Engineering Summer Programme
Girton College, University of Cambridge

Girton College Cambridge
Summer Programmes

Course Outline

This Engineering Summer Programme allows ambitious students to take an engineering course comprising three modules covering different cutting edge topics in engineering; areas in which Cambridge has a particularly strong reputation. The modules will be:

The Jet Engine
Nanotechnology
Quantum Technologies

Contact Hours: Minimum of 45 hours of contact time (15 hours for each module)

Assessment: Presentations in each of the modules

The Jet Engine

In this module, we will explore together how different pieces of 'cold metal' can be integrated together to achieve the amazing thing - jet propulsion. It is going to introduce the past, the current and the future path of this revolutionary technology. We will learn the basic ideas and the fundamental principles which keep the engine running. This will also lead us to explore the state of art technologies of making the current engines more safe, efficient and environmentally friendly. Consequently, we will discuss the directions and challenges of developing the future generations of jet engines. Finally, a number of high impact academic researches carried out in Cambridge to the revolution of the jet engines will be introduced. This will give an example of what is good academic research in this filed looks like.

Lecture 1:
• Brief history of jet engine

Lecture 2:
• Principles of jet propulsion and key components
• Applications of gas turbine technology

Lecture 3:
• Basic thermodynamics and fluid mechanics
• Gas turbine cycle and layout of jet engine
• Key technologies and the future

Lecture 4:
• Turbomachinery: Compressors and Turbines

Summer Programmes, Girton College, Cambridge CB3 0JG
telephone: 01223 338944
email: summer@girton.cam.ac.uk www.girton.cam.ac.uk
Registered charity number 1137541

Lecture 5:
• Computational Fluid Dynamics (CFD)

Lecture 6:
• Research work in turbomachinery

Lecture 7:
• Group presentation for assessments

Lecture 8:
• Group presentation for assessments

Assessment
Small group presentations about future potential technologies for making jet engines safer, more efficient and more environmentally friendly.

Contents requirements:
(1) Background
(2) Mechanisms
(3) Challenges
(4) Research proposal (optional)
(5) Conclusions

Nanotechnology

Nanotechnology is all-pervasive and has applications in and implications for almost all areas of our lives. In this course, we will look at what Nanotechnology is and where it is used. We will explore the evolution of modern science and see how it paved the way for nanoscience, which set the foundations for nanotechnology. We will present and analyse the basic scientific principles behind the properties of matter and how and why they change at the nanoscale, and see how to make use of this in our everyday lives in areas such as in the automotive, aerospace, medicine, construction, computing and cosmetic industries. We will look in detail at nanomaterials including nanoparticles such as graphene, quantum dots, carbon nanotubes and nanowires, and describe where they are found, how to make them and how they are used.

Course structure:

Lecture 1: Introduction to all things nano, background and core concepts
Lectures 2 and 3: Quantum mechanics, including wavefunctions, the Schrödinger equation, and quantum confinement
Lectures 4 and 5: Nanomaterials and nanodevices
Lectures 6: Visualising the nanoworld with electron microscopy and scanning probe microscopy

Assessment: 100% presentation. For the presentation the students will work in groups of 5-6 students, and each student must contribute equally. Each group will be allocated an aspect of nanotechnology, and will present their findings on that topic to the other students in a 20-minute oral presentation.

Quantum Technologies

In this module, we will look at what quantum technologies are, where they have come from and where they can and are being used. We will explore the foundations of quantum mechanics and how they led to a deepening of our understanding of the world around us, and how many of the properties of matter can be explained. We will look at how this has led to novel devices in computing, data storage, information processing and other fields, and gain an appreciation for this often-misunderstood branch of science. We will introduce the Schrodinger equation and solve it for a number of everyday problems which will reveal the breadth of this field. We will also consider some of the more challenging aspects of the interpretation of quantum mechanics calculations, which are often highly counter-intuitive.

Course structure:
Lecture 1: Introduction to Quantum Mechanics
Lecture 2: How to use Quantum Mechanics
Lecture 3: Specific examples of the application of Quantum principles
Lecture 4: Introduction to spintronics
Lecture 5: Introduction to quantum communication
Lecture 6: Introduction to quantum computing

Assessment: Small group presentations

Preliminary Reading List

The Jet Engine

Jet Propulsion: A Simple Guide To The Aerodynamic And Thermodynamic Design And Performance Of Jet Engines, Nicholas Cumpsty, 2nd edition, 2003

Gas Turbine Theory, HIH Saravanamutto, GFC Rogers, H Cohen,5th edition, 2001

Fluid mechanics and Thermodynamics of Turbomachinery, S.L. Dixon and C.A. Hall, 7th edition, 2014

Nanotechnology

Jahangirian, Hossein et al. (2017). A review of drug delivery systems based on nanotechnology and green chemistry: green nanomedicine. *International Journal of Nanomedicine*, 12, 2957–2978.

Allen, Matthew et al. (2010). Honeycomb Carbon: A Review of Graphene. *Chemical Reviews*, 110 (1), 132-145.

Liu, Yiyao et al. (2007). Nanomedicine for drug delivery and imaging: A promising avenue for cancer therapy and diagnosis using targeted functional nanoparticles. *International Journal of Cancer*, 120, 2527–2537.

Yang, Peidong et al. (2010). Semiconductor Nanowire: What's Next? *Nano Letters*, 10, 1529–1536.

Quantum Technologies

Introduction to Quantum mechanics, David Griffiths

Introduction to Spintronics, Supriyo Bandyopadhyay & Marc Cahay

Quantum computation and Quantum information, Michael Neilson & Isaac Chuang

Quantum Computer Science, N. David Mermin