth and Other Planets (15)

Effects of Solar Wind on Planetary Magnetic Fields – Formation of Geomagnetic Cavity – Magnetopause – Magnetosheath and Bow Shock – Polar Cusp and magnetotail – Effect of Interplanetary Magnetic field on Magnetosphere - Plasmasphere and Van Allen Radiation Belts – Magnetotail Dynamics - Substorms , Aurorae and Storms - Magnetosphere of Other Planets

5.4 Space Weather and its Effects (10)

Geomagnetic Storms – Sub-storms and Current Systems – Coronal Mass Ejections – Effect of Magnetic Disturbance on Ionosphere and Thermosphere System - Effects on Space and Ground Based Systems

Paper 6 SAS.202 Astronomy and Astrophysics (50)

6.1 Introduction to Astronomy (8)

Introduction —Coordinate Systems – Time - Observable quantities - Stellar Parameters –Brightness, Luminosity - Magnitude Scale - Colour - Black Body Temperature - Size.- Distances - Spectrum - Spectral Lines - Formation of Spectral Lines - Saha's Equation)—Spectral Classification—H R Diagram— Binary stars and Stellar Masses and Sizes.

6.2 Solar System Objects and their Exploration (5)

Planets and satellites of the planets and their orbits - Structure and topography of planets and their satellites - Physical and chemical characteristics - Space imagery of planets and their environment - Comets, asteroids and other minor bodied in the solar system - Their orbits, surface and composition - Comet and asteroid collisions

6.3 Introduction to Astrophysics (12)

Star Formation—Molecular Clouds —Stellar Evolution (Main Sequence - Energy Sources - Nuclear Energy for a Star - Energy Transport - Inter Stellar Matter —Dust—Extinction –Stellar Old Age -- Planetary Nebulae - White Dwarf,—Death of A Star—Supernovae - Neutron star – Pulsars - Black Hole – Milky Way Galaxy -- Hubble Classification of Galaxies.

6.4 High Energy Astrophysical Processes and Phenomenology (10)

Radiation processes - Cosmic Rays – Composition, energy and origin - X-ray Sources - X Ray Binaries - Supernova Remnants – Pulsars – Galaxies - Active Galactic Nuclei - Solar X-rays - Gamma –ray astronomy- Gamma-rays from Pulsars - Supernova Remnants and Active Galactic Nuclei - Neutrino astronomy

6.5 Astronomical Instruments and Observing Techniques (15)

Telescopes - Different types of telescopes - Angular resolution and Diffraction Limited Resolution - Image formation in a camera - Plate Scale - Observatories (Ground Based & Space Based) - Focal Plane Instruments—Imagers - Photometers - Spectrometers – CCDs and their use in astronomy - Detectors for Optical, Infrared, UV, X-rays, and Gamma-rays - Effect of Atmosphere (Seeing and Scintillation)

Pilot Project SAS.203

The Pilot Project will be done throughout, after completion of papers 5 and 6 during Semester-II. Course participants select a pilot project in consultation with their parent institution and a host institution project supervisor. The participants are encouraged to choose topic of interest to their respective home country. It is supposed to be precursor to the one-year project undertaken by the participant in their home country. This also ensures that the participant can start the research project right away.

The titles of pilot projects taken up by participants of previous courses have been given in Annexure A.6

4.3 Experiments

In addition to morning theory classes, participants spend considerable time in the afternoon sessions in carrying out various practicals involving laboratory work, where they conduct various experiments under supervision of experts at host institution. Some of the experiments are available at select institutions in India and the experiments are conducted there during the educational tours.List of Experiments suggested for sixth course have been given below:

Semester I: Any six of the following experiments are to be carried out

1. Plasma Characteristics by Langmuir Probe *
2. Ionospheric Sounding using an Ionosonde
3. Surface Monitoring of Ozone
4. Multiwavelength Airglow Photometer *
5. Study of Ionospheric Scintillations
6. Characterization of Interference Filters
7. Optical Depth Measurement Using Filter Photometer
8. Balloon borne measurements of Atmospheric Ozone
9. Total Electron Content measurements using GPS receiver
10. Measurements of Aerosols by Micro pulse Lidar
11. Airglow Imaging at Mount Abu*
12. Photoionization studies using Recoil Ion Momentum Spectrometer

Semester II: Any six of the following experiments are to be carried out

1. Light Curve of a Binary Star
2. Interferometric Study of Planetary Nebulae
3. Mass of aerosols using QCM
4. Radio Pulsar Studies using GMRT/OSRT
5. Study of Solar Spectrum (At USO)
6. Charaterization of Fabry Perot Etalons
7. Measuring Energy resolution of CZT detector with X-rays from a radioactive Source *
8. Characteristics of a Proportional Counter*
9. Measurement of Atmospheric Temperature by Nd Yag Lidar*
10. Three Component Atmospheric Wind by MST Radar*

Note: New Experiments have been marked with asterix *

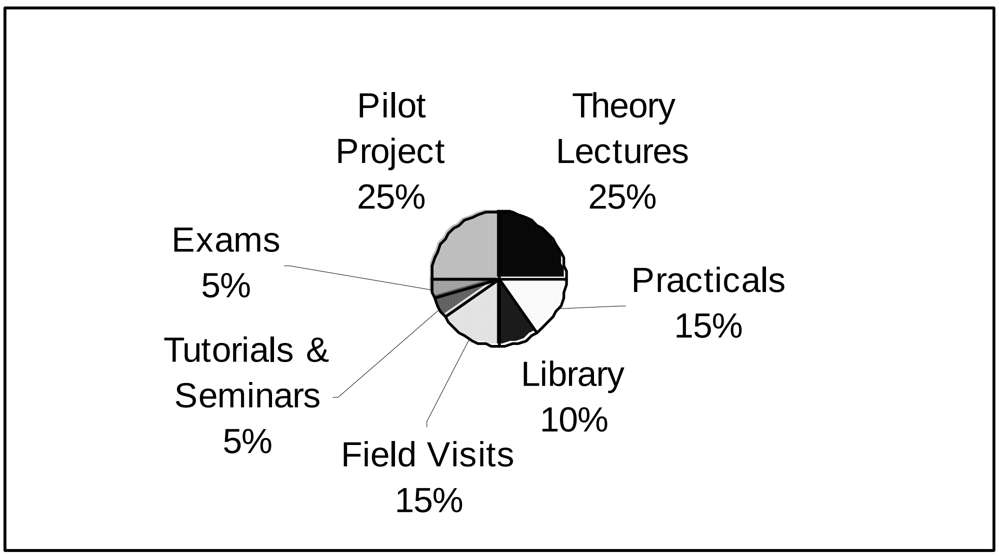
Phase II of the Programme, award of M Tech by Andhra University.

The course participants, as part of phase II of the programme, undertake a research project of one year duration .After completion of the project, a report in the form of a dissertation is submitted to CSSTEAP. The dissertation is evaluated by panel of experts and viva voce examination is also conducted at the parent institution of the participant. If reports of the examiners, both internal as well as external, are satisfactory and the work is recommended to be suitable for M.Tech., the dissertation is forwarded to Andhra University for consideration of M.Tech. degree. The candidate, may be awarded M.Tech. by Andhra University, subject to his/her meeting the eligibility and other academic requirements.

Titles of M Tech thesis submitted by the previous participants, and accepted by Andhra University are listed in Annexure A.7

5. Allocation of time proposed for 6th Course

Total 9 months (200 working days, 6 Hrs. each day)		= 1200 Hrs.	
a.	Theory Lecture (6 papers, 50 periods per paper)	= 300 Hrs.	~ 25%
b.	Experiments (12 experiments)	= 180 Hrs.	~ 15%
c.	Library Work	= 120 Hrs.	~ 10%
d.	Tutorials and Seminars	= 60 Hrs.	~ 5%
e.	Field Visit (5 Weeks in 2 sessions, 6 Hrs/day, 6 days/week)	= 180 Hrs.	~ 15%
f.	Examinations	= 60 Hrs.	~ 5%
g.	Pilot Project - (10 Weeks. x 5 days x 6 Hrs.)	= 300 Hrs.	~ 25%
	Total	**1200 Hrs**	**100%**



6. General Observations and Recommendations:

The Committee had discussions with the previous Course Directors. They brought to the notice of the Committee some suggestions to improve the conduct of the courses. In view of these the Committee recommends the following measures to overcome these problems:

(1) It is found that many of the overseas students enrolled in the course have rather poor knowledge of the English language. They have difficulty in oral communication and to a limited extent in written language also. This makes it difficult for them to follow the lectures in the early phase of the course. The Committee strongly recommends that an Orientation Course in English Language be conduced in their parent countries to improve working knowledge of the students in the English language.

(2) Most students have little or no familiarity with topics under Space and Atmospheric Science course and almost no exposure to astronomy. The Committee recommends that at the beginning of the course one or two general lectures be arranged in each of the 3 or 4 major discipline of the course to convey the excitement and challenges of these areas to the students. These lectures should be delivered by scientists working in those areas and possessing very good oratorical and communication skills.

The following topics are suggested for these lectures:

(a) What is new in Atmospheric Science ?
(b) Greenhouse Gases and Global Warming : A challenge to mankind.
(c) Radio communication and its link with space weather.
(d) Solar activity and how it affects the earth.
(e) Origin and evolution of the Universe.
(f) Birth and Death of Stars.
(g) A Glimpse of the Invisible Universe.
(h) Are we alone in the Universe? A quest for life elsewhere.
(i) Challenge of Instrumentation development for Space Missions

It is suggested that at least four talks, one related to each of the four major areas of the course, be selected from the above list. Additional titles may also be considered for the selection of the talks.

(3) From talks with the course Directors it emerged that many teachers generally use power point presentations for teaching. Too much material packed in the power point based lectures makes it difficult for the students to follow and grasp the content of the lecture. It is recommended that the teachers be encouraged to follow the black board style of communication especially for the theoretical parts of the papers.

(4) It is recommended that experiments the students are supposed to perform, should be such that the students are required to actively participate in making measurements or observations so that they get a first hand experience of working of instruments and excitement of experimental research.

7. Recommended Books

Structure, Composition and Dynamics of Planetary Atmospheres

Andrews, D. G., Middle Atmosphere Dynamics (Int Geophysics Series V40), Holton Jr, USA, Academic Press, 1987.

Atreya ,S. K., Atmospheres & Ionospheres of the outer planets & their Satellites (Physics & Chemistry in Space V 15), New York & Berlin, Springer Verlag , 1986.

Brasseur ,G & Solomon , S., Aeronomy of the Middle Atmosphere Chemistry & Physics of the Stratospherer & Mesosphere, Dordrecht, D. Reidl, 1984.

Dieminger, W. & Hartman, G. K. , R Leitinger eds, Upper Atmosphere: Data Analysis and Interpretation, Berlin Springer, Verlag, 1996.

Rees M. H. Physics and Chemistry of the Upper Atmosphere, Cambridge, Cambridge University Press, 1989.

Wallace, John & Hobbs, Peter , Atmospheric Sciences- An Introductory Survey, Academic Press, 2006. (NEW)

Liou K N , An Introduction to Atmospheric Radiation, Academic press ,San Diego, 2002

Ionospheric Physics

Davies, K., Ionospheric Radio Propagation , 1990 edition
(available on-line on http://books.google.com/books) **(NEW)**

Giraud, A & Petit, M., Ionosphere Techniques and Phenomena ,Dordrecht, D. Reidel, 1978.

Hargreaves, J. K., The Solar – Terrestrial Environment: An Introduction to Geospace – The Science of the Terrestrial Upper Atmosphere, Ionosphere, and Magnetosphere, Cambridge University press, 1992.

Kelley, M. C. & Heelis, R. A., Earth's Ionosphere Plasma Physics & Electrodynamics (Int Geophysics series V43), San diego, Academic Press, 1989.

Rajaram G & Pisharoty, P R , Earth's Magnetic field, New Delhi, Oxford & IBH Publishing , 1998.
Schunk ,Robert W. & Nagy , Andrew F., Ionospheres Physics, Plasma Physics, and Chemistry, Cambridge University Press, 2004. **(NEW)**

Kivelson, M G & C T Russel, An introduction to Space Physics, Cambridge Univ. Press (1995)

Rishbeth H and O K Garriott, Introduction to Ionospheric Physics ,Academic Press, New York , 1969

Degaonkar S. S. Introductory Course on Space Science & Earth's Environment Gujarat University,1975

Ghosh S N, Electromagnetic Theory and Wave Propagation, 2nd ed. Narosa Publishing House , New Delhi, 2002

Measurement and Data Analysis Techniques

Kennedy, George Davis & Bernard , Electronic Communication Systems, 4th ed. Tata McGraw Hill

Bass, M. Handbook of Optics Vol. I- IV, Optical Society of America, McGraw Hill, 2001 (Reference)

Bevington , Philip & Robinson, D. Keith , Data Reduction and Error Analysis for the Physical Sciences, McGraw-Hill Education, 2002. **(NEW)**

Taylor, John R., An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements, University Science Books, 1997. **(NEW)**

Basics of Space Technology

Fortescue P. Ed , Stark , J. & Swinerd , G. eds, Spacecraft Systems Engineering, 3rd ed, John Wiley and Sons, 2003.

Meyer, R.X., Elements of Space Technology for Aerospace Engineers, San Diego, Academic Press, 1999.

Pisacane, Vincent L., Editor: Fundamentals of Space Systems, Oxford University Press, 2005. **(NEW)**

Introduction of Solar Physics, Magnetospheric Physics and Space Weather

Bhatnagar, A., Livingston , W., Fundamentals of Solar Astronomy, Singapore, World Scientific Publishing, 2005.

Das A. C., Space Plasma Physics -- An Introduction , Narosa Publishing House. New Delhi.

Gurnett, D.A., & Bhattacharjee, A., Introduction to Plasma Physics With Space and Laboratory Applications, Cambridge University Press, 2005.**(NEW)**

Moldwin, Mark , An Introduction to Space Weather, Cambridge University Press , 2008. (NEW)

Phillips, K.J.H., Guide to the Sun, Cambridge, Cambridge University press, 1995.

Stix M., Sun: An Introduction, 2nd ed, Berlin & New York, Springer Verlag, 2004.

Astronomy and Astrophysics

Abhyankar, K.D., Astrophysics Of the Solar System, Hyderabad, Universities Press, 1999.

Bradt, Hale, Astronomy Methods - *A Physical Approach to Astronomical Observations,* Cambridge University Press, 2003. **(NEW)**

Charles, P. A. B., & Seward,F.D., Exploring the X-ray Universe, Cambridge University Press, 1995.

Kitchin C. R., Astrophysical Techniques, 3rd, Bristol & Philadelphia Institute of Physics Publishing, 1998.

Longair M. S., High Energy Astrophysics Vol 1: Particles, Photons and their Detection, 2nd Ed, Cambridge, Cambridge University press, 1992.

Longair M. S., High Energy Astrophysics Vol 2: Stars, the Galaxy and Interstellar medium, 2nd Ed, Cambridge, Cambridge University press, 1994.

Kutner, Marc L. Astronomy : A Physical Perspective, Wiley, 2003. **(NEW)**

Gehrels , Tom ,Survival Through Evolution from Multiverse to Modern Society Amazon,Book Surge Publishing, Charleston, SC, USA, 2007

Useful Web sites for reference and free on-line Books

1. **http://en.wikibooks.org/wiki/Astronomy (Book on 'Introduction to Astrophysics').**
2. **http://en.wikipedia.org/wiki/Ionosphere (Book on Ionosphere).**
3. **http://www.nineplanets.org (Material on planets and solar system objects).**
4. **http://www-ssg.sr.unh.edu/406/index.html (Good site for Astronomy material).**
5. **http://ocw.mit.edu/ocwweb/web/home (At this site famous free on-line courses of MIT can be accessed).**
6. **http://www-istp.gsfc.nasa.gov/Education/Intro.html (Education site by Donald P. Stern and Mauricio Peredo on 'The Exploration of the Earth's Magnetosphere').**
7. **http://onlinebooks.library.upenn.edu/webbin/book/bookupid) Material on Greenhouse gases, Ozone Depletion and Climate Changes).**
8. **http://www.oulu.fi/~spaceweb/textbook/ (On-line free text book on Space Physics**

ANNEXURE I

CURRICULUM AND OTHER DETAILS FOR 4^{TH} – 5^{TH} COURSES

(2004-2007)

4^{TH} SPACE AND ATMOSPHERIC SCIENCES COURSE (2004-2005)

It was noticed during the tenure of Course 3, that the load on the first semester was large. The duration of modules has been changed as follows to get teaching load balanced within two semesters.

Semester 1, Modules 1 and 2: Duration increased to 10 weeks from existing 7 Weeks,
(2 Theory Papers and number of experiments increased to 5 from existing 4)

Semester2,Module3 and 4: Duration increased to 15 weeks from existing 13 Weeks,
(3 Theory Papers and number of experiments reduced to 7 from existing 8)

Module 5 consisting of Pilot Project was reduced to 5 weeks from existing 10 weeks,.
The remaining 9 weeks were utilized for Field Trips, Examinations etc

A.1 Curriculum structure of the fourth Space and Atmospheric Science Course

Module 1

Paper 1 Structure, Composition and Dynamics of Planetary Atmospheres

1.1 Basic concepts of Earth’s Atmosphere
1.2 Dynamics of Earth's Atmosphere
1.3 Solar Radiation and its Effect on Atmosphere
1.4 Atmospheres of Planets and Satellites

Paper 2 Ionospheric Physics

2.1 Structure and Variability of Earth's Ionosphere
2.3 Ionospheric Propagation and Measurement Techniques
2.3 Ionospheric Plasma Dynamics
2.5 Airglow Emissions
2.5 Ionospheres of other Planets and Satellites

Module 2 5 Experiments

Module 3

Paper 3 Solar Wind, Magnetosphere and Space Weather

3.1 Elements of Solar Physics
3.2 Magnetic Field of Earth
3.3 Magnetosphere of Earth
3.4 Space Weather
3.5 Measurement Techniques of Solar & Geomagnetic Parameters

Paper 4 Astronomy and Astrophysics

4.1 Introduction to Astronomy and Astrophysics
4.2 Astronomical Instruments and Observing Techniques
4.3 Optical and Near IR Studies of Stars and Galaxies
4.4 High Energy Astrophysics
4.5 Radio Astronomy Studies

Paper 5 Elements of Space Technology and Instrumentation
(Basics of Spacecraft Design, Construction and Launch)

5.1 Orbital Dynamics, Control and Guidance

5.2 Spacecraft Power Sources
5.3 Telemetry and Telecommand
5.4 Spacecraft systems, Sounding Rockets and Launch Vehicles
5.5 Space borne Instrumentation Techniques

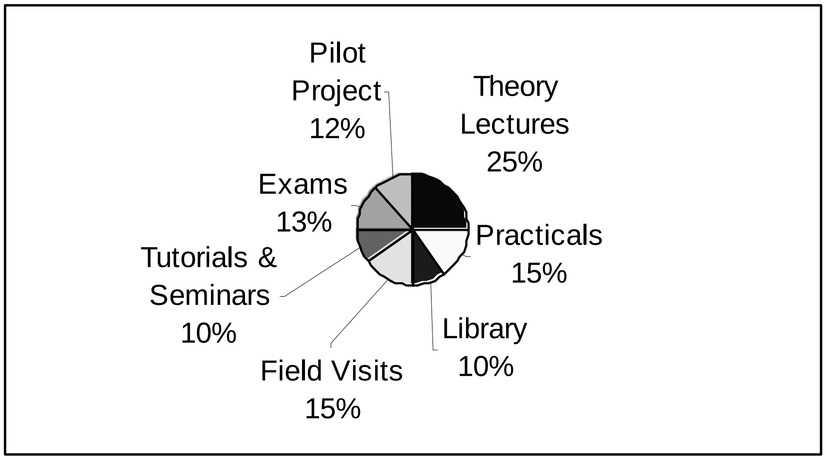
Module 4 7 Experiments

Module 5 Pilot Project 5 weeks

Time Schedule

The time schedule has been restructured as follows:

Total 9 months (200 working days, 6 Hrs. each day)	= 1200 Hrs.	
a. Theory Lecture (5 papers, 60 Hrs. per paper	= 300 Hrs	~ 25%
b. Experiments: 12 experiments to be done.	= 180 Hrs.	~ 15%
c. Library Work,	= 120 Hrs.	~ 10%)
d. Tutorials and Seminar,	= 120 hrs	~ 10%
e. Field Visit - 5 weeks (in 2 sessions,6 Hrs/day, 6 days/week)	= 180 Hrs.	~ 15%
f. Examination	= 155 Hrs.	~ 13%
g. Project work, 5 Wks. x 5 days x 6 Hrs.	= 145 Hrs.	~12%
Total	1200 Hrs	100%



Evaluation

1. Students have to present one seminar each, based on subjects based on the 5 papers (i.e., total 5 seminars during the course). These seminars are presented on Thursdays and marks will be awarded.

2. Marks:

a. Theory papers (5 x 120) = 600 marks

b. Practical

i. Examination (at the end of session) 100 (final Exam 70, internal 30)

ii. Record mark 50

(includes presentation, dedication and discipline)

Total ((100+50) x 2) = 300 marks

c. Seminar (5 x 20; 2 and 3 in either session) = 100 marks

d. Pilot Project = 200 marks

Total = 1200 marks

A.2 Curriculum details for the 4th Space and Atmospheric Sciences Course

Paper 1. Structure, Composition and Dynamics of Planetary Atmospheres: (60 Hours)

1.1 Basic Concepts of Earth's Atmosphere: (10 periods of 70 minutes each)
Atmospheric Nomenclature - Hydrostatic Equations - Scale Height - Geopotential Height – Chemical Concepts of Atmosphere – Thermodynamic Considerations – Elementary Chemical Kinetics – Composition and Chemistry of Middle Atmosphere and Thermosphere – Thermal Balance in Thermosphere – Modeling of Neutral Atmosphere.

1.2 Dynamics of Earth's Atmosphere: (18 periods of 70 minutes each)
Equation of Motion of Neutral Atmosphere – Thermal Wind Equation - Waves and Tides in the Atmosphere- Effects of Dynamics on Chemical Species - Experimental Techniques,Lidar,MST Radar ,Radiosonde etc.

1.3 Solar radiation and its Effect on Atmosphere: (18 periods of 70 minutes each)
Solar Radiation at the Top of the Atmosphere – Attenuation of Solar Radiation in the Atmosphere – Radiative Transfer – Thermal Effects of Radiation – Photochemical Effects of Radiation – Modeling of Radiative Effects of Aerosols, Measurements Techniques of Aerosols, greenhouse gases and Global Warming.

1.4 Atmospheres of Planets and Satellites: (5 periods of 70 minutes each)
Inner and Outer Planets – Atmospheric Structure and Composition of Moon, Jupiter, Mars, Venus and Saturn and their Important Satellites

Paper 2. Ionospheric Physics: (60 Hours)

2.1 Structure and Variability of Earth's Ionosphere: (12 periods of 70 minutes each)
Introduction to Ionosphere – Photochemical Processes – Chapman's Theory of Photoionisation – Production of Ionospheric Layers – Loss Reactions and Chemistry of Ionoshperic Regions.

2.2 Ionospheric Propagation and Measurement Techniques: (12 periods of 70 minutes each)
Effect of Ionosphere on Radio Wave Propagation – Refraction, Dispersion and Polarization – Magneto-ionic Theory – Critical Frequency and Virtual Height – Oblique Propagation and Maximum Usable Frequency – Ground Based Techniques – Ionosonde – Radars – Scintillations and TEC – Photometers – Imagers and Interferometers – Ionospheric Absorption – Morphology of Earths Ionosphere.

2.3 Ionospheric Plasma Dynamics: (13 periods of 70 minutes each)
Basic Fluid equations – Steady State Ionospheric Plasma Motions due to Applied Forces – Generation of Electric Fields – Electric Field Mapping – Collision Frequencies – Electrical Conductivities – Plasma Diffusion- Ionospheric Dynamo – Equatorial Electrojet – Elementary Models of Ionosphere.

2.4 Airglow Emissions: (7 periods of 70 minutes each)
Nightglow – Dayglow – Twilight Glow – Aurora – Techniques of Airglow Measurements for Ionospheric Dynamics and Composition.

2.5 Ionospheres of Other Planets: (7 periods of 70 minutes each)
Ionospheres of Mars, Venus and Jupiter

Paper 3. Solar Wind, Magnetosphere and Space Weather: (60 Hours)

3.1 Elements of Solar Physics: (5 periods of 70 minutes each)
Structure and Composition of Sun – Sun as a Source of Radiation – Sunspots and Solar Cycles – Solar Flares

3.2 Magnetic Field of Earth: (12 periods of 70 minutes each)
Generation of Geomagnetic Field - Local Elements of Geomagnetic Field– Secular Variations of Geomagnetic Field – International Geomagnetic reference Field –Measurements of Geomagnetic Field, Geomagnetic Indices of Station – Diurnal Variation of Geomagnetic Field .

3.3 Formation of Magnetosphere of Earth: (10 periods of 70 minutes each)
Solar wind and its Characteristics – Interplanetary Magnetic Fields and Sector Structure – Formation of Geomagnetic Cavity – Magnetopause – Magnetosheath and Bow Shock – Polar Cusp and magnetotail – Plasmasphere and Van Allen Radiation Belts –

3.4 Space Weather: (14 periods of 70 minutes each)
Geomagnetic Storms – Sub-storms and Current Systems – Coronal Mass Ejections –Effects on Interplanetary Medium- Modification of Earth's magnetosphere During Magnetic Disturbance and its Implications – Effect of Magnetic Disturbance on High, Mid and Low Latitudes-Space Weather Effects on Terrestrial Systems.

3.5 Measurement Techniques for Solar Geomagnetic Parameters: (10 periods of 70 minutes each)
Optical , Radio and X-Ray Techniques for Solar Parameters – Techniques for Solar Magnetic Field Measurements.

Paper 4 – Astronomy & Astrophysics: (60 Hours)

4.1 Introduction to Astronomy and Astrophysics: (16 periods of 70 minutes each)
Basic Parameters in Astronomical Observations (Magnitude, Scale, Coordinate Systems) - Stellar Classification - H.R. Diagram – Saha's Equation - Jean's Criteria for Stellar Formation - Stellar Evolution – Galaxy Formation – Cosmology.

4.2 Astronomical Instruments and Observation Techniques: (10 periods of 70 minutes each)
Telescopes - f# - Plate Scale - Types of Telescopes - Seeing Conditions - Diffraction Limited Resolution - Photometers - Spectrometers (Interferometers, Gratings) - Imaging Detectors (CCD, IR Arrays and MCPs) - High Angular Resolution Techniques (Speckle, Lunar Occultation, Adaptive Optics).

4.3 Optical and Near IR Studies of Stars and Galaxies: (10 periods of 70 minutes each)
Spectral Energy Distribution (in Optical and IR Bands) in Stars - Rotation of Stars - Study of Binary Stars - Gaseous Nebulae - Extinction Curve of Interstellar Matter - Dust - Rotation Curves of Galaxies - Spectral Energy Distribution - Color-Color Studies (Imaging of Galaxies in Different Bands)

4.4 High Energy Astrophysics: (5 periods of 70 minutes each)
Atmospheric Transmission - Detection Techniques for X-ray and Gamma-ray - X-ray Telescopes – Imaging and Spectroscopy – Radiation Processes – Accretion Disks in Black Holes and X-Ray Binaries – Active Galactic Nuclei

4.5 Radio Astronomy: (10 periods of 70 minutes each)
Radio Telescopes - Aperture Synthesis - IPS Techniques - Very Long Base Interferometry (VLBI) – Radio Galaxies - Pulsars - Distribution of H1 Gas in Galaxies - Radiation Mechanism

Paper 5. Elements of Space Technology and Instrumentation

5.1 Orbital Dynamics and Control and Guidance: (12 periods of 70 minutes each)
Spherical Coordinate System – Kepler's Laws – Sub-satellite Point – Orbital Parameters – Sun-synchronous and geo-synchronous Orbits – Low-Earth Orbits – Atitude Sensors – Sun Sensors – Star Sensors – Earth Sensors – Magnetic Aspect Sensors- Accuracies – Spin Stabilization and Gyros .

5.2 Power Sources: (8 periods of 70 minutes each)
Spacecraft Power System – Power Sources – Solar Cells and Panels – Nuclear Power – Thermoelectric Generation – Fuel Cells – Primary and Secondary Batteries – Controller Hardware

5.3 Telemetry and Telecommand: (12 periods of 70 minutes each)
FM-FM and PCM Telemetry Systems – Signal Conditioning – Multiplexing – Telecommand – Pulse and Data Commands – RF Systems – Synchronising and De-multiplexing – Data Archival and Retrieval – On-board and Ground Segments – Real-time and Offline Processing.

5.4 Spacecraft Systems, Sounding Rockets and Launch Vehicles: (17 periods of 70 min each)
Mechanical and Thermal aspects of Space craft Sub-systems – Rocket Nose-cone and Shrouds – Effects of Vibrations and Shock on Spacecraft Sub systems— Thermal Paints and Surface Finish –

Reliability Considerations – Selection of Parts – Fabrication of Electronics – Tests and Evaluations – Corona Discharge.

Materials for Space Environment – Out-gassing – Special Alloys and Insulating Materials – Coating and Coating-compounds – Radiation Damage

Principles of Rocketry, Sounding Rockets, Launchers, Multistage Rockets, Satellite Launch Vehicles.

5.5 Space borne Instrumentation Techniques: (10 periods of 70 min each)

Langmuir Probe – Electric Field Probe – Retarding Potential Analysers – Mass Spectrometers and Magnetometers – Vapour Release – Satellite Drag for Neutral Densities, Particle detectors, X-ray detectors, Limb Sounding,.

Module 5 Pilot Project

This module on the Pilot Project will be of five weeks duration. The aim of this module is to ensure that

a) The one year project work, which has to be done in the home country of the participant, is finalised in consultation with both the supervisors,
b) Some ground work is done for the one year project work, in terms of identifying and procuring necessary data, software and literature etc. and
c) The participant has developed reasonable depth of understanding of the field under the guidance of the Indian Supervisor.

This also ensures that the participant can start the research project right away.

5th SPACE AND ATMOSPHERIC SCIENCES COURSE (2006-2007)

A.3 Changes in course 5 as compared to course 4

In one of the meetings of the Apex Committee of Andhra University and CSSTEAP, which was held at NRSA Hyderabad, to discuss the academic issues related to M.Tech. program, Andhra University representatives indicated that the paper structure of the Post Graduate courses of CSSTEAP should broadly match the structure as followed by the constituent colleges of Andhra University.

To achieve this objective, the nomenclature of papers and structure of the course was modified. Module-1 and Module 2 are to be henceforth referred to as Semester-I whereas Module-3 ,4 and 5 together will be called as Semester-II. Semesters I and II will thus form Phase-I of the course. Each of the semesters would of equal duration of 14 weeks. The post-diploma, one-year project work, comprising phase-II of the course, is to be regarded as equivalent to Semesters-III and IV. Following the pattern of Atmospheric Sciences course of Andhra University as guideline, the number of theory papers were increased to 9 from the present 5, (followed up to 4th course). Each of these 9 papers will be of 100 marks and would be covered in about 50 periods. 5 papers will be taught in semester-I and 4 in semester-II. Time for pilot project was reduced and it will be equivalent to the 10th paper and carry 100 marks (5th paper of semester-II) Pilot project will be done one day a week during Semester-II and at the end of Semester-II, students will be given 2 weeks time for compilation

Pass criteria: Students who score minimum 40% of total marks in each paper AND aggregate 50% will be declared passed.

Students going for M.Tech.: (Optional). Students who undertake dissertation (in their home country/parent institution) will have to submit their thesis to the Andhra University through the Coordinators of CSSTEAP within three years after the completion of their theoretical papers (in other words, within 4 years of joining CSSTEAP Space Science course.)

Admission criteria: Students having M.Sc. degree in Physics / Geophysics / Astronomy / Electronics / Atmospheric Science or Space Science and related fields can apply for the course. Students having B.E/B.Tech. degree in Electronics and Communication / Telecommunication / Instrumentation and Control and Environmental Engineering may also apply.

Paper Structure of 5th PG course in Space and Atmospheric Sciences

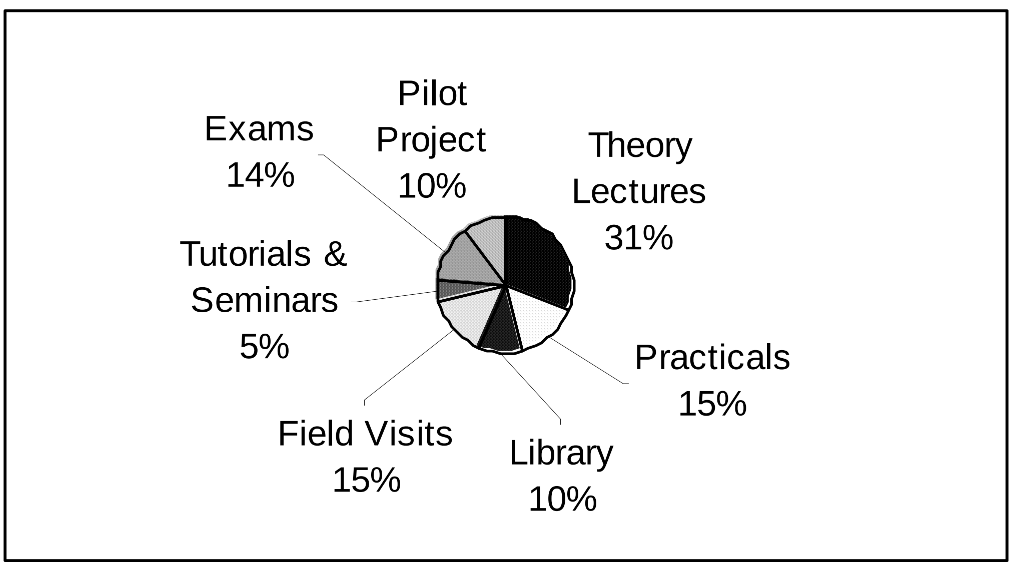
Course No	Title	Sess. Marks	Sem. End Mark	Total Marks	Min * Marks
I Semester					
Theory					
SPA.101	Structure ,Composition and Dynamics of Planetary Atmospheres	40	60	100	40
SPA.102	Ionospheric Physics	40	60	100	40
SPA.103	Electromagnetic Wave Propagation and Antennas	40	60	100	40
SPA.104	Measurement Techniques	40	60	100	40
SPA.105	Basics of Space Technology I	40	60	100	40
Practicals					
SPA.106	Practical	80	120	200	100
SPA.107	Viva		50	50	25
	Total	280	470	750	375 *
II Semester					
Theory					
SPA.201	Solar Wind, Magnetosphere And Space Weather	40	60	100	40
SPA.202	Astronomy & Astrophysics I	40	60	100	40
SPA.203	Astronomy & Astrophysics II	40	60	100	40
SPA.204	Basics of Space Technology II	40	60	100	40
SPA.205	Pilot Project	100		100	40
Practicals					
SPA. 206	Practical	80	120	200	100
SPA.207	Viva		50	50	25
	Total	340	410	750	375 *
	Grand Total	620	880	1500	750

Semester III and IV
Phase-II - Project Work and Dissertation

* to comply with minimum 50% aggregate for pass condition

A. 4 Time schedule for Course 5

Total 9 months (200 working days, 6 Hrs. each day)	= 1200 Hrs.	
a. Theory Lecture *(9 papers, 50 periods per paper)*	= 375 Hrs.	~ 31%
b. Experiments (*12 experiments)*	= 180 Hrs.	~ 15%
c. Library Work	= 120 Hrs.	~ 10%
d. Tutorials and Seminar	= 60 Hrs.	~ 5%
e. Field Visit - *5 weeks (in 2 sessions, 6 Hrs/day, 6 days/week)*	= 180 Hrs.	~ 15%
f. Examinations	= 165 Hrs.	~ 14%
g. Pilot Project , *(2 Wks. x 5 days x 6 Hrs , Also once a week during Semester II , 14 days)*	= 120 Hrs	~ 10%
Total	**1200 Hrs**	**100%**



A.5 Curriculum of 5th Space and Atmospheric Sciences Course (2006-2007)

(Numbers in parentheses indicate number of periods of 50 min duration)

Semester I: 14 Weeks , 5 papers 100 Marks each

Paper 1 SPA .101 Structure, Composition and Dynamics of Planetary Atmospheres

1.1 Basic concepts of Earth's Atmosphere (15)
Atmospheric Nomenclature - Hydrostatic Equations - Scale Height - Geopotential Height – Chemical Concepts of Atmosphere – Thermodynamic Considerations – Elementary Chemical Kinetics – Composition and Chemistry of Middle Atmosphere and Thermosphere- Thermal Balance in Thermosphere .

1.2 Solar Radiation and its Effect on Atmosphere (15)
Solar Radiation at the Top of the Atmosphere – Attenuation of Solar Radiation in the Atmosphere – Radiative Transfer – Thermal Effects of Radiation – Photochemical Effects of Radiation – Radiation budget and Aerosols, Greenhouse Gases – Atmospheric Ozone

1.3 Dynamics of Earth's Atmosphere (10)
Equation of Motion of Neutral Atmosphere – Thermal Wind Equation – Elements of Planetary Waves – Internal Gravity Waves and Atmospheric Tides – Fundamental Description of Atmospheric Dynamics and Effects of Dynamics on Chemical Species – Basic Concepts of Neutral Atmospheric Modeling.

1.4 Atmospheres of other Planets and Satellites (10)
Inner and Outer Planets – Characteristics of Atmospheric Structure and Composition of Moon, Jupiter, Mars, Venus and Saturn and their Important Satellites.

Paper 2 SPA .102 Ionospheric Physics

2.1 Structure and Variability of Earth's Ionosphere (15)
Introduction to Ionosphere – Basic Concepts of Plasma Physics applied to ionosphere_ Photochemical Processes – Chapman's Theory of Photoionization – Production of Ionospheric Layers – Loss Reactions and Chemistry of Ionoshperic Regions – Morphology of Ionospheres.

2.2 Ionospheric Plasma Dynamics (15)
Elements of Plasma -- Basic Fluid equations – Steady State Ionospheric Plasma Motions due to Applied Forces – Generation of Electric Fields – Electric Field Mapping – Collision Frequencies – Electrical Conductivities – Plasma Diffusion- Ionospheric Dynamo – Equatorial Electrojet – Basic Principles of Ionospheric Modeling.

2.3 Ionospheric Studies using Airglow Emissions (10)
Nightglow – Dayglow – Twilight Glow –– Applications of Airglow Measurements for Ionospheric Dynamics , Composition and Aurora

2.4 Ionospheres of other Planets and Satellites (10)
Ionospheres of Mars, Venus, Jupiter, Saturn and Titan

Paper 3 SPA.103 Electromagnetic Wave Propagation and Antennas

3.1 Electromagnetic Waves in Free Space (8)
EM wave and its propagation in space, Poynting vector, Polarization

3.2 Propagation of EM waves in Ionized Media (12)
Effect of Ionosphere on Radio Wave Propagation – Refraction—Scattering— Dispersion and Polarization – Appleton Hartree Refractive Index Formula, Dispersion relation, – Critical Frequency and Virtual Height – Oblique Propagation and Maximum Usable Frequency

3.3 Transmission lines and Wave guides (15)
Wave Guides, modes in rectangular and circular cross section waveguides. Parallel Plate transmission lines, strip lines and microstrip. Impedance Matching and Standing waves ,VSWR.

3.4 Antennas (15)
EM radiation, Small dipoles and Loops, Half wave dipole, Antenna Arrays, Basics of Helical and Reflector Antenna -- Longwire antenna and Rhombic Antenna. Impedance Matching.

Paper 4 SPA.104 Measurement Techniques

4.1 Optical Techniques (15)
Photomultipliers and phototubes, Image Intensifiers, Semiconductor Photonic Devices, Photo diodes, Avalanche diodes, Laser Diodes, Bulk Semiconductor devices Photometers – Imagers and Interferometers -- Lidar.

4.2 Radio Techniques (15)
RF Techniques, Receivers and Transmitters, Ionospheric Absorption ,Ionosonde, HF and VHF Radars, MST Radar. Scintillations and Total electron Content (TEC), Global Positioning System (GPS),

4.3 In Situ Techniques (15)
Rocket and Satellite borne Techniques – Langmuir Probe – Electric Field Probe – Retarding Potential Analyzers – Mass Spectrometers and Magnetometers – Vapour Release – Satellite Drag for Neutral Densities.

4.4 Techniques for Middle Atmospheric Studies (5)

Paper 5 SPA.105 Basics of Space Technology I

5.1 Rockets , Launch Vehicles and Satellites (10)
Principles of Rocketry, Rocket fuels, Solid and Liquid Fuel Rockets, Sounding Rockets, Launchers, Multistage Rockets, Satellite Launch Vehicles - Basics of Satellite Systems

5.2 Orbital Dynamics, Control and Guidance (10)
Spherical Coordinate System – Kepler's Laws – Sub-satellite Point – Orbital Parameters – Sun-synchronous and geosynchronous Orbits – Low-Earth Orbits

5.3 Spacecraft Sensors and Control System (10)
Attitude Sensors – Sun Sensors – Star Sensors – Earth Sensors – Magnetic Aspect Sensors- Accuracy – Spin Stabilization and Gyros – Control of Flight-path – Close-loop Guidance.

5.4 Materials for Space (20)
Behavior of Materials in Space (Temperature, Pressure and Radiation) – Outgassing —Corona Discharge— Coating and Coating-compounds – Radiation Damage –,Mounting of Subsystems – Structural and Mass Limitations – Carbon Fibers, Honeycomb Structures —Effects of Vibrations and Shocks on Spacecraft Structures – Spacecraft Thermal Environments – Thermal Paints and Surface Finish.

Semester II: 14 Weeks, 100 Marks each 4 papers and Pilot Project

Paper 6 SPA.201 Solar Wind, Magnetosphere and Space Weather

6.1 Magnetic Field of Earth and Other Planets (15)
Dipole Description of Geomagnetic Field –Local elements — Secular Variations – International Geomagnetic reference Field – Determination of Geomagnetic Coordinates of Station – Diurnal Variation of Geomagnetic Field – Magnetic Fields of Other Planets.

6.2 Elements of Solar Physics (10)
Sun and its Atmosphere – Sunspots and Solar Cycles – Solar Flares Solar Wind

6.3 Magnetosphere of Earth and Other Planets (15)
Effects of Solar Wind on Interplanetary Magnetic Fields – Formation of Geomagnetic Cavity – Magnetopause – Magnetosheath and Bow Shock – Polar Cusp and magnetotail – Plasma Sphere and Van Allen Radiation Belts – Magnetosphere of Other Planets.

6.4 Space Weather (10)
Geomagnetic Storms – Sub-storms and Current Systems – Coronal Mass Ejections – Effect of Magnetic Disturbance on Ionosphere and Thermosphere System.

Paper 7 SPA.202 Astronomy and Astrophysics I

7.1 Introduction to Astronomy (15)
Introduction —Coordinate Systems, Time ,observable quantities, Stellar Parameters –Brightness, Luminosity, Magnitude Scale, Colour, Black Body Temperature ,Size.- Distances - Spectrum (Spectral Lines, Formation of Spectral Lines, Saha's Equation)—Spectral Classification—H R Diagram—Binary stars and Stellar Masses—Sizes

7.2 Introduction to Astrophysics (15)
Star Formation—Molecular Clouds, Clusters —Stellar Evolution (Main Sequence, Energy Sources, Nuclear Energy for a Star, Energy Transport,) –Stellar Old Age_ Planetary Nebulae, White Dwarf,— Death of A Star-Supernovae, Neutron star, Pulsars, Black Hole, Galaxies and Large Scale Universe, types of Galaxies, Hubble Classification, —Milky Way—Contents, Inter Stellar Matter,—Dust—Extinction—Active Galactic Nuclei (AGN)—Cosmology (Scale of universe, expansion of universe, Big Bang)

7.3 Astronomical Instruments and Observing Techniques (12)
Telescopes, Light Gathering , Angular Resolution, Image formation in a camera —Types of Telescopes— f# — Plate Scale— Diffraction Limited Resolution –Observatories (Ground Based & Space Based)—Focal Plane Instruments— Photometers - Spectrometers — Imaging Detectors (CCD,

IR Arrays and MCPs)— Effect of Atmosphere (Seeing and Scintillation) -- High angular Resolution methods, (Speckle, Lunar occultation, Interferometers)

7.4 Data Processing Techniques and Error Analysis (8)
Least Square Fit, Aperture Photometry, Basics of Image processing and Analysis, IRAF, Binary Light curves, Energy Distribution ,Spectral and Temporal Analysis, Determination of Stellar Parameters.

Paper 8 SPA.203 Astronomy & Astrophysics II

8.1 Introduction to High Energy Astrophysics (10)
Radiation Processes, Interaction of radiation with matter—Atmospheric Transmission

8.2 Techniques in High Energy Astrophysics (20)
Detection Techniques for X-ray and Gamma-ray - X-ray Telescopes – Imaging Methods and Spectroscopy –Platforms for X Ray Astronomy

8.3 Radio Astronomy (10)
Radio Telescopes - Aperture Synthesis - Very Long Base Interferometry (VLBI) – Radio Sources and Radiation Mechanisms , Radio Galaxies.

8.4 Measurement Techniques for Solar Studies (10)
Optical Methods for Solar Parameters – Radio and X-Ray Techniques for Solar Parameters and Magnetic Measurements.

Paper 9 SPA.204 Basics of Space Technology II

9.1 Power Generation and Storage (15)
Spacecraft Power System –Solar Cells and Panels – Primary and Secondary Batteries— Special Power Sources – Fuel Cells — Regulators and Converters, Logic and Distribution.

9.2 Telemetry Tracking and Command (TTC) (15)
Telemetry System – Signal Conditioner – Multiplexer –analog to Digital Converter—Onboard Recorder— Telecommand – Encoder—Decoder—Pulse and Data Commands – RF Systems – Receivers, Transmitters and Antenna— Synchronizing and De-multiplexing – Ground Segments – Real-time and Off-line — Tracking.

9.3 Payload and Data Handling Systems (12)
Sensors , Signal Conditioners and Data Formatters—Data Transmitters—Selection of Parts – Fabrication of Electronics – Subassemblies

9.4 Integration and Quality Aspects (8)
Spacecraft System Integration —Electromagnetic Compatibility—Checkout—, Reliability Considerations and Derating –Test and Evaluation

Pilot Project SPA.205

The **Pilot Project** was assigned one day a week in Semester II and two weeks were provided for compilation. It would be equivalent to one theory paper of 100 Marks (Total contact hours 120).

Titles of pilot projects taken up by participants

First PG course in Space Science (1st June 1998 - 30th November 1998)

1. Geomagnetic Storms and their effects on the F region of the ionosphere

2. Photometric & Spectroscopic Observation of VW CEPHEL eclipsing Binary Star

3. Theoretical Aspects of Astrophysical problems .The first cycle of Solar Proton- Proton reaction with outgoing Neutrino Flux

4. Ozone Layer Over the Bolivian Altiplano: A Model

5. Influence of Troposphere Parameters on total Ozone Content

6. Study of the Radiative Properties of the Atmosphere

7. Study of the Radiative Properties of the Atmosphere

8. Studies of Ionisation Irregularities in the Middle Latitudes

9. Laser Sounding of the Atmosphere

10. Optical Imaging of Plasma Depletions

Second PG course in Space Science (1st August 2000 – 30th April 2001)

1. The Potential of GIS Techniques in the Study of Climatic Varaition

3. Study of Convective Cloud

4. Total Ozone Measurement over Kathmandu using Brewer Spectrophotometer

5. Design of Proton Precession Magnetometer

6. Study of Ozone using Satellite Data

7. Retrieval of Wind Speed from Satellite Data

8. Ionospheric Tomography

9. Atmospheric Aerosols

10. Ground based Study of Ionospheric Plasma Depletions

Third PG course in Space and Atmospheric Sciences (August 1, 2002 – April 30, 2003)

1. Spectraal Imaging Studies of Main Belt Asteroids of Kuiper Belt Objects

2. Multi-wavelength Studies of Mesospheric Airglow Emissions

3. The Study of J H K Photometry of Comet C/2000 EM-1 Linear

4. Estimation of Freid's Parameter at USO Lake Site

5. Near Infra Red Spectroscopy of Asteroids

6. Simulation of Photolysis Rates in a Box model

7. Long Term Temperature Changes in the Stratosphere over the Mongolian Region

8. Modeling of Tropospheric Ozone

9. Temperature Inversion at Lower Altitudes over Ulaanbaatar, Mongolia and its effect on Aerosol & Trace Gases Dispersal

10. Long Term Temperature variation over Mongolian Region

11. Solar Furnace Gamma Ray Telescope

Fourth PG course in Space and Atmospheric Sciences (August 1,2004- April 30,2005)

1. Studies of Plasma Depletions and Scintillations using GPS and VHF Scintillation data

2. Study of Ionospheric Plasma Depletions using PRL's All Sky Optical Imaging System.

3. Rocket-borne study of atomic Oxygen related nightglow emissions

4. Sun-photometer study on seasonal and diurnal variations in aerosol optical depth spectrum over Male'

5. Long term changes in meteorological parameters over Mongolia

6. Analysis of changes in visibility and rainfall during 1993-2003 over selected locations in Mongolia and examination of possible human impact

7. Study of the binary system V367 Cygni

8. Nonlinearity in tropospheric chemistry models.

9. Characterization and Observations of Astronomical Grade Array Detectors

Fifth P G course in Space and Atmospheric Sciences(August 1, 2006 – April 30,2007)

1. Relationship between vegetation index, temperature and precipitation drought and non drought years over Mongolia

2.“Investigation on the relationship between ionospheric plasma temperature and density over low-equatorial latitudes”

3.Study of Atmospheric Aerosols and Dust transport using Lidar

4. Ionospheric Scintillation using GPS data in Vietnam

5. Quantitative estimation of solar x-ray impact on the lower Ionosphere over Ahmedabad

6. Photometry of some Variable Stars using 45 cm Telescope

7. The Ionospheric Variability at low Latitudes

8. Source apportionment of chemical constituents in wet precipitation events over Tashkent (Uzbekistan)

9.“Seasonal and Long-Term changes in Total Ozone over Lao PDR”

10. A theoretical investigation on the OI 630.0 nm airglow intensity variation during the presence and absence of equatorial spread F irregularities.

11, Preliminary results in the studies of the impacts of magnetic storms on the oil and gas pipelines systems in Vietnam

12. CO_2 and CH_4 Concentration Levels Over Mongolia: Spatial and Seasonal Variations

A.7

Titles of M.Tech. thesis submitted to, and accepted by Andhra University

Course 1 (1998)

1. "Photometric and Spectroscopic Observation of VW Cephei Eclipsing Binary Star"
   T. Chandana Peiris, Sri Lanka (August 2000).

Course 2 (2000-2001)

1. "Ionospheric Tomography at Low Latitudes"
   Kalyan Bhuyan, India (May 2002)

2. "Study on Atmospheric Aerosols by measuring the Aerosol optical depth using Hand Held Sun Photometer" Pawan Gupta, India (April 2002).

3. "Multisatellite Observation of Indian Ocean Tropical Cyclones"
   Falguni Patadia, India (August 2002).

4. "Total Ozone Measurements over Kathmandu using Brewer Spectrophotometer"
   Narayan Prasad Chapagain, Nepal (December 2002).

Course 3 (2002-2003)

1. "Characterizing X-Ray Emission from Solar Flares using Solar X- Ray Spectrometer (SOXS)" Sumit Kumar, India (August 2004)

2. "Near-Infra Red Studies of Transient Clouds on Titan"
   Harsha S. Kumar, India, (August 2004)

3. "Chemistry of Lower Ionosphere of Mars"
   Vikas Singh ,India (August 2004)

4. "Estimation of Fried's Parameter at USO Lake Site" (August 2004)
   Nirvikar Dashora, India (August 2004)

5. "Multi Wavelength Studies of Mesospheric and Lower Thermospheric Airglow Emissions" Uma Kota, India (October 2004)

.

ANNEX. II

No.CSSTEAP/Revision/SS/07 Dated July 26, 2007

Sub: Revision of course curriculum, 9 month PG Diploma Course in Space and Atmospheric Science of CSSTEAP

Sir,

At the initiative of the UN office of Outer Space Affairs (UN-OOSA), regional centres have been established for space science and technology education in the developing countries. Centre for Space Science & Technology Education in Asia and the Pacific (CSSTEAP), was established in India in 1995, to cater for Asia and the Pacific region. The principal goal of the Centre is, the development of skills and knowledge of university educators, and research and application scientists, through rigorous theory, research, applications, field exercises and pilot projects, in those aspects of space science and technology, that can contribute to sustainable development of each country.

Towards this, the Centre primarily organizes post graduate level courses of 9-month duration in Remote Sensing and Geographic Information System, Satellite Communications, Satellite Meteorology and Global Climate and Space and Atmospheric Sciences. The successful candidates are awarded postgraduate diploma certificate. The participants, who thereafter, carry out 12 months research work, are awarded M.Tech. Degree by Andhra University India subject to fulfillment of other conditions. The course in Space and Atmospheric Sciences is organized every alternate year at Physical Research Laboratory (PRL), Ahmedabad. The first course was conducted in 1998, and five courses in total, have been conducted at PRL since then.

The curriculum of the course, has been developed by a panel of international experts convened by the UN. Since the students come from different academic standards, a "Board of Studies" (BOS) has been constituted by the Director CSSTEAP, to review the academic programme, including the course content and relative time allotted for each topic. The BOS meets once in a year towards the end of each course. While the overall course curriculum remains as established by UN, fine tuning of sub topic contents have been carried out based on the recommendations of the BOS.

Curriculum development is a continuous process that should take into account, among other things, various technological developments, new emerging application scenario and feedback received from the faculty and students. The following specialized committee is hereby constituted to review the current syllabus and make recommendation on changes needed, based on the advancements in the field :

1. Prof. P.C. Agrawal, TIFR -Chairman
2. Dr. B.V. Krishnamurthy - Member
3. Prof. K N Iyer, Saurashtra University, Rajkot - Member
4. Prof Rajesh Pandey, MLS University, Udaipur - Member
5. Prof. D. N. M. Rao, Andhra University,Visakhapatnam - Member
6. Prof. H. S. S. Sinha - Member
7. Mr. R N Misra, PRL - Member Secretary

Among other things, the Committee shall look into the following aspects

i) Review the syllabus followed till now
ii) Suggest changes/modification in the existing curricula, based on the latest advances in the field. Detailed sub topics under each module to be identified.
iii) Suggest time allotment for each topic
iv) Suggest mark allotment for each module
v) Review the existing practicals and recommend addition/deletion as deemed necessary.

vi) Suggest text books to be followed. Internet links also may be suggested for self study.

vii) Any other suggestions that make the course more effective to enhance the knowledge and skills of the students.

The recommendations of the Space Science Syllabus Committee will be submitted to Director, CSSTEAP by 30th September 2007.

I request you to spare your valuable time and actively participate in the deliberations. With your vast experience in the field, I am sure CSSTEAP will get the best advice.

Non DOS/ISRO members shall be paid TA/DA/Honorarium as per existing rules.

With kind regards,

Yours sincerely,

(George Joseph)

To

All the members of the Committee

Copy to: Director, PRL

Copy for Information: Chairman, CSSTEAP, GB

Table 1

Space and Atmospheric Sciences - PG Course Country wise Output (as on December, 2007)

S. N.	*COUNTRY*	Space and Atmospheric Science **1998**	**Space and Atmospheric Science 2000-01**	**Space and Atmospheric Science 2002-03**	**Space and Atmospheric Science 2004-05**	**Space and Atmospheric Science 2006-2007**	**Total**
1	**India**	2	4	5	**3**	**3**	**17**
2	**Indonesia**	1					**1**
3	**Korea DPR**	2					**2**
4	**Kyrgyzstan**		1				**1**
5	**Maldives**				**1**		**1**
6	**Mongolia**	2	2	5	**2**	**2**	**13**
7	**Myanmar**					**1**	**1**
8	**Nepal**		1				**1**
9	**Philippines**					**1**	**1**
10	**Sri Lanka**	1			**1**		**2**
11	**Uzbekistan**	1	1	1	**2**	**1**	**6**
12	**Vietnam**					**3**	**3**
13	**Lao PDR**					**1**	**1**
14	**Bolivia**	1					**1**
Total Participants		**10**	**9**	**11**	**9**	**12**	**51**
Total Countries		**7**	**5**	**3**	**5**	**7**	**14**