SEEING WHERE MATHS CAN TAKE YOU

Engineering in Action

A booklet for anyone considering a career in engineering

National HE STEM Programme

Institute of mathematics & its applications

maths careers ENDLESS OPPORTUNITIES

The Royal Academy of Engineering

Watch five short video clips of engineers talking about their careers. Go to www.mathscareers.org.uk/science_&_engineering/video_profiles.cfm

Maths is used everywhere and creates endless career opportunities. If you are thinking at all about a career in engineering, then this booklet is for you. Maybe you are taking your A Levels, thinking about what degree to take or maybe you are already doing an Engineering degree but are wondering about whether to stay in the profession after you graduate. Alternatively you may be taking a Mathematics or Physics degree and are thinking about whether you want to use your Maths skills in an engineering context.

In this booklet nine engineers talk about their experiences in areas as diverse as the NHS to the construction industry. We hope that they will inspire you and show you that using your Maths skills in engineering is an exciting and rewarding road to take.

This booklet was produced jointly by the Institute of Mathematics and its Applications and the Royal Academy of Engineering using funding from the National HE STEM Programme.

Many thanks to the engineers and their employers who gave up valuable time to make these resources a possibility.

Rosie Jones

MEng degree from Imperial, CEng IMechE

Senior Engineer

Skelly and Couch

SKELLY&COUCH Building Environment & Services Engineering Consultants

Engineering in Action
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Briefly describe the organisation you work for.

Skelly and Couch is a Building Environmental and Services Consultancy, established in 2007 with a staff of 20. We specialize in bespoke building projects with a construction value between £1M and £15M.

Explain what you do on an average day at work.

Average days are difficult to come by. In the last week my tasks have been:

1. To visit a boarding school to review their heating system and boiler installation to give recommendations on how to make the system more energy efficient.
2. Undertake calculations based on various heating system options and look at the financial and carbon savings of each .
3. Prepare service options for a house boat installation including heating, ventilation, lighting and drainage.
4. Attend a client meeting on a house boat to discuss the mechanical and electrical services for his new boat.
5. Review tender returns (market prices) for a large theatre and arts complex which we have spent 12 months designing.
6. Attend a job interview to win new work for the practice – the refurbishment of a large Grade 2 listed building in the City.
7. Generate Energy Performance Certificates using thermal modelling software for two primary schools.

What do you like most about your job?

The variety of work that it offers and the opportunity to work with intelligent and visionary designers.

What stimulated your interest in Maths, and when?

In honesty, I was reasonably good at it and I liked that there was always a logical answer to a problem.

What influenced your career choice?

I wanted to reduce the amount of energy we consume and reduce the carbon we generate – so I went into building environmental and services design.

Which skills do you consider to be essential for your job? In particular, what type of Maths is essential for your job?

Mathematical analysis, probability and statistics. Diplomacy and the ability to communicate clearly and concisely.

Any advice you may have for other individuals considering your career path.

Building services have a huge impact on the amount of energy that is consumed and the carbon generated. Designing efficient building services provides a comfortable internal environment and minimizes the effect on the external environment.

Most practices train individuals to be competent in the design of a single aspect of services such as sustainability, public health, heating, fire, electrical. A select few train their engineers in all disciplines so be focused in what you want out of your career.

Your future career plans.

I am very happy with my current company which is a small, but rapidly expanding company as it provides the opportunity to ensure bespoke and sustainable design. I am keen to focus on the sustainable aspects of the role. I am also aware that the skills I have are very transferable so that if we chose to live in a different city I would be able to pursue my existing career.

Some of the ways in which Maths is relevant to Rosie's work:

Maths Topic	Details
Mathematical Modelling	1. Thermal modelling of buildings to understand heat loads and cooling loads and how the internal environment changes with changing weather patterns. 2. Daylight analysis of proposed building solutions. 3. Fluid flow and frictional resistance in pipes and duct works for drainage, heating, hot water and ventilation systems.
Geometry	A common use of geometry is to predict the effectiveness of solar shading to prevent buildings overheating.
Exponential & Logarithms	Frequently used in the analysis of noise, to determine if noise from roads, railways, buildings, people & mechanical plants will impact on building users.
Statistics and Probability	We frequently take a view on the probability of an occurrence happening to determine how much of a safety factor to design in eg. rainfall, temperature & weather patterns, frequency of use of appliances in buildings.

Russ MacMillan
MA MEng Cambridge, Engineering Science
Secondary Nuclear Propulsion Manager

Ministry of Defence

Engineering in Action
Seeing where Maths can take you

Briefly describe the organisation you work for.

I work within the Defence Equipment and Support organization of the Ministry of Defence. The organization procures and then supports all UK military equipment with an annual budget in the region of £16bn per year. Within this organization I work for the Nuclear Propulsion team which delivers nuclear reactors to submarines.

Explain what you do on an average day at work.

New post: I manage a small team charged with delivering the engine room that interfaces with the next generation of nuclear reactor for the next generation of nuclear submarines programme. My days therefore consist of meetings with the team to discuss technical issues and decisions, meetings with industry (who are building the components and submarines for us). I regularly travel to the ship yard where the submarine is being built to monitor progress and discuss issues with the technical and project management teams.

Previous post: I worked for the Government Minister responsible for all defence procurement. He was a very busy individual and my responsibilities encompassed all of the ship, submarine and weapons programmes within the MOD. It was my job to make sure that he was properly briefed on the decisions he needed to make and that once he had made a decision I recorded it and communicated it to the wider Department.

Day-to-day I therefore helped to prioritise his time, sat in on all of his meetings covering my subjects, travelled around the UK and the rest of the world when meeting other foreign leaders or industrialists and provided an interface between the Minister and the Department by fielding phone calls from senior military and senior officials.

What do you like most about your job?

I enjoy the variety and feeling part of a team that is delivering something important in the interests of the defence of the UK. At the end of my time on the project I will have procured tangible items that will form part of the UK's next generation nuclear deterrent.

The MOD also offers excellent opportunities for exciting travel and military experience – I've been to sea on destroyers and submarines, flown in helicopters, tested weapons and driven tanks.

What stimulated your interest in Maths, and when?

From an early age I have had a keen engineering interest starting with Lego, through to computer programming and then whilst studying Engineering at University of Cambridge. This passion for technical things and an interest in problem solving led me toward a Maths and Science based education. This later proved critical in gaining my place at Cambridge and beginning my engineering studies.

What influenced your career choice?

I enjoy all things technical and hands-on 'making things' engineering. The MOD offered a training scheme which allowed me to get promoted quickly, provided opportunities for foreign travel (I have lived and worked in France, the US and Afghanistan) and offered a wide variety of exciting challenges.

Which skills do you consider to be essential for your job? In particular, what type of Maths is essential for your job?

In addition to my technical skills, working with and leading other people is essential and so general people skills are crucial. As you rise up the management chain the teams below you increasingly provide the detailed technical knowledge necessary to deliver a solution. But whatever level of management you end up at, having a general ability to understand complex engineering problems, analyse data and quantify risk is vital if you are to be able to make successful decisions and provide the leadership required. It is therefore my general engineering, mathematical and scientific background together with my outside interests that enable me to do my job.

Any advice you may have for other individuals considering your career path.

I would strongly advocate pursing a Maths and Science based education. This has proved crucial

to me now in understanding complex problems and being able to deal with numeric information – a key part of what I do every single day.

However, it is also important to pursue other 'fun' interests such as sports and leisure activities since it is these that develop your ability to work with other people on a day to day basis and develop people skills which are ultimately the way in which you'll be judged when applying for senior management positions.

Your future career plans.

I will work on this project for around three years and then will either seek a promotion to run a team of around 30-40 engineers or go to France to complete an MBA Business Degree whilst learning French.

Some of the ways in which Maths is relevant to Russ' work:

Maths Topic	Details
Mathematical Modelling	Complex engineering problems can generally be decomposed into mathematical models either in making design decisions or evaluating different options and deciding which is best for the project. Understanding these models and being generally numerate is important when making these decisions.
Numerical Methods	Much of my work involves numbers - being of a numerate mind with a sound technical background is immensely valuable and puts me at an advantage when set against 'generalist' project managers.
Statistics and Probability	Much of my work involves analysing competing data to make design decisions. The risk of each decision is very important - supported by statistics and probability.

Dr Moira Bowdrey
MEng, PhD
Engineering Manager

Kind Consumer

Engineering in Action
Seeing where Maths can take you

Briefly describe the organisation you work for.

Kind Consumer is a small start-up company that has developed cutting edge inhaler technology that can be used to help people try to quit smoking and is still being developed for further medical applications.

Explain what you do on an average day at work.

It is hard to describe an average day because there are so many aspects to my job. I might be spending time at the computer doing design work, planning a project with others or liaising with our manufacturers. It is a great mixture of technical work and working with people. Probably quite different to the stereotype that some people have regarding engineering.

What do you like most about your job?

I really like the fact that I can have a significant influence on a product that will make an enormous difference to people's lives. It makes work very satisfying.

What stimulated your interest in Maths, and when?

I became interested in Maths at A Level, as I realised how important it would be for opening up my career options; and from then on I enjoyed it increasingly, including through my university degree (MEng).

What influenced your career choice?

Doing the subjects I enjoyed (Maths, Physics, Chemistry) and being able to use them on a daily basis to solve real world problems. I'm a very lucky person as I love my job – I look forward to going to work each day!

Which skills do you consider to be essential for your job? In particular, what type of Maths is essential for your job?

The skills mix of an engineer needs to be quite broad ranging, you need to be a good communicator, be able to analyse problems and have the ability to work under pressure, while still being efficient. Then there is the Maths side of things, being able to use Statistics and do mathematical modelling is important.

Any advice you may have for other individuals considering your career path.

Make the effort to truly understand the Maths and Science subjects – that's when you'll start to enjoy it and it leads to some of the most interesting and fulfilling jobs.

Your future career plans.

Continue with product development and ultimately become a board member of a technology company.

Some of the ways in which Maths is relevant to Moira's work:

Maths Topic	Details
Mathematical Modelling	Used daily to see how our product will behave when we make design changes. For instance – finding where the highest pressures will occur in the product, and using this information to strengthen the design and prevent any internal damage.
Functions	Used within modelling to allow the engineers to repeat one calculation many times for many different problems. We've created a model for fluid flow through our device and we can use this to see how slower or faster flows will affect the end spray.
Geometry	Our product is made up of many different geometries that combine together – it's very important to be able to visualize this and sketch them for explanations to others.
Algebra	Basic algebra gets used, more complex algebra is mainly used as part of our models.
Integration	Finding areas within sections of our product.
Inequalities	Used in the product specification – e.g. we must have a flow rate greater than …….
Statistics and Probability	Used all the time to analyze all our results! We will be doing some consumer tests and will use stats to decide what flavours to use in our final product, and for many different types of product attribute.

Patrick Davies
BA, MEng
Chemical Engineer (Process Technology)

ExxonMobil Engineering Europe Ltd.

Engineering in Action
Seeing where Maths can take you

Briefly describe the organisation you work for.

ExxonMobil is the world's largest publicly traded international oil and gas company. ExxonMobil explores for, produces and sells crude oil, natural gas and petroleum products. I work for ExxonMobil Engineering Europe Ltd (EMEEL) which carries out engineering projects at ExxonMobil oil refineries in Europe and the Middle East.

Explain what you do on an average day at work.

I work in the Fluidized Catalytic Cracking (FCC) Process Technology group in EMEEL, and we provide technical support to our FCC units in Europe and the Middle East. FCC units break larger hydrocarbon molecules in crude oil to smaller, more valuable ones, using catalysts and high temperatures.

My primary role involves running monitoring meetings with the FCC engineers in each of our seven refineries in the region. Every month, I collect and analyse plant operating data for each site and review it with my supervisors (FCC technical experts) as well as the site's local engineers. Following each meeting, I follow up on any issues identified, and then provide additional troubleshooting support. Typically this whole process would take a couple of days to complete for each of our sites. I also spend time extending our monitoring process to include new plant variables, as well as assessing what the acceptable limits are for our plant operations by working with the local engineers.

My role also involves running and tuning software that enables us to model how our FCC units perform under different conditions. For example, we can use this software to predict how changes to the feed (i.e. the oil input to the process) will affect the operation.

Finally, I also spend several days a month working on a variety of support and design projects for our FCC sites. This work may involve re-designing existing parts of the FCC for replacement or involve the specification of completely new components that, for example, reduce the emissions. Often this work is accompanied by site visits and plant testing, which I have found greatly aids my understanding and technical development.

Mathematics is a skill that underpins all of my daily technical activities.

What do you like most about your job?

I thoroughly enjoy the variety. Technically, the job is extremely diverse. I spend around half of my time interpreting plant data, identifying areas where we can improve operations and troubleshooting a vast range of issues that arise. Additionally, I gain experience working on small design projects, running and tuning our complex molecular-management modelling software and participating in plant testing. I have also volunteered to participate in organizing other activities for the office, such as safety and social events.

I also love working with a spectrum of diverse colleagues from all around the world every day. I work closely with our site engineers across five countries, as well as our local experts in EMEEL and several specialists in our other global engineering offices, and particularly in Virginia, USA.

What stimulated your interest in Maths, and when?

While at school, Maths provided me with problem-solving challenges, which I really enjoyed completing. It is deeply satisfying to solve a mathematical puzzle because, unlike many other aspects of life, there is often one clear and correct answer. I especially enjoyed solving geometry puzzles, which led to my interest in other areas of Maths.

I have been fortunate to have had several inspirational Maths teachers over the years, who challenged me and developed my interest.

What influenced your career choice?

While at university, I had work experience with a number of Science, Technology and Engineering companies.

I realized that I wanted a career that enabled me to use the Science and Maths I had learned to solve problems in a practical and hands-on way. Simultaneously, I wanted to develop my chemical engineering skills, as well as commercial understanding.

I was drawn to the energy industry because of the huge variety of factors and influences that lead to very interesting work. No two days are the same.

Which skills do you consider to be essential for your job? In particular, what type of Maths is essential for your job?

Technical skills: understanding of chemical engineering fundamentals, and an underlying knowledge of different mathematical methods is essential. I use a wide range of mathematical methods in my job, from interpreting geometrical drawings to performing mathematical modelling and using numerical methods. Much of the raw computation in industry is now done using specialist computer software, but an underlying understanding of how that software operates is still necessary.

Communication skills and team working: I work with a large variety of people. Therefore, being able to work as part of a team and communicating clearly is essential.

Any advice you may have for other individuals considering your career path?

- Seek work experience in industry as early as possible to identify whether it is a preferred career path for you.
- Don't give up on a subject like Maths just because it is hard; persist and in the end the skills you gain will open up many options for you.

Some of the ways in which Maths is relevant to Patrick's work:

Maths Topic	Details
Mathematical Modelling	I use mathematical modelling regularly to understand how different factors affect the operation of our manufacturing units.
Geometry	I use geometry to interpret plant design drawings. This information is often used for further design work or unit modelling.
Algebra	Algebra is used frequently to determine relationships between different sets of plant data.
Exponential & Logarithms	Exponentials and logarithms are used when analysing plant data over a very large range. For example, quantities of particles of different sizes are plotted on logarithmic scales due to the range of sizes that exist.
Numerical Methods	I am helping to develop tools based on mathematical modelling and numerical methods that improve the optimization of our manufacturing plants.
Statistics and Probability	Operational risks are assessed using probabilities. I also use statistics when analysing certain manufacturing parameters to understand the significance of variations in a given time period.

Angela Crowther
MEng Civil and Architectural Engineering

Structural Engineer
Built Environment Designer

Expedition

Briefly describe the organisation you work for.

Expedition are an Archi-Structural Engineering company responsible for a number of iconic structures including the 2012 Olympic Velodrome and Infinity Bridge.

Explain what you do on an average day at work.

My average day can be a complete mixture. I can be dealing with technical analysis of structural elements depending on the project I'm working on; right through to research into materials and structural systems at the front-end of a project. Managing projects – looking at finances and the programme as a whole, with lots of focus on extracurricular development including arts classes, team design workshops…the list is endless!

What do you like most about your job?

The variety of work is stimulating. Beyond the fact that no two projects throw up the same challenges, I love being able to delve both into technical problem solving to produce engineering solutions yet also be involved from the design concept stages. Early involvement in a project gives the engineer an opportunity to really influence how the design evolves from an engineering perspective.

What stimulated your interest in Maths and when?

I first discovered enjoyment in finding an elegant solution to a mathematical problem during my A Levels. My interest in Maths has continued from there.

What influenced your career choice?

A love for design and interest in the built environment. Alongside a desire to be creative in a way that is reinforced by Science.

Which skills do you consider to be essential for your job? In particular, what type of Maths is essential for your job?

Applied mathematics – mechanics is particularly useful. You can perform many tasks at the click of a button but in order to be able to properly interrogate results it is important to have an understanding of the mathematical analysis happening in the background.

Any advice you may have for other individuals considering your career path.

Keep your eyes open for opportunities – professional bodies, including the Royal Academy of Engineering, offer great scholarships providing diverse and exciting experiences.

Your future career plans.

I would love to charter as both an engineer and architect and then work at the conceptual end of design.

2012 Velodrome

Some of the ways in which Maths is relevant to Angela's work:

Maths Topic	Details
Mathematical Modelling	Analysing structural systems using computer software.
Functions	Understanding the theory behind computer analysis.
Geometry	Analysing architectural plans.
Algebra	Hand calculations for quick structural analysis early in a project.
Differentiation	Understanding the theory behind computer analysis.
Integration	Understanding the theory behind computer analysis.
Trigonometry	Hand calculations for quick structural analysis early in a project.
Exponential & Logarithms	Understanding the theory behind computer analysis.
Numerical Methods	Understanding the theory behind computer analysis.
Differential Equations	Understanding the theory behind computer analysis.
Statistics and Probability	Making judgment calls when deciding how to analyse a structure.

Emmanuel Akinluyi

BA, MEng in Engineering for the Life Sciences, Mechanical and Information Engineering, Cambridge University (Graduated in '09). Part way through an MSc in Medical Engineering and Physics (Part of Training).

Clinical Scientist (trainee)

NHS, Guy's, King's and St Thomas' Hospitals

Engineering in Action
Seeing where Maths can take you

Briefly describe the organisation you work for.

The NHS is a huge organization. In fact, it is the third largest employer in the world, after the Indian rail service and the Chinese Army. Running any single hospital or clinical service is a huge operation and a wide range of staff are involved with ultimately delivering quality outcomes for patients; these may include administrators, support and maintenance staff, lawyers, technicians as well as the more visible Doctors and nurses.

You don't often hear about the work of Clinical Scientists and Engineers, but despite being only 5% of the UK healthcare workforce, they are responsible in some way, for around 80% of diagnoses. In Medical Engineering and Physics, their areas of expertise include CT scanning, Ultrasound scanning, Equipment management systems, MRI imaging and spectroscopy, to Radiation protection and Nuclear medicine. At the moment, I am on a clinical placement in Biomechanics, but as you can see the range of applications you can end up working in really is amazing.

In the 'Onesmallstep Gait laboratory', we analyse how patients move. Our patients are usually young children who have been diagnosed with conditions that make it difficult for them to walk 'normally' or for long periods of time. By far the most common movement disorders we see in the lab are Cerebral palsies- which are caused by a range of injuries to the movement centres of the brain in birth or early development. These injuries in turn can cause problems with how muscles, bones and nerves grow and function.

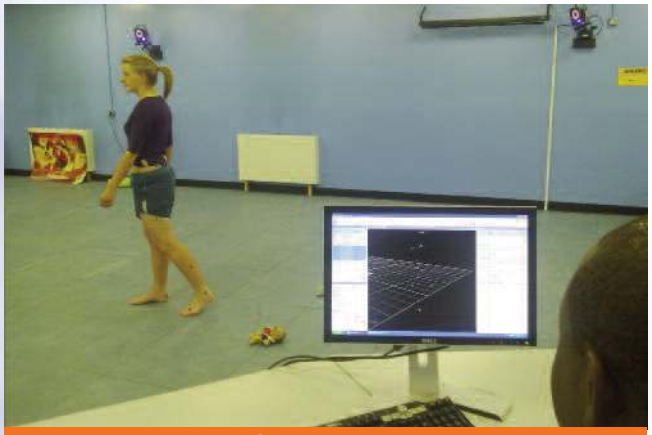
In order to alleviate some of the effects of these movement disorders, a number of approaches are available, including orthopaedic surgery, physiotherapy, muscular botox injections and special 'orthoses' devices like splints, that attach to the body externally. The role of a clinical scientist in this department is to collect and interpret as much useful information about a patient's condition and desired outcomes as possible. We work in a multidiscliplinary team with Surgeons, Neurologists, Physiotherapists and Support staff, to decide on the best approach for treating the patient.

Static Calibration

Dynamic Calibration

Explain what you do on an average day at work.

While on this clinical placement at Guy's hospital in the 'OneSmallStep' Gait (Biomechanics) Laboratory, We typically arrive a little before 9am and calibrate the equipment in the laboratory. The equipment we use is very sensitive, so we have to do this each day.



Conducting a trial

Special Infra Red Camera

Often I'm involved in the mid-morning patient session, but I have a chance to discuss research projects with my colleagues before they arrive.

Patient Session.

When the patient arrives (usually with a parent) a member of staff interviews them about their medical history and movement in day-to-day life. We then take them through to the lab and prepare them for their session. We take measurements of various body dimensions and joint ranges (a two person job) and examine particular joints.

We then attach special reflective 'markers' to particular places on their legs, using double-sided tape. These markers reflect infrared light that is emitted and detected by a set of seven specially designed cameras, that track the position of each marker.

We also attach 'Electro-Myography' (EMG) electrodes to the surface of their skin, over particular muscles using an adhesive tape. Electrodes tell us when our central nervous system (brain and spinal chord) sends a signal to each muscle to contract.

We then record videos of the patient walking, as well as their EMG signals and the trajectories of the reflective markers. After the session, I process the trial to generate a computerized model of the patient, that can be used to analyse their movements in a report.

After lunch time, I then work on research and development projects, designing software or devices that help us to use the data in the lab, or researching/investigating the conditions that we see. E.g. I have looked into new ways to analyse EMG signals, and have been designing devices that test how accurately we track the reflective markers in the lab.

Before heading home, I update a portfolio document that contains all of my activities, and will be examined when I apply to move on to the next level of the job.

What do you like most about your job?

I have found gait analysis to be very challenging and very enjoyable so far. Its great to be able to work directly with patients, and you get a real sense of purpose behind all the data analysis that you do. The department is also very open to innovation and new ideas, which is often the case when a group of Engineers get together! I think technology-based innovation is a particularly important aspect of improving patient care, and I've really appreciated having enough time to work on research and development projects.

Testing a prototype device

What stimulated your interest in Maths, and when?

When I was much younger, I was good at Maths, and found solving Maths problems

satisfying, but it took on a new meaning when I did some work experience at a small 'vision Science' company when I was 18. I got a chance to apply the Maths, Physics and some Biology to a design problem for the first time (I worked on designing some new eye-testing procedures), and I found that working towards a goal I could see made the Maths all the more relevant.

What influenced your career choice?

I've always liked problem solving, especially by designing things. I thought Engineering combined this, and my interests in Maths and Physics, so I pursued that. Since working on designing eye-tests during work experience, I've known that I want to work in the field of medical technology where my work might really benefit people who need it. For a long time the NHS has been thought of as 'behind the times' in its approach to technology, and its efficiency has had a lot of attention recently. This is true in some areas, but I strongly believe that it has the potential to be a huge driving force in medical innovations that can affect the rest of the world. I hope that in the next few decades, the roles of creative and technical people who want to make a difference will become more prominent and I want to be involved in that!

Which skills do you consider to be essential for your job? In particular, what type of Maths is essential for your job?

To do this job, you need to have a mixture of technical abilities and interpersonal skills. Being conscientious and focused is a great asset when collecting data, but I think that the ability to identify problems and to think creatively to solve them is very valuable. Whichever job you do you will keep on learning, so the most important things are to be willing to explore and learn some more, and to have a structured way of thinking (that studying Engineering or the Sciences can help you to develop).

I use vectors, matrices, calculus, geometry and mechanics in my job. However, in some situations, I've had to use other, less 'mainstream' methods. I'd say you should aim to understand the methods you're learning to a level where you can apply them to different problems.

Any advice you may have for other individuals considering your career path.

To be a Clinical Scientist in Medical Engineering and Physics, you can go the Engineering or Physics route through University so there is some flexibility there. The NHS training scheme for this job covers all bases well, so be prepared to learn some biology on the job too! The role of the clinical scientist has two sides: the routine clinical side of taking and interpreting measurements, and the research and innovation side. Be competent in that first area. In the second, try to keep in mind that you have a unique combination of skills and ideas to bring to the table. When in the job (or any other job, for that matter), do your best to add some value using this uniqueness, and if you want to do well in a position of leadership, try to recognize this in others too!

Your future career plans.

I hope to continue to work with the NHS for some time, and work on a PhD that relates to service improvement, design and innovation in one or more clinical services. After that Id love to find a role that contains this, and try to investigate different approaches to innovation in the organization.

The Lab

Some of the ways in which Maths is relevant to Emmanuel's work:

Maths Topic	Details
Mathematical Modelling	The day to day work here at the gait lab involves mathematical modelling of human motion and anatomy. For example, we model muscle and tendon properties in certain types of analysis.
Functions	Mathematical functions are critical because they help to describe natural phenomena. I have to write my own software functions a lot when designing bits of software for data analysis.
Geometry	Geometry is pivotal in accurately representing a patient in a computerized model. We factor patient measurements into our calculation. You also use it a lot when designing software and physical objects!
Algebra	Very useful tool if you want to make a program or design a device that takes an unknown input, and performs some calculations/processing.
Differentiation	Very useful in signal processing, and in finding out how quickly someone is moving or accelerating.
Integration	Useful for system control.
Trigonometry	Extremely useful in finding joint angles from marker positions. We work in 3D.
Exponential & Logarithms	These pop up all the time – particularly in probability distributions in statistics.
Numerical Methods	Useful in a number of different situations when you're looking for a solution to a certain type of problem- e.g. in optimisations.
Vectors	Our computer models are based around vectors.
Inequalities	Very useful. Especially if you want to detect when the EMG signal indicates that a muscle has been activated.
Differential Equations	In any mechanics, you can expect to deal with DEs because of the laws of motion.
Statistics and Probability	A lot of the time we deal with uncertainty in measurements.

Alhussein Albarbar
BSc, MSc, PhD, MIET, CEng

Senior lecturer in Automation & Control Engineering

Manchester Metropolitan University

Engineering in Action
Seeing where Maths can take you

Briefly describe the organisation you work for.

I work for Manchester Metropolitan University, a thriving university with one of the largest university campuses in the UK. There are more than 85,000 students studying in Manchester, so there is always a lot going on and it is a great place to live and work.

Explain what you do on an average day at work.

My work is really varied which is one of the things I love. One day I might be spending time on my own doing original research, another day I might be teaching large group of students or supervising individual postgraduate students. It is great to be able to help guide postgraduates when they are doing original research for the first time.

I also regularly visit national and international engineering conferences where I can meet people from around the world who are interested in the same research problems as I am.

What do you like most about your job?

I really like the scientific challenges – being presented with a real world problem which needs a solution. One of the areas which I am researching into is renewable power systems, so the outcomes are important for the environment and the future of our planet.

If I was asked what my favourite part of engineering is, it would probably be mechatronics, (mixed mechanical, electronic and electrical engineering systems), I find that side of things really interesting.

What stimulated your interest in Maths, and when?

Seeing the usefulness of Maths definitely stimulated my interest in the subject. Engineering wouldn't be possible without Maths – if you want to build a bridge across a motorway you can't test it out in advance, you need to predict whether it will stay up using Maths. Mathematics is very important because it enables engineering to predict results well before doing the real testing.

What influenced your career choice?

I wanted to do a job where I could make a difference to people's daily lives. In particular I got interested in sustainability and the whole area of renewable power systems. Engineering is very influential on how people live. We wouldn't have clean water, efficient transport or even washing machines without engineers.

Which skills do you consider to be essential for your job? In particular, what type of Maths is essential for your job?

Being hard working is pretty important, but that is the same in most fields, and the rewards are certainly worth it. In terms of Maths, becoming good at modelling real systems is important, but it can be learnt later on, if you haven't had much experience as an undergraduate.

Any advice you may have for other individuals considering your career path.

Getting hands on experience is always extremely useful; make the most of

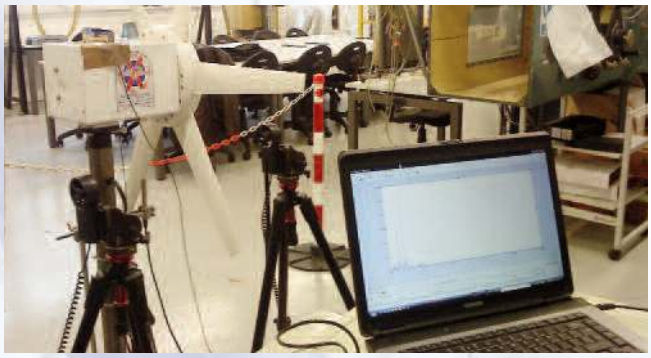
any work experience opportunities. If you wanted to enter my particular field of engineering then familiarising yourself with the latest sensing and control technologies and softwares would be useful.

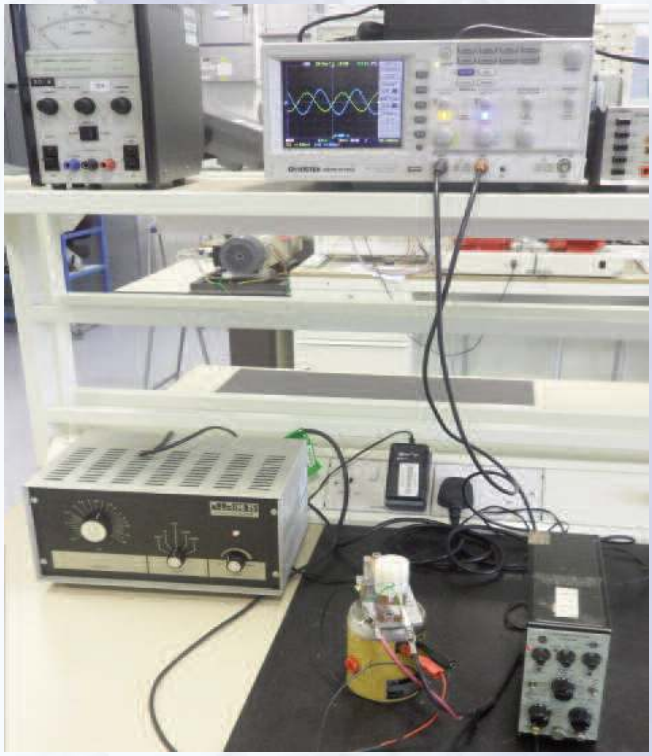
Your future career plans.

I want to do more research on power systems optimization and renewable energy. Hopefully this will help prevent global warming and environmental problems.

Some of the ways in which Maths is relevant to Alhussein's work:

Maths Topic	Details
Mathematical Modelling	Essential for predicting and controlling the vibration and noise generated from internal combustion engines and jet engines.
Geometry	Designing mechanical parts of robotics.
Differentiation	Modelling heat transfer.
Differential Equations	Modelling resonance.
Statistics and Probability	Monitoring the condition of machinery and evaluating performance.





Ben Clack
B Eng (hons) Mechnical Engineering
Acoustic Engineer

Mech-tool Engineering Ltd

Engineering in Action
Seeing where Maths can take you

Briefly describe the organisation you work for.

Mech-tool Engineering is a medium sized engineering company which creates products for a number of different sectors including the nuclear industry, petro-chemical industry and other companies which need to work offshore.

When you are working offshore in somewhere like the North Sea there are a number of hazards which companies need to protect their workers from. Mech-tool creates structures which help to reduce these risks, such as living quarters which can resist fire and explosions, or gas turbine silencers which help reduce dangerous levels of noise.

Explain what you do on an average day at work.

Much of my day is spent performing calculations and analysing the acoustic aspects of engineering projects. The results of my analysis forms the basis of designs and ultimately determines the size, shape and features of the equipment which Mech-tool builds.

What do you like most about your job?

It's a great feeling to start with a problem and come up with a working practical solution that can be proved mathematically. In the industries we operate in it is vital to be able to prove by engineering calculation and theory that a product will do what it is designed to do before the thing is built. Some of our structures are extrememly large. It just isn't possible to use trial and error - the calculations need to be correct so you can build successfully first time.

What stimulated your interest in Maths, and when?

I actually really struggled with Maths at school and didn't like it at all, however I also really enjoyed Science and Technology. At sixth form college I took Physics at A Level along with Design & Technology and History but quickly realized that without Maths I would struggle with Physics. I took up A Level Maths in the second year and found that I really liked it, it actually made sense to me! It was the application of Maths to the physical world that seemed to make Maths interesting to me.

What influenced your career choice?

I had some good advice from my Design & Technology teacher at A Level who saw what I was good at (and what I was not so good at!) and recommended engineering.

Offshore living quarters with fire and blast proof walls

Which skills do you consider to be essential for your job? In particular, what type of Maths is essential for your job?

Engineering analysis is essential. For acoustic analysis this involves applied Maths and in particular uses mathematical modelling, trigonometry, logarithms, calculus and simultaneous equations. To converge on a working solution requires quite a few attempts or iterations until all aspects are satisfied.

Any advice you may have for other individuals considering your career path.

Maths is a fundamental aspect of engineering and its importance can't be emphasized enough. You don't need to be a mathematical genius but rather you need to have a firm grasp of the mathematical concepts along with a practical approach and an inquisitive mind. These qualities will go a long way to helping you have a successful career in engineering.

Your future career plans.

I would like to be able to provide technical leadership as a professional engineer to other engineers.

Some of the ways in which Maths is relevant to Ben's work:

Maths Topic	Details
Mathematical Modelling	Use of software such as Mathcad or Excel spreadsheets and even Finite Element Analysis to perform lengthy calculations involved in mathematical modelling of acoustic problems. These models include many of the topics below.
Geometry	Size and geometry of say an exhaust system is a fundamental aspect of how gasses and noise travel through and out of the structure.
Algebra	Probably the most used Maths topic in my job. Manipulating equations is a daily task.
Differentiation	Differentiation and integration are usually needed when deriving from first principles many of the equations and formulae we use in acoustics.
Trigonometry	Direction of the path noise travels must be worked out which involves trigonometry.
Exponential & Logarithms	In acoustics sound is measured and expressed in sound pressure levels and sound power levels. To make these figures relate to how humans hear the sound, we need to apply logarithmic scales. This means that we use a lot of logarithms and exponential functions in equations.
Numerical Methods	We frequently use numerical methods to provide reasonably accurate approximations for answers. Vibration or thermal analysis for instance.
Vectors	We rarely use them day to day but vectors are used in fluid dynamics software packages which we use to analyse fluid flow.
Differential Equations	Used in thermal analysis, i.e. working out temperatures of materials. The complex nature of the problems tends to require us to use Finite Element Analysis software to analyse thermal problems but these use differential equations and numerical methods and much more to calculate answers.
Linear Algebra	Use of matrices is used to work out simultaneous equations for example.

Alasdair Gardner
Masters of Engineering (Aero) and Post Graduate Certificate in Aerospace Design and Management
Performance Technologist

Rolls-Royce plc

Engineering in Action
Seeing where Maths can take you

Briefly describe the organisation you work for.

Rolls-Royce is a global power systems provider. We provide propulsion and power generation systems for the aerospace, marine and energy sectors. We are probably best known for our jet engines which power many of the civil airliners in service today. Rolls-Royce employees 39,000 people world-wide and has a turnover in excess of £10 billion.

Explain what you do on an average day at work.

My working day starts at around 8.30am. After checking email and attending various morning briefings on the day's tasks I get down to my work. My department is responsible for developing future jet engine concepts and analysing their performance. Much of the work is computer based, since with the aid of computer modelling programs we can create and analyse engine concepts more quickly and accurately than we would be able to using hand calculations. I'm part of the team working on the preliminary design of our next large "Trent" engine. At present I am carrying out various trade studies to understand how attributes such as engine fan diameter can be optimised to minimise fuel burn. A typical afternoon consists of more analysis work, discussions with colleagues and perhaps design reviews or project team meetings. I try to get down to the build line, test beds and repair shops as often as possible to get my hands on engine hardware, since this helps me understand the engines we are modelling. The dynamic nature of the business I work in means that no two days are ever the same.

What do you like most about your job?

I find it really exciting that the engine concepts I'm working on today will first power aircraft into the skies ten years from now, and are likely to continue to do so throughout my lifetime. Because of the time scales involved, and the economic and environmental pressures we face, the work we do is always pushing the boundaries of technology. The modern jet engine is one of the greatest technological achievements of our time. It gives me a great deal of pleasure to know that through my work I'm building on this achievement and shaping the future of air travel.

What stimulated your interest in Maths, and when?

I always enjoyed Maths, but I first became really interested in it when I began to understand how it could be applied to model and solve real world problems. For this reason the algebraic problems covered at GCSE and the mechanics modules at A Level really appealed to me. I also enjoyed the mathematical aspects of Physics and Chemistry.

What influenced your career choice?

I didn't really make a career choice until the final year of my degree when I decided that having enjoyed studying engineering, I should at least consider engineering jobs before looking elsewhere. I actually took a broad range of A Levels and considered studying languages at university, but thought an engineering degree would give me more options later on. After finishing school I took a year out to do an internship with BMW in the factory where the Mini is assembled. This gave me my first real taste of

engineering and confirmed my degree choice. During my four years at university I did further engineering internships in Germany, the US and India. I really enjoyed the work and travel, and so went into engineering as a profession hoping for more of the same.

Which skills do you consider to be essential for your job? In particular, what type of Maths is essential for your job?

A strong grounding in Maths is essential to my job since it underpins everything that I do. Likewise, an understanding of thermodynamics (the study of heat and energy transfer) is absolutely essential. Much of thermodynamics can be expressed in mathematical equations. It is the ability to manipulate these equations and physically interpret the expressions in them which I rely on. The solution of these equations is often not straight-forward, hence we need to use computer models which employ numerical methods to make headway. We use lots of computing power and statistical methods to quantify the uncertainty inherent in our models and assumptions.

Any advice you may have for other individuals considering your career path.

Firstly, don't underestimate the value of Maths and sciences at school. They're all but essential for most jobs in engineering and they open up many exciting opportunities at degree level and beyond. Secondly, make the most of the opportunities available to you. In engineering particularly, there are lots of internship, sponsorship and scholarship opportunities at school and university – you just have to go out and find them! The Royal Academy of Engineering as well as the other engineering institutions, and engineering employers in your area are a good place to start.

Your future career plans.

I aspire to become a Chief Engineer at Rolls-Royce, with responsibility for the design and development of a future jet engine. This will require a vast range of technical and managerial experience and expertise, so for the time being I'm focussed on developing my technical knowledge and credibility through my current job.

Some of the ways in which Maths is relevant to Alasdair's work:

Maths Topic	Details
Mathematical Modelling	Mathematical modelling of the thermodynamic behaviour and performance of future engine concepts.
Geometry	Evaluating the weight and drag associated with the geometry of future engine concepts.
Algebra	Manipulation of algebraic equations used to model engine concepts.
Integration	Aircraft mission analysis: understanding the impact of instantaneous engine performance on aircraft mission attributes (e.g. range, fuel requirement).
Exponential & Logarithms	Analysis of jet engine sound emission using the decibel logarithmic scale.
Numerical Methods	Iterative solution of equations.
Vectors	Application of "free body diagrams" to analyse engine and aircraft structures.
Inequalities	Expressing engine requirements.
Differential Equations	Manipulation of, and physical interpretation of terms in governing equations of thermo and fluid dynamics.
Linear Algebra	Solution of large systems of equations.
Statistics and Probability	Quantifying uncertainty inherent in methods and assumptions. Application of probabilistic methods to solution of complex problems.

Which subject at degree level gives you access to a thousand different careers?

Accountant Actuary Aerodynamicist
Aeronautical Engineer Air Traffic Controller Aircraft
Tracking Researcher Architect Archivist Army Officer
Astronaut Astronomer Audio Software Engineer Auditor Bank
Manager Bioinformatician Biokineticist Biomathematician
Biostatistician Business Decision Analyst Business Owner Cartographer Civil
Servant Complexity Modeller Computer Games Developer Computer Programmer
Computer Scientist Construction Manager Cosmologist Credit Risk Modelling Analyst Cryptologist Data
Analyst Data Mining Specialist Database Developer Defence Analyst Detective Ecological Modeller
Econometrician Economist Epidemiologist Financial Analyst Financial and Investment Manager
Financial Engineer Fluid Dynamicist Hospital Manager Hydrologist Information Security
Officer Insurance Analyst Insurance Underwriter Intelligence Specialist
Investment Banker Investment Manager Lawyer Lecturer Lighting
Director Logistics Manager Management Consultant Market
Researcher Mathematical Biologist Mathematical ModellerMathematics
Researcher Medical Sales Representative Medical Statistician
Merchant Banker Merchant Navy
Epidemiologist
Financial Analyst
Financial and Investment Manager
Financial Engineer
Fluid Dynamicist
Patent Attorney Pilot Policy Advisor Portfolio
Analyst Project Manager Psychologist
Quality Assurance Manager Quantitative
Analyst Quantity Surveyor RAF Officer Risk
Analyst Royal Navy Officer Sales Forecaster
Science Communicator Science Journalist
Science Librarian Scientific Instrument Designer
Software Engineer Sound Technician Sports
Engineer Statistician Stockbroker Stress
Analyst Systems Analyst Teacher
Technical Author Telecommunications
and IT Analyst Town Planner Biokineticist
Transport Planner Web Developer
Econometrician Economist
Epidemiologist Financial Analyst
Financial and Investment Manager Biostatistician
Financial Engineer Fluid Dynamicist
Biomathematician
Business Decision Analyst
Cartographer
Civil Servant
Complexity Modeller
Computer Games Developer
Computer Scientist
Construction Manager
Cosmologist
Data Analyst
Data Mining Specialist

YOU THINK YOU DO MATHS!

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