KES Physics Newsletter

Spring term 2018

The end is nearly upon me. After much consideration I have decided to change my course from the four year integrated masters, to the three year bachelors. I shall be taking a year out to assess what I want to do with my life, whether it be applying for the masters in audiology, pursuing a career in charity (one of my extra-curricular passions) or doing a PGCE to get into teaching. As such this is my penultimate newsletter entry, but rest assured this edition will be a humdinger.

Matthew Latter

Studied Physics, Maths, Music tech, Further maths (AS)

Reading Acoustical engineering at Southampton University

At KES 2008 - 2015

So here are my new modules; Architectural acoustics is more or less how it sounds, it's the acoustics of architecture (shock horror), how a building responds to sound stimulus and how to design and modify buildings to make sure speech is intelligible, that privacy between rooms is assured and that any noise from building services (air conditioning, heating etc.) doesn't interfere with work or living. It's more or less exactly what did in my summer placement.

Biomedical Signal and Image Processing is by far my favourite module this semester (although it's definitely the one I'm worst at). In this module we look at signals from biomedical equipment such as ECGs (heartbeats) and EEGs (brainwaves) as well as images like MRIs and CT scans. Basically we look at how to obtain this vitally important information from the human body and how to convert it to a form that a doctor or surgeon can understand.

Human Response looks at how exposure to noise and vibrations effects the human body, how your hearing can deteriorate in certain conditions and how your body responds to extreme vibration and the diseases and health hazard associated with this. This module piques my interest as it shares common themes with audiology (which I may look into pursuing).

In addition to this I have been continuing with my individual project which I have modified such that it can now be used to extract any kind of biological cell from any kind of fluid. Pretty cool stuff if I do say so myself. That's the almighty power of acoustics folks!

Zak Goble

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

Reading Physics at Manchester University

At KES 2010 - 2017

I'm Zak, and this is a generic introduction into my part of the newsletter.

We've moved into our 2nd, and final, term of the year at Manchester after a pretty decent set of exams to finish the first term. This term, I'm studying five more modules, including maths (decent), properties of matter (boring), electricity and magnetism (sick), vibrations and waves (just pendulums, really) and advanced dynamics (properly advanced).

Maths this term has focused heavily on calculus; in particular, complicated and pointless functions. I'd list some of them, but you'd get bored of my section and go back to reading Rob's instead, so I won't bother. In properties of matter, we've looked at some of the properties of crystalline structures and the wave deflections from them as well as interactions between different states of matter, such as liquids and gases, which were pretty swanky. The content of electricity and magnetism includes understanding the maths behind electric and magnetic fields and features cool words, like 'flux' and 'weber' (pronounced 'vaber'.) Maxwell's equations underline every aspect of the course. The content is awesome in its own right, but the subject's lectures are bolstered by the fact that our lecturer does a Kahoot quiz at the start of every session, so coming up with a hilariously savage username every week pretty much dominates the work in that course. Vibrations and waves...yeah, pendulums are pretty much it to be honest. Nobody really has a clue what's going on in advanced dynamics because, as the name suggests, it's advanced. It's a lot of useless and boring notation rather than any actual crunchy physics. The lecturer is also an evil, miserable man. Good teacher, though.

The best part about this term so far is that the memes and the banter have reached a breathtakingly exquisite level now that lectures have started to be podcast. Every somewhat DJ-like hand gesture from lecturers is captured and sent straight to the Tomorrowland mainstage via Photoshop for maximal meme-age. Being in a physics degree, we've got a few trainee hackers on the course that have managed to change the coding when playing Kahoot quizzes, allowing them to use these Photoshopped images as their display name, optimising their savagery towards lecturers. This is an equally generic closing sentence to my part in this newsletter. Zak.

This term, my lectures have included; optics, statistical mechanics, lots more quantum mechanics, and an additional course on advanced classical mechanics.

In addition to my normal studies, a substantial amount of my time has been spent on writing applications for various summer research programs. If successful, I hope to tell you all much more about these in the next couple of newsletters!

Robert Clemenson

Studied Physics, Chemistry, Maths, Further maths

Reading Physics at Oxford University

At KES 2008 - 2015

With regards to lab work, this term I spent two days working in the electronics lab. My lab partner and I built a few different analogue circuits, designed to solve various algebraic and differential equations. The general method here was to look at the form of the equations to be solved, and using the equations of the different circuit components, build a circuit whose components produced an output voltage governed by the same form of equation to be solved. The output voltage was then displayed on an oscilloscope, thus giving a visual display of the desired solution form. (Sounds confusing… Very simple to look at in a lab!)

At the beginning of next term, I will give a brief 15 minute presentation to the other physicists in my college and our college tutors on an area of physics of my choice. This forms part of the practical aspect of my degree, and all physicists in my year must take part. The title I have chosen is 'Symmetry in physics'. You probably have some idea of what I mean by 'symmetry'. In our everyday experience, we may describe something as symmetric if it looks the same viewed from some other angle, or perhaps, looks the same when looked at through a mirror. This intuitive idea of symmetry is not too far removed from the basic elements of symmetry within physics. From a mathematical point of view, symmetries are described in generality by a branch of mathematics called 'group theory' (something I recommend the budding mathematicians reading this look into for an idea of what to expect from a maths degree!).

In general, we can define a 'symmetry' as some aspect of the system that remains unchanged, when we perform a transformation on the system. A transformation here could mean a number of things, such as rotating the system, or boosting it off in some direction at some speed. For example, imagine you are looking at a meter ruler from across the room. Rotating your head sideways while you look at the ruler, of course, doesn't change its length. We would say, the length of the ruler is a symmetry of the system under rotation. This is a continuous symmetry, as we can rotate our head through any angle (at least in theory…) i.e. there are not a discrete set of rotations we must stick to in order for the rod to stay at the same length. (One example of a discrete symmetry some simple systems possess is 'time symmetry', see Alex's entry for further discussion on the 'arrow of time').

Now consider standing in a wind tunnel. When you are still with respect to the floor of the tunnel, you feel the wind on your face at a speed of 10mph. Now suppose our transformation takes the form of a speed boost, into the direction of the wind source. If we are boosted at a speed of 2mph, we would feel the wind on our face at 12mph. So here, wind speed is NOT a symmetry of the system under a speed boost.

One of the most important symmetries in physics concerns the invariance of the speed of light. For those of you that don't know about this remarkable fact of nature, suppose in the wind tunnel example above, we replace the wind source with a light source. And you wear on your chest some kind of light speed-detector. When you are still, your detector will read about 300,000,000 m/s. Now suppose you again move towards the light source, now at a speed of 100,000,000 m/s (presumably with some assistance…). We would expect, as in the calculation we performed above, to measure the speed of light hitting us to be 400,000,000 m/s. This is not the case! We instead measure the exact same 300,000,000 m/s value as before! I'm not going to talk much more about how this can be true, but instead discuss this 'invariance of the speed of light' in the context of symmetry.

The speed of light is a symmetry for all observers boosted at some constant velocity. These transformations, which switch from the perspective of one observer 'A' to another observer 'B' who is moving at some velocity with respect to 'A', are called 'Lorentz transformations'. Mathematically, they appear to mix up the space and time of observer 'A', with that of observer 'B', such that space and time can no longer be considered as separately defined concepts. Just as we considered length as being symmetric under rotation in our first example, we can consider a different kind of 'length' as being symmetric under Lorentz transformations. This 'length' (called the space-time interval) not only includes the distances involved in the dimensions of our ruler, but also the time coordinates of its two ends. As such, Lorentz transformations can be considered to be a sort of four dimensional rotation in space-time. Confused? Good!

So, to be straight with you, this semester has not been too much different than the last one. I am still doing my research project into a simulator for the NASA HL-20, a space plane that was never built. Well, I say never built, some students and staff at a couple of North Carolinian universities did build a full-scale model for research in the summer of 1990 but I doubt Bristol would give me the money or facilities to do the same.

Timothy South

Studied Physics, Government and Politics, Maths, Further maths (AS)

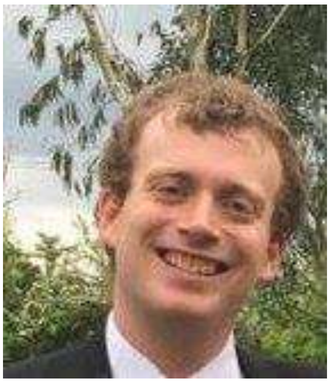
Reading Aerospace engineering at Bristol University

At KES 2008 - 2015

We're still studying structures and materials, well we were until Wednesday when the final topic finished. I would say that S&M is probably one of the units that most closely relates to the study of physics as we look at topics which discuss the integrity of structures (lots of mechanics) or the properties of materials. I remember when we studied material properties at KES (or is the acronym KEA yet?) we had to assess the ductility, hardness, brittleness etc. of different sweets. I don't know if you get to do that, but you might as well ask now that I've mentioned it (you're welcome)!

One of the new topics we are studying is aircraft propulsion which is being taught to us by someone who used to work at Rolls-Royce Holdings (the one that makes jet engines). I mean, could you have a more apt person for the job?! We started off looking at turbojet engines (the ones you get on most large civil and military fighter) as well as engines for hypersonic vehicles (over 5 times the speed of sound not a powered-up hedgehog).

Now for something away from my university-work, which got a brief mention last time, the composite rocket project in the space society. I've managed to snag myself the job of chief nose-cone engineer (self-appointed) which is a very cool and important role (I get to lead a whole team of one!). As part of this role I have been 3D printing nose-cone prototypes which use an original screw type mechanism (by yours truly, patent not pending) which connects the top and bottom half of the nose-cone together. The purpose of this is to allow the payload, which is a lot of electronics, to be accessed more easily, right up until launch which has been a problem in recent years. I also had to help cut out a foam tube for the mould of the rocket body using a hot wire cutter which, turns out, might release toxic fumes so if I'm not in the next physics letter you know why.



As previously mentioned, I recently started a project studying how volcanic ash settles out of the atmosphere to the ground. When Eyjafjallajökull in Iceland erupted in 2010, European airspace was closed for a week because of the damage the fine ash does to engines. At the time, scientists could only make limited predictions about how long the ash would stay airborne, and if the dispersal of ash had been better forecast, then some parts of the airspace could have re-opened earlier.

Paul Jarvis

Studied Physics, Chemistry, Maths, Biology

Read BA and MSci natural sciences at Cambridge University

Ph.D. in Geology from Bristol University

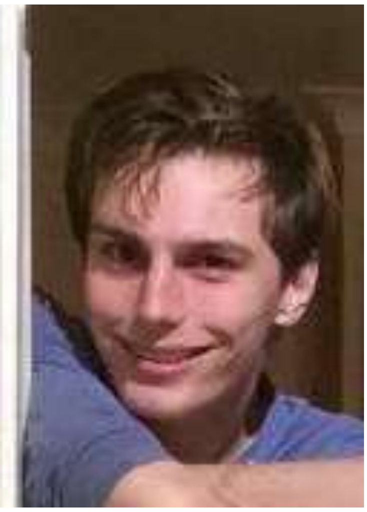
Currently a post-doctoral research assistant at the University of Geneva

At KES 2001 - 2008

Therefore, there is now a huge focus on improving understanding of the dispersal and settling of ash. Historically, it has been assumed that ash particles settle at their terminal fall velocity, which increases with particle size. The result is that coarser ash fall out quicker than fine ash meaning you expect to find coarser ash closer to the eruptive vent whereas fine ash will be deposited further away. However, field studies show fine ash is often found closer to the volcano than expected.

In this project, we will be performing a combination of experiments, computer simulations and field work to try and understand the mechanisms behind this discrepancy. To begin, some colleagues and I spent six weeks in a lab at Arizona State University in the USA to perform some preliminary experiments that have given us some insight. A video of one of these experiments can be seen at:
https://www.youtube.com/watch?v=HQGX1lOOIFY

In the experiment, we filled up tank with a sugar solution. Then, we injected a mixture of glass spheres (about 60 micro-meters in diameter) and water into the tank. The particle mixture was less dense than the sugar solution so it spread along the surface of the water whilst the particles 'rained' out. The spheres did not settle homogeneously and variations in the particle concentration can be seen suggesting that the particles are not independent, but rather interact with each other, thus providing a possible mechanism for how fine ash might settle faster than expected. The next stage is to use our preliminary results to design a new experiment, custom built for this investigation. In particular, we want to understand how particle size and concentration, and the flow velocity control the particle settling. At the same time, we are waiting for a volcano to erupt where it will be possible to measure the concentration of airborne ash in the field. Hopefully, we will not have to wait too long.



Alex Broad

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

Read BSc Physics at Swansea University

Reading MSc Physics at UCL

At KES 2012 - 2014

I'm now approaching the end of my second-term lectures in my MSc in Physics at UCL. So far I have been completing lectures in biophysics, statistics and climate physics. My most interesting module this term has been Advanced Topics in Statistical mechanics, in which we have covered topics such as droplet nucleation, the dynamics of randomly moving particles, running basic computer simulations and the true meaning of entropy. The latter topic has certainly been the most interesting to me. Entropy is a way of giving a number to a system quantifying its freedom of movement (people may call it a measure of disorder, but this turns out to be a terrible definition!). Historically, people became very confused over how a world of reversible dynamics (i.e. no particular reason for time to go forward rather than backward) can give rise to the irreversible processes we see every day, such as heat dissipating from a cup of tea as it cools, or the gradual sharing of heat throughout the Universe as it expands. It's been very interesting learning about the reasoning that changed our understanding of our irreversible Universe.

Aside from modules, I've been continuing with my MSc project. I started work last term on a project concerning bacterial mechanosensitive channels. These are a type of protein found in a lipid bilayer (cell membrane) which are able to respond to mechanical forces from a pressure difference on either side of the cell. Their purpose is to let water and other solutes through the membrane when the pressure gets too great on one side. This prevents the cell membrane from rupturing. My project has been to run highly coarse-grained (zoomed-out) simulations on a small group of channels to see how they interact with one another. By using computer simulations, I am able to change all kinds of properties of the mechanosensitive channels. It's early days at the moment, but so far I have been able to change the strength of the bonds holding the channels together and plot their size against the pressure against the membrane. I found that this has no effect on the channels' gating threshold. The 'gating threshold' means the pressure at which the channels go from a state of 'open' to 'closed'. This summer I will study the effects of having many different types of channel on one membrane.