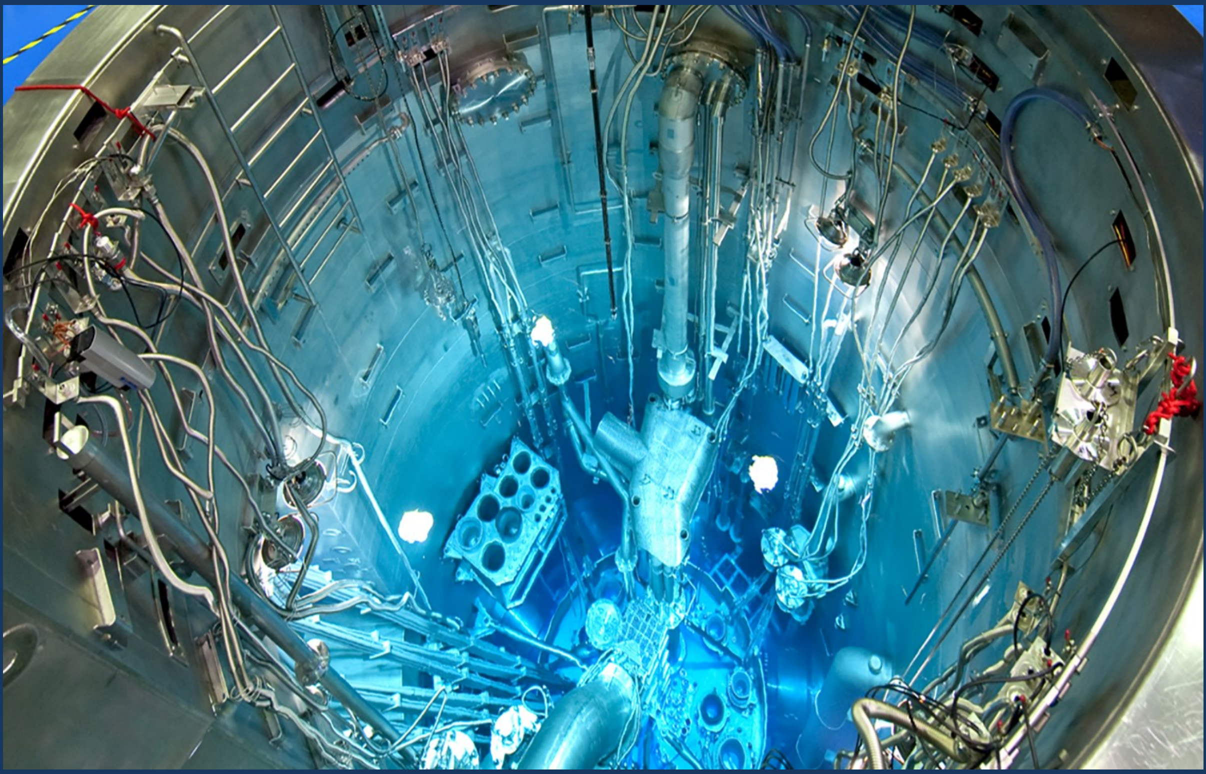
University of Glasgow | School of Physics & Astronomy



PHYS5038 Nuclear Power Reactors

Course Information Guide

1 Course Details

PHYS5038 Nuclear Power Reactors is a level 5 Physics Masters course. It is elective for many physics degree options. It is composed of 18 lectures and 2 full class tutorials, all given in Semester 1.

Lecturer: Dr David Mahon
Room 514, Kelvin Building
David.Mahon@Glasgow.ac.uk

Recommended Text: Serge Marguet, The Physics of Nuclear Reactors (Springer); this book is available as an electronic copy through the university library.

Course notes, suggestions for further reading and question sheets are made available on Moodle.

2 Assessment

The course will be assessed via an examination in the April/May diet. It provides 10 M-level credits.

3 Required Knowledge

Although there is no specific course which is a prerequisite for Nuclear Power Reactors, students are expected to be familiar with concepts such as nuclear reactions, diffusion theory and eigenvalue equations.

4 Intended Learning Outcomes

By the end of this course, students will be able to demonstrate knowledge and a broad understanding of the scientific and technological principles which underpin the operation of nuclear power reactors. They should be able to explain the role of nuclear power reactors in meeting the needs for electricity generation in the UK and worldwide. They should also be able to explain the principles of operation of nuclear power reactors and the associated fuel cycle technologies for a range of current and future designs. This also includes the basic principles of nuclear fusion. They should be able to critically discuss the issues of operational safety of reactors and waste management. Students should also be able to able to apply simple nuclear reaction theory and more advanced theories such as one-group and modified one-group diffusion to a variety of problems relating to neutron moderation, reactor control and criticality.

5 Course Outline

5.1 Reactor History and Principles of Operation

In the context of a historical overview of the development of fission reactor technology we will review current reactor types and the principles of their operation. This will include an overview of the role played by the different reactor components and the relevant nuclear physics which underpins their utilisation in energy production. We will review radioactivity, nuclear reactions, neutron interactions with matter, criticality and reactivity. The basic physical principles of fusion reactors with a focus on the relevant nuclear reactions will also be reviewed.

5.2 The Nuclear Fuel Cycle

We will then review the nuclear fuel cycle by discussing the scientific and technological aspects of conventional UOX fuel production, reprocessing, storage and disposal. This will lead to a more in-depth treatment of advanced fuel cycle strategies for modern reactors including MOX and other plutonium-based fuel utilisation and the associated impact on waste management.

5.3 Advanced Reactor Technologies

We will discuss the key differences between the operation of thermal and fast critical reactors. This will lead to a detailed introduction to the Gen III+ and Gen IV reactor and fuel technologies. We will also discuss highly advanced concepts such as accelerator-driven subcritical reactors, together with partitioning and transmutation deployment as well as key aspects of future fusion reactors.

5.4 Reactor Safety

An historical overview of reactor accidents will provide the framework for an introduction to the key concepts of reactor safety. This will be followed by a more detailed discussion of the safety systems for Gen III+ reactors.

5.5 Neutron-induced Reactions

Basic nuclear reaction theory will be discussed, with a focus of scattering, capture and fission reactions. Examples of applying these calculations in the framework of moderation and reactor control will be given, as will examples involving neutron multiplication and criticality.

5.6 Neutron Transport and Diffusion

The neutron transport equation will be derived, which will then be followed by a demonstration of its application in one-group and modified one-group diffusion theory to different reactor geometries. Examples will be given for various solutions to the critical reactor equation and the link made to criticality and non-leakage probabilities.