Fitzwilliam College Online Winter School Programme 2024

Course brochure

The Fitzwilliam College Online Winter School Programme is organised by Fitzwilliam College, one of the constituent colleges of the University of Cambridge. The programme will let you experience the type of advanced teaching offered at our institution. The same academics who teach our undergraduate students will help you develop your academic skills. The challenging problem-solving and discussion sessions will reflect the style of Cambridge supervisions, which are the core of the excellent teaching offered at the University.

This brochure contains a list of the various short courses that Fitzwilliam College is going to offer in February 2024. Here you can find a detailed description of the contents of each short course, together with a list of prerequisite knowledge and a recommended reading list for the various courses. This document will be updated with the exact teaching times and office hours by mid-January at the latest.

I am delighted that Fitzwilliam College can offer you the opportunity to participate in this Winter School Programme. I hope you will enjoy exploring your chosen topic and that partaking in our course will nourish your passion for the subject. I am looking forward to welcoming you soon to our Winter School Programme!

Dr Peter Bolgar
Director of the Winter School Programme

Contents:

Microbiology & Microbial Genetics
(Biology)

Dr Ashraf Zarkan
Research Fellow and Group Leader, Department of Genetics, University of Cambridge
Bye-Fellow, Fitzwilliam College, University of Cambridge

5th – 16th February, 2024

Dr Ash Zarkan is a microbiologist with a long-standing interest in infectious diseases and microbial genetics. Ash is an expert on antimicrobial resistance (AMR), and his research is focused on tackling the rise of AMR, especially in the human pathogen *Escherichia coli* (*E. coli*). His clinical focus is on urinary tract infections (UTIs) where *E. coli* is the major pathogen affecting 150 million people per year worldwide. He is an active member of the Microbiology Society, and he serves as an academic reviewer for several prestigious microbiology journals and grant funding bodies. Ash has lectured on several summer programmes in Cambridge on topics ranging from infectious diseases, immunity, vaccination, and antimicrobial resistance. He is an excellent and engaging speaker, with an interactive teaching style that brings the excitement and experience of his research to his audience. Ash is very passionate about tackling the rapid rise of AMR and intends to pass on such passion to those who attend his courses.

Departmental Profile: https://www.gen.cam.ac.uk/staff/dr-ashraf-zarkan
Cambridge Infectious Diseases Profile: https://www.infectiousdisease.cam.ac.uk/directory/dr-ashraf-zarkan
LinkedIn Profile: https://www.linkedin.com/in/ashraf-zarkan/

Module Structure and Syllabus:

Time and Date	**Monday 5th Feb 9am – 1pm**	**Tuesday 6th Feb 9am – 1pm**	**Wednesday 7th Feb 9am – noon**		
	Intro Microbiology & Pathogens	Transmission, Prevention & The Immune System	Antimicrobial Therapies		
Time and Date	**Monday 12th Feb 9am – 1pm**	**Tuesday 13th Feb 9am – noon**	**Wednesday 14th Feb 9am – 1pm**	**Thursday 15th Feb 9am – 1pm**	**Friday 16th Feb 9am – 1pm**
	Antimicrobial Resistance	Biofilms	Vaccines	Microbial Genetics	Final Presentations

Intro Microbiology: Introduces students to the microbial world and its diversity.

Intro Pathogens: Introducing students to the main types of pathogens.

Transmission & Prevention: Methods that are used for pathogen transmission (how do they make us sick?) and approaches for infection prevention.

The Immune System: The role of our immune system in combatting infectious diseases.

Antimicrobial Therapies: The range and mechanisms of antimicrobial medications against infectious pathogens.

Antimicrobial Resistance (AMR): what is it and why is it happening? What is the scale of the problem?

Biofilms: An overview of microbial biofilms and their role in infection and AMR.

Vaccines: Introduction to the principle and mechanisms of vaccines.

Microbial Genetics: Introduction to the main aspects of microbial genetic (DNA, RNA, replication…etc).

Pathogens Overview: Overview of some important pathogens and their role in infectious diseases.

List of prerequisite knowledge:
There is no required prerequisite knowledge for this course. A broad familiarity with the items on the list above will greatly enhance your understanding and enjoyment of the classes and good preparation by all students will contribute significantly to the success of the course.

Recommended reading list (optional):

Anderson, D. *Introduction to Microbiology*. Mosby, 1980
Not complex but a bit old now. It covers a lot of what we will be covering in the course.

Jacob, Francois and Jacques Monod. *Genetic regulatory mechanisms in the synthesis of proteins.* "What is true for *E. coli* is true for an elephant.....".
A classic paper, www.sciencedirect.com/science/article/pii/S0022283661800727

Madigan, M et al. *Brock Biology of Microorganisms*. Pearson, 2014
A useful (albeit detailed) introduction to microbiology for readers with a good level of background knowledge.

Kenneth Todar's online textbook of microbiology, http://textbookofbacteriology.net/
A fairly detailed introduction for the interested amateur.

For pure fun (plus easy accessibility of the papers, because they're linked) have a look at the PNAS list of "classics". They're from a variety of sciences, including microbiology, so you'll have to do a bit of sifting/filtering: www.pnas.org/site/classics/pnas_classics.xhtml

Office hours: Noon - 1 pm on Wednesday 7th Feb & 1 pm – 2pm on Wednesday 14th Feb.

Special Relativity and Quantum Mechanics
(Physics)

Dr Joao Rodrigues
Director of Studies, St Catharine's College, University of Cambridge
Bye-Fellow, Wolfson College, University of Cambridge

4th – 16th February, 2024

After many years working in Quantum Field Theory and Particle Physics, specifically in the parton structure of the nucleons, I changed my field of research to the climate of the polar regions. In the Polar Oceans Physics Group in Cambridge, I studied how the Arctic sea ice cover has changed in recent decades as a consequence of global warming. I examined sea ice thickness data collected by submarines and satellites and attempted to quantify the dramatic thinning of the Arctic Sea ice. At present, I teach several Physics and Mathematics courses for first-, second- and third-year students in the Natural Sciences and the Mathematical Tripos of the University of Cambridge.

College Profile: https://www.wolfson.cam.ac.uk/people/dr-joao-rodrigues

Module Structure and Syllabus:

Time and Date	**Sunday 4th Feb 9am – noon**	**Monday 5th Feb 8am – 11am**	**Tuesday 6th Feb 8am – 11am**	**Wednesday 7th Feb 8am – 11am**	**Thursday 8th Feb 8am – 11am**
	The Lorentz Transformation	Relativistic Kinematics	Relativistic Dynamics	Relativistic Optics	Appearance of rapidly moving objects
Time and Date	**Monday 12th Feb 8am – 11am**	**Tuesday 13th Feb 8am – 11am**	**Wednesday 14th Feb 8am – 11am**	**Thursday 15th Feb 8am – 11am**	**Friday 16th Feb 8am – 11am**
	The historical development of QM	The postulates of QM and simple applications	The EPR paradox and the Bohr-Einstein debate	Bell's Inequality	Final Presentations

The Lorentz Transformation: We highlight the successes and difficulties of the pre-relativistic physics. The latter was very effective in predicting, for instance, the motion of the planets, but Einstein noticed what appeared to be an inconsistency between Newton's dynamics and Maxwell's electromagnetism. This led him to propose a new physical theory and a new transformation law for the coordinates of the same event in two different reference frames. Different observers may assign different times to the same event, a curious feature of what became known as the Lorentz transformation.

Relativistic Kinematics: The fact that time flows at different rates in different systems of reference has interesting consequences. We shall follow a fast-moving interstellar spaceship and compare the magnitudes of time intervals, distances and velocities measured by those in the ship with the corresponding measurements made by observers at rest. In this context, we shall examine in detail the well-known Twin Paradox.

Relativistic Dynamics: We introduce the notions of relativistic momentum and energy and study some examples of the conversion of mass into energy and vice-versa. We derive the famous formula $E=mc^2$ and explore its implications in some physical systems.

Relativistic Optics: The Doppler effect and the aberration of light were known phenomena in non-relativistic physics. We shall assess how Relativity modifies the classic formulas and explore some of the consequences of these changes.

Appearance of rapidly moving objects: When taking a photograph of a moving object, all rays generated at its boundaries arrive simultaneously at the camera. If the object has a non-negligible size, light rays must then leave its surface at different times. In most instances this causes a significant distortion on the appearance of objects that move at speeds close to the speed of light. However, perhaps surprisingly, some objects keep their shape in the photographs.

The historical development of Quantum Mechanics: The first quarter of the twentieth century is often regarded as one of the most productive periods in the history of science. We shall study the ideas of Planck, de Broglie, Heisenberg, Schrodinger, and others which culminated in 1925-1926 with the formulation of the Quantum Theory.

The postulates of Quantum Mechanics and simple applications: We introduce the notion of wave function, quantised energy levels and solve Schrodinger's equation for simple systems. We discuss how the equation can be applied to more complicated systems such as the hydrogen atom.

The EPR paradox and the Bohr-Einstein debate: The new ideas were not accepted without reluctance by some, among them Einstein. In 1935, together with Podolsky and Rosen, he wrote an article in which an apparent paradox suggested that the formulation of Quantum Mechanics was incomplete. We shall discuss their reasoning and the more modern version of the paradox due to Bohm.

Bell's Inequality: Almost 30 years after the EPR argument was formulated, Bell wrote what has been described as one of the most important scientific works of the 20th century, in which it was shown that Quantum Mechanics could not be completed with the so-called hidden variables. We shall have a good discussion of Bell's theorem and some of its variants, namely due to d'Espagnat.

List of prerequisite knowledge:

Newtonian dynamics: - Newton's Laws
- Notions of force, mass, momentum, energy and work

Optics: - The laws of reflection and refraction
- Notion of frequency, period, wavelength

Mathematics: - Elementary techniques of differentiation and integration
- Techniques for solving simple first and second order differential equations (desired but not strictly necessary)

Recommended reading list (optional):

Halliday and Resnick, *Fundamentals of Physics* (Relativity and Quantum Mechanics chapters only);
A Einstein, *The Principle of Relativity*;
R Feynman, *The Feynman Lectures on Physics*, Quantum Mechanics (Chapter 1 only);

Office hours: 11am – noon on Thursday 8th and 15th Feb

Mathematics for the Natural Sciences

(Mathematics)

Mrs Serena Povia
College Teaching Associate at St John's College
Supervisor at Magdalene and Jesus
Involved in Cambridge Admissions for the past 6 years in several colleges
STEMSMART Supervisor

3rd – 16th February, 2024

I specialise in teaching Mathematics and Physics at the University level. I have been a supervisor in physics and mathematics for the Natural Sciences course for about ten years. My current teaching commitments are the Physics and Mathematics courses for the first year and the second year of the respective Tripos. I previously taught third-year courses too.

College Profile: https://www.joh.cam.ac.uk/fellow-profile/410

Syllabus:

Differential equations 1: Using physics, we introduce the need to use differential equations with some simple examples – possibly including systems of differential equations in nuclear decay.
Integration 1: A very flexible day on integration – it serves as a recap and extension for those who have done a lot of integration and as an introduction for those who have not seen much integration yet.
Complex Numbers: We need the formalism of complex numbers to solve harder physics problems. We introduce and use the cartesian and polar forms.
Differential equations 2: Simple harmonic oscillator physics requires a different style of solution that will use Complex Numbers.
Manipulating Vectors: Dot Product and Cross Product and a few applications in Physics.
Introduction to multivariable calculus: if we need to describe physical phenomena, we need to be able to express quantities in more than one dimension. We look at how to interpret a scalar function of two variables as a surface.
Differential equations 3: We cover simple examples of multivariable differential equations (for example wave equation, Laplace equation, Diffusion Equation)
Integration 2: We introduce simple forms of multivariable integration (surface, volume, centre of mass)
Differential operators: We focus on definitions of vector functions and simple applications of div, grad, curl. We cover very simple examples of physics that requires the use of vector operators.

Teaching Schedule:

Saturday, 3rd Feb, 9am – 1pm
Sunday, 4th Feb, 9am – 1pm
Monday, 5th Feb, 8.30am – noon
Wednesday, 7th Feb, 8.30am – noon
Sunday, 11tt Feb, 9am – 1pm
Monday, 12th Feb, 8.30am – noon
Wednesday, 14th Feb, 8.30am – noon
Friday, 16th Feb, 8.30am – 12.30pm

List of prerequisite knowledge:

Simple derivatives (polynomials, trigonometric, ln), product and chain rules for derivatives, simple integrals (polynomials, trigonometric, ln).

Office hours: 12.30pm – 13.30pm on Thursday 8th and 15th Feb

Psychology and Neuroscience

Dr Alexandra Krugliak
Visiting Researcher at the Department of Psychology, University of Cambridge
Supervisor, Trinity College, University of Cambridge

3rd – 18th February, 2024

I studied Psychology and Cognitive Neuroscience at The University of Maastricht (The Netherlands), before obtaining a PhD from the University of Birmingham (United Kingdom). Currently I am a Research Associate at the Department of Psychology at the University of Cambridge. My main research interest is how the human brain processes natural objects. I combine neuro-imaging techniques such as Electroencephalography (EEG), Magnetoencephalography (MEG), and functional Magnetic Resonance Imaging (fMRI) with cutting-edge computational approaches to study neural representations of visual and auditory objects.

Departmental Profile: https://www.psychol.cam.ac.uk/staff/dr-alexandra-krugliak

Syllabus:
Intro Psychology: Introduction to the fundamentals of Psychology.
Methods: Overview of the methods used in research and applied Psychology.
Cognitive Psychology: Theoretical frameworks of how humans think and process information.
The Brain: Brain anatomy and function.
Cognitive Neuroscience: Studying the brain with neuro-imaging methods and computational approaches, and what it reveals about how the mind works.
Visual Perception: How visual information is perceived and processed in the brain: organisation of the visual systems in humans and animals, visual illusions, effects of lesions on visual experience.
Memory: Mechanisms underlying the formation and retrieval of memories: short- versus long-term memory, memory formation, remembering, patient studies.
Attention: Attention guides how we perceive the world: theories of attention, selective attention, active perception.
Psychopathology: What happens when the brain and behaviour work atypically: examples of mental disorders.

Teaching Schedule:
Saturday, 3rd Feb, 10am – 1pm
Sunday, 4th Feb, 9am – 1pm
Monday, 5th Feb, 9am – 1pm
Wednesday, 7th Feb, 9am – 1pm
Monday, 12th Feb, 9am – noon
Tuesday, 13th Feb, 9am – noon
Friday, 16th Feb, 9am – noon
Saturday, 17th Feb, 10am – 1pm
Sunday, 18th Feb, 10am – 1pm

List of prerequisite knowledge:
No pre-requisite knowledge is needed.

Office hours: Noon – 1 pm on Tuesday 6th and noon – 1 pm on Friday 16th Feb

Sustainable Vehicles
(Engineering)

Dr Andrea Giusti
Bye-Fellow, Fitzwilliam College, University of Cambridge
Lecturer in Thermofluids, Department of Mechanical Engineering, Imperial College London

3rd – 17th February, 2024

Andrea is a Lecturer in Thermofluids at Imperial College London, Department of Mechanical Engineering and Bye-Fellow of Fitzwilliam College, Cambridge. He studied Mechanical and Energy Engineering in Florence (Italy). He obtained a PhD in 2014 at the University of Florence, working on a project for the development of clean engines for airplanes. Following his PhD, Andrea joined the Engineering Department at the University of Cambridge as a Rolls-Royce Research Associate. He was appointed Lecturer by Imperial College in October 2018. In addition to the academic role at Imperial College, Andrea supervises undergraduate students at Fitzwilliam College. He is also Editor-in-Chief of the International Journal of Spray and Combustion Dynamics.

College Profile: https://www.fitz.cam.ac.uk/people/dr-andrea-giusti
Departmental Profile: https://www.imperial.ac.uk/people/a.giusti

The objective of the module is to learn the fundamentals to develop an innovative conceptual design of a sustainable vehicle. The set of problems designed to support the learning will lead the student to a proposal of an innovative vehicle and a critical evaluation of its feasibility.

Module Structure and Syllabus:

Time and Date	**Saturday 3rd Feb 7am – 10am**	**Sunday 4th Feb 7am – 10am**	**Monday 5th Feb 6am – 9am**	**Tuesday 6th Feb 7am – 10am**	**Thursday 8th Feb 7am – 10am**
	Engineering and Innovation	Sustainability and Life cycle assessment	Vehicle dynamics	Hydrodynamic forces	Internal combustion engines
Time and Date	**Monday 12th Feb 7am – 10am**	**Tuesday 13th Feb 7am – 10am**	**Thursday 15th Feb 7am – 10am**	**Friday 16th Feb 7am – 10am**	**Saturday 17th Feb 7am – 10am**
	Fuels and emissions	Electrification of cars	Future vehicle concepts	Ethics and intellectual property	Final Presentations

1. **Engineering and Innovation**
    a. Duration: 3 hours (2 hours of lecture; 1 hour of problems/discussion)
    b. Syllabus: ideal engineering system, S-shaped curve, transition to the super-system, micro-scale interactions, systematic innovation, nature-inspired innovation, examples.

   c. In-class problems: finding bio-inspired solutions for the improvement of the performance of a car.
   d. Assignment: definition of ideal car and identification of barriers to innovation.

2. **Sustainability and Life cycle assessment**
   a. Duration: 3 hours (2 hours of lecture; 1 hour of problems/discussion)
   b. Syllabus: the lifecycle of a component/system, climate crisis, the concept of sustainability, multi-criteria decision analysis, the various phases of the life cycle assessment, example.
   c. In-class problems: life cycle assessment of a car.
   d. Assignment: multi-criteria decision analysis.

3. **Vehicle Dynamics**
   a. Duration: 3 hours (2 hours of lecture; 1 hour of problems/discussion)
   b. Syllabus: forces on vehicles, wheels and forces exchanged on the ground, power requirements.
   c. In-class problems: identification of engine power requirements for a given performance.
   d. Assignment: computation of power required for different slope angles.

4. **Hydrodynamic forces**
   a. Duration: 3 hours (2 hours of lecture; 1 hour of problems/discussion)
   b. Syllabus: fundamentals of friction and drag, flow separation, streamlining, wing profiles, lift and downforce.
   c. In-class problems: computations of reduction of drag (case study).
   d. Assignment: sketch of an aerodynamic vehicle.

5. **Internal Combustion Engines**
   a. Duration: 3 hours (2 hours of lecture; 1 hour of problems/discussion)
   b. Syllabus: overview of internal engines, fundamentals of thermodynamics, torque, power, efficiency.
   c. In-class problems: coupling between an engine and a car; introduction to gear box.

6. **Fuels and emissions**
   a. Duration: 3 hours (2 hours of lecture; 1 hours of problems/discussion)
   b. Syllabus: classification of fuels, emissions from engines, biofuels, hydrogen
   c. In-class problems: quantification of carbon dioxide emitted by hydrocarbon combustion.

7. **Electrification of cars**
   a. Duration: 3 hours (2.5 hours of lecture; 0.5 hours of problems/discussion)
   b. Syllabus: hybrid cars, fully electric cars, fundamentals of fuel cells and batteries, energy, and power density.
   c. In-class problems: coupling between a car and an electrical powertrain.

8. **Future vehicle concepts**
   a. Duration: 3 hours (1.5 hours of lecture; 1.5 hour of problems/discussion)
   b. Syllabus: autonomous vehicles, urban air mobility, electric aircraft.

   c. In-class problems: conceptual design of a sustainable vehicle.

9. **Ethics and Intellectual property**
   a. Duration: 3 hours (2 hours of lecture; 1 hour of problems/discussion)
   b. Syllabus: patents, copyright, registered design, trademark, confidentiality, professional ethics, engineering ethics.
   c. In-class problems: patent search, patent reading.

List of prerequisite knowledge:
Fundamental concepts of mechanics (Newton's second law, friction force, velocity, acceleration along a straight line); the concept of energy and power; the concept of pressure. Optional: chemical reactions (reading reactants and products; balancing the reaction).

Recommended reading list (optional):
Any book on physics for high school.

Office hours: 10am – 11am, Tuesday, 6th and 13th Feb

Computer Science

Dr John Fawcett
Churchill College, University of Cambridge

4th – 16th February, 2024

Since completing his PhD, John Fawcett has been working in industry alongside lecturing, tutoring, supervising and directing studies in Computer Science at Cambridge. Over more than 15 years, John has seen around 500 students through to graduation. John has delivered courses in summer schools for over 10 years and is active in undergraduate admissions, including as Subject Convenor for the Computer Science undergraduate course. John served as University Senior Proctor in the 2021/22 academical year after being Praelector for 6 years at Churchill.

College Profile: https://www.chu.cam.ac.uk/fellows/dr-john-fawcett/

Module Structure and Syllabus:

Time and Date	**Sunday 4th Feb 6am – 9am**	**Monday 5th Feb 6am – 9am**	**Tuesday 6th Feb 6am – 9am**	**Wednesday 7th Feb 6am – 9am**	**Thursday 8th Feb 6am – 9am**
	Computer Architecture	Operating Systems 1	Operating Systems 2	Starting Processes	Interprocess Communication
Time and Date	**Monday 12th Feb 6am – 9am**	**Tuesday 13th Feb 6am – 9am**	**Wednesday 14th Feb 6am – 9am**	**Thursday 15th Feb 6am – 9am**	**Friday 16th Feb 6am – 9am**
	Network communication	Graphics 1	Graphics 2	Graphics 3, GPUs and accelerators	Final Presentations

Each of the following will use lecture time to introduce and explain new concepts, followed each day with practical programming exercises: learning-by-doing through scaffolded exercises giving room for learners to solve problems in their own ways.

Computer Architecture: the components inside a computer and styles of interacting with them. Programmed I/O. Interrupts. DMA.

Operating Systems 1: virtual memory for protection between processes. Address translation. Hardware acceleration.

Operating Systems 2: cooperative and preemptive multi-tasking. Scheduling algorithms.

Starting Processes: system calls, fork(), the shell.

Interprocess Communications: understanding Unix pipes, marshalling datatypes into bytes.

Network communication: sockets, server applications, a simple webserver.

Graphics 1: ray-tracing, Phong shading, imperfect and perfect reflections.

Graphics 2: triangularisation, Painters' Algorithm, Z-Buffers.

Graphics 3: texture maps, bump mapping, displacement mapping.

GPUs and accelerators: contrasting CPU pipelines with GPUs, understanding vectorizable workloads, OpenGL/CUDA coding.

List of prerequisite knowledge:
No computer science knowledge is assumed but programming experience is always useful. Later work on graphics assumes knowledge of vectors and basic geometry.

Recommended reading list (optional):
Computer Architecture and Organisation, S.P. Wang, published by Springer. ISBN 978-981-16-5661-3 (e-book 978-981-16-5662-0).

Office hours: 10.30am – 11.30am on Wednesday 7th and 14th

Elements of Mathematical Economics

(Mathematics and Economics)

Dr Vasileios Kotsidis

College Associate Lecturer, St. John's College

4th – 16th February, 2024

Vasileios Kotsidis uses tools from traditional and evolutionary game theory to analyse social interactions that (potentially) involve strategic motives. His research focuses on the scope and limitations of models based on methodological individualism in interpreting individual behaviour (human or otherwise) as it is manifested in social settings. It spans along three main directions: how individuals think, what they are motivated by, and what the researcher can infer. He obtained his PhD in Economics at the University of Nottingham. His doctorate explored some theoretical aspects of social (strategic) behaviour and investigated its empirical manifestations. He also enjoys practicing karate, studying the philosophy of mathematics, and reading fantasy literature.

Module Structure and Syllabus:

Time and Date	**Sunday 4th Feb 9am – noon**	**Monday 5th Feb 9am – noon**	**Tuesday 6th Feb 9am – noon**	**Wednesday 7th Feb 9am – noon**	**Thursday 8th Feb 9am – noon**
	Elements of Mathematics I	Elements of Mathematics II	Elements of Statistics I	Elements of Statistics II	Rational Choice Theory I
Time and Date	**Monday 12th Feb 9am – noon**	**Tuesday 13th Feb 9am – noon**	**Wednesday 14th Feb 9am – noon**	**Thursday 15th Feb 9am – noon**	**Friday 16th Feb 9am – noon**
	Rational Choice Theory II	Stochastic Dominance	Dynamic Choice	Information	Final Presentations

Elements of Mathematics I and II: These lectures introduce students to fundamental concepts of mathematics that have useful applications in economics.

Elements of Statistics I and II: These lectures provide the statistical foundations necessary for the analysis of economic processes and relations.

Rational Choice Theory I and II: These lectures introduce a formal theory of choice and examine some applications in economic transactions.

Stochastic Dominance: This lecture discusses conditions under which certain options outperform others, with reference to some key statistical properties.

Dynamic Choice: This lecture discusses formal choice in a temporal setting and examines financial decisions with varying time-horizons.

Information: This lecture investigates the ways in which rational agents can incorporate newly acquired pieces of information into their decision-making process.

List of prerequisite knowledge:
Basic differentiation is necessary and basic integration is desirable.

Office hours: Noon – 1pm on Wednesdays, 7th and 14th Feb

Supramolecular Chemistry: Designing and Building Smart Materials

(Chemistry)

Dr Giulia Iadevaia

Teaching Bye-Fellow at Churchill College, University of Cambridge

Chemistry Laboratory Operations Manager, The Francis Crick Institute, London

4th – 16th February, 2024

Dr Giulia Iadevaia gained her MSc in Chemistry from the Sapienza University of Rome in 2010 after doing her final year project on anion recognition. She got her PhD from the University of Sheffield in 2014 working on cooperative hydrogen bonded systems. She then worked for two years as a postdoctoral researcher in the group of Professor Christopher Hunter FRS, at the Department of Chemistry at the University of Cambridge. She was then appointed as Research Laboratory Manager in the same group and she held the position for six years. Her research focused on the study of supramolecular systems, more specifically on the synthesis and analysis of abiotic analogues of information molecules like DNA. Giulia currently works at the Francis Crick Institute in London, where she is responsible for the science operations and the smooth running of the Chemistry Laboratories.
Over the past 8 years, Giulia has taught a wide range of courses in Chemistry at the University of Cambridge, from all years of the undergraduate curriculum. Since 2021 she has been a Teaching By-Fellow at Churchill College. She is passionate about organic chemistry, in particular about physical organic chemistry and supramolecular chemistry.

College Profile: https://www.chu.cam.ac.uk/fellows/giulia-iadevaia/

Syllabus:

Introduction to supramolecular chemistry: Explore the exciting field of supramolecular chemistry through an introduction to key design principles, including chelate, macrocyclic, cryptate effect, cooperativity, and solvation effects.

Synthesis of supramolecules/supramolecular synthons: Explore various non-covalent interactions used by supramolecular chemists to link molecules, including electrostatics, hydrogen bonding, π-interactions, and van der Waals forces. Introduce common reactions used to make supramolecular synthons, including the 2022 Nobel Prize-winning click reaction.

Explore Host-Guest interactions: Discuss host-guest recognition in supramolecular chemistry, including the design principles behind cation, anion, and neutral guest recognition. Learn about the impact and significance of this field, as exemplified by the Nobel Prize in Chemistry awarded in 1987.

Characterising Host-Guest complexes: Learn about various techniques, including NMR, UV, and fluorescence spectroscopy, used to identify and analyse the structural and dynamic properties of host-guest complexes.

Self-assembly of molecular structures: Discuss the process of self-assembly, where large supramolecular structures are formed/organised through non-covalent interactions, with a focus on examples found in nature such as DNA.

Synthesis and applications of molecular machines: Discuss the 2016 Nobel Prize in Chemistry and the various techniques used to synthesize molecular machines and their applications.

Uncovering the inspiration for chemistry: A Q&A session to explore students' motivations for pursuing chemistry, discuss inspiring stories of researchers and their impactful discoveries and give an insight into a life of a chemist.

Teaching Schedule:

Sunday, 4th Feb, 7am – 11am
Monday 5th Feb, 7am – 11am
Sunday 11th Feb, 6am – 9am
Monday 12th Feb, 6am – 10am
Tuesday 13th Feb, 6am – 10am
Wednesday 14th Feb, 6am – 10am
Thursday 15th Feb, 6am – 10am
Friday 16th Feb, 6am – 9am

Prerequisite knowledge:

Basic thermodynamics (entropy, enthalpy, Gibbs free-energy)
Simple calculations of position of equilibria, equilibrium constants
Basic organic chemistry (reactions that would normally be covered at secondary school-level organic chemistry, familiarity with the meaning of curly arrows desirable but not essential)

Office hours: Monday 12th Feb, 10.30am – 11.30am and Thursday 15th Feb, 9.30am – 10.30am