SSERC *Bulletin*

Ideas and inspiration supporting science and technology for all Local Authorities

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That uncertain feeling

Planck's Constant is inconveniently small when it comes to carrying out classroom experiments on the Uncertainty Principle. However, considering the behaviour of classical waves can give us insight into phenomena usually considered to be quantum in nature. Here we use apps running on tablets to investigate classical uncertainty, then relate our findings to quantum physics.

In Bulletin 244 [1] we looked at the use of frequency spectrum analysis software as a tool for investigating the Doppler Effect. More recently, we have found apps [2] that do the same job.

The left hand part of Figure 1 shows the frequency spectrum analysis of a steady sinusoidal tone generated by a function generator app set to 10 KHz. The tablet running the function generator app was connected to an active loudspeaker. The frequency spectrum analyser is running on a second tablet. Frequency is on the y-axis, time on the x. Looking closely at the width of the frequency trace, an uncertainty of a few tens of Hertz can be seen. The uncertainty in time - when, exactly was the frequency 10 kHz? - is very large because the wave is continuous.

On the right of the image, the function generator has been set to produce bursts of sound of the same frequency. 10 bursts per second, each 200 wavelengths long, were created. Looking at an individual burst, the uncertainty in time is much smaller. Conversely, the uncertainty in frequency is much greater - the trace is much more spread out in the y-direction.

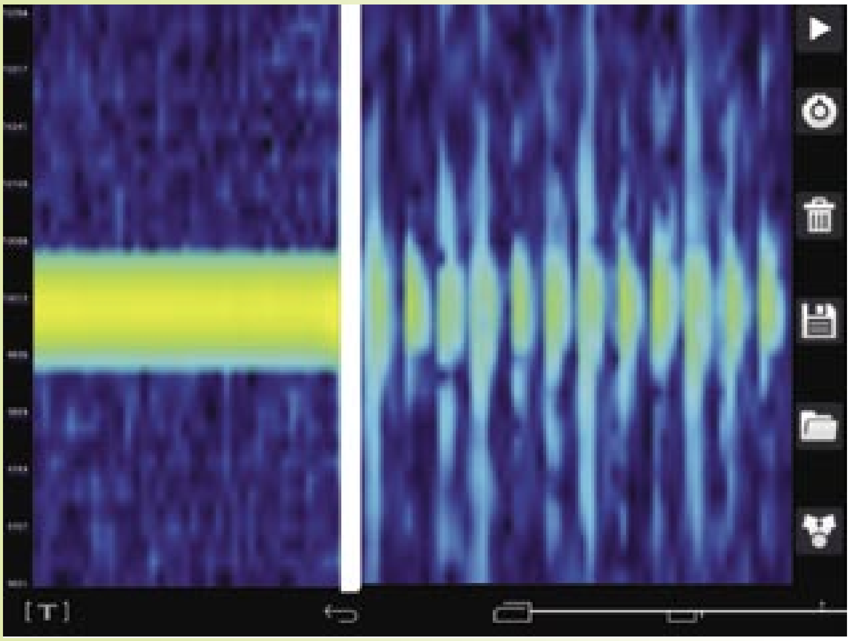

Figure 1 - Frequency spectrum analyser trace.

The best explanation is in terms of Fourier components. An infinite sinusoidal wave is made of a single Fourier component, i.e. a wave of one frequency. Any other wave train is made up of a sum of Fourier components, i.e. a sum of waves of different frequencies.

In summary, as Δt decreases, Δf increases.

If your students have no knowledge of Fourier analysis, they may gain some understanding from a simulation such as the one shown in Figure 2 [3].

Students can start with a sine wave and add in harmonics. The preset "wave packet" function shows how a range of different frequencies are needed to create something that is localised in space or time.

If this is beyond your students, they should at least be able to appreciate that the longer the wave train, the easier it will be to accurately determine frequency. Ask them to think of the relative difficulty in identifying the pitches of long and short-lived musical tones.

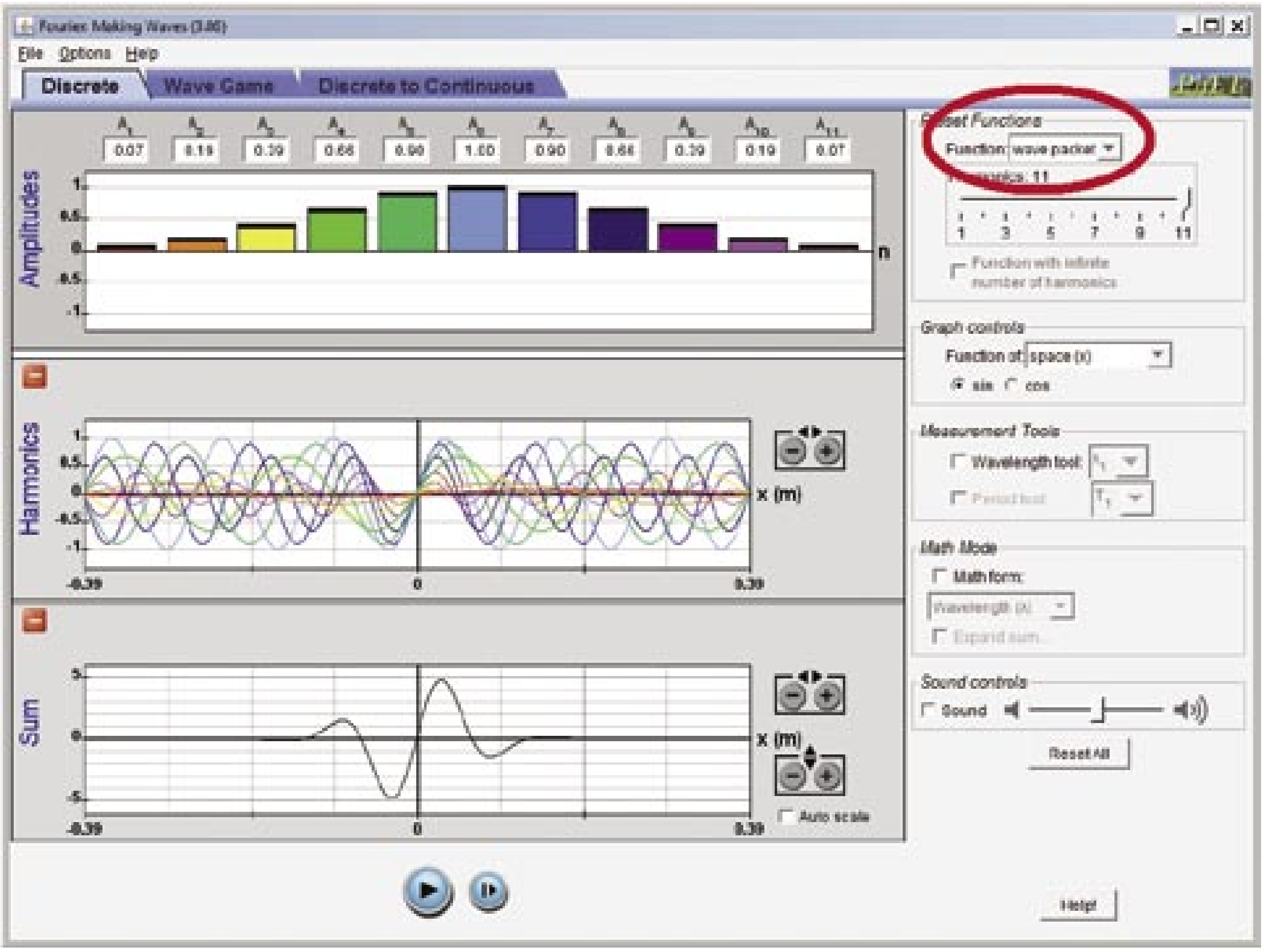

Figure 2 - Simulating adding Fourier components.

None of this is quantum physics. However, at a quantum level, particles display wave-like properties and these waves behave exactly like classical waves. The link is the equation $E = hf$ where E is the energy of the particle, f is the frequency and h is Planck's Constant. Because h is constant, we can now say,

as Δt decreases, ΔE increases

We are lucky at SSERC, and indeed in Scottish physics education in general, to be able to call upon the wisdom of some top class Higher Education personnel for guidance. When we asked our "go to" quantum physicist about this activity, she reminded us that, "each individual quantum particle has these uncertainties associated with it - it's not just that there are many particles with a spread of exactly-known energies. Each particle's energy is uncertain."

Guidance on using both of the apps featured in this article is contained in the document accessed via the link in reference [2] below. The original idea for this activity came from Harvard Natural Sciences Lecture Demonstrations [4]. The Harvard version does not use a function generator app, but we felt that few, if any schools in Scotland would have the necessary hardware to do this any other way. We believe that our use of a frequency spectrum analyser is a worthwhile enhancement.

References

[1] http://www.sserc.org.uk/images/Bulletins/244/SSERC%20bulletin%20244-p2-3.pdf.

[2] http://tinyurl.com/physics-apps.

[3] https://phet.colorado.edu/en/simulation/fourier (accessed April 2017).

[4] http://sciencedemonstrations.fas.harvard.edu/presentations/uncertainty-principle (accessed April 2017).

Demonstration corner

AUTOCATALYSIS

Catalysis is a basic principle in chemistry and biochemistry whereby a chemical (the catalyst) facilitates a reaction without being used up in the process.

Some reactions are autocatalytic: a product of the reaction actually catalyses further reactions. One example of this is the reaction between potassium manganate VII and glycerol. This is another attractive demonstration of the process which seems to have its origins in the book: *Chemical Demonstrations: A Sourcebook for Teachers. Volume 1* by Lee R Summerlin and James L Ealy Jr. published by the American Chemical Society in 1965.

A solution, coloured with bromophenol blue, is placed in a measuring cylinder. A small volume of acid is added to the top of the cylinder to initiate the reaction. This forms a yellow layer. Over the next few minutes the yellow layer moves down the column as the autocatalysis effect takes place.

You will need:

- 4 g potassium chlorate
- 12.5 g sodium sulfite
- 5 mg bromophenol blue (or a big enough squirt of the solution to give a good colour)
- 5 cm^3 concentrated sulfuric acid
- 1 x 100 cm^3 measuring cylinder
- 2 x 100 cm^3 beakers

Figure 1 *- The yellow-blue interface moves slowly down the graduated cylinder.*

Health & Safety

Concentrated sulfuric acid is highly corrosive. Handle with care when diluting wearing goggles (BS EN 166 3) or a face shield and gloves. The 3 M solution is also corrosive: wear goggles (BS EN 166 3) and gloves.

The reaction produces sulfur dioxide but most of this dissolves in the solution so very little is released to the atmosphere during the actual experiment. Disposal, however, can cause a larger release. (To dispose of the solution, dilute about 10:1 with water and then neutralise with a weak alkali such as sodium carbonate and then wash to waste with plenty of running water).

The reaction is exothermic. The solution will not boil but could get hot enough to be uncomfortable to hold.

Procedure

1) Place 50 cm^3 of water in a beaker and dissolve 4 g of potassium chlorate, followed by 12.5 g of sodium sulfite. Then add the bromophenol blue indicator.
2) Prepare a 3 M solution of sulfuric acid by adding 5 cm^3 of concentrated sulfuric acid to 18 cm^3 of distilled water.
3) In a second beaker, add 4 cm^3 of the 3 M sulfuric acid to 50 cm^3 of water with stirring.
4) Slowly, with constant stirring, add the diluted acid from the second beaker to the blue solution in the first beaker. Stir until all solids dissolve. The solution should be blue/violet.
5) Fill a 100 cm^3 measuring cylinder with the blue-violet solution.
6) Carefully add 5 cm^3 of 3 M sulfuric acid solution to the top of the liquid in the cylinder. (This is best done with a pipette).
7) A yellow colour will appear at the top of the solution, and a yellow/ blue interface is formed.
8) Observe for several minutes as the yellow-blue interface moves slowly down the graduated cylinder (Figure 1).

The chemistry

This is a redox reaction (see Figure 2).

The pH on the reactant side is about 7; the pH on the product side is less than 7. Thus, the reaction proceeds only in an acidic solution. Dropping sulfuric acid on the surface produces acidic products:
$3H^+ + SO_2^{2-} \rightarrow HSO_3^-$

These acid products catalyse further reactants to produce additional acidic products; hence the autocatalytic effect.

Bromophenol blue indicator is yellow in the presence of an acid. Thus, as autoctalysis proceeds, the blue colour of the indicator changes to yellow. The blue solution has a pH between 6.5 and 7.0 due to the buffering effect of the bisulfite/ sulfite ions.

$$Cl0_3^-{}_{(aq)} + 3HSO_3^-{}_{(aq)} \rightarrow Cl^-{}_{(aq)} + 3\ SO_4^{2-}{}_{(aq)} + 3H^+{}_{(aq)}$$

blue **yellow**

Figure 2 *- The redox reaction.*

Reference

[1] http://www.sserc.org.uk/chemistry-demonstrations/chemistry-demonstrations/3218-hot-stuff.

Have a ripping time

Regulations and risk assessments are constantly in a state of flux. It is important to ensure that you are up to date with changes in working practices and procedures.

The biggest change recently, with regards to *Safe Use of Fixed Workshop Machinery*, has to be the position of the rip fence whilst rip cutting.

The old practice (Figure 1) was to set the fence to the half way point of the blade; however, it has been suggested that this may increase the risk of kickback.

A revision in BS4163:2014 now states that:

> "The ripping fence, if used, should be accurately adjusted to not extend more than 50 mm beyond the tips of the saw teeth, in the direction of the feed" (Figure 2). (BS4163:2014 - 13.6.2.2 Page 71)

This new setup limits the amount of contact the timber has, between the blade and fence, reducing the risk of kickback.

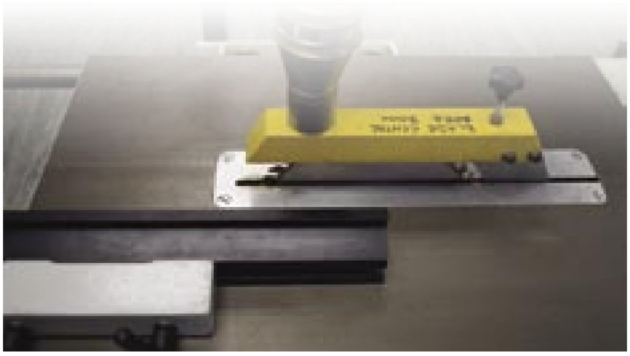

Figure 1 *- Set the fence to the half way point of the blade.*

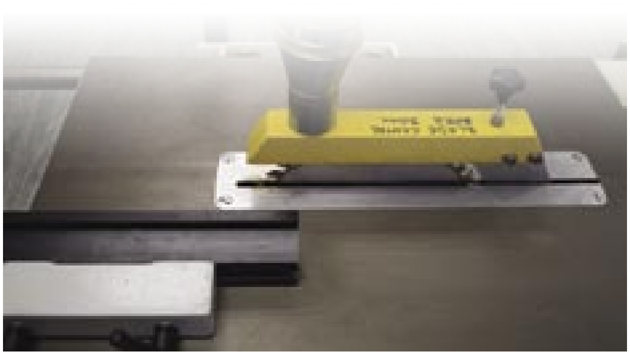

Figure 2 *- Set the fence no further than 50 mm beyond the the saw teeth.*

National 5 Laboratory Science: Skills for Work

The National 5 Laboratory Science: Skills for Work course is attracting attention from a number of schools. Within SSERC we are increasingly being asked if we might offer professional development opportunities for teachers and technicians to come together to share ideas and information in relation to the course.

We plan to support National 5 Laboratory Science: Skills for Work by offering participants the opportunity to explore laboratory procedures and practices which can be used in delivery across the course. Combined with opportunities for professional networking, our course will offer participants a rich and vibrant programme that will enhance teaching and learning within their institutions.

We are pleased to say that we have been able to secure funding through the National STEM Learning Centre (*NSLC*) for a maximum of 15 participants. *NSLC* will provide ENTHUSE Bursaries of £480 which will meet the course fee, resources, and accommodation. The course will be held in 2 parts.

Reference

[1] http://www.sserc.org.uk/cpd-sserc/chemistry-courses-sserc/4230-laboratory-science-national-5-lab-skills.

N5

The course dates are 22-23rd September 2017 and 9th February 2018. Further details including a draft programme and details on how to apply can be found on the SSERC website [1].
The closing date for applications is 25th August 2017.

Lathe speeds and

Have you ever been bewildered by the vast array of buttons and levers on your department's centre lathe headstock? Ever thought, "Why bother to change anything, as it looks so complicated?" Back in Bulletin 233 [1], we highlighted the importance of changing pillar drill speeds in relation to the size of holes being drilled, the type of drill bits used and the material being drilled. Well, machining safely and correctly on the centre lathe commands the same degree of importance and the machine should have its speed set appropriately. Having said that, it can look pretty complicated, with each centre lathe having different arrangements to select and change speeds.

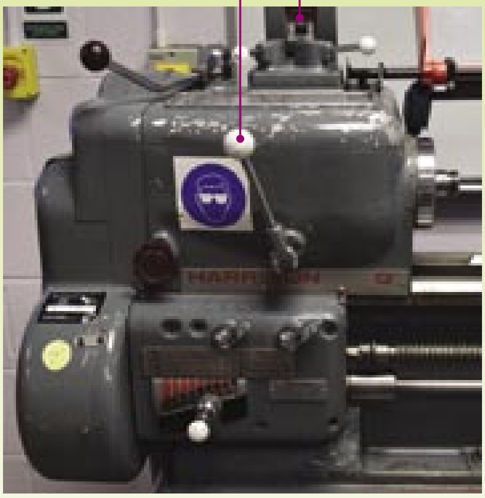

Figure 1 *- Headstock gear arrangement.*

Figures 1 and 2 show some common centre lathe headstocks. The arrangement of small levers in Figure 1 at the top of the machine controls the spindle speeds of the lathe i.e. the speed at which the chuck rotates. By moving these levers into the positions indicated on the diagram fixed to the machine, a number of speeds can be selected. Further reductions in speed can be obtained by moving the 'back gear' lever directly on the front of the machine. This not only provides reduced speed but also greatly increases the lathes turning power. In Figure 2, the spindle speeds are controlled by the large rotating dial type lever. All other levers on each of these machine relate to screw cutting operations. Generally speaking, the larger and harder the material being turned then the slower the speed. Larger materials are often heavy and thus the use of the back gear to provide more torque will be required.

Figure 2 *- Headstock gear arrangement.*

$$\text{Spindle Speed} = \frac{\text{cutting speed (c.s)}}{\text{Circumference of workpiece}} = \frac{C.S}{\pi d}$$

e.g. for a cutting speed of 25 m/min; bar diameter 20 mm

$$\text{Spindle Speed} = \frac{25 \times 1000}{\pi \times 20} = 398 \text{ rev/min (approx.)}$$

Figure 6 *- The Formula.*

Most centre lathes typically have a number of selectable speeds ranging from 45 rpm up to 3000 rpm. These speeds ranges cover a wide range of machining operations, such as facing off, taper turning, parallel turning, parting off, knurling and screwcutting. They also adequately cover a wide range of materials that are usually found in schools such as ferrous, non-ferrous metals and some forms of plastic. In order to select the most appropriate spindle speed, we must consider the cutting speed of the material being turned.

Cutting speeds

Cutting speeds, which have a constant value for a given material, are unusually expressed in metres per minute and they indicate the optimum speeds required in order to achieve a quality finish (see Table 1).

To achieve and maintain these cutting speeds, smaller diameter work has to turn much faster than larger diameter work and, depending on the given cutting speed and diameter (d) of material being turned, the approximate lathe spindle speed can be calculated from the formula shown above.

tool angles

Spindle speeds

Table 2 shows a quick 'handy reckoner' guide of preferred spindle speeds for a range of materials of varying diameters. It is assumed that these cutting speeds are for moderate depths of cut and feeds; the feed being the distance the cutting tool moves along the lathe bed in one revolution.

For a smoother finish, longer tool life and faster cutting speeds a lubricant (cutting fluid or coolant) must be used. A common cutting fluid is soluble oil and water, although light machine oil is sometimes used.

Material	Spindle speeds (rev/min) for given diameters			
	Ø9 mm	Ø12 mm	Ø18 mm	Ø25 mm
Mild Steel	880	660	440	320
Plastics (e.g. Nylon)	1400	1050	700	500
Brass	2650	1990	1330	960
Aluminium	3000	2200	1400	1000

***Table 2** - Spindle speeds.*

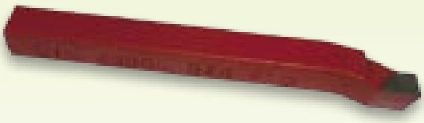

***Figure 3** - Brazed carbide tip tool.*

***Figure 4** - H.S.S tool and holder.*

Lathe tools

The tooling used in turning also plays an important role in selecting the correct speed. Typically the most common type of cutting tool used in school workshops are made from high speed steel (H.S.S). Other types are available such as carbide tipped tools (Figure 3). These types of tools offer faster material removal in most cases and as the carbide is more expensive and more brittle than steel it is brazed onto a steel shank. Almost all high-performance cutting tools use indexable inserts. This type of tooling allows for the cutting edge to be rotated when dull, to a fresh edge. This can be done a number of times before the insert needs replacing. However, these types of tools are more expensive than the traditional high speed steel tools.

H.S.S cutting tools come in the form of a square section that is held in a tool holder (Figure 4). It is important that when selecting the correct speed for the material being turned that the cutting edge of tool is also properly ground. This edge is formed by grinding a clearance angle, below the cutting edge, known as front clearance, and a slope on the top side, away from the cutting edge, known as the top and side rakes respectively.

***Figure 5** - Index tooling.*

During machining, the cutting edge must retain maximum strength and cut with minimum friction. Generally, when cutting soft metals like aluminium and copper, the tool angle can be relatively small but when cutting hard and brittle metals like brass and cast iron the tool angle must be large (for maximum strength) to avoid breakage.

Material	Meters per min (MPM)
Steel (tough)	15 - 18
Mild Steel	30 - 38
Cast Iron (medium)	18 - 24
Alloy Steels	20 - 37
Carbon Steels	21 - 40
Bronzes	24 - 45
Aluminium	75 - 105
Brass	90 - 210

***Table 1** - Cutting speeds, using H.S.S tool bit.*

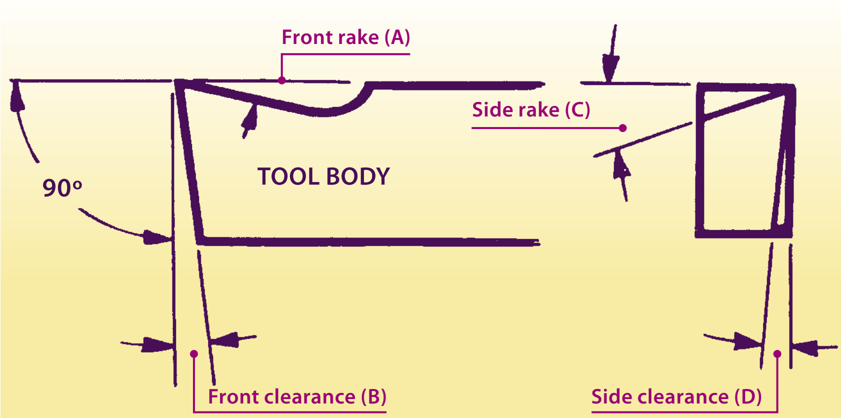

***Figure 6** - Grinding clearance.*

Material	Front Rake (A)	Front Clearance (B)	Side Rake (C)	Side Clearance (D)
Soft Steel	15°	8°	15° - 20°	6°
Medium Steels	8° - 10°	8°	12° - 15°	6°
Hard Steels	5°	6°	6° - 10°	6°
Cast Iron	8°	8°	10° - 15°	6°
Brass & Bronze	1°	6°	0° - 3°	6°
Copper	20° - 25°	10° -15°	20° - 30°	2° - 5°
Aluminium	35° - 55°	6°	10° - 20°	1° - 3°

***Table 3** - Rake and clearance angles.*

For various materials, the rake and clearance angles are listed in Table 3.

It should be noted that from the chart the top rake angle varies the most and generally increases as the material being turned get softer. The front clearance angle varies least and should be no more than necessary. If excessive clearance is ground then the point of the tool becomes too sharp, losing necessary strength and heat dissipating area.

Conclusion

In order to operate and machine safely on a centre lathe, produce accurate and quality work, spindle speeds and cutting tool angles must be changed and ground accordingly. Spindle speeds which are set too fast and cutting tools that have too little clearance can cause tool breakage, poor surface finishes, overheating and chatter (vibrating noise while cutting). So next time you use the lathe check the tables and change the speed to match what you are turning.

Reference

[1] SSERC Bulletin (2010), The 'hole truth and nothing but....', **233**, 2-4.

Chemistry probationers - A professional development opportunity

SSERC is pleased to announce that it will be working in partnership with The Royal Society of Chemistry (RSC) during 2017/18 on a new initiative to support probationer teachers of chemistry in Scotland.

The scheme offers the opportunity to take part in a free 2-part professional development course combined with a personal chemistry specialist mentor during your probationer year.

The RSC has set up this initiative to try and help with the decreasing number of chemistry specialist teachers in Scotland, and ensure that students are getting the highest quality chemistry education possible. If the initiative is successful, there will be scope to continue and expand the programme in future years.

This programme will start with a two-day residential course in SSERC. As well as running CPD training, we will use part of this meeting to link the probationer teachers with a chemistry specialist mentor who will have been trained by the RSC.

The course dates are 29-30th September 2017 with a follow-up day on 11th May 2018. Further details are on the SSERC website [1]. **The closing date for applications is 1st September 2017.**

Reference

[1] http://www.sserc.org.uk/cpd-sserc/probationers/4231-rsc-chemistry-probationers-29th-30th-sept-2017-and-11th-may-2018.

The Rolls-Royce Science Prize

The Rolls-Royce Science Prize is an annual awards programme that helps teachers implement science teaching ideas in their schools and colleges.

The Prize recognises and rewards excellence in science teaching across the full spectrum from special education needs to high ability pupils. It also promotes innovative and sustainable strategies for teaching science which address a specific need in the schools or colleges and at the same time contributes to teachers' continuing professional development.

Andrew Johnston (Gairloch High School) - Runner-up Rolls-Royce Science Prize 2015

The prize scheme is open to individuals who have been on an ENTHUSE-funded course either at the National STEM Learning Centre (NSLC) or at SSERC. The awards are based on the quality of an Action Plan submitted at the end of a course. Each year 50 Special Merit Awards of £1,000 are made and the winners of those awards are then eligible to progress through the scheme. Over recent years a number of delegates from SSERC courses have made it to the finals and along the way have generated significant funding for their schools. So, for example, both Andrew Johnston from Gairloch High School and the team from St Vincent's Primary in East Kilbride have been awarded in excess of £10,000 for their schools/departments over the past 2 years.

We have recently heard that judging for the 2017 Rolls-Royce Prizes has taken place. The really good news is that 5 participants on a recent SSERC course (Supporting STEM) run by our Primary Team have been nominated to receive Special Merit Awards. Rolls-Royce

The team from St Vincent's Primary School - Runners-up Rolls-Royce Science Prize 2016.

tell us that 5 Awards to participants on a single course is 'unprecedented'. Our congratulations go to all the winners and of course the Primary Team in SSERC for this fantastic outcome.

STEM
AMBASSADOR HUB

STEM Ambassadors

What's the actual impact of STEM Ambassadors in schools? Do they increase pupil engagement? Is there any overall value for teachers?

These are just some of the questions answered by the recent impact report produced by STEM Learning, the new administrators of the UK wide STEM Ambassador programme. Published in late 2016, the report shows the full effect that STEM Ambassadors can have on young people to enthuse them in STEM subjects. The report used independent data collected from a network of STEM Ambassadors, as well as teachers and young people. The results are favourable, with 90% stating that STEM Ambassadors increase young people's engagement in science, technology, engineering and maths subjects, while 81% said STEM Ambassadors improve teacher understanding in their discipline 'so they can better articulate information about STEM careers'. Across the UK there is a network of 19 Hubs that manage the volunteering opportunities for the UK's 33,000 registered STEM Ambassadors. As of October 2016, SSERC assumed lead role in Scotland for the STEM Ambassadors programme working collaboratively with the 3 Scottish Hubs, delivering STEM Inspiration.

STEM Ambassadors work with young people to bring STEM subjects alive through real life experiences. They are volunteers from age 17 years upwards, representing a vast range of STEM-related jobs across the UK. Ambassadors help to open the doors to a world of opportunities and possibilities which come from pursuing STEM subjects and careers. As well as inspiring young people Ambassadors can also support teacher CPD by demonstrating and explaining current applications of STEM in industry or research.

To find out more about STEM Ambassadors in your area, please visit www.stem.org.uk [1]. To read an interview with a STEM Ambassador, please visit www.gla.ac.uk [2].

References
[1] www.stem.org.uk/stem-ambassador-hub-contacts.
[2] http://www.gla.ac.uk/explore/scienceconnects/news/headline_523990_en.html.

Hello... Goodbye


Alastair MacGregor


Fred Young

In September, SSERC will have a new Chief Executive Officer. He is Alastair MacGregor, known to many of you as Head of Science, Technology, Engineering and Mathematics at SQA. He takes over from Fred Young, who joined SSERC in 1999. Fred was previously head of Chemistry at Lochgilphead High School. His first role at SSERC was as the Chemistry Advisor but in 2005 he became Chief Executive Officer.

Fred has led SSERC through a period of enormous change. With the replacement of subject PTs by Faculty Heads and the reduction in numbers of Science Advisors and Senior Technicians, SSERC's advisory role is even more vital than ever. SSERC has also addressed fundamental issues in primary science education with a highly regarded programme that empowers teachers to confidently bring real, practical science into their own classrooms. Technician CPD is stronger than ever as there are now levelled, SQA accredited SSERC courses for support staff. Following the acquisition of another building, our support for technology education has also expanded. Whilst Fred would be the last person to claim sole credit for these innovations, his sharp mind, leadership, good humour and sometimes astonishing levels of persistence and patience with outside agencies has helped to make them all possible. We wish him well.

SSERC professional development courses

Our professional development courses range from twilight events, day-courses through to residential meetings lasting up to 6 days in total. Our curriculum coverage spans both primary and secondary sectors and we offer events for teachers as part of their career long professional learning, newly qualified teachers and technicians. Many of our events receive funding from the ENTHUSE awards scheme or the Scottish Government.

Courses available for online booking at this time include:

COURSE NAME	RESIDENTIAL?	DATES	CLOSING DATE	SECTOR
Biology Residential	Yes	14-16 September 2017 09-10 March 2018	23 August 2017	Secondary
Laboratory Science National 5	Yes	22-23 September 2017 09 February 2018	25 August 2017	Secondary
Pneumatics & Hydraulics (SSERC_Meet)	No	28 September 2017	28 August 2017	Primary
Teddy in the Park (SSERC_Meet)	No	04 October 2017	04 September 2017	Primary
Leading for Excellence in Science	Yes	12-15 November 2017 11-12 March 2018	06 September 2017	Secondary
Engineering Bench Skills	Yes	26-27 October 2017	28 September 2017	Secondary
Safety in Microbiology for Schools	Yes	01-03 November 2017	29 September 2017	Technicians
Getting to Grips with Friction (SSERC_Meet)	No	07 November 2017	09 October 2017	Primary
Microbiology for Teachers	Yes	23-24 November 2017	20 October 2017	Secondary
Health and Safety Update	No	21 November 2017	20 October 2017	Secondary
Pneumatics & Hydraulics (SSERC_Meet)	No	20 November 2017	23 October 2017	Primary
Supporting STEM	Yes	17-18 November 2017 23-24 March 2018	27 October 2017	Primary
Working with Radioactive Sources	No	28 November 2017	27 October 2017	Secondary
Risk Assessment	No	15 January 2018	01 December 2017	Secondary
Science for Secondary Probationers	Yes	05-06 February 2018 05-06 June 2018	30 November 2017	Secondary
Fabrication Skills	Yes	19-20 February 2018	19 January 2018	Secondary
Carbon Dioxide Chemistry for Primary Schools (SSERC_Meet)	No	28 February 2018	29 January 2018	Primary

No escape from (Virtual) Reality

In virtual reality (VR), a computer is used to recreate a 3D environment that a user can interact with. At present, this is usually done with a special headset. Some have built-in screens, others, such as Google Cardboard, are just holders for smartphones. Some teachers are beginning to use the technology in lessons. Are there any safety issues that we should consider?

At a recent meeting of a British Standards Committee that deals with optical radiation hazards, a member stated that there is no risk associated with the light emitted by the screen of a VR device. He added, however, that there were numerous reports of people feeling unwell after using the technology. It appears that VR sickness is a recognised phenomenon.

The cause of this sickness, which manifests in various ways such as nausea and dizziness, is not well understood. It is thought by some to be similar to motion sickness. The theory often used to explain this is sensory conflict. Information from your eyes does not match that from your vestibular system, the latter being the mechanism involving parts of your inner ear that are responsible for balance and perception of orientation.

Children from 2-12 are particularly sensitive to motion sickness and therefore may be more likely to feel ill when using VR. The most sensible control measure is to limit use. We suggest no more than 5 minutes of uninterrupted virtual reality for primary and early secondary children. Pupils should be sitting down and there should always be a responsible adult who can observe the children, unimpaired by a headset.

Is the "5 minute" limit too draconian? Perhaps you use VR yourself. Please tell us about your experiences.

Product recall: Rapid 318C digital multimeter

We have been informed that the Rapid 318C digital multimeter has been recalled. The company states:

As a precautionary measure, we have initiated a recall of the above product. This is due to a possibility of it not reading AC voltages correctly. In extreme cases use of this product may lead to an electrical shock hazard.

On further investigation, we were informed that this only applies to the 200/600 V a.c. range. Nobody in a Scottish school should be measuring a.c. voltages anywhere close to these values. In other words, you are unlikely to use this range setting. Nevertheless, the company suggest you contact them for a free replacement.

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