

Module Guide

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1 Introduction

Welcome to S818 *Space science*. This module provides an in-depth introduction to the methods of conducting scientific measurements and observations in the space environment and the technologies needed for space missions. The main aims of this module are to prepare you for further academic research in space science and to help you to develop skills and knowledge that are relevant to employment in the space sector.

S818 has been designed as the first module to be studied in the MSc in *Space science and technology*, and it is a key required module in the Postgraduate Diploma in *Space science and technology*, and the Postgraduate Certificate in *Space science*.

This Module Guide is both a launch pad for the module and a point of reference to be used throughout the year. It contains information on:

- the nature and scope of the module;
- the format of the module;
- module assessment;
- tutor support arrangements;
- the online resources.

All of the module resources can be accessed from the S818 website. You should, however, buy a copy of the set book. As well as the resources we provide, you will be expected to search for further information yourself. We will provide you with selected links to useful articles, websites etc., but you will need to search for other material to fill in any gaps in your knowledge and help you to deepen your understanding of the material we have provided. You will have access to a wide-range of scientific literature electronically via the OU Library.

1.1 Nature and scope of the module

Space science covers such a wide range of topics (from micrometeoroids to the microwave background) that it would be difficult for any module to cover them all in a comprehensive fashion. Consequently, this module takes the approach of using case studies to illustrate the diversity of science topics covered by space science. The case studies also demonstrate the key considerations that influence the design and operation of space missions.

Space science draws on knowledge and skills from a range of disciplines, such as physics, astronomy, engineering, geosciences, chemistry and mathematics. Students studying this module are likely to come from across these different backgrounds, and may hold first degrees in any these discipline areas. We do not expect you to start S818 as an expert in all of the subject areas involved but you should have strengths in at least one, and we expect you to be prepared to carry out the necessary background reading to fill in any gaps in your understanding of other disciplines. This will take additional self-study time which you will have to plan, although you should note that this has been accounted for in the design of the module. We provide you with suitable starting points for your additional reading, much of which is based on OU undergraduate teaching material. However, it is likely that you will have to go beyond this provision in order to be able to

engage with the forefront of research activity in space science, and you should be prepared to locate and use books and other resources that will help you in this regard. S818 is divided into a series of case studies, preceded by an introductory block as follows:

- Block A: Introduction to space science and technology
- Block B: Apollo 11
- Block C: Gaia
- Block D: Rosetta
- Block E: Curiosity on Mars

You will be expected to assess your own background knowledge and skills to determine what further reading you need to do in order to tackle the case studies successfully.

During the introduction you will need to use the set book for this module, Fortescue, P., Swinerd, G., & Stark, J. (eds) *Space Systems Engineering* (4th edn) Wiley - ISBN 9780470750124. Please make sure you have purchased a copy, it costs about £55. It is important to appreciate that the set book focuses on spacecraft engineering rather than space science. However, the book does provide an introduction to many of the technical aspects of spacecraft systems that you need to know about in order to understand space science missions. The set book does not cover scientific results, and it is expected that you will develop your understanding of space science through the relevant scientific literature (typically peer-reviewed papers) that you will be guided to as part of the case studies.

As part of the introduction, you will be expected to develop your skills in the Python programming language. Being able to use a programming language is important because so many aspects of space science and space engineering are dependent on software, whether that is for data processing, scientific analysis or instrument control. In particular, in S818 we expect you to be able to use Python to analyse data and present your results graphically. In order to introduce Python programming, we expect all students to work through the first three quarters of an online course called *Learn to Code for Data Analysis*. This course is provided through the OU's Openlearn website and uses so-called "Jupyter notebooks" as a way of developing Python code in an interactive way. Jupyter notebooks are particularly well suited to data exploration and code development.

While *Learn to Code...* is general, and uses a variety of sources of data in its exercises, it provides a firm basis for the analysis of space science data that you will meet in the module. If you already have some experience of Python programming you will find it easy to work through this course, but you should still do so to ensure that you understand the capabilities of the Python data analysis library called 'pandas'.

It is also vital that you work through the software installation options in *Learn to Code...* so that you can develop your own Jupyter notebooks.

Note that we assume that you already know how to use spreadsheet packages, and you may find that some of the activities in the module could be carried out using spreadsheets rather than Python. However, where we have specified that you should carry out a task using Python, you should do so.

The case studies (described in more detail below) use specific missions to explore scientific goals and results in space science. However, they also act to illustrate how specific technical challenges have been met through the design and operation of these missions. These include such topics as the design of imaging detectors, the operation of robotic rovers and the very exacting requirements of human spaceflight. In addition, since

space research generally requires substantial funding from governments, there is also some consideration of the political and social context of space missions.

1.2 Module learning outcomes

The learning outcomes for this module are divided into four categories: knowledge and understanding, cognitive skills, key skills, and practical and professional skills.

S818 provides you with the opportunity to develop and demonstrate these learning outcomes as listed below.

Knowledge and understanding

On completion of S818 you should be able to demonstrate a knowledge and understanding of:

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- Kn1 the space environment within the Solar System,
 - Kn2 the design and operation of space-based instrumentation,
 - Kn3 the aspects of space mission design and operation relevant to scientific applications,
 - Kn4 scientific debates within planetary and space sciences, based on current research findings.
-

Cognitive skills

On completion of S818 you should be able to:

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- C1 critically evaluate methodologies of scientific measurement in the space environment,
 - C2 select and apply appropriate mathematical methods for modelling and analysing science and engineering data obtained in the space environment.
-

Key skills

On completion of S818 you should be able to:

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- Ky1 manipulate and present data in a variety of ways,
 - Ky2 demonstrate proficiency in using a programming language in a space science related context,
 - Ky3 communicate information and conclusions effectively, to specialist and non-specialist audiences,
 - Ky4 use information and communications technology (ICT) to locate information and to communicate effectively with others.
-

Practical and/or professional skills

-
- P1 plan and carry out a scientific investigation using data from space-based instrumentation.
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2 The study guides

As noted above, the module comprises a series of blocks, each of which is described by the online study guide (one for each case study, plus one for the introduction). The study guide directs your progress through the module.

It is important to appreciate that each block contains activities which you should work through. The activities are varied in nature, and include readings of scientific or technical papers, readings from the set book, use of web-based resources, searching for appropriate literature, examining scientific images, carrying out scientific investigations using online experiments, as well as analysis and presentation of data (using IPython). The activities in each block are numbered sequentially (e.g. A.1, A.2...) and you are expected to work through them all.

Many activities have a 'Comments' button which provide you with some guidance about what the activity should achieve. It should also be noted that most of the tasks required for the Tutor Marked Assignments are related to the activities.

Most activities are followed by one or more 'Exercises' that allow you to assess what you have learnt from the preceding activity. Each exercise has an 'Answer' which you should only look at after you have made an attempt at it.

An approximate timing is given for each activity. Note that this estimate *includes* the time taken to complete any exercises that follow the activity.

Blocks A–D are each expected to require four weeks of study time, while Block E is somewhat shorter at 3 weeks. Following most of the blocks there is a consolidation week. This additional time is built in because it is recognised that the majority of students will need to develop their skills and knowledge in areas that were not covered in their prior learning. We also schedule a study week for preparation of each Tutor Marked Assignment.

It is important that you appreciate that after the end of Block E, you will be required to work for one of the specified "rover weeks". This is a team task using a robotic rover in our Mars yard, and since it is assessed work, you **must be available** to work online with other students for one of these weeks. While you will be asked for your preferences for which week you work, if you foresee any problems with your availability in this time, you should alert your tutor as soon as possible.

Any time after the end of Block E, apart from your rover week, is expected to be spent in preparing your End-of-Module Assessment.

2.1 Part A: An introduction to space science and technology

This introductory block provides essential background about the design and operation of space science missions. You will consider an example solar physics mission before looking at the space environment, celestial mechanics, mission analysis and spacecraft systems.

The skills development in this part concentrates on: mathematical problem solving (orbits), proficiency in using Python to analyse data and present results, and analysis of your learning needs. You will analyse data from orbit modelling software and from an operational cubesat (a simple but very small satellite).

This block requires background knowledge in physics and associated mathematical skills (equivalent to first or second year undergraduate physics or engineering). Links to appropriate study resources are provided for students without this background.

2.2 Part B: Apollo 11

The first case study, Apollo 11, looks at the iconic NASA moonshot of 1969 and the topic of lunar exploration. You will examine the motivations behind the Apollo programme and review the current state of lunar science. You will consider the way in which modern exploration of the moon differs from the Apollo missions and look at aspects of spacecraft design that are particularly pertinent to human spaceflight, such as the thermal balance of spacecraft and the mitigation of risk due to micrometeoroid impact.

You will use an online optical microscope (in the Open Science Laboratory) to conduct investigations and work in a team to plan a hypothetical field excursion on the lunar surface.

You will develop your skills in: analysing experimental data, mathematical problem solving (thermal analysis), information literacy, and team working.

This block requires some background knowledge in planetary sciences, and links to appropriate study resources are provided.

2.3 Part C: Gaia

The Gaia case study considers the European Space Agency (ESA) mission to accurately measure the positions, brightnesses and motions of about one billion stars in our Galaxy. In addition to engaging with the science data, you will also explore the technology behind the spacecraft, with a particular emphasis on the specialised CCD detectors that are at the heart of this mission.

In addition to assessing scientific literature, you will further develop your programming and practical skills. You will conduct an online experiment using a radiation detector and you will have the opportunity to carry out an observation of a Gaia transient source using one of the OU's robotic telescopes.

This block requires some background knowledge in astronomy, and links to appropriate study resources are provided.

2.4 Part D: Rosetta

Block D looks at ESA's Rosetta mission to comet 67P Churyumov-Gerasimenko. There is an emphasis on the Ptolemy mass spectrometer that was on the Philae lander in order to highlight the challenge of conducting what is usually a laboratory-based analytical investigation on board a spacecraft. You will consider mission risks and why this comet was selected, as well as looking at the timeline of the comet landing and the science results.

In addition to assessing the scientific advances made through this mission, you will develop communication skills and skills in planning scientific investigations.

This block requires background knowledge of analytical techniques (in particular, mass spectrometry) and links to relevant study resources are given.

2.5 Part E: Curiosity on Mars

This case study considers the science goals of NASA's Curiosity rover that is part of the Mars Science Laboratory. Motivated by the question of life on Mars, you will learn about the geology of the Martian surface and appreciate how field work is conducted using robotic rovers. This case study leads towards an assessed group project in which you will work in teams to carry out a rover-based mission in the OU's Mars yard.

You will develop your skills in conducting scientific investigations, assessing scientific and technical literature, and team-working.

This block requires some background knowledge in geology, and links to appropriate study resources are provided.

3 Assessment

The assessment of S818 comprises two elements – the continuous assessment (TMAs 01–04) and the examinable component (EMA). To be sure of passing the module you must achieve at least 50% in both the continuous assessment and the examinable component.

3.1 Continuous assessment

The continuous assessment consists of four tutor-marked assignments (TMAs) that must be submitted electronically via the electronic TMA (eTMA) system, which you can access via StudentHome. The substitution rule does not apply to any of the TMA scores so it is important that you submit them all. The TMAs are equally weighted – i.e. they contribute equally to your Overall Continuous Assessment Score (OCAS).

You will find copies of the assignments on the appropriate weeks of the S818 website Study Planner. Further advice on completing and submitting TMAs can be found at the beginning of each assignment, in the *Assessment handbook* (accessible via StudentHome) and in the eTMA system itself.

The TMAs relate to the module material as follows:

TMA	Contribution to OCAS	Coverage
01	25%	Block A: An introduction to space science and technology
02	25%	Block B: Apollo 11
03	25%	Block C: Gaia
04	25%	Block D: Rosetta

3.2 Examinable component

The examinable component consists of two end-of-module tasks (EMA tasks 1 and 2) which are submitted together. EMA Task 1 is worth 20% of the Overall Examination Score (OES) and EMA Task 2 is worth 80% of the OES.

EMA Task 1 assesses a group activity in which you remotely control a rover to conduct experiments in a specially-constructed Mars yard. The EMA task requires you to reflect on this activity and your role in the team.

EMA Task 2 pulls together aspects from all of the module and requires you to write a technical report to inform a mission proposal. Some of the work you do in the TMAs will provide you with the skills you will need to successfully complete this part of the EMA. This makes it even more essential that you complete all of the TMAs. Whilst the report that you submit for EMA Task 2 must be your own work, there will be opportunities for you to discuss and exchange ideas with other students.

Your EMA must be submitted via the eTMA system (as TMA30) on the cut-off date given on the website Study Planner. No extensions are permitted for the EMA. Closer to the end of the module you will be sent a reminder of the cut-off date and provided with a link to the document *Information for Students Submitting Examinable Work Electronically* (which you can also access from the *Assessment and exams* section of the [Help Centre](#)). This document provides you with general University guidance on completing and submitting EMAs, explains the penalty for late submission of EMAs, as well as what to do if you need to defer or postpone completion of the module or have special circumstances which affected your performance.

Note that in order to guarantee a pass grade in this module, you must achieve at least 50% in both your OCAS and OES.

4 Tuition

Shortly before S818 begins, you will be allocated a tutor who will be your main point of contact for the module. Your tutor will mark your assignments, help with your academic queries and provide guidance throughout the module. He/she will also facilitate and support your group work tasks. Tutors and Module Team members will run online tutorials and seminars throughout the presentation and will provide additional support via the S818 website forums.

5 Study/Academic skills

S818 is a postgraduate module and it is assumed that students already have study skills and an approach to academic practice that is appropriate for a graduate. However there are useful links under the 'Resources' section of the S818 website that provide help on academic writing, information literacy and other study skills.

You should also be aware that instances of plagiarism in assessed work, and violations of the computing code of conduct are matters that may be treated under the University's formal disciplinary procedures. You are reminded that it is your responsibility to be aware of the University's regulations.

6 The S818 Production Team

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7 Contacts

If you have difficulties or queries relating to your studies, your StudentHome page provides details of who to contact.

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