ASTRONOMY COURSES 2004-2005

This booklet contains important information about your course; please read it carefully, then keep it with your notes so that you can refer to it as the course progresses.

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http://www.roe.ac.uk/ifa/undergrad/ast1/

Revision 2004/2005:1 September 2004

The Course Organiser has tried to ensure that information given in this booklet is correct at the time of printing. Any alterations or amendments that prove necessary will be notified through the course web pages and posted on the Astronomy 1 notice board in the Appleton Tower concourse.

P. W. J. L. Brand

Course structure

Astronomy A: The Physics of Stars is aimed at physical scientists, and is recommended, for example, to be taken by those students registered for Astrophysics. It concentrates on the physics and life story of stars and how this illuminates our understanding of the Universe.

Astronomy B: Frontiers of Astronomy is intended to be accessible to students taking a variety of courses. It can be taken as a single half-course, or together with Astronomy A or C to make up a full course in astronomy. It consists of five sections covering hot topics in astronomy.

Astronomy C: Introduction to Astronomy is a wide-ranging introduction to astronomy, and together with Astronomy B (where topics are studied in more detail) gives a good full course introduction to astronomy for those with a limited physical science background.

Astronomy A and Astronomy C cannot be taken together.

Entry requirements

These half courses do not have a formal entry requirement. However, for entry to Astronomy A, prior attendance at a physical science course to SCE Higher Grade or equivalent is desirable. Some simple calculus is used in parts of Astronomy A, and the underlying physics is discussed throughout the course.

Complicated mathematics will not be used in Astronomy C and Astronomy B, but students are expected to be able to perform simple arithmetic and to understand basic geometry and simple algebra. Astronomy B also explores the physics underlying the topics studied in rather more detail than in Astronomy C, and students who have no prior physics background will find some of the topics quite challenging.

Astronomy Course Organiser: Prof. Peter W.J.L. Brand
email: `P.Brand@ed.ac.uk`
phone: (0131) 668 8354

Course secretary: Nathalie Dupin
`Nathalie.Dupin@ed.ac.uk`
(0131) 668 8374

address:
Institute for Astronomy
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ

The course home page, with latest updates, course notes, coursework exercises and notices, is at:

`http://www.roe.ac.uk/ifa/undergrad/ast1/`

There is also a course notice board in the Appleton Tower concourse.

Registration

In addition to formal registration through your Director of Studies, you **must** also complete a course registration form; these are on the web **at the URL above**, and paper copies will be available at the first few lectures, and **should be returned promptly** so that tutorial groups can be arranged.

Timetable

Astronomy A and Astronomy C run in the first semester and Astronomy B runs in the second semester. Lectures and tutorials are scheduled on Monday and Friday afternoons. Full details are given in this booklet, and may be updated on the course web pages (previous page).

Workload

In summary, **each** course has:

- 30 contact hours
- 4 (3 in Astronomy A) tutorials on Monday/Friday at 3pm
- 2 coursework exercises to be handed in (these are assessed and count towards the final mark)
- 2 visits to the Observatory (strongly recommended but not compulsory)
- self-assessment problem sheets (also strongly recommended)
- degree examination at the end of the course

Observing

Students should try to obtain some practical experience with telescopes, and once you are registered for Astronomy A, B or C you are entitled to **one free admission** to use the Popular Observing Telescopes at the Royal Observatory. This runs from 7.30 p.m. on Fridays normally between October and March. Check with the Royal Observatory Visitor Centre (0131-668 8404, 2-4pm) that there is observing that night. To obtain your free admission, present your matriculation card to the astronomer and sign opposite your name on the class register.

A visit to see the Royal Observatory (in daylight!) will also be arranged.

Textbooks

The recommended textbook for Astronomy A, and for students taking Astronomy A with Astronomy B, is:

> "Introductory Astronomy and Astrophysics"
> M Zeilik, S A Gregory
> Saunders College Publishing (4th edition, 1998)

Also suitable is:

> "Astronomy - A Physical Perspective"
> M L Kutner
> Cambridge University Press (2003)

The recommended textbook for Astronomy C (or Astronomy B alone), and for students taking Astronomy C with Astronomy B, is:

> "Astronomy: The Evolving Universe"
> M Zeilik
> Cambridge University Press (ninth edition, 2002)

Individual lecturers may recommend supplementary material from time to time; copies of this, and a few copies of the textbook, are usually available for consultation in the main library reading room.

Self-assessment

Problem sheets will be issued (for each module in Astronomy A and B, and most weeks in Astronomy C), to give you practice in the type of problems often set in examinations. Answer sheets for these problems will be made available, so that you can check your work. If you have difficulties with the problems set, you should contact a member of staff in the tutorials, or for Astronomy C you can also ask in the problem sessions.

You are expected to read through your lecture notes and handouts, and to read appropriate sections of the textbook. It is important that you wrestle with any difficulties for yourself before coming back to us if you are still stuck.

Assessed coursework

In each Astronomy 1 half-course you will be asked to hand in two assignments by the specified dates given in the detailed timetable information towards the end of this booklet. Details of the assignments (which may be essays, posters or numerical work) will be given several weeks in advance. You will have a choice of options for each assignment.

You **must** complete the coursework and hand it in **on time**. It will be marked and returned to you; there is a marking **penalty of 5% per working day,** for five days, with a mark of zero thereafter, for late work. **The assessed coursework is included in the final mark for the course;** see 'What is required to pass the course' below for details of how this is done. This means that any **marks lost for late coursework make it harder to pass the course**.

You will be required to sign a statement that the work is your own; without this statement the work will not be marked. (See the section on "Plagiarism" below.)

Examinations

The examination formats are as follows.

Astronomy A and B: There is a two hour exam consisting of a multiple choice section, a short questions section and a problem-solving section.

Astronomy C: There is a multiple choice exam of two hours.

Degree examination papers for previous years are available (see our web pages). Departmental calculators will be issued for use in the examinations.

What is required to pass the course

The course grade and pass/fail will depend on the degree examination (or August re-sit) and the coursework marks. Note that, to be awarded a pass on the course, in addition to achieving the *overall* pass mark (40% on the University Common Marking scale) you must score a minimum of 35% on the Degree Examination itself. The overall pass mark is calculated from:

- 2/3 examination
- 1/6 first coursework assignment
- 1/6 second coursework assignment

Plagiarism

It is essential that work submitted for assessment is the student's own work. A necessary skill is the critical evaluation of published sources (which now include information on the Internet) and the work of others. All sources used ***must be acknowledged***. Plagiarism is treated very seriously as an offence by the University. Full details of the procedures can be found in the examination regulations.

Full details of the Examination Regulations are available online at:

`http://www.aaps.ed.ac.uk/regulations/exam.htm`

A paper copy of this document is also available from the Undergraduate Teaching Secretary in the Department of Physics and Astronomy.

Disability

If you have some disability which may affect your studies, you are asked to register, in confidence, with Ms Manya Buchan in the Teaching Office (School of Physics, James Clerk Maxwell Building, Room 4314, phone 650 5254).

Appeals

The University has two official channels for resolution of student grievances, these being the *Student Complaints Procedure* to deal with non-examination related issues and the *University Appeals Procedure* to deal with examination issues and results.

Student Complaints Procedure: Full details of the Student Complaints Procedure can be found online at:

`http://www.aaps.ed.ac.uk/regulations/Complaints/`

A paper copy of this document is also available from the Undergraduate Teaching Secretary in the Department of Physics and Astronomy.

Appeals Procedure: The formal University appeals procedure is detailed in the Degree Examination Regulations at

`http://www.aaps.ed.ac.uk/regulations/exam.htm`

Students considering a complaint or appeal are strongly advised to discuss the matter with their Director of Studies or with the Head of School.

Data protection

Personal information related to the course will be held and used within the constraints of the University's data protection registration**.**

Astronomy A: The physics of stars **24 September to 17 December**

Monday 14.00 Appleton Tower, Theatre 5
Friday 14.00 Appleton Tower, Theatre 5
Friday 16.10 Appleton Tower, Theatre 3

Week			**Module**	**Lecturer**
First Term				
1	24 Sep	F2, F4	Surveying the Universe	Professor J Dunlop
2	27 Sep	M2	Surveying the Universe	
	First coursework assignment set: Monday 27 September			
	01 Oct	F2, F4	Surveying the Universe	
3	04 Oct	M2	Surveying the Universe	
	08 Oct	F2, F4	Stellar Structure	Dr A Taylor
4	11 Oct	M2	Stellar Structure	
	15 Oct	F2, F4	Stellar Structure	
5	18 Oct	M2	Stellar Structure	
	22 Oct	F2, F4	Stellar Evolution	Professor A Heavens
	23 – 26 October		**BREAK**	
6	29 Oct	F2, F4	Stellar Evolution	
	First coursework deadline: Friday 29 October			
7	01 Nov	M2	Stellar Evolution	
	Second coursework assignment set: Monday 01 November			
	05 Nov	F2 *	Stellar Evolution	*** practice exam F4**
8	08 Nov	M2	Observations	Professor P Brand
	12 Nov	F2, F4	Observations	
9	15 Nov	M2	Observations	
	19 Nov	F2, F4	Observations	
10	22 Nov	M2	Star Death	Dr A Meiksin
	26 Nov	F2, F4	Star Death	
11	29 Nov	M2	Star Death	
	03 Dec	F2, F4	Star Death	
	Second coursework deadline: Friday 03 December			
	06 – 17 December EXAMS			

Tutorials: at 3pm on Monday and Friday. The class will probably be organised into six groups. Each group will get 3 tutorials; details of dates, times and locations for each group will be posted on the Appleton Tower noticeboard, and in the course web pages.

Course requirements: We expect you to attend all the lectures and tutorials provided for you. The lectures present a guide to the material and set out the foundations of the course in the way that it will be examined (the lecturers are the examiners). The material covered by the exercises undertaken in the tutorials is intended to complement the lectures and may also be examined.

A. Surveying the Universe

Professor J Dunlop

This introductory module puts our Sun and other stars in perspective within the Universe. It reviews some of the basic physical ideas that are developed in the rest of this half-course, and introduces some of the concepts that are studied in detail in the other modules.

1. <u>A whirlwind tour</u>
   Earth to the edge of the Universe.
2. <u>An eye on the sky</u>
   What can we measure; how do we know?
3. <u>Heat, light and atoms</u>
   How spectra can tell us the contents, temperature and density of stars.
4. <u>The HR diagram</u>
   Stellar sociology. Luminosity and flux; temperature and colour.
5. <u>Hot, hot, hot!</u>
   The interiors of stars; the nuclear furnace; our 'birthplace'.
6. <u>Birth and death</u>
   How stars form and how they end.

A. Stellar Structure

Dr A Taylor

Our knowledge of the internal structure of stars is one of the great achievements of modern physics. This may seem surprising in view of the fact that we can't actually see inside stars or perform experiments with them! This course looks at how the application of physics to the data from observational astronomy has given us great insight into how stars work.

1. <u>Review of observational data</u>
   The Sun; H-R diagrams; mass-luminosity relationship; summary of star properties.
2. <u>Dynamical equilibrium</u>
   Dynamical timescale.
3. <u>Thermal equilibrium</u>
   Thermal timescale.
4. <u>Nuclear reactions</u>
   Nuclear timescale.
5. <u>Properties of models</u>
   The main sequence.
6. <u>Evolution onto the main sequence</u>

A. Stellar Evolution

Professor A Heavens

It is thought that nearly all of the chemical elements heavier than helium were made inside stars.

1. <u>Main Observations</u>
   Cosmic abundances, general trends, "magic number" peaks, variation of heavy element abundances during the history of the galaxy, red giant stars with exotic abundances.

2. Nuclei
   Mass number and atomic number. The binding together of nuclei, the valley of nuclear stability, how unstable nuclei decay.

3. Nuclear Burning in Stars
   Energy release and the mass deficit, energy availability and time scales. Why high temperatures are needed. Hydrogen burning, helium burning, explosive burning.

4. Making the Heaviest Elements
   Neutron addition, the slow process, magic number and even-odd effects. The rapid process, distinguishing between r and s. Very heavy element production and dating.

5. Nucleosynthesis and Stellar Evolution
   Mass loss from stars. Advanced stellar evolution and supernovae. Possible sites for the r and s process and observational evidence from red giants, supernova remnants etc. Is there element production outside stars?

A. Astronomical Observations

Prof P W J L Brand

In astronomy we cannot experiment, we can only make observations; our observational tools are therefore of crucial importance to the testing of ideas. This course looks at the tools of the astronomer, showing how it is essential that the most up-to-date technology is used to obtain the greatest advantage from the world's large telescopes.

1. Telescopes
   Diffraction at aperture, resolution; forming images; telescope drive; mirror details.

2. The CCD array detector
   Physics of detection; charge transfer and readout; use in fast scan (TV) and integration/slow scan (low light levels).

3. Instrumentation
   2D photometry with CCD; magnitudes; colour filters; colour index.

4. Prism and grating spectrographs
   Spectrograph efficiency; objective prism; photographic detector; plate measuring machines.

5. Quantum detectors
   Photocell; photomultiplier; electron imaging; image tube; quantum efficiency.

6. Photon counting
   Aperture photometer; statistics; signal-to-noise ratio; examples of non-optical observations (X-ray, radio).

A. Star Death

Dr A Meiksin

The late stages of a star's life give rise to some of the most dramatic phenomena in the Galaxy, and involve some novel and exciting physics. In this course we investigate the final states that a star may have: white dwarfs, neutron stars and black holes. We find stars with a central density of a billion tonnes per cubic centimetre, and stars the mass of the Sun spinning a thousand times a second.

1. Quick review of stellar evolution
Energy crises in a star's life; the final state.

2. Gentle and violent death
Planetary nebulae and supernovae, and supernova remnants. How to estimate the energy of a supernova explosion.

3. White dwarfs
The strange physics of degenerate matter; the relation between mass and radius for a white dwarf; the maximum mass of a white dwarf. Explosive reactions.

4. Neutron stars and pulsars
Models of supernova explosions; structure of neutron stars.

5. Compact stars in binary systems
Novae and X-ray busters.

6. Black holes and introduction to general relativity
Gravitational redshift, gravitational bending of light.

Astronomy B: Frontiers of Astronomy **10 January to 25 March**

Monday 14.00 Appleton Tower, Theatre 3
Monday 16.10 Appleton Tower, Theatre 3
Friday 14.00 Appleton Tower, Theatre 3

Week				
2	10 Jan	M2, M4	Science of Astronomy	Dr M Hawkins
	First coursework assignment set: Monday 10 January			
	14 Jan	F2	Science of Astronomy	
3	17 Jan	M2, M4	Science of Astronomy	
	21 Jan	F2	Science of Astronomy	
4	24 Jan	M2, M4	Origin of the Planets	Dr M Kishimoto
	28 Jan	F2	Origin of the Planets	
5	31 Jan	M2, M4	Origin of the Planets	
	04 Feb	F2	Origin of the Planets	
6	07 Feb	M2, M4	Measuring the Universe	Dr A Meiksin
	11 Feb	F2	Measuring the Universe	
	First coursework deadline: Friday 11 February			
7	14 Feb	M2, M4	Measuring the Universe	
	18 Feb	F2	Measuring the Universe	
	Second coursework assignment set: Friday 18 February			
8	21 Feb	M2, M4	The Big Bang	Dr A Ferguson
	25 Feb	F2	The Big Bang	
9	28 Feb	M2, M4	The Big Bang	
	04 Mar	F2	The Big Bang	
	07 Mar	M2, M4	Black Holes	Dr A Ferguson
	11 Mar	F2	Black Holes	
	14 Mar	M2, M4	Black Holes	
	18 Mar	F2	Black Holes	
	Second coursework deadline: Friday 18 March			
	21 Mar	M2	**Practice exam**	
	25 Mar	F2	**Good Friday – No lecture**	

Tutorials: at 3pm on Monday and Friday. The class will probably be organised into nine groups. Each group will get 4 tutorials; details of dates, times and locations for each group will be posted on the Appleton Tower noticeboard, and in the course web pages.

Course requirements: We expect you to attend all the lectures and tutorials provided for you. The lectures present a guide to the material and set out the foundations of the course in the way that it will be examined (the lecturers are the examiners). The material covered by the exercises undertaken in the tutorials is intended to complement the lectures and may also be examined.

B. The Science of Astronomy

Dr M Hawkins

This module introduces the scientific quest for an objective picture of the Universe, its history and fate. First we discuss what it means to be scientific. Then we discuss two classic "tools of the trade" and show examples of how we can learn about the Universe using them.

1. Whirlwind tour
   From the Earth to the edge of the Universe.
2. The Scientific Method
   What does it mean to be scientific?
3. Gravity and motion, part I
   How Newton's Laws explain the motion of the planets, and can be used to weigh stars.
4. Gravity and motion, part II
   How we know that galaxies are spinning, but faster than they ought to be.
5. Thermal radiation, part I
   What is it, and what does it tell us?
6. Thermal radiation, part II
   A spectral tour of the Universe. How the Universe looks different as our wavelength of vision shifts from radio through visible light to X-rays.

B. The Origin of the Planets

Dr M Kishimoto

The Sun, Moon and planets include some of the most obvious astronomical bodies, and from earliest times have been included in mankind's speculation on "origins". This module begins with a look at past ideas about solar system formation, and an outline of the generally accepted model, before studying this model in more detail, and examining how it explains the observed properties of the solar system. We also look at the evidence for other planetary systems, and the evidence for violent activity in the solar system.

1. History of ideas, and what we have to explain
   Evolutionary and catastrophic theories; review of solar system contents and properties; the "solar nebula" model; other planetary systems?
2. Details of the Solar system
   Planetary orbits; solar and planetary rotation; orbital spacing; distribution of mass and angular momentum; cometary orbits; chemical compositions; the condensation sequence; overall abundances.
3. How to make planets
   Gravitational collapse, condensation, accretion; planetesimals; tidal disruption; planetary rings.
4. The Solar System in the Galaxy
   Location and epoch of Solar system formation in our Galaxy; timescale for formation; post-formation events leaving observable traces; the future of the solar system.

5. <u>Extra-solar planets</u>
   Importance for the solar nebula model; What are we looking for? Evidence for other planetary systems; future programmes
6. <u>Impact events in a mature solar system</u>
   Recorded events and near misses; the energy involved in a collision; dinosaur extinction? Can we prevent collisions?

B. Measuring the Universe

Dr A Meiksin

The nature of the spiral nebulae revealed by large telescopes was until relatively recently the subject of controversy, culminating in the "Great Debate" between Shapley and Curtis in 1920. It became clear that the spiral nebulae were "island universes" comparable with our own Milky Way galaxy, that the structural scale of the observable Universe was much greater than had been supposed, and that the Universe was uniformly expanding.

1. <u>The Solar System and beyond</u>
   Early cosmologies; Greek distance estimates; distances of stars and star clusters.
2. <u>"Standard candles" among the stars</u>
   Identification of star types of "standard" luminosity, and their use to extend the distance scale.
3. <u>The Milky Way</u>
   Herschel and "the construction of the heavens"; debate on the extent of our Milky Way galaxy; rotation of the Galaxy.
4. <u>"The Great Debate"</u>
   The Shapley-Curtis debate of 1920. Discovery of Cepheid variables as distance indicators in spiral nebulae; vindication of the "island universe" hypothesis; recession of the nebulae.
5. <u>The realm of the galaxies</u>
   Distance indicators for external galaxies and clusters of galaxies.
6. <u>Red-shifts and the Hubble constant</u>
   Calibration of the extragalactic distance scale; Hubble's constant and the expansion of the Universe. Was there a Big Bang?

B. The Big Bang

Dr A Ferguson

Our current understanding of the entire Universe we live in and where it comes from is one of the greatest intellectual adventures of mankind. Since the revolution in physics started by Einstein it has become possible to give an amazingly simple and accurate description of the behaviour of the Universe from the first few seconds until the present moment. This module will describe the principles and outline the History of the Universe.

1. <u>The appearance of the extragalactic sky</u>
   Hubble's work on recession velocities and the present picture. The cosmological principle.

2. The consequences of the cosmological principle
   Cosmological models - cosmic time and curved space (space-time). Recession and redshift.
3. The Universe at earlier times
   The microwave background.
4. The Universe at earlier times
   Recombination epoch, matter domination and radiation domination.
5. Physics at high energy and density
   Particles and antiparticles. The origin of the light elements.
6. The History of the Universe.

B. Black Holes

Dr A Ferguson

Einstein's General Theory of Relativity makes a number of unusual predictions, the most curious of which is the possible existence of objects whose gravity is so strong that not even light may escape. In this module we look at some of the properties of black holes, consider how well General Relativity has been tested, and look at the evidence for black holes existing in the Universe.

1. Gravity
   Escape velocity in Newtonian gravity. Light with 'weight' - the gravitational redshift. Time and curved space near black holes.
2. Testing General Relativity
   Light bending; echoes from Venus; wobbles in Mercury's orbit; the binary pulsar; the Kerr galaxy; gravitational waves.
3. Stellar black holes
   Maximum mass of neutron stars.
4. Active Galaxies
   Seyfert galaxies; radio galaxies; quasars.
5. Energy from black holes
   Accretion power; Eddington limit; accretion disks.
6. Black holes in normal galaxies
   The Milky Way; Andromeda.

Astronomy C: Introduction to Astronomy **24 September to 17 December**

Monday 14.00 Appleton Tower, Theatre 1
Monday 16.10 Appleton Tower, Theatre 4
Friday 14.00 Appleton Tower, Theatre 2

Week		**2pm**	
1	24 Sep F	Introduction	Prof. P Brand
2	27 Sep M2,4	Changing Cosmos	
	First coursework assignment set: Monday 27 September		
	01 Oct F2	Changing Cosmos	
3	04 Oct M2,4	Changing Cosmos	
	08 Oct F2	Changing Cosmos	
4	11 Oct M2,4	The Planets	Dr J Cooke
	15 Oct F2	The Planets	
5	18 Oct M2,4	The Planets	
	22 Oct F2	The Planets	
	23 – 26 October BREAK		
6	29 Oct F2	The Planets	
	First coursework deadline: Friday 29 October		
7	01 Nov M2,4	The Universe of Stars	Dr J Cooke
	Second coursework assignment set: Monday 01 November		
	05 Nov F2	The Universe of Stars	
8	08 Nov M2,4	The Universe of Stars	
	12 Nov F2	The Universe of Stars	
9	15 Nov M2,4	Cosmic Evolution	Dr M Hawkins
	19 Nov F2	Cosmic Evolution	
10	22 Nov M2,4	Cosmic Evolution	
	26 Nov F2	Cosmic Evolution	
11	29 Nov M2,4	Cosmic Evolution	
	03 Dec F2	**Practice exam**	
	Second coursework deadline: Friday 03 December		
	06 – 17 December EXAMS		

Tutorials: at 3pm on Monday and Friday. The class will probably be organised into five groups. Each group will get 4 tutorials; details of dates, times and locations for each group will be posted on the Appleton Tower noticeboard, and in the course web pages.

Course requirements: We expect you to attend all the lectures and tutorials provided for you. The lectures present a guide to the material and set out the foundations of the course in the way that it will be examined (the lecturers are the examiners). The material covered by the exercises undertaken in the tutorials is intended to complement the lectures and may also be examined.

Syllabus: the course follows the content of the recommended text closely.