联 合 国 A/AC.105/L.240

大会

Distr.: Limited
14 March 2002
Chinese
Original: English

和平利用外层空间委员会

空间科学和技术教育区域中心
（附属于联合国）
空间和大气科学课程

目录

	段次	页 次
一、导言	1-2	2
二、空间和大气科学工作组的审议情况	3-19	2
A．课程宗旨和建议的专题	5-8	3
B．对教育课程审查委员会的建议的审查	9-10	6
C．修订的第三期空间和大气科学课程	11-19	8
附件		
一．第三期课程安排具体说明		12
二．修订的第二期课程		15
三．第一期课程		20
四．推荐的教材		23
五．对课程的解释性说明		25

V.02-52408

一、导言

1． 几千年前，在一个围绕着普通旋涡星系中一颗中等大小的恒星运行的多岩石小行星上，我们的祖先仰望星空，思索着他们在地球与天空之间的位置。到了二十一世纪，人们仍然问着关于宇宙是如何诞生和演化的？人们是如何达到这里的？他们要到哪里去？他们在宇宙中是否是独一无二的？等同样深奥的问题。经过宇宙时间长河的瞬间之后，我们正在开始回答这些问题。在最近的四十年里，空间探测和空间观测在这一过程中发挥了重要作用。

2． 如今，空间和大气科学的活动与研究团体正在世界范围内每天带给我们新的消息。它们负责开展各种有关天文学、太阳系、太阳及其与地球相互作用的方案。空间和大气科学涵盖从地球大气中层（大约 60 千米以上）到几十亿光年以外宇宙边缘的各个方面。考虑到未涉及的领域，它可能有助于我们理解空间和大气科学的以下方面：

(a) 地球科学方案从事有关地球直到大气中层（大约 60 千米以上）的科学研究。 其中包括如全球变暖和臭氧耗竭等研究专题。

(b) 正在通过载人宇宙飞船和空间站进行人类空间探索与开发。尽管空间和大气科学可能偶尔利用宇宙飞船和空间站作为空间试验的载体，但它并非是这些航天器的主要使用者并且没有介入它们的管理。

(c) 生物和物理研究方案负责在宇宙飞船和空间站进行材料科学和生命科学研究。

(d) 航天技术方案致力于开发更先进的航天器和未来的运载工具（火箭）技术。

二、空间和大气科学工作组的审议情况

3． 外层空间事务处与欧洲航天局合作，组织召开了 2001 年 9 月 3 日至 7 日在意大利弗拉斯卡蒂举行的联合国空间科学和技术教育区域中心：现状和未来的发展专家会议。该会议的一个主要目标是审查和修订区域中心在以下四个方面的教育课程：遥感；卫星气象学；卫星通信和空间科学。本报告载有空间和大气科学工作组的审议情况。

4． 工作组审查并修订了第三期课程（附件一），该课程将于 2002 年 8 月 1 日在

亚洲和太平洋空间科学和技术教育中心开设。第二期和第一期课程分别载于附件二和附件三。

A. 课程宗旨和建议的专题

5. 工作组认为，空间和大气科学课程应该满足发展中国家建立空间科学综合能力以便对基础设施发展给予必要支持的需要。它将适合于具有物理学或工程学背景、希望进行空间科学的研究生学习或者其他研究的学生，需要掌握良好的空间科学总体知识的大学、学院或中学的教师，在空间或地面段参与航天任务的工程师；以及任何空间活动领域的管理人员。

6. 该课程的总体结构将采用其他研究生课程的形式，即进行九个月的讲授，包括利用各种教学方法——讲课、辅导、实习和讨论等——然后是大约两个月时间的试点项目。随后将开展为期一年的研究项目，研究项目往往在学员本国进行并且通常与该国密切相关，在此期间学生将有两个导师，一个来自区域中心，一个来自学员本国。认为最理想的是，试点项目应该成为以后为期一年的研究项目的初步阶段，这样就可以确保学员能够至少带着一些数据、适宜的研究训练以及与其来自中心的导师建立的一种工作关系回到自己的国家。这意味着最好在征寻本国导师的意见后再对试点项目做出选择。

7. 工作组强调，区域中心可以自由决定采用它们喜欢的并适合于其区域、特定条件和专长的教学方法及选择标准等。工作组建议了 7 个专题，还建议并审议了题为“空间测地学”的第八个专题。工作组认为，适当的空间和大气科学课程最好能够包括这七个或八个专题中的几个（三至五个），由提供课程的中心决定。可以对课程作灵活解释并可以进行调整，使其适合特定的课程设置，这些专题一般表明所期望达到的学习广度和深度。在某些情况下，例如航天器技术，课程设计者可能只想纳入某一科目的一些要素，但该课程能够为应列入的内容提供有用的指导。不过，整体标准必须完全保持在研究生水平。

8. 八个专题列举如下，仪器的使用通常也被列为适当专题的组成部分。

1. 空间科学家和工程师应掌握的数学知识

作为空间科学家和工程师的数学入门课，复习进修课程可涵盖下列专题：代数、几何、三角、线性代数、微积分、常差分方程、概率和统计（泊松和高斯分布）、数值分析入门、简单电脑程序设计和矢量分析学基本知识。最

好能够广泛利用从空间物理学领域收集到的诸如重力场中的运动、卫星轨道等实例。在复习进修课程结束后，将开设下述课程：

统计学和数据分析：误差分析、时序分析、趋势、傅里叶分析、噪音对数据的影响、拟和技巧、最小二乘法、最大概似法、线性过滤方法、显著性统计测试。

数值分析方法：内推法和外推法、有限差分方法、积分法。

建模：偏微分方程(式)的数解、简单数字模型的构建、数字模型的实际应用。

此表有意限制了长度，以便区域中心可酌情对其开设的其他空间科学课程补充适当的内容，另一方面是预计将要求学生参加一些短期项目，以便他们在数学方面有真正的提高。

2. 行星大气层的结构、组成、动力学和演变

大气层(包括地球大气层)
行星地球的能量聚集
地球大气层的结构、组成和动力学
太阳辐射和地球大气层变化的影响
与其他行星大气层的比较
大气层长期和短期的演变
区域气候学

3. 电离层物理学

地球电离层的结构和变化
电离层技术，尤其是空间技术
电离层等离子动力学
电离层的光辐射
行星及其卫星的电离层
电离层-大气层的相互作用
通过电离层的无线电通信

4. 太阳风、磁层和空间天气

太阳活动及其影响
地球和其他行星的磁场
地球和其他行星的磁层
行星际介质和空间天气

5. 天文学和天体物理学

天文学介绍
恒星和星系的结构与演变
所有波长的天文观测
宇宙射线
基本宇宙学

6. 航天器设计、建造和发射基本知识

轨道动力学和运载火箭
飞行姿态测定和控制
发电和储电
遥感勘测和定位控制、数据管理
机械设计和测试
热力设计和控制
有效载荷设计注意事项
空间系统所用的材料

7. 空间生物学

空间生物学介绍
空间飞行的生理综合反应
辐射和放射生物学
太空活动对健康造成的危害
在太空生存

8. 空间测地学

坐标系统：地面、全球和区域
从空间观测中建立坐标系统

全球定位系统（GPS）：理论和实践
地理信息系统（GIS）：理论和实践
空间测地学的科学应用：大陆漂移、地月分离等

B. 对教育课程审查委员会的建议的审查

9. 教育课程审查委员会是由亚洲及太平洋空间科学和技术教育中心为筹备 2001 年 9 月份会议而设立的一个特设机构，它推荐了一个经修订的第三期课程。经工作组审查的这一课程如下：

单元/分单元	专题
1	理论专题
1.1	行星大气层的结构、组成和动力学
1.1.1	地球大气层的结构
1.1.2	地球大气层的组成
1.1.3	地球大气层的动力学
1.1.4	太阳辐射及其对大气层的影响
1.1.5	行星和卫星的大气层
1.2	电离层物理学
1.2.1	地球电离层的结构和变化
1.2.2	电离层技术：地面、火箭和卫星
1.2.3	电离层等离子动力学
1.2.4	光辐射
1.2.5	其他行星和卫星的电离层
2	实验课
2.1	臭氧层表面监测
2.2	电离层无线电探测（电离层探测仪）
2.3	电子密度测量的兰米尔等离子测量仪
2.4	等离子耗损光学成像
2.5	中性大气的建模试验

单元/分单元	专题
3	
3.1	太阳风、磁层和空间天气
3.1.1	太阳物理学要素
3.1.2	地球和其他行星的磁场
3.1.3	地球和其他行星的磁层
3.1.4	行星际介质
3.1.5	空间天气
3.2	天文学和天体物理学
3.2.1	天文学介绍
3.2.2	天文仪器和观测技术
3.2.3	恒星和星系的光学和近红外（IR）研究
3.2.4	高能天体物理学
3.2.5	射电天文学研究
4	
4.1	双星光度测定
4.2	行星状星云的干扰研究
4.3	利用大型米波射电望远镜（GMRT）/Ooty 合成射电望远镜（OSRT）进行射电脉冲星研究
4.4	利用 IR 探测器进行外行星温度测量
4.5	太阳光谱研究

10． 建议采用的第三期课程的评价程序如下：

	分数
理论论文（4 篇论文 x 300 分）	1 200
实习	
参加实习（10 次实习 x 45 分）	450
考试或实习（两次考试 x 75 分）	150
讨论 （4 次讨论 X 75 分）	300

试点项目	300
总计	2 400

工作组经讨论后，建议采用关于航天器设计、建造和发射的第五个专题（见下文第 16 段），经修订的评价程序载于附件一，第 3 段。

C. 修订的第三期空间和大气科学课程

1. 关于第三期课程结构的建议

11. 第三期课程将包括下述五个单元：

1. 理论
2. 实验
3. 理论
4. 实验
5. 试点项目

特别是关于理论模型课程提纲的更全面详情，请见附件一。

2. 建议对从第二期课程起的提纲进行的修改

12. 第二期课程的讲课和实验课总课时各为 300 小时（见附件二）。建议课时安排方面的主要变动见下文。

理论专题的改变

13. 在第二期课程中，天文学和天体物理学安排为 50 课时。在修订的课程中增加到 60 课时，还应为行星物理学另安排 33 课时，具体安排如下：

	课时
行星和卫星的大气层	12
其他行星和卫星的电离层	8
地球和其他行星的磁场	6
地球和其他行星的磁层	7
总计	33

这样，在建议的课程提纲中，对天文学和天体物理学以及行星物理学将增加43 课时。

14． 在第二期课程中，为空间过程的光学和实验室研究安排了 50 课时。在修订的第三期课程提纲中，这些课时应减到 8 课时，并列在电离层传播和测量技术专题项下。

15． 在第二期课程中，为气候建模、中性大气、浮质的辐射影响、电离层和等离子泡沫的数值模拟安排了 50 课时。在修订的第三期课程提纲中，这些课时应缩减为大约 15 课时，在单元 4 中采用大气/电离层建模实验形式。

16． 此外，建议对航天器设计和发射基本知识这一新专题安排 59 课时。

17． 这样，理论模型的大纲如下：

单元/分单元	专题
1	
1.1	行星大气层的结构、组成和动力学
1.1.1	地球大气层的基本概念
1.1.2	地球大气层动力学
1.1.3	太阳辐射及其对大气层的影响
1.1.4	行星和卫星的大气层
1.2	电离层物理学
1.2.1	地球电离层的结构和变化
1.2.2	电离层传播和测量技术
1.2.3	电离层等离子动力学
1.2.4	气辉发射
1.2.5	其他行星和卫星的电离层
3	
3.1	太阳风、磁层和空间天气
3.1.1	太阳物理学要素
3.1.2	地球和其他行星的磁场

单元/分单元	专题
3.1.3	地球和其他行星的磁层
3.1.4	空间天气
3.1.5	太阳测量技术和地磁参数
3.2	天文学和天体物理学
3.2.1	天文学和天体物理学介绍
3.2.2	天文仪器和观测技术
3.2.3	恒星和星系的光学和近红外研究
3.2.4	高能天体物理学
3.2.5	射电天文学
3.3	航天器设计、建造和发射基本知识
3.3.1	轨道动力学、控制和导航
3.3.2	发电和储电
3.3.3	遥感勘测和遥控
3.3.4	机械、热力和有效载荷设计问题
3.3.5	空间系统材料

实验课的变动

18. 在第二期课程中，总共有 12 次实验课（见附件二）。其中，下述实验课应予以取消：

单色器的分光功能
利用吸收光谱学确定柱密度
利用质子进动磁力计测量地球磁场
电离层气辉的干涉测量
Rodamine 染料的荧光测量

建议开设下述新的实验课：

双星光度测定
行星状星云的干扰研究

大气层/电离层建模试验
利用 GMRT/OSRT 进行射电脉冲星研究
太阳光谱研究

3. 课程活动的时间安排

19. 为期九个月的课程将包括 200 个工作日，每天 6 小时，共计 1,200 小时，具体课时安排如下：

活动和安排	课时	占总课时的百分比
理论课： 5 个专题，每个专题 60 小时，每天三节课 9:00-10:00，10:40-11:50，11:50-13:00	300	25
实习：12 次实习，周一、周二和周三 14:30-17:30	180	15
图书馆工作：每周五 14:30-17:30	60	5
辅导课和讨论课：每周四 14:30-15:30	60	5
实地参观：5 周（分两次）每周 6 天，每天 6 小时	180	15
考试（包括准备时间）	120	10
项目工作（10 周，每周 5 天，每天 6 小时）	300	25
总计	1 200	100

Annex I

Specifications for the curriculum of the third course

1. Details of the theoretical topics are as follows:

Module/ submodule	*Topic and hours*
1	
1.1	Structure, composition and dynamics of planetary atmospheres (60 hours)
1.1.1	Basic concepts of the Earth's atmosphere (12 hours)
	Atmospheric nomenclature, hydrostatic equations, scale height, geopotential height; chemical concepts of the atmosphere; thermodynamic considerations, elementary chemical kinetics; composition and chemistry of middle atmosphere and thermosphere; thermal balance in the thermosphere; modelling of neutral atmosphere
1.1.2	Dynamics of the Earth's atmosphere (16 hours)
	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; lidar technique
1.1.3	Solar radiation and its effect on atmosphere (20 hours)
	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, modelling of radiative effects of aerosols
1.1.4	Atmospheres of planets and satellites (12 hours)
	Inner and outer planets; atmospheric structure and composition of the Moon, Jupiter, Mars, Venus and Saturn and their important satellites
1.2	Ionospheric physics (60 hours)
1.2.1	Structure and variability of the Earth's ionosphere (12 hours)
	Introduction to ionosphere; photochemical processes; Chapman's theory of photoionization; production of ionospheric layers; loss reactions and chemistry of ionospheric regions; morphology of the ionosphere
1.2.2	Ionospheric propagation and measurement techniques (16 hours)
	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 total electron content (TEC), photometers, imagers and interferometers, ionospheric absorption; rocket- and satellite-borne techniques—Langmuir probe, electric field probe, retarding potential analysers, mass spectrometers, magnetometers, vapour release, satellite drag for neutral density
1.2.3	Ionospheric plasma dynamics (16 hours)
	Basic fluid equations; steady state ionospheric plasma motions owing to applied forces; generation of electric fields; electric field mapping; collision frequencies; electrical conductivity; plasma diffusion; ionospheric dynamo; equatorial electrojet; ionospheric modelling
1.2.4	Airglow (8 hours)
	Nightglow; dayglow; twilight glow; aurora; applications of airglow measurements for ionospheric dynamics and composition
1.2.5	Ionospheres of other planets and satellites (8 hours)
	Ionospheres of Mars, Venus and Jupiter
3	

Module/ submodule	*Topic and hours*
3.1	Solar wind, magnetosphere and space weather (60 hours)
3.1.1	Elements of solar physics (6 hours)
	Structure and composition of the Sun; the Sun as a source of radiation; sunspots and solar cycles; solar flares
3.1.2	Magnetic field of the Earth and other planets (12 hours)
	Models for generation of geomagnetic fields; secular variations of geomagnetic fields; international geomagnetic reference fields; local elements of geomagnetic fields; determinations of geomagnetic coordinates of stations; diurnal variation of geomagnetic fields; magnetic fields of other planets
3.1.3	Magnetosphere of the Earth and other planets (14 hours)
	Solar wind and its characteristics; interplanetary magnetic field and sector structure; formation of geomagnetic cavity, magnetopause; magnetosheath and bow shock; polar cusp and magnetotail; plasma sphere and Van Allen radiation belts; magnetosphere of other planets
3.1.4	Space weather (16 hours)
	Geomagnetic storms, sub-storms and current systems; coronal mass ejections; modification of the Earth's magnetosphere during magnetic disturbances and its implications; effect of magnetic disturbance on high, mid, and low latitudes
3.1.5	Measurement techniques for solar and geomagnetic parameters (12 hours)
	Optical techniques for solar parameters; radio techniques for solar parameters; X-ray techniques for solar parameters; techniques for magnetic measurements
3.2	Astronomy and astrophysics (60 hours)
3.2.1	Introduction to astronomy and astrophysics (18 hours)
	Basic parameters in astronomical observations (magnitude scale, coordinate systems), stellar classification, Hertzsprung-Russell diagram, Saha equation, Jean's criteria for stellar formation, stellar evolution, galaxy classification, cosmology
3.2.2	Astronomical instruments and observation techniques (12 hours)
	Telescopes: f/# (a telescope of focal ratio f/# has an aperture equal to one #th of its focal length), plate scale, types of telescopes, seeing conditions, diffraction limited resolution; photometers: spectrometers (interferometers, gratings), imaging detectors (microchannel plate (MPC), charged couple device (CCD) and IR arrays), high angular resolution techniques (speckle, lunar occultation, adaptive optics)
3.2.3	Optical and near IR studies of stars and galaxies (12 hours)
	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, colour-colour studies (imaging of galaxies in different bands)
3.2.4	High-energy astronomy (6 hours)
	Atmospheric transmission, detection techniques for X-rays and gamma rays, X-ray telescopes, imaging and spectroscopy, radiation processes, accretion disks in black holes and X-ray binaries, active galactic nuclei
3.2.5	Radio astronomy (12 hours)
	Radio telescopes, aperture synthesis, interplanetary scintillation (IPS) techniques, very long base interferometry (VLBI), pulsars, radio galaxies, distribution of HI gas in galaxies, radiation mechanisms
3.3	Spacecraft design, construction and launch (details to be determined)

2. The revised practical modules are as follows:

Module/ submodule	*Topic*
2	
2.1	Operation of Langmuir probe
2.2	Ionospheric sounding using an ionosonde
2.3	Surface monitoring of ozone
2.4	Optical imaging of plasma depletions
4	
4.1	Photometry of binary stars
4.2	Interferometric study of planetary nebulae or measurement of temperature of outer planets using IR detectors
4.3	Mass of suspended particles using quartz crystal microbalances
4.4	Optical depth measurement using filter photometers
4.5	Modelling experiment on atmosphere/ionosphere
4.6	Characterization of interference filters
4.7	Radio pulsar studies using GMRT/OSRT
4.8	Study of solar spectrum

3. The evaluation of students will be based on their performance in theory, practical exercises, seminars and pilot projects. Students will have to present one seminar in each of the five theoretical topics. The allocation of points in theory, practical exercises, seminars and pilot projects will be as follows:

	Points
Theory (5 topics, 100 points each) as follows:	
Written exam (3 hours), 80 points per topic	400
Class tests by each lecturer, 20 points per topic	100
Subtotal	500
Experiments:	
Examinations (including orals)	80
Continuous assessment, dedication and discipline	120
Subtotal	300
Seminars (5 presentations, 20 points each)	100
Pilot project	200
Total	1,000

4. The grades will be given as follows:

A+ or distinction	750 points or more	(75 per cent or more)
A or first class	600 to 749 points	(less than 75 per cent to 60 per cent)
B or pass class	500 to 599 points	(less than 60 per cent to 50 per cent)

Annex II

Revised curriculum for the second course

1. The second post-graduate course in Space and Atmospheric Science was held at the Centre for Space Science and Technology Education in Asia and the Pacific from 1 August 2000 to 30 April 2001. The first course was organized in two phases: phase I (six months), which was conducted at the regional centre and phase II (six months), which was conducted in the home country of the participants. For the second course, the duration of phase I was increased to 9 months at the centre and of phase II to 12 months in the home country. After the successful completion of both stages, all the eligible participants were to be assessed by a host-country university of the regional centre for the award of a Masters in Technology degree in space science. Changes in the curriculum vis-à-vis the first course are outlined below.

A. Changes in the number of hours in the curriculum after the first course

2. Table 1 shows the differences between the first four modules in the first and second course, using the titles of modules and submodules for the first course.

Table 1
Comparison of modules/submodules in the first and second courses

Module/ submodule	*Topic*	*Number of hours*	
		First course	*Second course*
1[a]			
1.1	Structure and composition of neutral atmosphere	40	50
1.2	Plasma aspects of Earth's environment	40	50
1.3	Astronomy and astrophysics	40	50
	Subtotal	**120**	**150**
2[b]			
2.1	Measurement of mass of suspended particles	20	25
2.2	Measurement of Earth's magnetic field by proton precession magnetometer	20	25
2.3	Absorption spectrometry to determine column density of minor constituents of the atmosphere	20	25
2.4	Measurement of methane concentration in air samples	20	25
2.5	Low-current measurement using Langmuir probe	20	25
	Additional hours in second course	—	25
	Subtotal	**100**	**150**
3[a]			
3.1	Ionospheric physics and radio wave propagation	40	50
3.2	Optical and laboratory studies of space processes	40	50
3.3	Modelling of atmospheric processes	40	50

Module/ submodule	Topic	Number of hours: First course	Number of hours: Second course
	Subtotal	**120**	**150**
4[b]			
4.1	Characterization of interference filters	20	25
4.2	Interferometry using a Fabry Perot interferometer	20	25
4.3	Optical imaging/filter photometry	20	25
4.4	Use of dye in dye lasers	20	25
4.5	Ionospheric sounding using an ionosonde	20	25
	Additional hours in second course	___	50
	Subtotal	**100**	**175**
	Total	**440**	**625**

[a]The number of hours in the first course was insufficient because there was too little time for (a) discussions during the lectures and (b) explaining the mistakes made by students in written examinations.

[b]The number of hours in the first course was insufficient because the available time was inadequate for reading, preparing, demonstrations, observations, repetitions, checking and writing about experiments.

3. No attention was given to pilot projects in the first course owing to (a) shortage of time and (b) lack of knowledge about possible experiments in the home country of participants. This resulted in the following problems:

(a) Finalization of the pilot project was delayed;

(b) The availability of data to participants was delayed;

(c) Participation and interaction with the supervisor appointed by the regional centre was too little to be of any significance;

(d) The occasional change of supervisors in the home countries of participants.

In view of the above, two months were exclusively devoted to the pilot project in the second course.

B. Syllabus followed in the second course

4. Table 2 shows the syllabus followed in the second course, with details of the theoretical topics covered in modules 1 and 3.

Table 2
Syllabus followed in the second course

Module/ submodule	Topic	Number of hours
1		
1.1	Structure, composition and dynamics of the neutral atmosphere	50
1.1.1	Structure, composition, hydrostatic equilibrium, scale height thermodynamics	

Module/ submodule	*Topic*	*Number of hours*
1.1.2	Solar radiation, its transfer through the atmosphere, aerosols and radiative effects of aerosols	
1.1.3	Atmospheric dynamics, large-scale motions, tides' gravity waves and turbulence	
1.1.4	Greenhouse gases and trace gases: their chemistry and measuring techniques and global warming	
1.1.5	Satellite measurement of neutral parameters	
1.2	Plasma aspects of Earth's environment	50
1.2.1	Geomagnetism, global electric circuit	
1.2.2	Plasma physics	
1.2.3	Magnetospheric processes and solar wind, solar activity	
1.2.4	In-situ measurements of plasma parameters	
1.2.5	Ionospheric irregularities	
1.3	Astronomy and astrophysics	50
1.3.1	Basic astronomy (planetary, stellar and extragalactic)	
1.3.2	Gamma-ray, X-ray and UV astronomy	
1.3.3	Optical, IR and far IR astronomy	
1.3.4	Millimeter wave, radio and solar astronomy	
1.3.5	Recent advances in astronomical detection techniques	
2		
2.1	Measurement of mass of suspended particles	25
2.2	Surface monitoring of minor constituents	25
2.3	Determination of the slit function of a monochromator using a helium-neon (He-Ne) laser as light source	25
2.4	Ionospheric sounding using an ionosonde	25
2.5	Low-current measurement using Langmuir probe	25
2.6	Optical imaging of plasma depletions	25
3		
3.1	Ionospheric physics and radiowave propagation	
3.1.1	Formation and structure of the ionosphere	
3.1.2	Theory of ionospheric radio propagation	
3.1.3	Radio sounding of the ionosphere (ionosonde, HF Doppler, meteor wind radar, spaced receiver technique, total electron content)	
3.1.4	Ionosphere scintillations, tomography and GPS systems	
3.1.5	Ionospheric radars (VHF backscatter radar, incoherent scatter radar and MST radar)	
3.2	Optical and laboratory studies of space processes	
3.2.1	Basic optics	
3.2.2	Photometers and images	
3.2.3	Spectral imaging of the atmosphere	
3.2.4	Laser sounding of the atmosphere	
3.2.5	Laboratory astrophysics	

Module/ submodule	*Topic*	*Number of hours*
3.3	Modelling of atmospheric processes	
3.3.1	Climate modelling	
3.3.2	Modelling of the neutral atmosphere	
3.3.3	Modelling of radiative effects of aerosol	
3.3.4	Modelling of ionosphere	
3.3.5	Numerical simulation of plasma bubbles	
4		
4.1	Absorption spectrometry to determine column density of minor constituents	25
4.2	Filter photometer for optical depth measurement	25
4.3	Measurement of Earth's magnetic field by proton precession magnetometer	25
4.4	Interferometry using a Fabry-Perot interferometer	25
4.5	Measurement of transmission of MgF_2 window	25
4.6	Characterization of interference filters	25
5	Pilot project	[a]

[a]Two months.

5. Module 5, a pilot project of two months' duration, was conducted at the completion of the four modules. Because many of the participants did not have a clear-cut idea of what was feasible as a one-year home project in their countries, the pilot project at the regional centre initiated the foundation of that project. The pilot project was undertaken in consultation with the supervisors in the regional centre's host country as well as in the home country. The purpose of the two-month module was to allow participants to work under the guidance of a regional centre host-country supervisor and get (a) guidance on the course of action to be pursued at home; (b) all the necessary experimental data, if required; and (c) the necessary software tools etc.

C. Evaluation procedure followed in the second course

1. Modules 1 and 3 (theory)

6. Faculty members taught each subsection of the modules. At the end of their lectures, all faculty members gave a one-hour class test. The average of all the class tests was calculated for each subsection. For each of the subsections, each participant was required to give one seminar, which was evaluated by a committee of faculty members. Finally, for each of the subsections, a three-hour written examination was conducted. The allocation of points was as follows:

	Points
Three-hour written test	125
One-hour class test (average of five tests)	50
Seminar	25
Total	200

7. The total for modules 1 and 3, with 200 points per topic and six topics was 1,200 points.

2. Modules 2 and 4 (practical)

8. Points were given for completing practical exercises in the 12 topics under modules 2 and 4 and one practical exercise was chosen in each module for practical examination and evaluation. The allocation of points was as follows:

	Points
Points for completing 12 practical exercises in modules 2 and 4 (40 points each)	480
Practical examination in one practical exercise each in modules 2 and 4 (60 points each)	120
Total	600

9. The total for the course was 2,400 points and grades were given based on a percentage of the points received as follows:

A+ or distinction	75 per cent or more
A or first class	Less than 75 per cent to 60 per cent
B or pass class	Less than 60 per cent to 50 per cent

D. One-year project

10. After completing the stage I at the regional centre, all participants are expected to complete a one-year project in their home country under the supervision of a supervisor in that country with regular communication with the regional centre's home-country supervisor. After completion of the one-year project work, each participant is expected to write a thesis, which must be approved and signed by both the supervisors as well as the candidate. The thesis is sent for evaluation to a supervisor appointed by the regional centre. After obtaining approval from that supervisor, the thesis is sent to the host-country university for consideration for the award of a Masters in Technology degree in space physics for those who are eligible.

Annex III

Curriculum for the first course

1. The first Post-Graduate Course in Space and Atmospheric Science was held at the Centre for Space Science and Technology Education in Asia and the Pacific from 1 June to 30 November 1998.

Table
Syllabus followed in the first course

Phase and module	*Title (duration)*	*Number of lectures*
I	First semester (three months)	
I.1	Atmospheric science	60
I.2	Ionosphere and solar terrestrial interaction	60
	Project work and laboratory work Visit to astronomical observatory (two weeks) Exams	
	Second semester (three months)	
I.3	Instrumentation, techniques and data processing	75
I.4	Modelling	50
II	Project work in home country of participant (six months)	

2. The detailed course content of the theoretical portion of the course was as follows:

Module 1: Atmosphere

Structure and composition, hydrostatic equilibrium, scale heights, thermodynamics, solar radiation and its transfer through atmosphere, aerosols and radiation

Atmospheric electricity, global electric circuit

Atmospheric dynamics, large-scale motions, tides, gravity waves, and turbulence

Ozone, trace gases and chemistry, methods of measurements, ozone depletion; concentration of carbon dioxide (CO_2) and other greenhouse gases, global warming, long-term changes in atmosphere due to anthropogenic changes

Module 2: Ionosphere and solar terrestrial interaction

Basic plasma physics

The sun, solar radiation, solar activity, solar wind, geomagnetism, magnetosphere

Photoabsorption and photoionization, formation of ionospheric layers, magneto-ionic theory, radio propagation in ionosphere, radio sounding, maximum usable frequency (MUF) and high frequency (HF) radio link calculations, features of ionosphere at low latitudes, equatorial electrojet, equatorial sporadic-E and equatorial spread-F

Solar flares, geomagnetic storm and effects in the ionosphere, magnetosphere-ionosphere coupling

Radio propagation through ionosphere, Faraday rotation, differential phase and group delay measurements, ionospheric tomography, radiowave scintillations

Radiowave scattering processes, coherent and incoherent backscatter radars

Probe theory, probe characteristics, in-situ measurements, airglow emissions, principles of optical measurements, optical aeronomy

High-energy astronomy, X-ray astronomy, X-ray sources, detection techniques; gamma-ray astronomy, sources, telescope and detectors in space, ground-based Cerenkov telescopes and very high energy gamma-ray astronomy; engineering trends and recent advances in detection techniques

Space biology

Module 3: Instrumentation techniques and data processing

Radio sounding: ionosondes, HF Doppler technique, spaced receiver technique

Radio beacon methods for electron content, tomography and scintillation studies

Radars for atmospheric and ionospheric studies, coherent backscatter radar, incoherent backscatter radar, meteor radar and mesosphere/stratosphere/troposphere (MST) radar

In-situ probes and artificial modification experiments, Langmuir probe, double probe, retarding potential analyser (RPA), magnetometer, mass spectrometer, and chemical release experiments; balloon-borne conductivity, ion density and electric field probes for stratosphere

Optical aeronomy experiments, photometers, spectrometers, imaging camera for day and night airglow emissions

Lidar techniques, principle and application, aerosol lidar, Rayleigh lidar, Doppler lidars and differential-absorption lidars (DIALs)

Instrumentation for atmospheric chemistry and aerosol studies, Dobson absorption spectroscopy, cryosampler, gas chromatography, sun photometer, aerosol sampler, remote sensing techniques

Techniques for laboratory measurements, instrumentation for laboratory experiments on photoabsorption and photoionization

Instrumentation for astronomical observations, telescopes, polarimetry, high resolution and spectrophotometry and spectroscopy, array detectors

Module 4: Modelling

Ocean-atmosphere and land-atmosphere interaction, past climate studies

Tropospheric and stratospheric ozone chemistry, aerosol-solar radiation interaction

Continuity equation, ionospheric models, numerical simulation studies, ionospheric scintillations, planetary atmospheres

3. For the experimental portion of the course, 8 of the following 11 experiments should be carried out:

1. Characterization of interference filters
2. Interferometry using a Fabry Perot interferometer
3. Measurements of mass of suspended particles
4. Measurements of Earth's magnetic field with a proton precession magnetometer
5. Argon mini arc light source
6. Use of dye in dye lasers
7. Absorption spectrometry to determine column density of minor constituents of the atmosphere
8. Measurements of methane concentration in air samples
9. Principle of operation of an ionosonde
10. Low-current measurements using a Langmuir probe
11. Optical imaging/filter photometry

Annex IV

Recommended teaching material

Atreya, S. K. Atmospheres and ionospheres of the outer planets and their satellites. New York and Berlin, Springer-Verlag, 1986.

Atreya, S. K., J. B. Pollack and M. S. Matthews, eds. Origin and evolution of planetary and satellite atmospheres. Tucson, University of Arizona Press, 1989.

Bennett, J., M. Donahue, N. Schneider and M. Voit. The cosmic perspective. New York, Addison Wesley Longman, 1998.

Boyd, T.J.M. and J. J. Sanderson. Plasma dynamics. London, Nelson and Son, 1969.

Brasseur, G. and S. Solomon. Aeronomy of the middle atmosphere. Dordrecht, D. Reidel Publishing, 1984.

Budding, E. Astronomical photometry. New York, Cambridge University Press, 1993.

Christiansen, W. N. and J. A. Hogbom. Radiotelescopes. New York, Cambridge University Press, 1988.

Daglis, I. A. Space storms and space weather hazards. NATO science series II: mathematics, physics and chemistry. Vol. 38. Dordrecht, Kluwer Academic Publishers, 2001.

Davies, K. Ionospheric radio waves. London, Blaisdell Publishing, 1969.

Davies, J. K. Satellite astronomy: the principles and practice of astronomy from space. Chichester, Ellis Horwood, 1988.

Degaonkar, S. S. Space science and Earth's environment. Gujarat University, 1975.

Fichtel, C. E. and J. I. Trombka. Gamma-ray astrophysics: new insight into the universe. NASA reference publication 1386. Greenbelt, Maryland, Goddard Space Flight Center, 1996.

Giraud, A. and M. Petit. Ionospheric techniques and phenomena. Dordrecht, D. Reidel Publishing, 1978.

Hargreaves, J. K. The upper atmosphere and solar-terrestrial relations. New York, Van Nostrand Reinhold, 1979.

Hargreaves, J. K. The solar-terrestrial environment. Cambridge, Cambridge University Press, 1992.

Jansen, F., R. Pirjola and R. Favre. Space weather: hazard to the earth? Zurich, Swiss Re Publishing, 2000.

Jastrow, R. and M. H. Thompson. Astronomy fundamentals and frontiers. New York, John Wiley and Sons, 1972.

Kelley, M. C. The Earth's ionosphere: plasma physics and electrodynamics, San Diego, Academic Press, New York, 1989.
With contributions from R. A. Heelis.

Kitchin, C. R. Optical astronomical spectroscopy. Bristol and Philadelphia, Institute of Physics Publishing, 1995.

Lang, R. K. Sun, Earth and sky. New York, Springer-Verlag, 1995.

Lang, R. K. 3rd enlg. and rev. ed. Berlin and Heidelberg, Springer-Verlag, 1999. I: Radiation, gas processes and high-energy astrophysics. II: Space, time, matter and cosmology.

Mattei, J. A. and J. R. Percy. Hands-on astrophysics. Cambridge, Massachusetts, American Association of Variable Star Observers, 1998.

Matsushita, S. and W. H. Campbell, eds. Physics of geomagnetic phenomena. New York, Academic Press, 1967.

McCormac, B. M. and A. Omholt, eds. Atmospheric emissions. New York, Van Nostrand Reinhold, 1969.

Pasachoff, J. M. and L. Golub. The solar corona. Cambridge, Cambridge University Press, 1997.

Phillips, K.J.H. Guide to the Sun. Cambridge, Cambridge University Press, 1992.

Ratcliffe, J. A. Introduction to the ionosphere and magnetosphere. Cambridge, Cambridge University Press, 1972.

Rees, M. H. Physics and chemistry of the upper atmosphere. Cambridge, Cambridge University Press, 1989.

Rishbeth, H. and O. K. Garriot. Introduction to ionospheric physics. New York, Academic Press, 1969.

Shimazaki, T. Minor constituents in the middle atmosphere. Dordrecht, D. Reidel Publishing, 1985.

Shu, F. H. The physical universe: an introduction to astronomy. Berkeley, University of California, 1982.

Stix, M. The Sun: an introduction. Berlin and New York, Springer-Verlag, 1991.

Tinbergen, J. Astronomical polarimetry. Cambridge, Cambridge University Press, 1996.

Walker, G. Astronomical observation: an optical perspective. Cambridge, Cambridge University Press, 1987.

Wentzel, D. G. Astrophysics for university physics courses. http://www.seas.columbia.edu/~ah297/un-esa/astrophysics/index.html

Zeilik, M. and J. Gaustad. Astronomy: the cosmic perspective. New York, John Wiley and Sons, 1990.

Zirin, H. Astrophysics of the Sun. Cambridge, Cambridge University Press, 1988.

Annex V

Explanatory notes for the curriculum

CCD	charged coupled device
CO_2	carbon dioxide
DIAL	differential-absorption lidar
f/#	a telescope of focal ratio f/# has an aperture equal to one #th of its focal length
GIS	geographic information system
GMRT/OSRT	Giant Metrewave Radio Telescope/Ooty Synthesis Radio Telescope
GPS	global positioning system
He-Ne	helium-neon
HF	high frequency
HI region	region of space where there is a large amount of ordinary hydrogen gas
IR	infrared
MCP	micro channel plate
MgF_2	magnesium florid
MST	mesosphere/stratosphere/troposphere
MUF	maximum usable frequency
RPA	retarding potential analyser
sporadic-E	E-region traces seen in an ionogram (mode of VHF propagation via the ionosphere that is of sporadic nature)
spread-F	diffused F-region trace seen in an ionogram (nighttime plasma instability phenomenon typical for the Earth's equatorial ionosphere)
TEC	total electron content
UV	ultra violet
VHF	very high frequency
VLBI	very long base interferometry
X-ray	electromagnetic radiation with wavelengths shorter than those of ultraviolet radiation but longer than those of gamma rays