KES Physics Newsletter

Spring term 2020

After returning to university after the Christmas break, I have started a fresh set of 4 modules in first year. These have been modules in Waves and Optics, Properties of Matter, a second Maths module and a practical Astrophysics module.

The two physics modules have never been my favourite aspects of physics, personally I never found interference patterns in A level waves interesting or particularly special, however after this term I can say I was wrong.

Harry Baskett

Studied Physics, Maths, Further Maths, French

Reading Physics and Astrophysics at Exeter University

At KES 2012 - 2019

There are plenty of interesting aspects of waves like simple harmonic motion with damping and a driving force which can be described using the Euler form of complex numbers or the nature of the transmissions and reflections of waves as they move between mediums. With the help of an inciteful and enthusiastic lecturer I have found waves one of the best aspects of this term along with practical astrophysics.

Speaking of which handling actual astrophysical data and processing it through to meaningful solutions has been great. If in year 13 you select the astrophysics module in physics you will learn about HR diagrams which display the temperature and luminosity of a cluster of stars. Using data in my astrophysics sections I have recreated these diagrams for a few stellar clusters, these diagrams aren't as clear as those in A level but have useful information that can be extracted. I have also measured the vector velocities of ejecta like knots from the formation of proto-stars by comparing the positions of ejecta between a series of pictures. After Easter I will have exams in my maths and physics modules then I am finished for this year and move onto further modules next year.

Callum Shingleton-Smith

Studied Physics, Maths, Chemistry, Computing (AS)

Reading Physics (with a foundation year) at Royal Holloway University of London

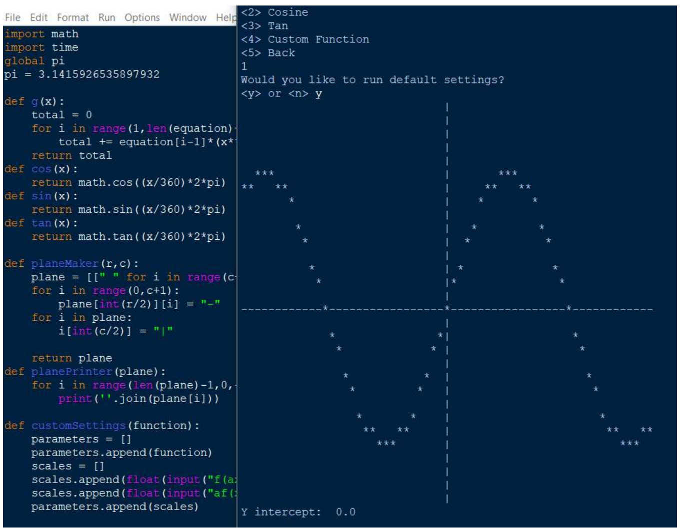
At KES 2012 - 2019

My first term of university has taught me a lot about independent learning and organisation - finding a balance between coursework and a part time job means that time management has become a key part of my daily routine. The pace of teaching has definitely increased from sixth form, so starting assignments early and reading ahead is essential.

Currently, in my foundation year programme, the two modules that I am most focused on are Maths and Computing, these will be very important for physics next year so I'm making sure I have a full understanding of both modules. A major part of the course is building on the content from A-Level, for example the maths I am doing now overlaps with a lot of the A-level further maths content. It has been especially interesting learning about the proofs for many of the formulae we use on a day to day basis and how we can apply these to many areas of Physics and Maths. Lately we have worked on deriving Euler's identity ($e^{i\pi}+1 = 0$) which was quite interesting.

The computing module involves programming in python, this will be useful for next year since we will have to write custom algorithms to analyse and graph results from experiments. With python being a relatively simple open source language there is a lot of freedom when it comes to writing specialised programs. A python project I have been working on recently is a graphing program like Desmos which can graph custom functions and tell you their properties.

Overall my first term at university has been great, and I'm looking forward to continuing my course in the next two terms. Some advice I would give for new students would be to make the most out of your time and the resources available to you – at RHUL for example they have a library open all hours where you can catch up on work and study.



Zak Goble

Studied Physics, Maths, Economics, Further Maths (AS)

Reading Physics at Manchester University

At KES 2010 - 2017

I'm Zak, and I'm currently in self-isolation (and have been for many years). This term, I'm studying cosmology, nuclear physics, applied nuclear physics, particle physics, and mathematical methods for physicists.

Cosmology is all about space and stuff. We're currently learning about the way in which the universe expands and, eventually, how, or even *if* it will end depending on the universe's density relative to the critical value. If it is less, the universe will reach a maximum size before collapsing back in on itself to nothing. If it is more, the universe will continue to expand indefinitely. If the density is exactly equal to the critical density, the universe will reach a maximum size and stay precisely where it is.

Nuclear physics concerns the size and structure of nuclei. The coolest thing we've learnt so far as that one can fire muons at nuclei to create muonic atoms (for those yet to begin A level particle physics, muons are basically wham electrons). Due to being at home for most of this term (i.e. bunking off), I've only ever podcasted nuclear physics lectures and have hence never seen the face of our lecturer until recently. He sounds like a young man, perhaps in his thirties, but, to my shock when I saw him for the first time, he looks exactly like Governor Tarkin from Star Wars. I'm yet to be able to look at him without imagining him telling me that I may fire when ready.

Particle physics is about the creation, detection, and categorization of particles. Although the Large Hadron Collider in Switzerland is 27 kilometres in circumference, colliding particles (protons and anti-protons) are travelling so fast that they go round the whole ring 11,000 times per second. This equates to travelling at a speed 29 *million* times as fast as Usain Bolt.

Manchester has recently decided to ban all attendance at lectures due to coronavirus and has dictated that all lectures must now be watched via podcast. Whilst recent weeks have seen the cancellation of many hotly-anticipated events such as festivals, I think we can all just about tolerate this one. It's like a snow day that will go on for months.

Fin Cooney

Studied Physics, Maths, History, Further Maths (AS)

Reading Physics at Loughborough University

At KES 2011 - 2018

This term we have been studying copious amounts of electrodynamics and electrostatics. For those of you unaware of what these two words mean, electrostatics is the study of electric charges at rest; Coulomb was largely responsible for formulating much theory around this area and also came along with his law to help model this. Electrodynamics is the study of how moving charges or currents interact with electric and magnetic fields around them. Electromagnetism is modelled with more complex (pun intended) mathematics including operations like curl and divergence. These two vector operators are extremely useful to model fields. Curl is effectively how much rotation is happening in a field and divergence is the scalar quantity of how much field is coming out go going into the centre of the field. Using things like Gaussian surfaces the flux of a field can be calculated which can also be very helpful. This has been the main bulk of the Physics that we have been studying this term and so far, it has been very interesting.

In my Computational module we have been looking at how to model electromagnetic waves using numerical analysis know as Finite-difference time-domain method. This uses what is called the Yee Method to predict the movement of EM waves. The coursework we have been assigned is to basically do this by translating some Objective C into swift (easier than it sounds) and make it look nice and have some other bells and whistles on it and have it ready to present to hypothetical company bosses known as, "the Management". The end result will be a presentation by us to "the Management" where we will make a sales pitch and tell them why our code is so much better than everyone else – COVID-19 pending.

In maths we have been discussing what is effectively the maths behind all of the electromagnetism and this is obviously applied to the computational and physics modules which is helpful.

Hi again! Soooo I'm now way into my second semester of my second year of studying Mechanical Engineering and I have to say it's going so quickly. My modules this semester are; project management, structural mechanics, integrated engineering systems and mechatronic systems modelling and control. My favourite module at the moment is integrated engineering systems. (Don't be fooled by the word integrated there is no calculus involved, yay!). Instead we had the opportunity to build this robot arm (Lots cooler than maths). My lecturer informed us it took him 3 days to build so I foolishly decided to take on the challenge to try and beat his time. I did manage to assemble it quicker than him, HOWEVER it did involve me trying to piece together 229 components with 5 different hydraulic system and a gear system from 1am to 6am using the wrong size screwdriver. (I know who starts building a robot at 1am? …me…I do.) Still it only took me 5 hours and now I have a pretty cool robot arm. The engineering element to building a robot at 1 am is that as a small group we must analyse the different systems consisted within. We have been tasked with breaking down the different parts to form a component list and system diagram to show how they interact with each other and discuss the inputs and outputs of the system.

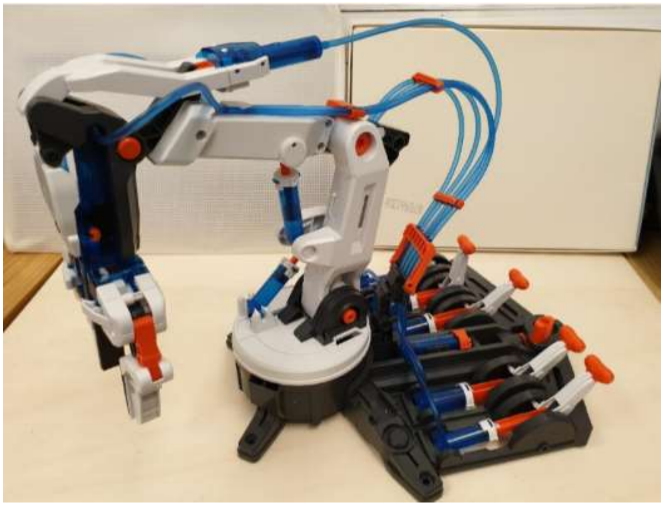
Trinity Wills

Studied Physics, Maths, Art

Reading Mechanical Engineering at Hertfordshire University

At KES 2011 - 2018

Here is a system diagram for a mountain bike whilst riding and as you can see even something as simple as a bike has many different components, inputs and outputs to think about. Hopefully we will manage to complete an adequate system diagram for the robot arm and we won't be scrambling at 1am to 6am to finish it. We shall see!



Trinity xx

Robert Clemenson

Studied Physics, Chemistry, Maths, Further Maths

Read BA Physics at Oxford University

Reading MMathPhys Mathematical and Theoretical Physics at Oxford University

At KES 2008 - 2015

This term has been packed with courses, application deadlines, and interviews! Fortunately, I've been given offers from a couple of PhD programs! I look forward to telling you more about these later, after I decide which university I'll be spending another four years at!

My courses this term have been the most challenging of my degree so far: Advanced Quantum Field Theory, String Theory, Supersymmetry and Supergravity, Astroparticle Physics, and Cosmology.

A major theme in multiple lecture courses has been the idea of a 'gauge choice'. This is an important notion in theoretical physics, that corresponds to a 'redundancy of description'. A schematic example you may have encountered of such a redundancy arises when considering the potential energy of an object in a gravitational field. If you're trying to calculate the speed of an object after it falls through certain height due to gravity, you can work out the change in gravitational potential energy, and equate this to the gain in kinetic energy ($^1/_2 mv^2 = \Delta GPE$). You'll notice that the physically observable quantity in this experiment (the velocity of the object) depends only of the difference of the GPE. I.e. we are free to add any constant value we like to the gravitational potential energy of the object, as this constant value will always cancel when we take the difference in potential energy at two points.

In quantum field theory, gauge symmetries introduce new particle interactions into a theory. If we start off with a theory containing one type of particle and its corresponding antiparticle (e.g. electrons and positrons), by demanding this theory possesses a so-called 'local U(1)' gauge symmetry an extra particle appears naturally to preserve consistency, this particle is spin-1 and massless. I.e. the photon!

Very broadly speaking, the area of maths that deals with gauge symmetries (and symmetries in general) is called 'group theory'. This fairly pure area of mathematics isn't dealt with in a lot of detail on some physics university courses, but it's well worth studying for mathematically interested physics students!

Recently I have been using some simple physics to inform hazard assessments for volcanic eruptions. The particular hazard in question are volcanic bombs; these are large fragments of rock (> 64 mm) that are ejected by volcanoes and can seriously injure or kill people. To try and quantify the hazard associated with volcanic bombs, volcanologists use the equations of projectile motion to predict where they might land. For a bomb moving at a given speed and angle, these equations predict how high and far the bomb can travel. By considering different possible bomb sizes, initial velocities and ejection angles, we can estimate the probability of a bomb landing in a given location.

Paul Jarvis

Studied Physics, Chemistry, Maths, Biology

Read BA and MSci Natural Sciences at Cambridge University

Ph.D. in Geology from Bristol University

Currently a post-doctoral research assistant at the University of Geneva

At KES 2001 - 2008

The 1886 eruption of Mt. Tarawera, New Zealand, produced a large number of volcanic bombs that travelled kilometres from the vents. In fact, a number of bombs have been found at such large distances from the vent that the projectile motions equations cannot fully explain how they got there. This suggests that there is some process happening allowing the bombs to travel further which is not currently captured in the equations. We think that this could be spinning of the bombs.

When an object is spinning whilst moving through the air, its motion is influenced by the Magnus effect. If the object has topspin, then the air above the object pushes it down. Alternatively, if it has backspin, then the air below the object can push it up. Both of these effects are commonly seen in tennis. Meanwhile, side spin can lead to spectacular goals in football (https://youtu.be/crKwlbwvr88).

We think that backspin may explain how bombs have been able to reach large distances; the Magnus effect creates an upward force keeping the bomb in the air for longer, allowing it to travel further. We are currently modifying the projectile motion equations to account for the Magus effect. We hope this small change to the equations will better constrain the hazard and therefore make people safer.

Alex Broad

Studied Physics, Maths, Psychology, Further Maths (AS)

Read BSc Physics at Swansea University

Read MSc Physics at UCL

Physics Ph.D. student at UCL

At KES 2012 - 2014

All in all, I don't really have much to report this term: I've spent most of my time either writing papers, reports or presentations. This is the less exciting side of science, in my opinion at least. It hasn't all been boring though: this week I went to the houses of parliament to present a poster on my work on crystallisation. It went pretty well, except the guy next to me generated a lot more interest for his work on lasers (word of advice: if you go into scientific research at PhD level or above, specialise in lasers rather than crystals. People take a lot more interest in your work). It was still a lot of fun though, and I saw some MPs I recognised from Question Time, so definitely worth going.

I've also submitted my first ever 'first author' paper to be published, and I'm waiting to hear from them now. I mentioned the topic last time, it's all about trying to understand why certain types of starfish use magnesium nanoparticles in their skeletons to prevent their bones from fracturing. I should hear back from them soon and I'm quite confident it'll get through, so that should be all done and dusted soon enough. I've also been working on how memory affects our calculations of reaction rates. To give a brief overview: if you want to calculate a reaction rate that happens too rarely to simulate, you can use simulations to deliberately nudge atoms along what we call a 'reaction coordinate'. For example, you can force two atoms together by taking the reaction coordinate to be the distance between the two atoms. The problem is, however, that if you pick a 'bad' reaction coordinate (i.e. one that doesn't account for everything that goes on in a reaction) then you get these 'memory' effects that ultimately mean you can get a reaction rate over one hundred times too large. I've spent some time demonstrating that you can recover a much better reaction rate by introducing memory. More recently, I've been looking at how likely memory problems are to be encountered in practice. In short, I've found that memory problems are easy to detect and, in fact, make the methods used to calculate reaction rate impossible to use anyway. I found that, instead of getting answers one hundred times too large, the effects are unlikely to give an answer any more than twice as large. This is much less cause for concern, especially considering most methods that computational modellers use are likely to be pretty inaccurate anyway.