1st Year
Course Descriptions

2018/19

INTRODUCTION

This handbook contains details about all the constituent courses for 1st year full-time undergraduate programmes which are planned to be offered by the Department of Physics and Astronomy in Session 2018/2019. For example, for each course you will find aims and learning outcomes, the syllabus and its teaching and assessment methodology. The handbook should be consulted in conjunction with another Departmental publication *BSc/MSci Programme Structures 2018/2019.* If you do not have a copy of this, one may be obtained from the Undergraduate Teaching section of the Departmental website. The latter handbook gives information on how these courses fit into particular degree structures as well as brief descriptions of the courses themselves. Please note that it cannot be guaranteed that all courses offered will run and that only the most usual pre-requisites for courses are given.

If you need guidance on your choice of course(s), please contact the Departmental Programme Tutors:

Dr. Daven Armoogum (Years 1 and 3) and Dr. Nick Nicolaou (Years 2 and 4)

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While every effort has been made to ensure the accuracy of the information in this document, the Department cannot accept responsibility for any errors or omissions contained herein.

A copy of this Handbook may be found at the Departmental Web site:
http://www.ucl.ac.uk/phys/admissions/undergraduate

CONTENTS

PHAS0002 (PHAS1245) – MATHEMATICAL METHODS I (TERM 1)

Dr. Stan Zochowski

Prerequisites

It is assumed that, to take this course, students should normally have achieved at least a grade B in A-level Mathematics or other equivalent qualification. Knowledge of A-level 'Further Mathematics' is not required.

Description

This module aims to provide students with the mathematical foundations required for all the first term and some of the second term courses in the first year of the Physics and Astronomy programmes, and to give students practice in mathematical manipulation and problem-solving. Topics include: complex numbers, vectors, (partial) differentiation, integration, and series.

Aims

This course aims to:

- provide the mathematical foundations required for all the first semester and some of the second semester courses in the first year of the Physics and Astronomy programmes
- prepare students for the second semester follow-on mathematics course PHAS0009
- give students practice in mathematical manipulation and problem solving

Learning Outcomes

After completing this half-unit course, the student should be able to:

- understand the relation between the hyperbolic and exponential functions

- differentiate simple functions and apply the product and chain rules to evaluate the differentials of more complicated functions
- find the positions of the stationary points of a function of a single variable and determine their nature
- understand integration as the reverse of differentiation
- evaluate integrals by using substitutions, integration by parts, and partial fractions
- understand a definite integral as an area under a curve and make simple numerical approximations
- differentiate up to second order a function of 2 or 3 variables and test when an expression is a perfect differential
- change the independent variables by using the chain rule and work with polar coordinates
- find the stationary points of a function of two independent variables and show whether these correspond to maxima, minima or saddle points
- evaluate line integrals along simple curves in three-dimensional space
- manipulate real three-dimensional vectors, evaluate scalar and vector products, find the angle between two vectors in terms of components
- construct vector equations for lines and planes and find the angles between them, understand frames of reference and direction for interception using vectors
- express vectors, including velocity and acceleration, in terms of basis vectors in polar coordinate systems
- understand the concept of convergence for an infinite series and apply simple tests to investigate it
- expand an arbitrary function of a single variable as a power series (Maclaurin and Taylor), make numerical estimates and apply l'Hôpital's rule to evaluate the ratio of two singular expressions
- represent complex numbers in Cartesian and polar form on an Argand diagram
- perform algebraic manipulations with complex numbers, including finding powers and roots
- apply de Moivre's theorem to derive trigonometric identities and understand the relation between trigonometric and hyperbolic functions using complex arguments

Methodology

There are 40 scheduled periods in this half-unit course, and the lecturer aims to spend roughly 15% of the time on worked examples that are typical of the questions set in the end-of-session examination. In addition, there is a revision lecture in term 3. Though mathematical formalism is developed throughout the course, the emphasis in the weekly homework sheets and final examination is very much on problem solving rather than demonstrations of bookwork. Since it is important that students become fluent in the application of Mathematics to Physics and Astronomy, the lectures are supplemented by problem solving tutorials which are an integral part of the course. Here, small groups of students are given a problem sheet which they attempt there and then as well as being able to discuss other aspects of the course. Demonstrators circulate around the class to give advice on how questions should be tackled. Attendance at the problems classes is considered vital and is closely monitored.

Assessment and Feedback

The course is given in the first semester and test examinations are held just before Reading Week and just before Christmas. The primary objective of these is diagnostic, but they also prepare students for the style of examination current at UCL. Roughly half of each test will be on seen material from the homework sheets and problem classes with the other half new problems. Additional classes on PHAS0002 material in term 2 are obligatory for students who do poorly in the tests. The final written examination counts for 85% of the assessment. The 15% continuous assessment component is based on the two tests.

Textbooks

A book which covers essentially everything in both these and the second-year mathematics course from a more advanced standpoint is *Mathematical Methods for Physics & Engineering*, Riley, Hobson & Bence, C.U.P.

Syllabus

In total, 33 lectures, 7 example classes and 4 problem solving tutorials (2 hours each).

Complex Numbers [6 hrs]
Representation; addition; subtraction; multiplication; division; Cartesian; polar exponential forms; De Moivre's theorem; powers and roots; complex equations.

Vectors [6 hrs]
Definition, addition, subtraction, scalar and vector multiplication; frames of reference
Vector and scalar triple products; vector equations (third order determinants only very briefly)
Vector geometry - straight lines and planes; appropriate direction for interception
Vector differentiation; vectors in plane polar, cylindrical and spherical polar coordinates.

Differentiation (mainly revision) **[4 hrs]**
Definition; product rule; function of a function rule; implicit functions; logarithmic derivative; parametric differentiation; maxima and minima.

Integration (mainly revision) **[4 hrs]**
Integration as converse of differentiation; changing variables; integration by parts; partial fractions; trigonometric and other substitutions; definite integral; integral as the area under a curve; trapezium rule; integral of odd and even functions.

Partial Differentiation **[7 hrs]**
Definition; surface representation of functions of two variables; gradient; total differentials; chain rule; change of variables; second order derivatives; Maxima, minima and saddle points for functions of two variables; line integrals.

Series **[6 hrs]**
Sequences and series; convergence of infinite series; Power series; radius of convergence; simple examples including the binomial series; Taylor and Maclaurin series; L'Hôpital's rule.

PHAS0003 (PHAS1130) – Practical Skills 1A (Term 2)

Dr. Steve Fossey

Prerequisites

There are no formal prerequisites.

Description

The first-year Practical Astronomy (Practical Skills 1A) course is conducted at the Department of Physics and Astronomy's observatory in Mill Hill, NW London - the UCL Observatory (UCLO). Instruction is given in the use of telescopes and CCD cameras, used by students to observe on clear evenings, and in robotic mode during clear-weather out of class hours. There are set experiments which make use of prepared materials, designed to demonstrate important concepts in astrophysics, complementing the material taught in lecture courses at UCL, and introducing students to techniques of measurement used in astrophysics.

Aims of the Course

The aims of this course are to:

- introduce the student to contemporary methods in observational astrophysics;
- develop an understanding of astronomical coordinate systems and time, in order that the student can plan a programme of observations effectively;
- introduce the use of astronomical telescopes and detectors;
- give students first-hand experience of using telescopes at UCL's observatory (ULO) to observing the Sun, Moon, planets, comets, asteroids, nebulae, and galaxies; and experience of operating a robotic telescope system to acquire digital images;
- teach the principles of the CCD as an astronomical detector, and how to acquire astronomical images with the ULO telescope systems;
- develop an appreciation of the range and application of astronomical data available in printed and on-line sources, and experience of software tools to visualise and explore those data;
- develop the student's ability to make scientific measurements of a sample of astronomical image and spectroscopic data, and to evaluate and analyse the results;
- develop expertise in the application of basic statistics in experimental science;
- develop the student's ability to write a formal scientific report.

Learning Outcomes

On successful completion of this course, the student should be able to:

- demonstrate a working knowledge of astronomical coordinate systems and time, and be able to determine which part of the sky may be observed on any given date/time;
- collect information for planning the observation of astronomical objects, using on-line and printed astronomical databases;
- use the Fry and Celestron telescopes at ULO to locate astronomical objects, and make observations;
- construct an accurate record of observations, including the date, time and conditions under which they were made;
- devise and submit requests for astronomical image data to the C14 robotic-telescope interface, making an appropriate choice of exposure times and filters;

- use a CCD camera to obtain images of astronomical objects;
- apply systematic corrections to CCD image data to render the images useful for scientific measurement;
- use the computer system and software at ULO to inspect, interpret, and measure astronomical image data;
- make photometric measurements of the brightness of stars in CCD image data;
- apply basic statistics, including estimating experimental uncertainties and their propagation in calculations;
- produce a formal scientific report based on the measurement and analysis of astronomical data.

Methodology

The course is undertaken at UCL's Observatory (ULO) in Mill Hill, NW London.

Assessment and Feedback

Assessment is continuous. Students complete a number of practical observing sessions at the telescope and conduct tasks using prepared material in the laboratory, and produce written reports for which credit is awarded. About 10 percent of the course marks are awarded for performance during telescope-training exercises, for which no written work is submitted. The remaining credit is acquired through submission of prepared answers to exercises, and written reports of investigations into selected areas of astrophysics, using either data obtained by the student or data prepared and provided by the course organizer.

Textbooks

- D. Scott Birney, G. Gonzalez, D. Oesper, *Observational Astronomy (2nd edition)*, ISBN 0 521 853705 (Cambridge University Press, 2006)

Either of the following is recommended for statistical analysis of data:
- R.J. Barlow, *Statistics*, ISBN 0 471 92295 1 (John Wiley & Sons, 1989)
- L. Kirkup, *Experimental Methods*, ISBN 0 471 33579 7, (John Wiley & Sons, 1994)

Syllabus

Astronomical coordinates and time
Telescope training: Fry 8-inch refractor; Celestron 14-inch Schmidt-Cassegrain
Robotic telescope observing: target selection and submission
Robotic telescope observing: data inspection and image analysis
Use of a CCD camera
Basic CCD image reduction and processing
Basic photometry of stellar sources in digital images (including the magnitude scale)
Photometry of a variable source (e.g., construction of a supernova light curve)
Classification and measurement of stellar spectra
Observational tasks: visual observation of the Sun, Moon, planets; CCD imaging of asteroids, nebulae, galaxies.

PHAS0004 (PHAS1202) – Atoms, Stars and the Universe (Term 1)

Prof Ryan Nichol and Prof Ofer Lahav

Pre-requisites

A-level Maths & Physics, or equivalents.

Aims of the course

This course aims to give first-year Physics-related and Astronomy-related students an overview of modern ideas. They should meet, in an accessible form, the ideas of quantum mechanics, and acquire a broad view of the origin and evolution of the Universe as it is currently understood.

Learning Outcomes

Students should gain an historical perspective on quantum physics and an elementary comprehension of fundamental quantum concepts. They should also acquire a basic understanding of radiation processes and their applicability in stars, an appreciation of stellar evolution, and a grasp of the fundamentals of modern cosmology.

Methodology

This course is based on lectures, supplemented by problem solving tutorials/discussion, with opportunities to visit University of London Observatory and research labs in the Department.

Assessment and Feedback

Final assessment is by 2 In-Course-Assessment (ICA) tests during the term based on seen homework problems (15%) and a final written examination (85%).
Feedback will be provided through Moodle resources including model solutions to homework problems, discussion during PSTs and in class, and via return of ICAs.

Textbooks

- “Physics for Scientists and Engineers with modern Physics” (8th edition), J W Jewett & R A Serway
- "Introductory Astronomy and Astrophysics" (4th edition), Michael Zeilik & Stephen A. Gregory (Thomson Learning, ISBN 0030062284)
- "Universe" (7th edition), by Roger A. Freedman & William J. Kaufmann III, may provide useful supplementary reading

Syllabus

(Approximate allocation of lectures to topics given in brackets)

Part 1 – Atoms, Photons and the Quantum World

1) Introduction [3 hrs]
Light as a wave? Problems with wave view of light; Evidence for light as a particle; Black-body radiation and photo-electric effect; Relativistic energy, the Compton effect; Modern evidence for light as a particle; The Photon; Photons in a Mach-Zehnder interferometer

2) Atomic Theory from 400BC to 1913AD [2 hrs]
Development of the atomic model; Rutherford experiment and planetary model; Atomic Spectroscopy; Rydberg Formula; Bohr model (motivated by Rydberg formula); Successes and failings of the Bohr model

3) Particles as Waves [1 hr]

de Broglie waves, Photon Momentum, de Broglie Wavelength, Young's double slit experiment with electrons and molecules

4) Elements of Quantum Mechanics I – The wave-function [3 hrs]
Review of Probability theory for discrete and continuous variables; Probability Density; Wave-functions; Born Rule; Normalisation; Continuity; Expectation values; Heisenberg Uncertainty Relation

5) Elements of Quantum Mechanics II – Energy in quantum mechanics – [6 hrs]
Time-independent Schrödinger Equation (TISE): Potential Energy; Solving TISE for a free particle - sinusoidal ; Time-independent Schrödinger Equation (with a potential); Infinite Well; qualitative treatment of Finite Well; boundary conditions (from finite energy assumption); Tunnelling and applications (qualitative treatment); TISE for Hydrogen atom. Quantum numbers and shape of wavefunctions; Spin; Bosons and Fermions; Pauli Exclusion Principle; Quantum numbers and structure of the periodic table

Part 2 – Stars and the Universe

1) Radiation [2 hrs]
Planck, Stefan-Boltzmann, and Wien Laws; stellar luminosity, effective temperature

2) Stellar spectra [1 hr]
(absorption and emission processes); Stellar classification, H-R diagram

3) Energy generation [2 hrs]
Nuclear fusion, solar neutrinos

4) Stellar evolution [2 hrs]

5) End points of stellar evolution [2 hrs]
White dwarfs, neutron stars (pulsars), stellar-mass black holes

6) Galaxies [2 hrs]
Dark matter (evidence from clusters of galaxies; X-rays; virial theorem; gravitational lensing)

7) Redshift and Hubble's law [4 hrs]
Evidence for an evolving Universe (cosmic microwave background; Primordial nucleo-synthesis; evolution of large-scale structure); How does the Universe evolve? (Hubble flow; supernova cosmology; Dark Energy)

PHAS0005 (PHAS1224) – Waves, Optics and Acoustics (Term 2)

Prof. Peter Doel and Dr. Jasvir Bhamrah

Prerequisites

In order to take this course, students should be familiar with the basic principles of physics to a standard comparable with a grade B at A level, and to have a level of competence in mathematics consistent with having passed course PHAS0002.

Description

This module aims to provide students with foundation understanding of wave motion and the properties of different types of waves with major applications in physical and geometrical optics and propagation of sound waves. Topics include: basic properties of waves, transverse and longitudinal waves, dispersion, Doppler effect, properties of light, interference.

Aims of the Course

This course aims to provide:

- an account of the phenomenon of wave propagation and the properties of the wave equation in general, in a form which can be applied to a range of physical phenomena;
- an explanation of the way in which wave equations arise in some specific cases (transverse waves on a string; longitudinal sound waves in gases and solids);
- a discussion of reflection and refraction, illustrating the relationship between the wave and geometric (ray) pictures;
- a description of phenomena which arise from the superposition of waves, including interference and diffraction;
- an overview of simple optical devices in terms of geometric optics, including small numbers of lenses and curved mirrors, with a discussion of the limitations placed on such devices by diffraction;
- an introduction to simple optical devices which rely on interference;
- a description of the propagation of waves in free space and in simple enclosures;
- a foundation for the description of quantum mechanical wave phenomena in course PHAS0022 Quantum Physics and the theory of electromagnetic waves in PHAS0021 Electricity and Magnetism.

Learning Outcomes

After completing this half-unit course, the student should be able to:

- discuss the relationship between simple harmonic motion and wave motion, and make calculations of the motion of systems of masses connected by springs;
- make calculations on simple properties of wave motion, including wave packets, phase velocity, group velocity, and the propagation of waves in one, two and three dimensions;
- use the complex exponential representation for waves, and extract real values from it for the description of observable quantities;
- discuss the propagation of energy in waves;
- make calculations on and draw graphs illustrating the superposition of waves and the phenomenon of beats;
- Make calculations on systems with moving sources and receivers (the Doppler effect).

- sketch and describe standing waves, especially on strings and in pipes with various boundary conditions, and make calculations on them;
- draw phasor diagrams for systems of interfering waves and use these or complex number methods to derive general formulae and to describe specific cases;
- derive the wave equation for transverse waves on a stretched string, and for longitudinal waves in compressible materials;
- describe polarization of transverse waves, and discuss the phenomena which arise therefrom;
- derive formulae for the reflection and transmission coefficients of waves at barriers, express them in terms of impedances, and apply them;
- describe and make calculations on simple guided wave systems;
- describe what is meant by phase coherence, and explain the qualitative differences between light from different types of source;
- describe Huygens's principle and apply it to simple cases;
- derive formulae for the diffraction patterns of single and double slits, and for diffraction gratings with narrow and finite slits;
- derive the criterion for the resolving power of a grating;
- draw geometric ray diagrams for simple systems involving prisms, lenses, and plane and curved reflecting surfaces;
- make calculations in geometric optics for simple systems involving slabs, prisms, lenses, and plane and curved reflecting surfaces;
- describe the operation of simple optical instruments, derive object and image positions and magnifications, and discuss quantitatively their resolving power;
- calculate the properties of and describe applications of the Michelson and Fabry-Perot interferometers.

Methodology

This course is based on lectures, supplemented by problem solving tutorials/discussion.

Assessment and Feedback

Final assessment is by 2 In-Course-Assessment (ICA) tests during the term based on seen homework problems (15%) and a final written examination (85%).
Feedback will be provided through Moodle resources including model solutions to homework problems, discussion during PSTs and in class, and via return of ICAs.

Textbooks

Most of the course material is covered in the basic First Year text: *Physics for Scientists and Engineers with Modern Physics*, by Serway and Jewett, (Thomson).

Other books which may be useful include the following, but note that they cover more material than is in the syllabus, and in some cases are more mathematical in approach.

- R.W. Ditchburn, *Light*, Wiley (1963)
- O.S. Heavens and R.W. Ditchburn, *Insight into Optics*, Wiley (1991)
- F.G. Smith and J.H. Thomson, *Optics* (2nd edition), Wiley (1987)
- E. Hecht, *Optics* (2nd edition), Addison-Wesley (1974)
- S.G. Lipson and H. Lipson, *Optical Physics*, Cambridge (1969)
- R.S. Longhurst, *Geometrical and Physical Optics*, Wiley (1967)
- H.J. Pain, *The Physics of Vibrations and Waves* (4th edition), Wiley (1993).

Syllabus
(The approximate allocation of lectures to topics is shown in brackets below.)

Introduction [2 hrs]
Simple harmonic motion; phasors; complex number representation; beats
Basic Properties of Waves [2 hrs]
types of wave motion; progressive waves; simple harmonic form; definitions of amplitude, frequency etc.; phase and phase velocity; general differential equation of wave motion; superposition

Transverse waves [3 hrs]
stretched string; reflection and transmission at boundaries; impedance; energy and energy propagation; impedance matching; standing waves and normal modes

Longitudinal waves [1 hr]
sound in gases; sound in solid rod

Dispersion [2 hrs]
dispersion relations; phase velocity and group velocity

Doppler effect [1 hr]

General properties of light [3 hrs]
transverse nature; polarization; selective absorption and double refraction; waves and rays; Fermat's principle; Huygens's principle; interference and coherence

Interference by division of wavefront [3 hrs]
Fraunhofer and Fresnel limits; Young's slits; finite single slit; rectangular and circular apertures

Multiple beam interference [2 hrs]
diffraction gratings (narrow and finite slits); spectral resolving power; antenna arrays; Bragg reflection.

Interference by division of amplitude [3 hrs]
thin films; anti-reflection coatings; Newton's rings; Michelson spectral interferometer (including treatment of doublet source); Fabry-Perot interferometer; the etalon as a filter.

Resolution [1 hr]
Rayleigh criterion; Abbe theory.

Geometrical optics and instruments [4 hrs]
reflection at a spherical surface; mirror formulae; refraction at a spherical surface; thin lens formulae; formal aspects of thick lenses; systems of two thin lenses; magnifying glass; astronomical telescope, compound microscope, telephoto lens; aperture, stops and *f*-numbers.

PHAS0006 (PHAS1228) – Thermal Physics (Term 2)

Prof Peter Barker and Dr Chris Howard

Prerequisites

A-level Physics and Mathematics

Description

The module aims to develop, via a discussion of heat and the interaction of heat with matter, an understanding of the laws of thermodynamics. Simple statistical ideas of heat are introduced which are fully developed in a later course. Students are able by the end to apply thermodynamics to simple systems.

Aims of the Course

This course aims to:

- introduce and apply the laws of Classical Thermodynamics;
- obtain predictions from the kinetic theory, and derive and apply the Maxwell–Boltzmann distribution;
- discuss the symmetry and stability of the three primary phases of matter.
- describe a crystal structure in terms of a lattice and a basis

Learning Outcomes

After completing this course, students will:

- understand the meanings of heat and thermal equilibrium, state variables, state functions and equations of state;
- understand what is meant by an ideal gas and the ideal gas equation of state;
- understand the role of Avogadro's number and the mole;
- understand the separation of electronic, vibrational and rotational energy scales for gas molecules and be able to obtain the mean energy of each degree of freedom (equipartition of energy).
- understand the concepts of internal energy, heat and work, and be able to apply the first law of thermodynamics;
- be able to define specific heats and latent heat, and understand and manipulate Cp and Cv for ideal and real gases;
- be able to define isolated, isothermal and adiabatic processes;
- be able to derive, from thermodynamic arguments, the form of the Maxwell-Boltzmann distribution, and obtain the normalized velocity and speed distributions in an ideal gas;
- be aware of the ubiquity of the Maxwell-Boltzmann distribution for systems in thermal equilibrium;
- be able to obtain expressions for the mean collision and diffusion lengths from simple kinetic theory;
- be able to distinguish between reversible and irreversible processes;
- understand the concept of entropy and its relationship to disorder and its role in the fundamental equation (e.g. for an ideal gas).
- be able to obtain the ideal adiabatic equation of state;
- understand free adiabatic expansion as an example of an irreversible process;
- be able to derive the efficiency of the Carnot cycle, and understand the ideal operation of heat engines, refrigerators and heat pumps;
- be able to state the Zeroth, First, Second and Third Laws of thermodynamics;
- be able to combine the First and Second Laws of thermodynamics;
- understand the van der Waals equation of state for a real gas, and the form of the Lennard-Jones model for atomic interactions;

- be aware of the origin of covalent, ionic, metallic and van der Waals interactions;
- understand phase equilibria and the Gibbs and Helmholtz free energy;
- understand the concept of a phase and appreciate the diversity of the phases of matter.
- be able to sketch typical phase diagrams, including the triple and critical points.
- be able to sketch stress strain curves for brittle and ductile solids
- explain the meaning of elastic deformation and plastic deformation
- understand the concept of stored elastic energy and be able to calculate the stored elastic energy in a strained solid
- be able to describe a crystal structure in terms of a Bravais lattice and a basis
- be able to sketch the atomic positions of simple crystal structures
- be able to use Miller indices to describe directions and planes in crystals
- understand and the origin of x-ray diffraction in a crystal
- be able to derive Bragg’s law and use to do calculations on cubic crystal structures

Methodology

This course is based on lectures, supplemented by problem solving tutorials/discussion.

Assessment and Feedback

Final assessment is by 2 In-Course-Assessment (ICA) tests during the term based on seen homework problems (15%) and a final written examination (85%).
Feedback will be provided through Moodle resources including model solutions to homework problems, discussion during PSTs and in class, and via return of ICAs.

Textbooks

- *“Physics for Scientists and Engineers with Modern Physics”,* Serway and Jewett
- *“Physics”,* Thornton, Fishbane and Gasiorowitz, Prentice Hall
- *“Thermal Physics”,* Finn, Chapman and Hall
- *“The Properties of Matter”,* Flowers and Mendoza, Wiley
- *“Understanding the properties of Matter*”, de Podesta, UCL
- *“Statistical Physics”,* Mandl, Wiley

Course content

Part 1: Thermodynamics and Kinetic Theory [15 hrs] (recommended books; Finn, Podesta)

Temperature and the Zeroth Law [3 hrs]
Heat and thermal equilibrium; The Zeroth Law; Temperature scales; Macroscopic description of an ideal gas; State functions; Equation of state for an ideal gas; Boyle’s Law; Charles’s Law; The mole and Avogadro's number

Energy and the First Law [3 hrs]
Internal energy, work and heat; The First Law; Heat capacity, specific heat and latent heat; Isolated, isothermal and adiabatic processes; Transfer of energy; Thermal conductivity

Kinetic Theory of Gases [4 hrs]
Molecular model of an ideal gas; Kinetic theory and molecular interpretation of temperature and pressure; Specific heats, adiabatic processes; Equipartition of energy; Specific heat; Adiabatic processes; Maxwell-Boltzmann distribution of molecular speeds; Collision and diffusion lengths in gases, effusion; Law of atmospheres; Thermal conductivity of gases

Entropy and the Second Law [5 hrs]

Reversible and irreversible processes; Entropy, disorder on a microscopic scale; The Second Law, entropy as a state function; Fundamental equation; The arrow of time and the fate of the Universe; Ideal adiabatic expansion; The Carnot heat engine, refrigerators and heat pumps; Combined First and Second Laws

Part 2: The Properties of Matter [15 hrs] (recommended books; Podesta, Flowers and Mendoza)

Real gases and liquids [2 hrs]
Non ideality; The van der Waals equation of state; Structure of liquids

Phase equilibria [3 hrs]
Equilibrium between phases; Phase diagrams, triple point and critical point; Clapeyron equation; Clausius-Clapeyron equation.

Bonding [2 hrs]
Covalent, ionic, metallic and van der Waals bonding; Classification of solids; Interaction potentials (Lennard Jones and other functional forms); Thermal expansion; Cohesive energy calculations for van der Waals, covalent and ionic crystals.

Mechanical Properties of Solids [3 hrs]
Elastic properties; Definitions of stress and strain; Bulk modulus, Young's modulus (calculate from interatomic potentials)

Crystal Structures [5 hrs]
Crystal structures described in terms of the Bravais lattice and basis; Examples of crystal structures (hcp, bcc, fcc , diamond, ZnS and CsCl structures); Primitive and conventional unit cells; Crystal structures of ionic materials using models of packed spheres; Miller indices to designate lattices, planes and directions in crystals; X-ray diffraction; Bragg's law.

PHAS0007 (PHAS1240) – Practical Physics and Computing 1 (Term 1)

Dr. Paul Bartlett

Prerequisites

There are no pre-requisites.

Description

This module aims to provide students with a foundation in practical physics, computing and data analysis. Students will conduct experiments in the laboratory and UCL Observatory, and record, analyse and report on their results. In parallel, students will gain practical experience in mapping physics problems onto a computational framework, and will use computers to model, visualize and solve physical problems using Python.

Aim of the course

All Practical Physics courses within the Department contribute to a continuing development of students' practical skills extending throughout the four/three years of the physics-related MSci/BSc degrees. Collectively the courses have the overall aim of equipping the student with those practical skills which employers expect to find in graduates in physics whether they are employed in scientific research or development, or in a wider context. Course PHAS0007 is the first course encountered by students in making the transition from school to University level studies. It aims to take the first steps in this process of training in practical skills by addressing the following objectives.

Learning Outcomes

By the end of the course the students should:

- have become familiar with some basic items of laboratory equipment
- have acquired increased skill and confidence in the acquisition and analysis of experimental data through the performance of experiments at an introductory level
- have improved ability to record work concisely and precisely as it is done, through repeated practice in recording experiments in a laboratory notebook, guided by frequent feedback from teachers
- have an increased understanding and ability in applying the principles of data and uncertainty analysis, introduced in lectures, to experiments
- have increased conceptual understanding of topics in the theoretical part of the degree via the performance of linked experiments
- have increased ability to condense the information in their personal lab book record of an experiment into a concise, but precise and complete, formal report of the experiment in word processed form
- have used computers to analyse experimental data, and thus, by comparison with physical models, evaluated the appropriateness of the model
- have experience in mapping a physics problem onto a computational framework
- have used computers to model, visualize and solve physical systems, particularly those relevant to core first-year lecture modules
- have used the Python programming language to produce documented computer code that is clear, efficient, reusable and follows good coding practice
- have started to develop the skills and attributes of an autonomous scientific professional

Course Contents

Computing Component:

Practical sessions
The computing component consists of ten afternoon practical sessions introducing both Python as a programming language and the IPython notebook. In the first few sessions, fundamental concepts of computing will be introduced and illustrated with example problems from the physics curriculum. We will then look at how to analyse and effectively present experimental data, including an introduction to straight-line fitting.
The final part of the course will introduce students to creating computational models of physical systems and animating them using Vpython. New concepts are introduced via video screencasts available in advance of each session. During each session, students will complete a task under the close supervision of the course staff, and be given immediate verbal and written feedback.

Individual assignments
In addition to the continuous assessment in the sessions, students will also complete two longer individual assignments in their own time. The first of these (completed in and after Reading week) will be related to the computational treatment of experimental data, while the second (completed over the Christmas vacation) will be a more open-ended assignment to create a computational model of a physical problem.

Laboratory component:

Experimental Procedures and Data Analysis
Six lectures on good practice in obtaining and recording experimental data and an introduction to data analysis and the analysis of experimental uncertainties are given. In addition, the process of producing Scientific Papers is discussed. Two Moodle Quizzes are set.

Initial Experiment
Students will conduct an initial (unassessed) experiment that is guided by a demonstrator. This is undertaken so that students can become familiar with the process of conducting experiments.

Main Experimental Work
Students will conduct two 'main' experiments that will challenge how they see experimental physics at university level, when compared to what they have done before at 'A' Level (or equivalent). This work will be assessed by ongoing oral assessments and Moodle Quizzes. In particular, a 'Data Retrieval Test' Moodle Quiz will form the bulk of this experimental mark. It is designed to see if students have completed their Laboratory Notebooks, based on best practice, so that they can answer questions on the two main experiments.

ULO/Medical Physics Work

All students will spend time either in the University of London Observatory or within the Medical Physics department (for Medical Physics students). This work will be assessed via coursework based on their experimental sessions.

Formal report
A report (in the form of a scientific paper) must be prepared on a Main Experiment which has been completed.

Methodology

In the laboratory sessions, both in the introductory experimental skills part and the main series of experiments, students work typically in pairs following scripts for the experiments. Great emphasis is placed on the formation of good habits in the keeping of a laboratory notebook for which students are given detailed advice. Lab sessions are supervised at the rate of about one demonstrator per 10 to 12 students. Demonstrators not only help students understand experiments and overcome difficulties as they arise, but also inspect student notebooks to provide instant formative feedback to any bad practice arising.

Assessment and Feedback

In the computer-based skills component, assessment is continuous, and will consist of weekly feedback on the work done in each session, as well as two longer assignments completed in the students' own time, one in Reading Week and one in the Christmas vacation.
The formal report element is the first time at University that the students are faced with the task of distilling the information in their personal laboratory notebook record of an experiment into a concise report to a third party in word-processed form. They are given detailed advice on how to approach this. The different course components contribute the total assessment with the following weights:

- Experiment-related assessment and formal report, 50% (40% former, 10% latter)
- Computing component, 50% (37.5% individual assignments, 12.5% continuous assessment from sessions)

Students will need to achieve a minimum of 30% in both the computing and experiment-related assessments for the course to be considered to have been passed.

Textbooks

There is no textbook which the students are expected to buy either for the computing or laboratory components. The following are provided for reference in the laboratory and the students are expected to consult them and others held in the laboratory, to find relevant information required in experiments.

- *"Table of Physical Constants*" by Kaye and Laby
- "*Handbook of Chemistry and Physics*" CRC Press
- *"Experimental Methods"* by L. Kirkup
- *"Measurements and their Uncertainties: A practical guide to modern error analysis"* by Hughes and Hase, OUP

PHAS0008 (PHAS1241) – Practical Skills 1P (Term 2)

Dr. Paul Bartlett

Prerequisites

Normally PHAS0007 Practical Skills 1C

Description

This module aims to provide students with developing confidence and skills in experimental physics, through a selection of guided experiments that are appropriate to our degree streams and core physics. These experiments provide experience in experimental techniques, including data recording, data analysis and report writing.

Aim of the Course

All Physics Laboratory courses within the Department contribute to a continuing development of students' practical skills extending throughout the four/three years of the physics-related MSci/BSc degrees. Collectively the courses have the overall aim of equipping the student with those practical skills which employers expect to find in graduates in physics whether they are employed in scientific research or development, or in a wider context. Course PHAS0008 follows on directly from course PHAS0007, Practical Skills 1C, and by further practice contributes to reinforcing and extending many of the same objectives. The objectives for PHAS0008 are listed below.

Learning Outcomes

By the end of the course the students should:

- have extended the range of basic items of laboratory equipment with which they are familiar
- have acquired increased skill and confidence in the acquisition and analysis of experimental data through the performance of experiments at an introductory level
- have improved ability to record work concisely and precisely as it is done, through repeated practice in recording experiments in a laboratory notebook, guided by frequent feedback from staff
- be further practiced in using the data analysis programs which are maintained on the laboratory computers (currently Python-based)
- have an increased understanding and ability in applying the principles of data and uncertainty analysis, introduced in lectures, to experiments
- have increased conceptual understanding of topics in the theoretical part of the degree via the performance of linked experiments
- have increased ability to condense the information in their personal lab book record of an experiment into a concise, but precise and complete, formal report of the experiment in word processed form
- have the confidence to modify experiments under the guidance of demonstrators
- have consolidated the skills and attributes of an autonomous scientific professional that they started to develop in previous modules

Course Contents

Experiments
22 afternoons spent performing experiments of First Year standard, some of which illustrate principles encountered in the lecture curriculum.

Formal report
One of these must be prepared on an experiment which has been completed.

Methodology

In the laboratory sessions students work typically in pairs following scripts for the experiments. The experiments are of the same standard as those in the prerequisite course, PHAS0007. Great emphasis is placed on the formation of good habits in the keeping of a laboratory notebook for which the students are given detailed advice. Lab sessions are supervised at the rate of about one demonstrator per 10 to 12 students. Demonstrators not only help students understand experiments and overcome difficulties as they arise, but can also inspect student notebooks to provide instant correctives to any bad practice arising.

Students will conduct three 'main' experiments that will emphasise the need for students to develop critical thought processes and creativity within a physics context. They will also conduct 'Skill of Hand' tasks that will introduce them to skills they will need in later courses.

Assessment and Feedback

The work will be assessed by ongoing oral assessments and Moodle Quizzes. In particular, a 'Data Retrieval Test' Moodle Quiz will form the bulk of this experimental mark. It is designed to see if students have completed their Laboratory Notebooks, based on best practice, so that they can answer questions on the two main experiments and the Skill of Hand tasks.

The different course components contribute to the total assessment with the following weights:

- Experiments, 85%
- Formal report, 15%

Textbooks

There is no textbook which the students are expected to buy. The following are provided for reference in the laboratory and the students are expected to consult them and others held in the laboratory, to find relevant information required in experiments.

- "*Table of Physical Constants*" by Kaye and Laby
- "*Handbook of Chemistry and Physics*" CRC Press
- "*Experimental Methods*" by L. Kirkup
- *"Measurements and their Uncertainties: A practical guide to modern error analysis"* by Hughes and Hase, OUP
- *"The Art of Electronics, 3rd Edition"* by P Horowitz and W Hill

PHAS0009 (PHAS1246) – Mathematical Methods II (Term 2)

Dr. Frank Kruger and Prof Serena Viti

Prerequisites

It is assumed that, in order to take this course, students should normally have completed satisfactorily the first semester PHAS0002 or other equivalent course. Knowledge of A-level Further Mathematics is not required.

Description

This module aims to provide students with the mathematical foundations and understanding required for their studies in physics and astrophysics related degree programmes, and to give students experience and skills in mathematical manipulation and problem-solving. Topics include: differential equations, multiple integrals, matrices and linear transformations, vector operations.

Aims

This course aims to:

- provide, together with PHAS0002, the mathematical foundations required for all the first year and some of the second year courses in the Physics and Astronomy programmes
- prepare students for the second year Mathematics course PHAS2246 and MATHB6202
- give students further practice in mathematical manipulation and problem solving

Learning Outcomes

After completing this half-unit course, the student should be able to:

- Find the general solutions of first order ordinary linear differential equations using the methods of separation, variation of integration constant and perfect differentials, and find particular solutions through applying boundary conditions;
- Find the solutions of linear second order equations with constant coefficients, with and without an inhomogeneous term, through the particular integral complementary function technique
- Set up the limits when integrating in 2 and 3-dimensions and evaluate the resulting expressions
- Find a vector normal to a surface and evaluate surface integrals
- Change integration variables. In particular to judge when polar coordinates are appropriate and to be able to change to them
- Do matrix multiplication. Be able to evaluate the determinant, the trace, the transpose and the inverse of matrices of arbitrary dimension
- Manipulate vectors in a complex *n*-dimensional space and represent linear transformations in this space by matrices
- Perform matrix algebra, including multiplication and inversion, using a wide variety of matrices including unitary, Hermitian, and orthogonal matrices
- Solve linear simultaneous equations through the use of matrices and determinants
- Summarise the reasons for the failure of Newtonian mechanics as speeds approach that of light
- Understand the derivation of, and be able to use, Lorentz transformation equations in the special theory of relativity and apply them to the space-time and momentum-energy four-vectors
- Apply relativistic kinematics to high energy particle physics, so as to treat the Doppler effect for photons and determine the threshold energy for pair-production in different frames of reference

Methodology

The methodology is very similar to the precursor first-semester PHAS0002 half-unit, with 40 scheduled periods, of which roughly 15% are used to go through worked examples. In addition there are four two-hour supervised problem solving tutorials in term 2 as well as two revision lectures in Term-3.

Assessment and Feedback

Though mathematical formalism is developed throughout the course, the emphasis in the weekly homework sheets and final examination is very much on problem solving rather than demonstrations of bookwork.
Final assessment is by 2 In-Course-Assessment (ICA) tests during the term based on seen homework problems (15%) and a final written examination (85%).

Textbooks

The book recommendations are similar to those given for the first semester precursor course, for example Riley, Hobson and Bence. A book which treats essentially everything in both these and the second-year PHAS0025 mathematics course from a more advanced standpoint is *Mathematical Methods in the Physical Sciences*, by Mary Boas (Wiley). However, many first year students have in the past found it to be too formal. The special relativity content should be found in most general physics texts, though the course does not follow any of these very closely.

Syllabus

33 lectures, 7 discussion classes and 4 problem-solving tutorials.

(The provisional allocation of lectures to topics is shown in brackets. The ordering an allocation is subject to change, outlined on the course info website)

Differential Equations **[5 hrs]**
Ordinary first-order; separable, variation of integration constant; change of variables; exact differential; Ordinary second order homogeneous and non-homogeneous including equal roots

Multiple Integrals **[5 hrs]**
Area and volume integrals; gradient in 3D, normal to a surface, surface integrals; change of coordinates; area and volume elements in plane polar; cylindrical polar and spherical polar coordinates

Matrices and Linear Transformations **[14 hrs]**
Matrix multiplication and addition; Finding the determinant, trace, transpose and inverse of a matrix; Matrices as a representation of rotations and other linear transformations; Definition of 2, 3 and higher order determinants in terms of row evaluation (no use is made of □$_{ijklm}$..); the rule of Sarrus; Manipulation of determinants; Cramer's rule for the solution of linear simultaneous equations

Revision of real 3-dimensional vectors; Complex linear vector spaces; Linear transformations and their representation in terms of matrices

Special Theory of Relativity **[9 hrs]**
Implications of Galilean transformation for the speed of light Michelson-Morley experiment; Einstein's postulates; Derivation of the Lorentz transformation equations and the Lorentz transformation matrix; length contraction, time dilation, addition law of velocities, "paradoxes"; Four-vectors and invariants; Transformation of momentum and energy; Invariant mass; Conservation of four-momentum; Doppler effect for photons, threshold energy for pair production, the headlight effect

PHAS0010 (PHAS1247) – Classical Mechanics (Term 1)

Dr. Mario Campanelli

Prerequisites

In order to take this course, students should have achieved at least a grade A in A2-level Mathematics or other equivalent qualification.

It is not assumed that you will have taken Further Mathematics or Mechanics modules at A2-level but you will have a knowledge of the following topics to A2-level or equivalent.

- Physical quantities, dimensions and units;
- Definitions of velocity and acceleration, force and momentum;
- Newton's laws of motion;
- Definition of gravitational acceleration and weight;
- Equations of uniformly accelerated motion in 1D: $v = u + at$; $s = ut + 1/2\ at^2$; $v^2 = u^2 + 2as$, and definitions of the relevant symbols;
- Newton's inverse-square law of gravitational force, and the corresponding gravitational potential energy;
- Definitions of kinetic and potential energy, work and power;
- Relationship between force and potential energy for constant forces (e.g. gravitational field near the Earth's surface);
- Centripetal force and centripetal acceleration (circular motion only);
- The principle of moments.

In addition the following core topics from A2-level mathematics will be assumed:

- Calculus (basic integration and differentiation);
- Vectors, including expansion using a basis set, addition and subtraction.

Description

This modules aims to allow students to understand the importance of classical mechanics in formulating and solving problems in many different areas of physics and develop problem-solving skills more generally, and to introduce the basic concepts of classical mechanics and apply them to a variety of problems associated with the motion of single particles, interactions between particles and the motion of rigid bodies.This is an introductory course in Classical Mechanics. Starting from Newton' s Law of Motion, it sets up the techniques used to apply the laws to the solution of physical problems. It is essential background for many of the succeeding courses within the degrees in Physics and Astronomy.

Aims of the Course

This course aims to:

- convey the importance of classical mechanics in formulating and solving problems in many different areas of physics and develop problem-solving skills more generally;
- introduce the basic concepts of classical mechanics and apply them to a variety of problems associated with the motion of single particles, interactions between particles and the motion of rigid bodies.

Learning Outcomes

After completing this half-unit course students should be able to:

- state and apply Newton's laws of motion for a point particle in one, two and three dimensions;
- use the conservation of kinetic plus potential energies to describe simple systems and evaluate the potential energy for a conservative force;
- understand an impulse and apply the principle of conservation of momentum to the motion of an isolated system of two or more point particles;
- evaluate kinematic quantities in the centre of mass system;

- solve for the motion of a particle in a one-dimensional harmonic oscillator potential with damping and understand the concept of resonance in a mechanical system;
- appreciate the distinction between inertial and non-inertial frames of reference, and use the concept of fictitious forces as a convenient means of solving problems in non-inertial frames;
- describe the motion of a particle relative to the surface of the rotating Earth through the use of the fictitious centrifugal and Coriolis forces;
- derive the conservation of angular momentum for an isolated particle and apply the rotational equations of motion for external torques;
- solve for the motion of a particle in a central force, in particular that of an inverse square law and so be able to describe planetary motion;
- describe the motion of rigid bodies, particularly when constrained to rotate about a fixed axis or when free to rotate about an axis through the centre of mass;
- calculate the moments of inertia of simple rigid bodies and use the parallel and perpendicular axes theorems;
- appreciate the influence of external torques on a rotating rigid body;

Methodology

There are 18 two-hour lectures augmented with 4 two-hour problem solving tutorials (PSTs) in term-1 and a revision lecture at the start of term-3. In PSTs, groups of students attempt to solve sets of problems under the supervision of two demonstrators. This exercise is specifically designed to help in the development of a student's problem-solving skills.

Assessment and Feedback

The final assessment is based on two In-Course-Assessment (ICA) tests taken in the middle of term-1 and at the start of term-2 and a final written 2.5 hour examination. The ICAs are based on seen homework and PST problems and amount to 15% of the final mark with the other 85% coming from the mark in the final examination.
Feedback will be provided through Moodle resources including model solutions to homework problems, discussion during PSTs and in class, and via return of ICAs.

Textbooks

The content of the course and general level of the topics is similar to the material in "Physics for Scientists and Engineers" by Serway and Jewett. Three more advanced texts: "Classical Mechanics (5th Edition)" by Kibble and Berkshire; "An Introduction to Mechanics" by Kleppner and Kolenkow and "Dynamics and Relativity" by Forshaw and Smith also cover the material but much of these texts are at a level beyond this introductory course.

Syllabus

Mathematical preliminaries
Units and dimensions, Vectors, Scalar and Vector Products, Calculus, Differentiation and Integration with vectors.

Newton's laws of motion
Symmetries, Invariance under spatial, time and rotational translations, boosts between frames of reference, motion under a constant force, momentum and impulse, projectile trajectories under gravity, conservation of momentum for isolated systems.

Work, power, kinetic and potential energy
Definitions of work, power, KE and PE, conservative forces in one and three dimensions, friction and dissipative forces,

Centre of mass and collisions
Centre of mass, relative displacement and reduced mass, single-body collision with a rigid wall, coefficient of restitution,
collision between two bodies of finite mass (head-on and glancing), inelastic vs elastic collisions

Polar Coordinates, angular momentum, and motion in a central force
Motion in a plane expressed in plane polar coordinates, circular motion, angular momentum and torques, central forces, PE for a central force.

Orbits
Motion under inverse square law of force, Kepler's Laws, conic sections, eccentricity.

Accelerating and rotating frames of reference
Transformation of velocity and acceleration, rotating frames of reference, fictitious forces: centrifugal and Coriolis forces.

Simple Harmonic motion
Undamped motion, PE and KE in SHM, damped oscillations, forced damped oscillator.

Rigid bodies
Angular momentum of a rotating rigid body, moment of inertia, KE of rotating body, equation of motion for a rotating body, compound pendulum, parallel and perpendicular axis theorem, centre of percussion, rolling vs slipping.

PHAS0011 (PHAS1423) – Modern Physics, Astronomy and Cosmology (Term 1) *Natural Sciences and BASc students only*

Dr. Paul Bartlett, Dr. Peter Doel & Prof. Ofer Lahav

Prerequisites

A-level Maths and Physics or equivalents. Students must be able to differentiate and be familiar with the basic principles of diffraction, electromagnetism, classical mechanics, force etc. No previous knowledge of Quantum Physics, Astronomy or Cosmology is required.

Description

This module aims to: introduce students to new concepts in quantum physics which underlie much of Modern Physics (including Medical Physics) and Astronomy and Cosmology; approach the frontiers of understanding in Modern Physics (including Medical Physics) and Astrophysics and Cosmology; introduce students to experimental physics in the university context.

Aims of the Course

- To introduce new concepts in quantum physics which underlie much of Modern Physics (including Medical Physics) and Astronomy and Cosmology
- To approach the frontiers of understanding in Modern Physics (including Medical Physics) and Astrophysics and Cosmology
- To provide a basis of descriptive knowledge for Natural Sciences stream choices later in year 1
- To introduce students to experimental physics in the university context

Learning Outcomes

Quantum and Atomic Physics
After taking the course the student should be able to:

- Explain the failures of classical physics at the atomic scale
- State the revised versions of relativistic momentum and energy obtained from Special Relativity
- Describe the hypotheses of Planck, Einstein and de Broglie on the duality of waves and particles, and the evidence supporting them
- State Heisenberg's uncertainty principle
- Write down the time-independent Schrödinger equation and its solutions for a free particle and a particle in an infinite square well, explaining how they give rise to quantum numbers
- Explain how this, in combination with the Exclusion Principle, gives rise to the observed structure of atoms

Medical Imaging
After taking the course the student should be able to:

- Describe the basic physical principles involved in the major medical imaging techniques, including: x-ray imaging, computed tomography, ultrasound, magnetic resonance imaging, radioisotope imaging, and electroencephalography
- Explain the contrast mechanisms in each of the above methods, and understand the difference between anatomical and functional imaging
- Differentiate between the clinical uses of the alternative techniques based on the information they provide and the risk/benefit to the patient

Astronomy and Cosmology
After taking the course the student should be able to:

- Describe the main stellar spectral classification scheme, with connection to the effective temperature and luminosity of the objects
- Explain the processes by which energy is generated in stars
- Outline the main evolutionary paths of stars, including properties of their end-states. Outline the main observational factors in support of the Big Bang model

- Explain simple ‘world models’ in cosmology

Laboratory Physics
After taking the course the student should:
- Have become familiar with some basic items of laboratory equipment
- Have acquired increased skill and confidence in the acquisition and analysis of experimental data through the performance of experiments at an introductory level
- Have improved ability to record work concisely and precisely as it is done, through repeated practice in recording experiments in a laboratory notebook, guided by frequent feedback from teachers

Methodology

The course is based on 30 hours of timetabled lectures plus 5 hours of problem solving tutorials including in-course-assessments classes and discussion. There will also be three 3.5 hour laboratory sessions to introduce practical physics lab work.

Assessment and Feedback

The full assessment for the module will have three components:

• Examination	70%
• Two In Course Assessments	15%
• Physics labs	15%

Feedback will be provided through Moodle resources including model solutions to homework problems, discussion during PSTs and in class, and via return of ICAs.

Recommended Books
- *Physics for Scientists and Engineers with Modern Physics*, Serway and Jewett (Thomson)
- *Physics for Scientists and Engineers* (2nd Ed), Fishbane, Gasiorowicz and Thornton, Prentice Hall (1996)
- *Introductory Astronomy and Astrophysics* (4th Ed) Michael Zeilik and Stephen A. Gregory (Thomson Learning, ISBN 0030062284)
- *Universe* (7th edition), by Roger A. Freedman & William J. Kaufmann III, may provide useful supplementary reading
- *Medical Physics* by Emily Cook and Adam Gibson. Booklet available online at: www.teachingmedicalphysics.org.uk
- *Physics of Medical Imaging*, Edited by S. Webb, (Adam Hilger: Bristol), 1988. ISBN 0-85274-349-1
- *Measurements and their uncertainties: a practical guide to modern error analysis.* Hughes, Ifan and Hase, Thomas P. A, (Oxford University Press. ISBN 9780199566327). (2010)

Background Reading for the Whole Course
- *The New Physics for the 21st Century* (2nd Ed), ed Gordon Fraser, Cambridge University Press

Syllabus
[Approximate allocations of lectures to topics are given in square brackets]

Quantum and Atomic Physics [14 hrs]

Breakdown of Classical Physics – Light [6 hrs]

Waves; superposition and coherence; Newtonian optics; Young double-slit experiment; Michelson-Morley experiment; Special Relativity; blackbody radiation and Planck quantization; photoelectric effect; particle/wave “duality”; Compton scattering; pair production; Bragg scattering for light

Quantum Theory – Particles and Waves [4 hrs]

The de Broglie conjecture; electron diffraction (Davison/Germer, Thompson, and Bragg); probabilistic interpretation of the wavefunction; Uncertainty Principle; particle in a box; Schrödinger equation; tunnelling

Atoms [4 hrs]
Thomson model of atomic structure; Rutherford model of Hydrogen (from Geiger and Marsden experiment); atomic spectra; Bohr model of Hydrogen; solution of Hydrogen atom with Schrödinger equation (spherical coordinates, eigenfunctions, quantum numbers); fine structure; Pauli exclusion; periodic table

Medical Imaging [6 hrs]
X-ray imaging, including angiography. X-ray computed tomography; Diagnostic ultrasound, including Doppler imaging; Magnetic resonance imaging; Medical imaging using radioisotopes; Electroencephalography

Astronomy and Cosmology [10 hrs]
Stellar luminosity, effective temperature and spectral types; Energy generation and the evolution of stars; Overview of galaxies, Hubble's law and the Big Bang model; Concepts of inflation

Laboratory Physics [10 hrs]
Familiarisation, through the performance of basic experiments, with some basic laboratory equipment and with computer packages for the analysis of experiments

PHAS0012 (PHAS1449) – Computing for Mathematical Physics (Term 2)

Dr. Jasvir Bhamrah

Prerequisites

There are no prerequisites for this course, but it is itself a prerequisite for PHAS0030 Practical Mathematics II in the second year.

Description

The module aims to introduce students to the use of modern computer packages for the solution, by both analytic and numerical methods, of a wide range of problems in applied mathematics in science. This skill is of particular importance for students on the Theoretical Physics programmes. It is based on a state of the art system for mathematical computation, and will introduce key foundation concepts in computation.

Aims of the Course

The aim of this module is to reinforce and apply concepts of mathematical physics being taught in other first year modules.

Learning Outcomes

The course helps to demonstrate the application of mathematical methods to physical problems, reinforcing the student's knowledge of both the physics and the mathematics, and preparing the student for the use of computer-based mathematical methods in problem-solving.

Methodology

The course is based on the Mathematica programming language. Computing sessions will consist of demonstrations of the features of the language followed by application of the new material to problems under the guidance of the course teacher.

Assessment and Feedback

The students' grasp of the subject will be tested in problem sheets to be tackled in the students' own time. Assessment will be based on an unseen computer-based examination on Mathematica (60%) and coursework problem papers (40%).

The topics covered are as follows:

- "Computer Algebra" systems in general and *Mathematica©* in particular; Basic algebra, differential and integral calculus; Power expansions of functions; Limits
- *Mathematica©'s* structures (especially lists) and their relationship with mathematical structures; Operations on lists; Lists as sets; Inner and outer products; Lists of data
- Rules, patterns, and how to apply them; *Mathematica©'s* pattern constructions; Rules as returned when solving equations; Manipulating expressions with rules; More general pattern-matching: sequences, types, criteria and defaults; RepeatReplace and delayed rules
- Defining functions; Overloading of functions; Recursive procedures; Loops and control structures
- Graphics: basic line graphs, contour and surface plots; Controlling graph layouts, combining and animating graphs; Applications to visualisation of fields; Conformal Mapping; Domains of functions
- Numerical solutions of algebraic equations using FindRoot and using graphs to control the process; Methods of root-finding by bisection and the Newton-Raphson method
- Numerical solution of differential equations by finite difference methods, including simple stability analysis; Use of NDSolve

- Repeated operations without loops: Nest, While, FixedPoint, Through
- Series solution of differential equations; Boundary value problems (shooting methods); Brief treatment of partial differential equations
- Analysis of data: linear and non-linear fitting; Goodness of fit; Reading and writing external data files; Simple image processing; (pixellisation; edge enhancement)

PHAS0017 (PHAS1901) – Developing Effective Communication 1 (Term 1)

Dr. Chamkaur Ghag

Prerequisites

None

Description

This is the first of three modules that aim to develop your skills in getting your message across, and in understanding the messages of others. These skills are crucial not only for being an effective physicist, but also in functioning effectively in many career or non-career situations.

Aim of the Course

This is the first of two modules that aim to develop your skills in getting your messages across, and in understanding the messages of others. These skills are crucial not only for being an effective physicist, but also in functioning effectively in many career – or non-career – situations.

Learning Outcomes

After completing this module successfully, students should be able to:

- write short pieces for non-specialist and specialist audiences
- orally present scientific ideas to a small group of peers
- prepare proposals for science communication or public engagement projects
- use appropriate IT effectively

Methodology

This module runs for the first two terms, with one hour every week in the first term set aside for lectures, discussions, seminars, or surgeries. Some of the work is done as part of tutorials. Students will practice writing of short essays and reports, prepare, deliver and discuss short oral presentations to small and medium sized audiences, and construct a proposal for a scientific outreach project. The module continues in the second term, with oral presentations that take place during reading week.

Assessment and Feedback

Assessment will be of a written exercise (50%) and a written proposal including presentation during a mock review session (50%).This module is weighted 50% of the two year communications skills provision, which includes PHAS0035 in year 2. The two modules together will contribute to your assessment for honours at a level equivalent to approximately 5%.

Textbooks

A range of textual material will be used. Students should find *Getting the Message Across: Key Skills for Scientists*, edited by Kristy MacDonald, and published by the Royal Society of Chemistry at £1.20 a helpful booklet.

Assessment and Feedback

Students *should* expect to receive feedback within one calendar month of the deadline for submission of each piece of assessed work (including weekends and vacations). Departments are encouraged to provide this in a shorter timeframe if possible.

If, for whatever reason, a Department or module organiser cannot ensure that the one calendar month deadline is met then they *must* indicate, by direct contact with the students on the module through email/Moodle, when the feedback will be provided. It is expected that the extra time needed *should* not exceed one week.

Where feedback is not provided within the timescale, students *should* bring the matter to the attention of the Departmental Tutor or Head of Department who *should* take action as necessary. If students remain dissatisfied then the matter *should* be referred to the Faculty Tutor.

UCL Feedback Turnaround Policy

Regular feedback is an essential part of every student's learning. It is UCL policy that all students receive feedback on summative assessments within one calendar month of the submission deadline. This feedback may take the form of written feedback, individual discussions, group discussions, marker's answers, model answers or other solutions (although students should note that UCL is generally unable to return examination scripts or comments on the same). Students writing dissertations or research projects should also expect to receive feedback on a draft on at least one occasion.

The Department aims to return coursework within two weeks of the deadline and other work within four weeks of submission. Schedules for the distribution, submission and return of coursework should be available at the beginning of each term, and will be posted on the **Departmental website**.

If, for whatever reason, a department/division cannot ensure that the one calendar month deadline is met then they will tell students when the feedback will be provided - it is expected that the extra time needed should not exceed one week. Where feedback is not provided within the timescale, students should bring the matter to the attention of their Departmental Tutor or Head of Department.

Draft:

Draft: 17/08/2018

UCL Department of Physics and Astronomy

Provisional Assessment and Feedback Schedule

Year 1, Term 2 (Session 2018-19)

							Reading Week										
		Term 2															Term 3
	UCL Week ⇨	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
	Week starting ⇨	07-Jan-19	14-Jan-19	21-Jan-19	28-Jan-19	04-Feb-19	11-Feb-19	18-Feb-19	25-Feb-19	04-Mar-19	11-Mar-19	18-Mar-19	25-Mar-19	01-Apr-19	08-Apr-19	15-Apr-19	22-Apr-19
PHAS0005	Waves, Optics and Acoustics			PST1		PST2			PST3		PST4						
	Peter Doel						ICA1					ICA2					
	Jasvir Bhamrah								ICA1								ICA2
PHAS0006	Thermal Physics			PST1		PST2			PST3		PST4						
	Peter Barker						ICA1					ICA2					
	Chris Howard								ICA1								ICA2
PHAS0009	Mathematics II	HW1	PST1/HW2	HW3	PST2/HW4	HW5		PST3/HW6	HW7	PST4/HW8	HW9						
	Frank Kruger						ICA1					ICA2					
	Serena Viti		HW1	HW2	HW3	HW4		HW5	ICA1/HW6	HW7	HW8	HW9					ICA2
PHAS0012	Computing for Mathematical Physics	HW1	HW2	HW3	HW4	HW5		HW6	HW7	HW8							
Comp	Jasvir Bhamrah			HW1	HW2	HW3	HW4	HW5		HW6	HW7	Exam					
						HW1		HW2	HW3	HW4	HW5	HW6					HW/Exam
PHAS0008	Practical skills 1P	HW1/eTB1	eTB2	HW2	eTB3	HW3/eTB4				eTB6							
Lab	Paul Bartlett	HW1/eTB1	eTB2		HW2/eTB3	eTB4			HW3/eTB5	eTB6		Exam					
		HW1/eTB1	eTB2	TL1	HW2/eTB3	eTB4		TL2	eTB5	eTB6	TL3						Exam
PHAS0003	Practical skills 1A (Astronomy)					Prob1/CN1											
UCLO	Steve Fossey			Practical 1		Practical 2		Prob1/CN1		Practical 3	Practical 4			FR/CN2			
						Practical 1		Practical 2				Practical 3					FR/CN2/P4
PHAS0017	Communication Skills 1				Talk												
	Chamkaur Ghag						Talk										
								Talk									
	Student Voice: Feedback Session																
	Daven Armoogum and Nick Nicolaou						Student Feedback										
	Neal Skipper																

Please note: dates may change - please check course Moodle pages

Colour coding

Assignments:

Set	(blue)
Submitted	(red)
Feedback, Assessment	(green)

ICA Coversheet

UCL Academic Manual:
Assessment Requirements
Assessment Feedback
Marking and Moderation
Late Submission Penalties
Word Count Penalties
Irregularities & Plagiarism