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STEM bulletin

Supporting STEM for all Local Authorities through advice, ideas and inspiration

Resistance - it's (all) in the bag

Velostat™ or (Linqstat™) is a carbon-loaded polyethylene manufactured by 3m™. This material is often used in the form of a small bag 0.1 mm thick to protect static sensitive semiconductor components (Figure 1). The resistance across the long axis of a strip 0.1 mm x 30 mm x 130 mm is of the order of 50 kΩ.

Possible investigations using Velostat

a) Factors affecting Resistance (length and width)

A strip of Velostat of a fixed width can be cut. One end of the Velostat is attached over a piece of laminated graph paper (to make measurements of length simpler) using binder clips as shown in Figure 2. One lead of a multimeter set to a suitable resistance range is connected to this binder clip. The other end of the multimeter is connected to a similar binder clip which is used to push down on the Velostat at various distances (use the graph paper scale) from the first clip. Readings of distance between binder clips and resistance can then be noted. A typical graph is shown in Figure 3.

Strips of the same length but of different width can be used to investigate how the width (really the cross-sectional area as material has a uniform thickness of 0.1 mm) affects resistance. Plotting R against 1/w for five values of width results in a typical graph as shown in Figure 4.

For a slightly more detailed analysis (Figure 5) using the same data, plotting Ln(R) vs Ln(w) gives a gradient equal to the power to which the width is raised. >>

Figure 1 - Black conductive bag made from Velostat.

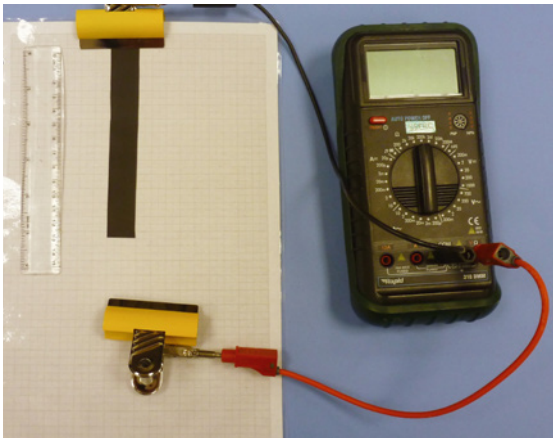

Figure 2 - Investigating Length vs Resistance.

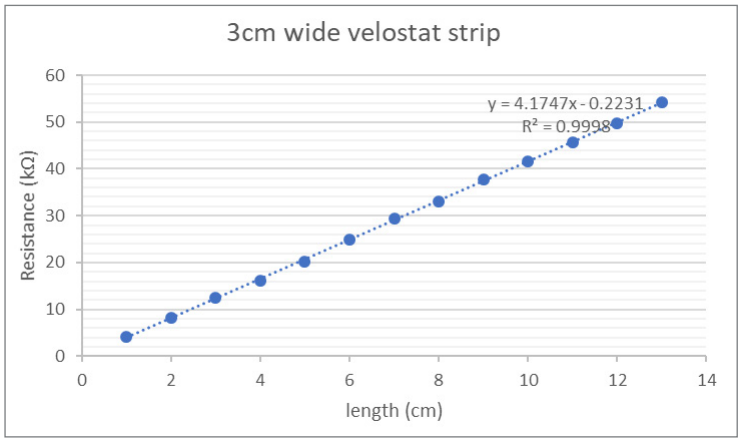

Figure 3 - Results of Length vs Resistance.

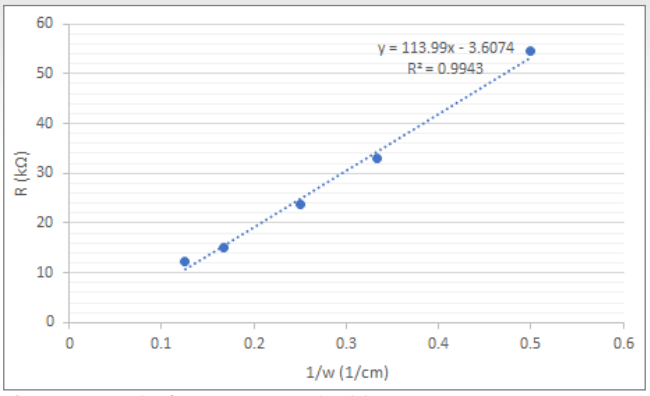

Figure 4 - Graph of Resistance vs 1/width.

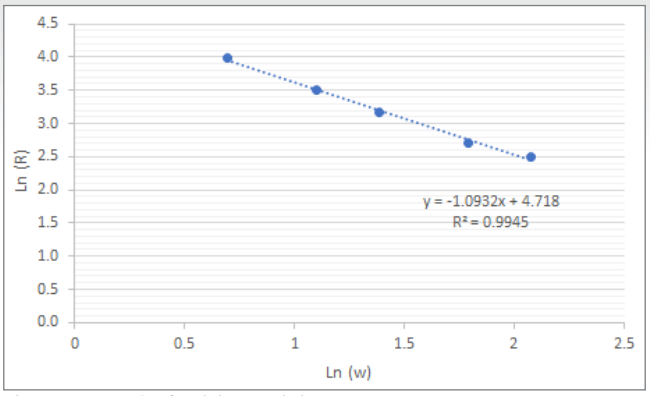

Figure 5 - Graph of Ln(R) vs Ln (w).

b) Factor affecting Resistance (temperature)
Noting the resistance of a strip of Velostat at different temperatures shows that the resistance increases as temperature increases. The resistance of a fixed length of Velostat was measured using a multimeter and the temperature measured using a non-contact infra-red thermometer. Readings were taken indoors, outdoors and in a fridge. This is awkward as an investigation and results were 'messy'.

c) Factor affecting Capacitance (area of overlap)
A similar test set up to Figure 2 can be used to investigate capacitance vs area of overlap. Two strips of Velostat (narrower strip uppermost if dissimilar) are separated by a piece of polythene cut from a small bag. Leads from a capacitance meter are attached as shown in Figure 6. The upper strip is moved to alter the area of overlap which can be calculated from the width of the upper strip and the length of overlap (again the ruler or graph paper can help). Typical results are shown in Figure 7.

The capacitance measured is small and for small areas of overlap there may be other factors to consider.

d) Factor affecting Capacitance (thickness of dielectric)
The experiment above can be repeated using several thicknesses of polythene as the dielectric. It was found difficult to exclude air from between the layers of dielectric (and from between the velostat and the dielectric) which had a noticeable effect on the measured capacitance.

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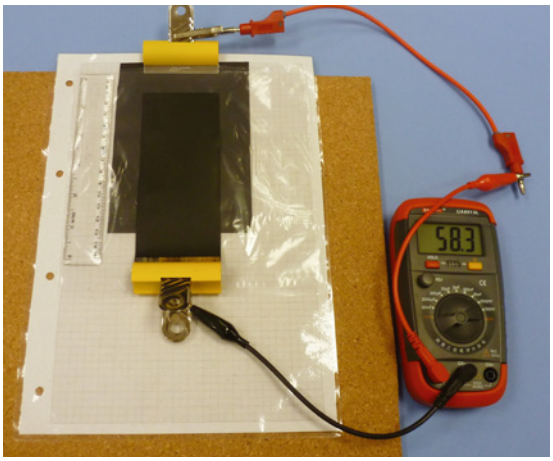

Figure 6 - Capacitance vs Area of overlap.

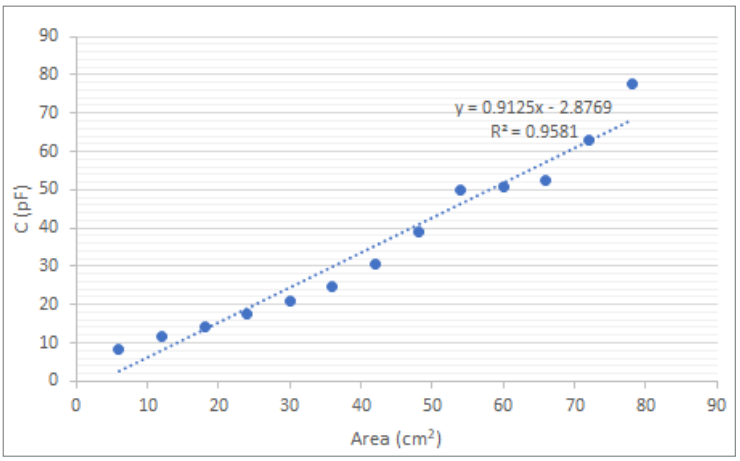

Figure 7 - Results of Area of overlap vs Capacitance.

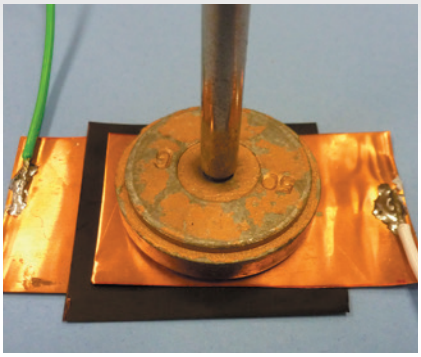

Figure 8 - Piezoresistance test set up.

e) Factor affecting resistance (Piezoresistance)

A small 'test rig' was constructed using two pieces of copper foil each approximately 50 mm x 30 mm and a piece of Velostat approximately 40 mm x 40 mm (Figure 8). Leads were soldered to the edge of the copper foil pieces and connected to a multimeter measuring resistance. The mass placed on top and the corresponding resistance were recorded. Typical results are shown Figure 9.

The data from Figure 9 plotted as R vs 1/F is shown in Figure 10. Plotting Ln(R) vs Ln(F) yields a gradient of -0.9415.

Summary

Velostat is available widely and cheaply and this article has described six potential physics investigations ranging from N3 to AH. Only the investigations involving capacitance require a specialist capacitance meter. The resistance investigations are straightforward and use equipment readily available in the physics classroom. <<

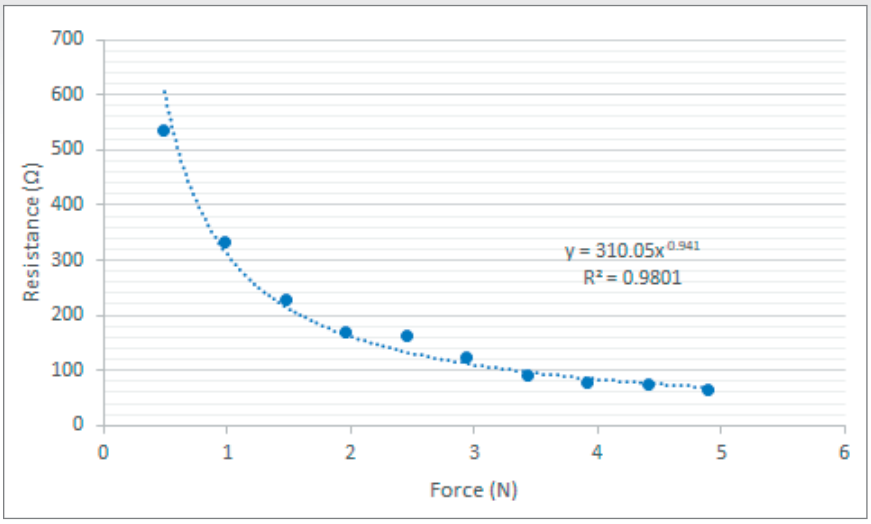

Figure 9 - Graph of Resistance vs Force.

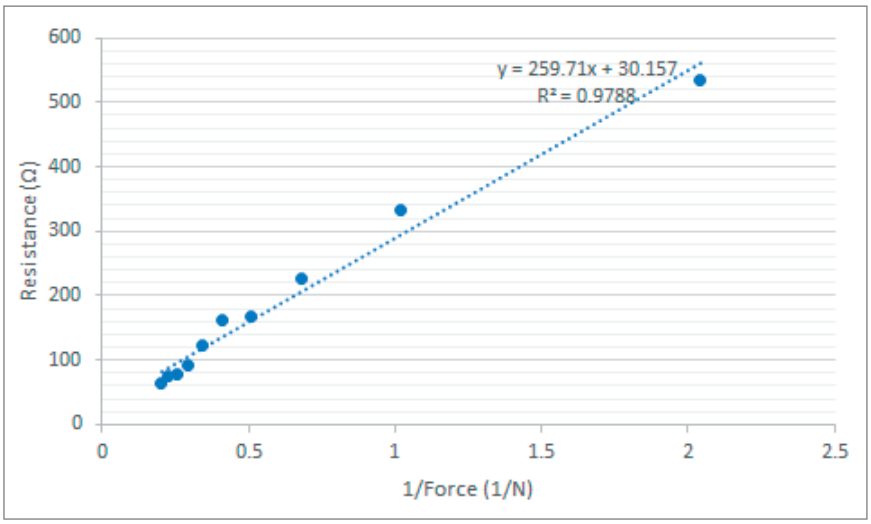

Figure 10 - Graph of Resistance vs 1/Force.

References & sources

[1] http://www.farnell.com/datasheets/2149000.pdf?_ga=2.15722230.1544946094.1579697240-734347397.1579697240 (accessed January 2020).

Velostat bags

100 bags (approx. 100 mm x 150 mm) - £3.95 + VAT + delivery. Order code 1687804, available at https://uk.farnell.com/multicomp/006-0003f/conductive-bag-101-6mm-x-152-4mm/dp/1687804?scope=partnumberlookahead&ost=006-0003F&searchref=searchlookahead&exaMfpn=true&ddkey=https%3Aen-GB%2FElement14_United_Kingdom%2Fw%2Fsearch (accessed January 2020).

Velostat conductive sheets

280 mm x 280 mm, per sheet £3.97 inc VAT + delivery. Product code Sku 1455, available at https://coolcomponents.co.uk/products/pressure-sensitive-conductive-sheet-velostat-linqstat (accessed January 2020).

SSERC professional learning courses

Our courses range from twilight events, day-courses through to residential meetings. Our curriculum coverage spans both primary and secondary sectors and we offer events for teachers, newly qualified teachers and technicians. Many of our events receive funding from the ENTHUSE Bursary scheme or the Scottish Government.

Courses available for online booking include:

COURSE NAME	RESIDENTIAL?	DATES	CLOSING DATE	SECTOR
Chemical Handling	No	2-3 September 2020	16 June 2020	Secondary Technicians
Physics Blended Learning	No No No No No Yes	2 September 2020 9 September 2020 16 September 2020 23 September 2020 30 September 2020 11-12 December 2020	26 June 2020	Secondary Physics
Support for Ad Higher Biology	No	5 September 2020	5 June 2020	Secondary Biology
Working with Radioactive Sources	No	7 September 2020	17 August 2020	Secondary Physics
Electrical Safety and PAT	No	8-9 September 2020	18 June 2020	Secondary Technicians
Safe Use of Fixed Workshop Machinery	No	9-10 September 2020	19 June 2020	Secondary Technicians
Ad Higher Chemistry	Yes	11-12 September 2020	12 June 2020	Secondary Chemistry
Hot & Cold Metal Forming	Yes	16-17 September 2020	12 June 2020	Secondary Technology
Creating a Microbit Smart Home	No	16 September 2020 & 18 March 2021	12 August 2020	Secondary Digital
Laboratory Science National 5	Yes	22-24 September 2020	12 June 2020	Secondary Science
Makey Makey Maker Space	No	25 September 2020 & 25 March 2020	6 August 2020	Secondary Digital
Environmental Science	Yes	1-2 October 2020	31 August 2020	Secondary
Safe Use of Fixed Workshop Machinery (Refresher)	No	2 October 2020	1 September 2020	Secondary Technicians
Introductory Physics	No	28-29 October 2020	29 September 2020	Secondary Technicians
Engineering Bench Skills	Yes	28-29 October 2020	4 September 2020	Secondary Technology
Capturing Learning using Digital Tools	No	30 October 2020	2 October 2020	Secondary Digital
Project work in Biology for Senior Phase	Yes	30-31 October 2020	18 September 2020	Secondary Biology
Safe Use of Fixed Workshop Machinery	No	4-5 November 2020	1 October 2020	Secondary Technicians
Maintenance of Fixed Workshop Machinery	No	10-12 November 2020	8 October 2020	Secondary Technicians
Safety in Microbiology	Yes	11-13 November 2020	7 October 2020	Secondary Technicians
Health and Safety Risk Assessment	No	17 November 2020	23 October 2020	Secondary
Intermediate Physics	No	18-19 November 2020	9 October 2020	Secondary Physics

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CLPL courses continued:

COURSE NAME	RESIDENTIAL?	DATES	CLOSING DATE	SECTOR
Hot & Cold Metal Forming	Yes	18-19 November 2020	2 October 2020	Secondary Technology
Working with Radioactive Sources	No	24 November 2020	26 October 2020	Secondary Physics
Intro to Microbits across the BGE	No	25 November 2020	28 October 2020	Secondary Digital
Science for Secondary Probationers	Yes	3-4 December 2020	30 October 2020	Secondary Science
Science for Secondary Probationers	Yes	3-4 February 2021	30 October 2020	Secondary Science
Wood Turning	Yes	24-25 February 2021	8 January 2021	Secondary Technology
Centre Lathe Turning	Yes	24-25 March 2021	20 February 2021	Secondary Technology

Please check our website pages at **https://www.sserc.org.uk/professional-learning/calendar/** for the most up-to-date details on our career long professional learning calendar. **Courses may be postponed due to the COVID19 situation.**

The Royal Society of Biology 25th Annual Teachers' Meeting

Due to the COVID-19 situation the 25th RSB (Scotland) Annual Teachers' Meeting is being postponed until May 2021. Please see the following message from Professor Jack Jackson. As Professor Jackson says, we sincerely hope that you will be able to join us at Moredun for the 2021 event.

Professor Jackson will be awarded the Royal Society of Biology President's Medal for 25 years (and more!) of service to the biology teaching community in Scotland.


Moredun Research Insitute.

Dear Colleagues,

It is with considerable regret that I have decided to postpone this year's Royal Society of Biology (Scotland) Teachers' Meeting which was to be held at the Moredun Institute on Thursday 28 May. Given the threat caused by COVID-19 and the fact that schools are closed, it would not have been sensible to hold this event as planned. I am hoping that we can hold the 25th Annual Teachers' Meeting on Thursday 27 May 2021 at the Moredun Institute and, if so, further details will be advertised nearer the time. In the meantime, please keep safe and well.

Best wishes,

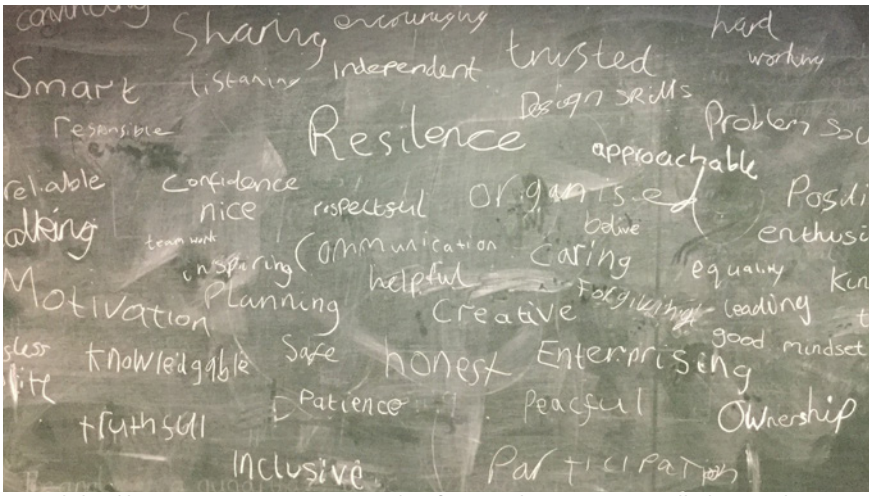
Jack
Professor Jack Jackson OBE FRSE FRSB

Getting involved with Young STEM Leader Programme (YSLP):

Frequently asked questions

What is Young STEM Leader?

Led by SSERC, the Young STEM Leader Programme (YSLP) is an exciting opportunity for young people in Scotland to discover, create, inspire and lead in STEM. The key aim is to facilitate the development of peer STEM role models, inspiring more young people to develop an interest in STEM. Every Young STEM Leader will explore their own interests before creating and delivering an inspiring STEM activity, event or interaction for a selected audience in their school or community. We believe that completing the YSLP will be of great value to Scotland's young people, giving increased access to the many exciting and engaging experiences that STEM offers whilst building valuable skills.



A word cloud by Primary 7 Young STEM Leaders from Bankier Primary in Falkirk. Here they are exploring the skills, qualities and behaviours of a good leader.

The YSLP is offered in two versions. The non-formal version at CfE Second, Third and Fourth Levels (YSL2, YSL3 and YSL4) is underpinned by a framework that identifies the skills, knowledge and behaviours expected of a Young STEM Leader at each curricular level. Young people will work towards four digital badges – Discover, Create, Inspire and Lead – at each level to gain the award.

Young STEM Leaders at Paisley YMCA support others to build their digital skills.

The formal version is offered at SCQF Levels 4, 5 and 6 (YSL4, YSL5 and YSL6), credit rated by SQA and underpinned by learning outcomes and performance criteria for each level. SCQF credit points and Insight data are included.

How do I get started?

Centres wishing to offer the YSLP will typically be schools, community groups or registered youth work organisations in Scotland. Any organisation that works with young people, with staff who are members of the PVG scheme, can apply to become a Young STEM Leader Delivering Centre.

Relevant staff members can then complete the Tutor Assessor (TA) training, becoming certificated by SSERC in the process. Training will take place online and lasts around two hours for each version. Centres will also be recognised and certificated by SSERC as Young STEM Leader Delivering Centres.

We're looking to recruit over 300 new centres – schools, community groups and youth groups – by the end of this year.

What do the young people need to do?

After some initial front-loaded learning delivered by a Tutor Assessor, young people complete a series of tasks in their Log (online or hard copy) which details all of the learning, planning and STEM leadership. This is an ideal way to ensure the Young STEM Leader is full prepared to deliver a safe and engaging STEM activity, event or interaction.

Visit our website www.youngstemleader.scot or Twitter @YoungSTEMLeader to see examples of our Young STEM Leaders in action!

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A Young STEM Leader of All Saints Secondary School in Glasgow leading a STEM activity with pupils of St Philomena's Primary.

Do you provide ongoing support?
Yes! Upon becoming a TA, you will have access to all of the supporting documentation for each level, including Support Notes and YSLP Logs. We will also produce Activity Packs for each level which will offer a set of lesson plans and guidance on how to support each level of the programme. The Young STEM Leader Project Team at SSERC are always on hand to answer any questions.

Is there a cost?
The programme is funded by the Scottish Government and is free to all young people, Tutor Assessors and delivering centres across Scotland. <<

How do I find out more?

To find out more about the Young STEM Leader Programme:

> Visit our website **www.youngstemleader.scot**
The case studies and resources sections are useful to find out more about the programme.

> Attend one of our online webinars, book at **www.youngstemleader.scot/events**

> To register your interest in becoming a Tutor Assessor visit **https://bit.ly/YSLSignUp**

> Contact us at **ysl@sserc.scot** or on Twitter **@YoungSTEMLeader**

Dissection of animal materials in school

We receive enquiries about animal material dissection on a regular basis from both teachers and technicians. Many of these simply ask, 'What are we allowed to do?' Our answer is that dissection of animal material is permitted if it is obtained from animals that have been slaughtered for human consumption. Such material may be obtained from butchers, abattoirs, or fishmongers. The dissection materials must be fresh or, if they have been frozen, recently defrosted [1].

A significant number of enquiries relate to the potential use of eyes and brains, with particular concerns over the possibility of them harbouring agents that cause transmissible spongiform encephalopathies (TSEs). Again, organs from animals prepared for human consumption may be used for educational purposes. Such animals are deemed to be safe when slaughtered within the prescribed age limit of twelve months for cattle, sheep and goats [2].

Whole organism dissection of mammals and birds is largely unnecessary for Scottish school-based courses. Entire dead vertebrate specimens should not be brought into schools unless obtained from butchers, abattoirs or fishmongers, or unless they have been specially prepared for dissection, or display. Preserved vertebrate specimens may be purchased for the purpose of dissection where relevant in senior phase courses.

While the use of animal material in school can be of considerable educational value, care must always be exercised regarding the sensitivity of pupils, for a variety of reasons, to the use of such material. <<

References

[1] More detailed guidance on the use of animal material for dissection or experimentation is contained in Section 4 of the document, 'Materials of Living Origin – Educational Uses: A Code of Practice for Scottish Schools and Colleges' (SSERC, 2018). The document can be accessed via the SSERC website: https://www.sserc.org.uk/health-safety/biology-health-safety/codes-of-practice/.

[2] Appendix 8 of 'Materials of Living Origin – Educational Uses: A Code of Practice for Scottish Schools and Colleges' (SSERC, 2018) contains specific guidance on the use of nervous tissue from cattle, sheep and goats. The document can be accessed via the SSERC website: https://www.sserc.org.uk/health-safety/biology-health-safety/codes-of-practice/.

Green laser babies

The query came in from a teacher on maternity leave. She had her baby at a sensory class and had been so concerned at one of the activities for the wee ones, she feigned having to change a nappy. The class leader was waving a green laser pointer around as babies crawled around on the floor, chasing the dot.

Leaving aside fictional examples such as the "Do you expect me to talk?" "No, Mr Bond, I expect you to die," scene in *Goldfinger*, it is difficult to think of a more striking example of **What Not to Do With a Laser**. Here is a brief summary of SSERC's guidance on the use of lasers in schools:

- Use only Class 1 or 2 lasers (and not 1M, 2M, etc).
- Lasers should be stable. In the case of laser diode modules, clamp them in a boss head or similar.
- Do not stare into the beam.
- Do not point the laser at anybody.
- Use a beam stop - some sort of shield to terminate the beam (a photocopy paper box is ideal).
- Beware of stray reflections. Use beam stops if necessary.

We say "no" to laser pointers for experiments and pupil use because they are not stable and often wrongly-labelled. It is too easy to pick them up and wave them around. In our considerable experience they are, more often than not, wrongly classified, especially green laser pointers. Class 2 means:

- Visible light only.
- Less than 1 mW output.

If these criteria are fulfilled, the human aversion response - blinking or turning from a bright light - should be enough to protect from permanent eye damage. A time of 0.25 for the response to kick in is assumed. That is for an adult. It would be wrong to assume that it is the same for a baby.

All but one of the half dozen or so green laser pointers we have tested have been significantly above 1 mW. We have heard of a green laser pointer with an output of 35 mW. It was still labelled as Class 2.

Now have a look at Figure 1. It is a graph obtained when a spectrophotometer was used to examine the output of one of the green laser pointers we tested.

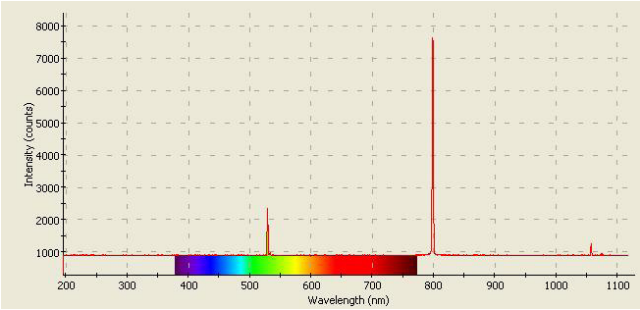

Figure 1 - Green laser output.

As you might expect, there is a peak of laser radiation at 532 nm. This is green light. That is all there should be, but there are also peaks at 808 nm and 1064 nm. To understand what is happening, we need to know how a green laser diode module works. Unlike red laser diodes, green ones use a multi-stage process.

- An infrared laser diode produces light at 808 nm.
- This is used to cause fluorescence at 1064 nm in a neodymium crystal.
- A frequency-doubling crystal then creates light at 532 nm.

We see that infrared radiation is produced at two stages in this process. Reputable manufacturers of laser diode modules ensure that any residual infrared radiation is filtered out. They also use automatic power control circuitry that continuously monitors the output power of the laser, reducing it if it creeps above the 1 mW limit.

The eye's response is not uniform over the visible spectrum. A 1 mW green laser diode module would be perceived as being as bright as an 8 mW red. You can see why green laser pointers are popular as presentation aids. Nevertheless, for the above reasons, we recommend using red rather than green for a presentation aid.

And we wouldn't shine either near a baby, even if we had a cast-iron guarantee that the lasers had been tested to prove they were Class 2. <<

Mercury rising

We at SSERC have long been telling schools that they should avoid eating and drinking in the laboratory. This is particularly important in a chemistry or microbiology lab but, in reality, there is no need to eat and drink in a lab at all.

There has been a fashion for pupils (and teachers) to carry water bottles with them wherever they go and sip as the whim takes them. This is certainly pleasant but avoiding drinking water for the duration of a lesson, even a double period, is going to have absolutely no negative effects. When weighed against the (still slight but) definite risk of ingestion of harmful chemicals or micro-organisms that may happen if drinking is allowed in the laboratory, the banning of food and drink is simple common sense.

There is, however, a further issue to consider: the use of laboratory equipment in a non-laboratory situation. One of the more common instances is the use of a fridge, usually in the prep room, to store food and drink as well as biological or chemical materials. This is simply not acceptable. There is no need and there is a clear and present danger of contamination.

A more serious, though hopefully less common, example was recently provided by a school who will remain nameless.

- A kettle was taken from the staff base to use in a chemistry laboratory.
- The reasons are obscure but the activity involved the taking of the temperature of the boiling water in the kettle.
- The pupil carrying out this activity had been given a mercury thermometer by mistake. (The school thought they had all been removed from circulation).
- At some point in the activity the thermometer bulb broke in the kettle and the student was either unaware of this or just pretended nothing had happened.
- The kettle was then returned to the staff base where it was used for making cups of tea and coffee.
- The following morning (or possibly the one after) one member of staff went to clean out his or her mug and noticed little droplets of mercury in the bottom!

Little droplets of mercury at the bottom of the mug.

At this point the alarm was raised. Investigations at SSERC suggest that the risk to those staff members who used the kettle is very low indeed. There was only a small amount of mercury present to start with, it is only sparingly soluble in water and metallic mercury is absorbed extremely poorly from the digestive system. But the whole affair could have been avoided by simply not using the staff base kettle for the experiment in the first place. <<

3D Printing in schools: changes to Health & Safety

Rapid Prototype machines (3D Printers) are being more commonly used within education establishments. There are a wide variety of machines on the market, but generally they can be categorised as either being enclosed systems or open air frames.

Recent research from the Health and Safety Executive has found that rapid prototype machines (3D Printers) can emit particles of a size range that can potentially enter the airwaves and lungs. Heating certain filaments were found to release vapours known to be hazardous to health.

There are a range of filaments available for 3D printing and the question of which are best to use is commonly asked. The main 2 we will look at is PLA (Polyactic Acid) and ABS (Acrylonitrile Butadiene Styrene)

PLA

PLA is the most common filament material. It is a starch/sugar cane based material with a low odour and will print at a lower melting temperature compared to other filament material. It is also classed as a biodegradable plastic which makes it more environmentally friendly. This filament comes in an array of colours.

ABS

ABS is another common filament material, however maybe not used in education as much as PLA. This filament material has a higher melting temperature and can be prone to warping without a heated bed. The important thing to remember when working with ABS is that due to its composition make up combined with its high melting temperature makes it prone to giving off harmful emissions.

HSE recommendations

Controlling these particles and fumes can be significantly reduced by implementing the following control measures:

- Only use filaments by a reputable supplier.
- Use filaments with a low emission rate.
- Reduce nozzle temperature to minimise fume and particle emissions.
- Using an enclosed machine with a suitable extraction system with a particulate filter to filter off any fumes or particles.
- Allow adequate time (20 minutes) before removing material from the print bed to allow fumes to be adequately extracted from the enclosure.
- A securely enclosed machine also reduces the risk of incidents and injuries e.g. trapping fingers in moving parts or sustaining burns from hot areas of the printer.

Following on from the research provided by HSE, SSERC as an organisation would recommend that all rapid prototype machines (3D Printers) are enclosed and a sufficient LEV (Local Exhaust Ventilation) system is in place to minimise the risk of the inhalation of potentially harmful fumes and vapours.

More information regarding the use of rapid prototype machines (3D Printers) can be found on the HSE website [1]. <<

Reference
[1] https://www.hse.gov.uk/research/rrpdf/rr1146.pdf.

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