sserc

scottish schools education research centre

STEM bulletin

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

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Easter Bush Science Outreach Centre

Jayne Quoiani, Science Outreach Centre Officer, tells us about a new facility available to schools in Scotland.

The new Easter Bush Science Outreach Centre (EBSOC), which is located in Midlothian next to The Roslin Institute on The University of Edinburgh's Easter Bush Campus, is a brand new purpose-built teaching laboratory where primary and secondary pupils engage with real-life science. The Centre enables school pupils to experience real scientific techniques, perform experiments and explore current research across The University of Edinburgh. We offer hands-on STEM based workshops for P6 to S6. We also support teachers, who teach STEM subjects, and support the **Developing the Young Workforce** initiative in a variety of ways, such as our popular #MeetTheScientists activity!

We currently have three primary workshops which are themed on the topics of DNA, inheritance, microorganisms, disease and body systems [1].

We have several secondary school workshops and of our six workshops, DNA profiling - The Great Escape and PCR: A Question of Taste use gel electrophoresis to separate DNA fragments [2].

Figure 1 - Delegates from SSERC's 2018 Biology Summer School on a recent visit to EBSOC.

Our workshops:

- are full-day;
- are hands-on;
- are linked to the curriculum-linked;
- offer real-world connections - actual lab equipment, chance to meet scientists and clinicians;
- provide tangible results;
- offer inspiration for studying STEM subjects at school and beyond and pursuing STEM careers.

Bookings for 2018-2019 are currently being taken - during the autumn term priority will be given to Senior phase pupils.

To remain updated about all EBSOC's workshops, events, funding opportunities, competitions and CPD sessions please join the mailing list by going to www.ed.ac.uk [3]. <<

References

[1] Workshop details at https://www.ed.ac.uk/easter-bush-campus/science-outreach-centre/primary.

[2] The details of all EBSOC's secondary workshops can be found at https://www.ed.ac.uk/easter-bush-campus/science-outreach-centre/secondary.

[3] Join the mailing list by going to https://www.ed.ac.uk/easter-bush-campus/science-outreach-centre/ebsoc-communications.

THE UNIVERSITY of EDINBURGH
Easter Bush
Science Outreach Centre

BeeSpi V

The BeeSpi V (Figure 1) is a relatively inexpensive, self-contained light gate and time-speed unit made by the NaRiKa Corporation of Japan. Usually when we review a device like this our biggest challenge would be to test the accuracy of the timer. Here, we had an additional issue. How do you actually pronounce BeeSpi V? We decided on "Bee Spy Vee", though some asked whether the final letter was a V or a nu.

Figure 1 - BeeSpi V straddling a stunt car track.

If we turn the unit upside down (Figure 2), we see that it has a pair of infrared light gates separated by approximately 3.9 cm. The picture also shows the sliding lid of the compartment for two AAA batteries.

Using the BeeSpi V could hardly be simpler. Position it so that the object whose speed is to be measured can pass through both light gates and press START. The device lets you know that it is expecting to take a measurement by flashing the units (e.g. m/s) at the bottom right of its display. When both light gates have been broken, the speed is displayed. The BeeSpi V can record 5 events, with the SELECT button being used to cycle through the measurements. Holding down the SELECT button cycles through different options for units of measurement - m/s, cm/s and km/h. It is claimed that it can measure speeds of up to 99.99 ms^{-1}.

Figure 2 - the BeeSpi V has a pair of light gates.

The BeeSpi V can also be set to measure lap time. To put it in this mode, the START button is held down until the units change from m/s to sec (sic). It is important to note that it does not display the time to travel between light gates - in this mode, the time is taken from when one light beam is interrupted until the same beam is interrupted again.

Just when we were turning metaphorical cartwheels at the usefulness and ease of use of the BeeSpi V, we came across the following phrase on the instruction sheet:

Measurement results may differ slightly from actual speeds.

Hmm…

When did you last buy a thermometer that claimed, "*Measurement results may differ slightly from actual temperatures*"?

Of course, all readings from measuring instruments are subject to uncertainties. The phrase did have us wondering whether or not those of the BeeSpi V were too large for serious use. How to test? We wondered about using another device with light gates before and after the BeeSpi V to compare results, but we realised that we had not recently tested any other time-speed equipment for accuracy. Figure 3 shows the solution we devised.

Having masked the BeeSpi V's LEDs, we used a BBC micro:bit to drive two infrared LEDS. These were carefully positioned opposite the BeeSpi V's light sensors, which we assumed to be photodiodes or phototransistors. The micro:bit was programmed to switch off one, then the other LED. This mimicked the first then second light gate being interrupted. The micro:bit pins used to drive the LEDs were connected to separate channels on our calibrated twin channel 10 MHz USB oscilloscope. We were thus able to measure the time between each event. Knowing the sensor separation, we could calculate the speed that should be displayed on the BeeSpi V and compare this with the actual reading. If an object passed between the device's light gates at the maximum speed of 99.99 ms^{-1}, the time between light gates would be around 400 microseconds. Whilst the measured time is short enough for there to be a risk of LED and >>

photodetector response times being long enough to have a significant effect on it, the chances of being able to make an object move at this sort of speed in the lab are vanishingly small. Our micro:bit program allowed us to alter the switch-off time between the two LEDs. We repeated our investigation several times for a number of intervals ranging from 20 ms to 1000 ms. We concluded the measurement could be assumed to be accurate to ± the smallest scale division, i.e. ± 0.01 s.

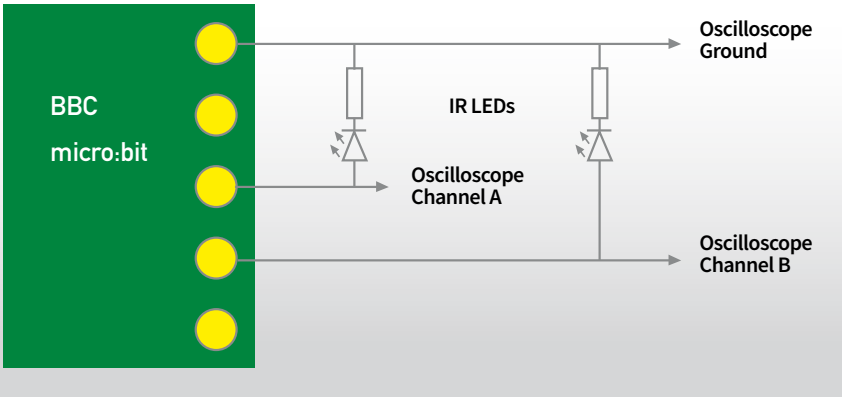

Figure 3 - Light gate test circuit.

At the time of writing, the BeeSpi V costs £22.77 (excl. VAT) from Scientific and Chemical. We liked the device enough to partner with IoP Scotland and give one away to every school that sent a teacher to the Institute of Physics Stirling Meeting 2018. We can see the device being particularly useful for practical work in National 5 Assignments. If you get one, please let us know what you use it for. <<

STEM Inspiration Awards

The STEM Inspiration awards are a free award scheme, designed to celebrate individuals and organisations working to inspire young people in STEM subjects.

What's involved?

Once you've completed our application form, a shortlist will be drawn up and you will be invited to attend our national award ceremony. The winners will be announced at a prestigious awards event at the Houses of Parliament.

Outstanding STEM Technician

This award recognises efforts to inform and inspire young people with apprenticeships and technician careers. It is aimed at those working in STEM who have a technical, non-graduate background and have used this to help inspire the next generation of technicians.

Outstanding STEM Club

This is award is designed to reward sustained and long-term engagement through a STEM Club.

Inspirational STEM engagement project

This award aims to draw together a number of supporters and is designed to reward sustained and long-term engagement through a single project or enrichment programme. It may involve communities, schools, non-school groups, STEM Clubs, STEM Ambassador Hubs, employers, and other institutions and organisations such as learned societies.

Applicants can be individuals or organisations involved in the project, but we would recommend you coordinate with partners to ensure a single application is made. This may include the number of people working as STEM Ambassadors as a proportion of the workforce, the ways the organisation supports its Ambassadors, and evidence of sustained engagement over the long-term (200 words).

The Joan Sjøvoll Award for STEM Leadership

This award recognises anyone employed in a STEM leadership role who has worked to foster an understanding of STEM subjects within their organisation, inspiring and leading others to actively promote STEM education and careers.

Nominees in this category need not necessarily be engaged in delivering to young people themselves, they may be in a role in which they enable and encourage others to do so. <<

STEM LEARNING

Applications are now open and will close on 14 September 2018.

Apply at www.surveygizmo.com/s3/4280328/2018-STEM-Inspiration-Awards.

Carbon dioxide and global warming

We have but one planet, and both the physical and economic processes that are driving climate change have enormous inertia. If a big ocean liner were steaming into dense fog in polar seas, only a fool would maintain full speed on the basis that the technicians were still discussing the distance to the first big iceberg [1].

There are several views about the current levels of CO_2 in earth's atmosphere and whether its apparently inexorable rise is the result of human activity. For over 50 years, in a series of measurements initiated by Charles Keeling, atmospheric CO_2 concentration has been monitored on a daily basis and data is made available by way of a so-called Keeling curve (see Figure 1) [2]. A short video giving some historical background is also available [3].

One criticism of the data depicted in the Keeling Curve is that we might be experiencing 'natural variation' and that the rise in CO_2 should not be a cause for concern. Indeed, there are some powerful voices who do not believe the evidence that links rises in carbon dioxide levels with a rise in global temperatures. In an interesting piece, Ward has suggested [4] that on his next visit to the UK, President Trump should be presented with a copy of a recent publication co-authored by HRH the Prince of Wales [5] so that the President might more fully understand the science involved.

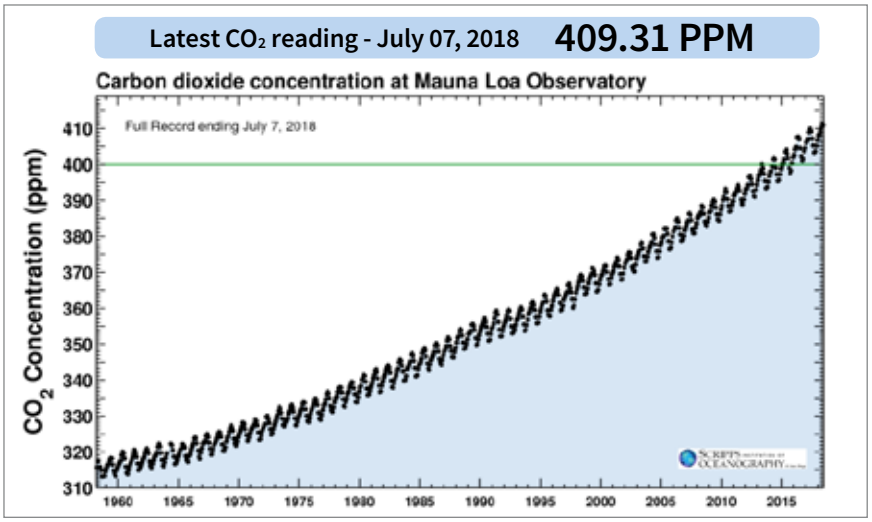

Figure 1 - CO_2 levels as measured at the Mauna Loa Observatory, Hawaii [2].

The 'natural variation' interpretation is not supported by studies of CO_2 levels in ice-core samples as shown in Figures 2-3 below. Data from samples from as long ago as 800,000 years (Figure 3) confirm that we do indeed have unprecedented levels of CO_2 in the atmosphere.

The relationship between elevated CO_2 levels and human activity is, for the overwhelming majority of climate scientists, well-established. CO_2 produced from fossil fuels and industrial activity accounts for some 65% of so-called greenhouse gases (see Figure 4).

At SSERC, we have been looking at ways of bringing climate science alive by looking at ways to investigate CO_2 concentrations in the classroom. The following experiments might serve as a practical context for discussing issues around climate change. >>

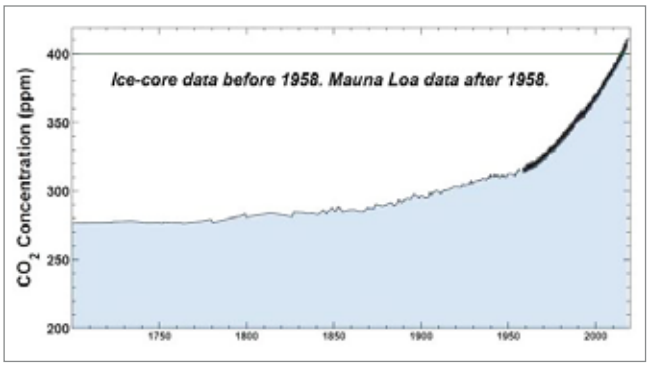

Figure 2 - Ice-core data before 1958, Mauna Loa Observatory data after 1958 [6].

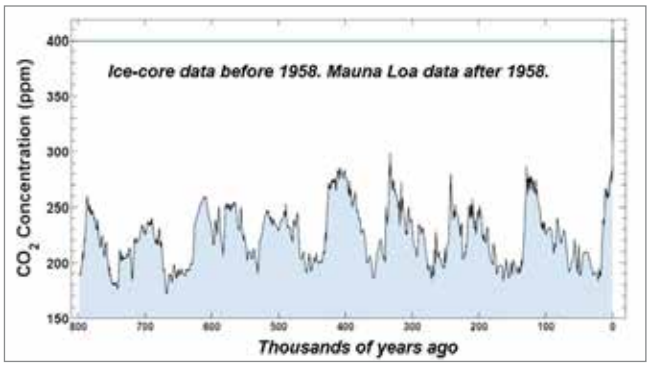

Figure 3 - Ice-core data before 1958, Mauna Loa Observatory data after 1958 [6].

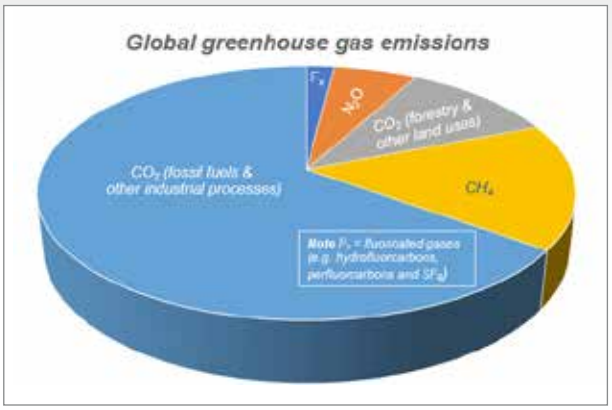

Figure 4 - Global greenhouse gas emissions by gas. Adapted from [7].

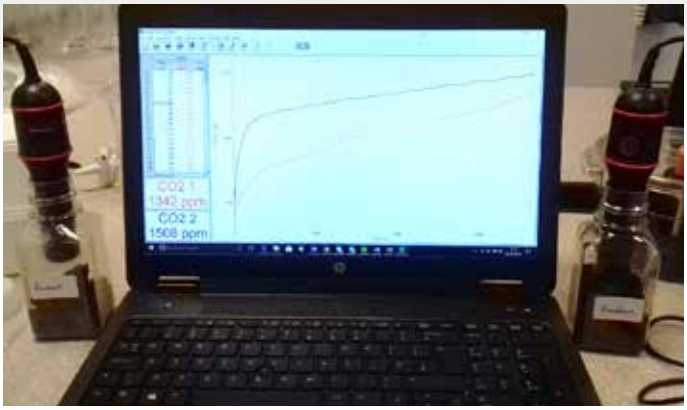

Figure 5 - Experimental set-up using a Pasco PS-3208 sensor.

Some 'Soil Science' experiments

1) Samples from different locations

With a CO_2 probe it is possible to measure the rate of release of CO_2 from soils as a result of respiration from microorganisms within the soil. Protocols for such experiments have been published before [8, 9]. Briefly, we obtained a given mass of soil (typically 100 g) and this was placed into an airtight container (see Figure 5). CO_2 levels were monitored over time using either a Vernier Carbon Dioxide Gas Sensor or a Pasco PS-3208 sensor.

The data in Figure 6 shows the rate of CO_2 release from soils taken from 2 different habitats.

There are a number of reasons why differences in the rates of respiration between garden and forest soils are observed. One key factor is that forest soils are rich in lignin which is more 'difficult' to break down than cellulose leading to lower respiration rates in such soils. Another factor which may be at play is the greater numbers and variety of organisms which might be present in garden soils. Other possible areas for investigation might include (the list is not exhaustive!):

- the effect of temperature;
- moisture content which can affect the nature of respiration (aerobic vs. anaerobic);
- pH;
- presence of pesticides;
- season(s) when samples are collected.

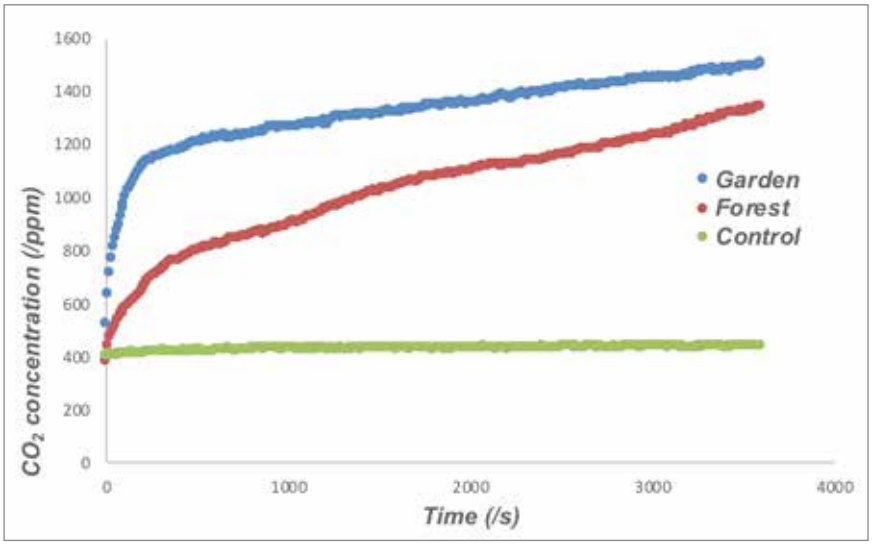

Figure 6 - CO_2 levels as a function of time for soil samples taken from garden and forest habitats. A control is also shown.

2) 'Permafrost'

The rise in global surface temperatures correlates well with the elevated levels of CO_2 present in the atmosphere. As the earth's surface temperature rises there is concern about the rise in sea levels that will occur as water from the polar ice-caps is released. Other, possibly less well-known, impacts of rising temperature include the thawing of regions of permafrost (ground which remains frozen for two or more consecutive years) across the globe. For example, it has been reported [10] that rising temperatures in the Arctic have triggered a significant increase in carbon dioxide emissions from thawing permafrost. It is believed that CO_2 emissions are now outpacing the uptake of CO_2 during the spring and summer growing season. In a recent article Taterka and Cory [11] consider how the potential rise in CO_2 concentration arising from thawing of permafrost can be measured experimentally in the school laboratory and we have adapted some of their ideas here. In Figure 7 we show data from a soil sample which was frozen overnight and then allowed to thaw (thereby mimicking thawing permafrost). The second sample was left at room temperature as a control. In both cases CO_2 levels were monitored for 7 hours.

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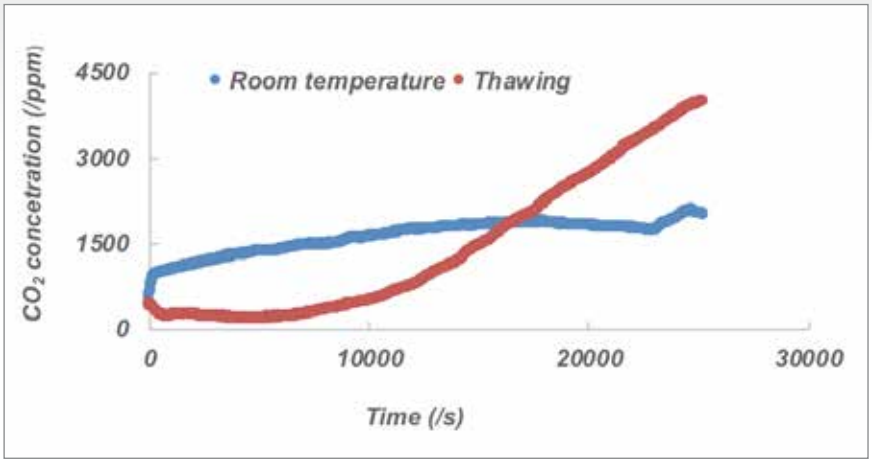

Figure 7 - CO_2 levels as a function of time for soil which had been frozen prior to measurement or left at room temperature.

Respiration in the 'frozen' sample is slow for the first 5000 seconds but then as the sample thaws there is a steady rise in the rate of CO_2 production. CO_2 levels increase slowly in the 'room temperature' sample and after some 5 - 6 hours reach a plateau. The shape of curve for the 'frozen' sample is interesting and merits some explanation. It has been reported that there is an increase in the amount of free amino acids and soluble sugars after freezing, which provide a pool of easily utilised organic matter for survivors to consume after a thaw [12]. Additionally, the spike in respiration during initial thaw may partially be a stress response because the spikes in respiration are less pronounced with subsequent freeze-thaw cycles [13]. The thaw itself and the availability of liquid solute in the substrate may also be triggering microbial metabolic activity as well as microbes simply becoming 'active' as the temperature increases [14].

The experiments described here were undertaken by Amy Molotoks a PhD student at the University of Aberdeen. Amy spent a period of 3 months with us funded through a BBSRC EASTBIO doctoral training partnership scheme.

References

[1] Grubbe, M. (2018), We're climate researchers and our work was turned into fake news. Available at https://theconversation.com/were-climate-researchers-and-our-work-was-turned-into-fake-news-89999 (accessed July 17th 2018).
[2] Scripps Institution of Oceanography (2018), *The Keeling Curve*. Available at https://scripps.ucsd.edu/programs/keelingcurve/ (accessed July 17th 2018).
[3] Video: Charles Keeling (1928-2005) and NOAA's Mauna Loa Observatory. Available at https://scripps.ucsd.edu/programs/keelingcurve/2015/10/26/video-charles-keeling-1928-2005-and-noaas-mauna-loa-observatory/ (accessed July 17th 2018).
[4] Ward, R. (January 30th 2018), *President Trump's fake news about climate change*. Available at http://www.lse.ac.uk/GranthamInstitute/news/president-trump-fake-news-climate-change/ (accessed July 17th 2018).
[5] Prince of Wales, HRH, Juniper, T. and Shuckburgh, E. (2017) *Climate Change* (A Ladybird Expert Book), Michael Joseph, London.
[6] Scripps Institution of Oceanography (2018), Pdf downloads. Available at https://scripps.ucsd.edu/programs/keelingcurve/pdf-downloads/ (accessed July 17th 2018).
[7] Working Group III (2014), *Climate Change 2014: Mitigation of Climate Change*. Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Available at https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_full.pdf (accessed July 17th 2018).
[8] Delpech, R. (2006), Making the invisible visible: monitoring levels of gaseous carbon dioxide in the field and classroom, *School Science Review*, **87** (320), 41-51.
[9] SSERC (2012), Measuring gaseous carbon dioxide, *SSERC Bulletin*, **238**, 5-7.
[10] Berwyn, R. (2017), Thawing Alaska permafrost sends autumn CO_2 emissions surging. Available at https://insideclimatenews.org/news/08052017/arctic-permafrost-thawing-alaska-temperatures-co2-emissions (accessed July 17th 2018).
[11] https://insideclimatenews.org/news/08052017/arctic-permafrost-thawing-alaska-temperatures-co2-emissions.
[12] Taterka, B. and Cory, R.M. (2016), Measuring CO_2, *The Science Teacher*, **83** (9), 29-35.
[13] Morley, C.R., Trofymow, J.A., Coleman, D.C. and Cambardella, C. (1983), Effects of freeze-thaw stress on bacterial populations in soil microcosms. *Microbial Ecology*, **9** (4), 329-340.
[14] Nikrad, M.P., Kerkhof, L.J. and Häggblom, M.M. (2016), The subzero microbiome: microbial activity in frozen and thawing soils. *FEMS Microbiology Ecology*, **92** (6), p.fiw081. Available at https://academic.oup.com/femsec/article/92/6/fiw081/2470083 (accessed 17th July 2018).

SSERC professional learning 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 include:

COURSE NAME	RESIDENTIAL?	DATES	CLOSING DATE	SECTOR
Intermediate Physics*	No	3-4 Sep 2018	13 Aug 2018	Secondary (Technician)
Biology Residential*	Yes	6-8 Sep 2018 & 1-2 Mar 2019	17 Aug 2018	Secondary (Biology)
Chemistry Residential*	Yes	13-15 Sep 2018 & 15-16 Mar 2019	17 Aug 2018	Secondary (Chemistry)
Welding Skills*	Yes	17-18 Sept 2018	17 Aug 2018	Secondary (Technology)
Physics (Blended Professional Learning)*	7 Dec 2018	5 Sep 2018 26 Sept 2018 12 Sep 2018 2 Oct 2018 19 Sep 2018 7-8 Dec 2018	20 Aug 2018	Secondary (Physics)
Laboratory Science National 5 (Lab Skills)	Yes	27-29 Sept 2018	31 Aug 2018	Secondary (Science)
Safe Use of Fixed Workshop Machinery (Refresher)	No	12 Oct 2018	20 Sep 2018	Secondary (Technology)
Introductory Chemistry	No	24-25 Oct 2018	1 Oct 2018	Secondary (Technician)
Engineering Bench Skills	Yes	25-26 Oct 2018	21 Sept 2018	Secondary (Technology)
Support for Advanced Higher Biology	No	27 Oct 2018	28 Sep 2018	Secondary (Biology)
Safe Use of Fixed Workshop Machinery	No	30-31 Oct 2018	8 Oct 2018	Secondary (Technology)
Safety in Microbiology for Schools	Yes	31 Oct-2 Nov 2018	21 Sep 2018	Secondary (Technician)
Pimping your Projects: Simple but effective statistical analysis	No	3 Nov 2018	5 Oct 2018	Secondary (Biology)
Safe Use of Fixed Workshop Machinery (Refresher)	No	7 Nov 2018	16 Oct 2018	Secondary (Technology)
Leading for Excellence in Science	Yes	11-14 Nov 2018 & 17-18 Mar 2019	21 Sept 2018	Secondary (Science)
Health & Safety Update	No	20 Nov 2018	19 Oct 2018	Secondary (Science)
Hot & Cold Metal Forming	Yes	21-22 Nov 2018	19 Oct 2018	Secondary (Technology)
Working with Radioactive Sources	No	27 Nov 2018	26 Oct 2018	Secondary (Science)
Safe Use of Fixed Workshop Machinery	No	5-6 Dec 2018	19 Nov 2018	Secondary (Technology)

* We recognise that the closing dates for these courses are early in the new term. Please call us (01383 626070) to see if places are still available.

We are in the process of putting the final touches to our full programme of CLPL for the new academic session and details will be made available through a range of channels. Please check our website **www.sserc.scot** for the most up-to-date details.

Catalase activity in immobilised yeast - an update

Background

In 2017 SSERC was approached by SQA to produce two resource packs in support of National 5 Biology investigations. We have recently published details of these resource packs [1] and copies can be downloaded from the SSERC website [2].

In a previous issue of the SSERC Bulletin [3] we gave details of experiments in which immobilised beads of yeast could be utilised as a source of catalase and we suggested that such an experimental system might be suitable for use in National 5 investigations.

We have subsequently heard from several teachers and technicians that the immobilised yeast/hydrogen peroxide method has been used as the basis of a number of National 5 and Higher investigations. We thought it might be useful, therefore, if we repackaged the original protocol in a similar format to our original 'SQA' resource packs. Both Teacher/Technician and Student Guides are now available [2]. We are very keen to receive feedback on the content of the Guides and their usefulness in order that we can (i) update as necessary, and (ii) produce more Guides to support National 5 and Higher investigations. Please send feedback to biology@sserc.scot. <<

Teacher/Technician Guide for Catalase activity in immobilised yeast.

References

[1] SSERC (2017) National 5 Biology assignment packs, *SSERC Bulletin*, **261**, 10-12. Available at http://info.sserc.org.uk/images/Bulletins/261/SSERC261p10_12.pdf (accessed 18th June 2018).

[2] National 5 Assignment, available at http://info.sserc.org.uk/biology-national-4 (accessed 18th June 2018).

[3] SSERC (2017), Hydrogen peroxide and immobilised yeast, *SSERC Bulletin*, **258**, 10-13. Available at http://info.sserc.org.uk/images/Bulletins/258/SSERC_S258p10_13.pdf (accessed 18th June 2018).

ASE Scotland Annual Conference 2019

ASE Scotland have sent us the following information about their annual conference which takes place on Saturday 9th March 2019 in Glasgow [1].

The ASE Scotland 2019 conference will see an exciting range of workshops running. From Primary Sensory Science to Advance Higher; there is something for every level.

This year will include, workshops run by SSERC on the latest research and guidance in Scottish Primary and Secondary Science Education, Raising Aspirations in Science Education and STEM and Learning beyond labels: Science Education for those with additional support needs. <<

Reference

[1] **Venue:** Hutchesons' Grammar School, 21 Beaton Road, Glasgow, G41 4NW.

In partnership with

Book online www.ase.org.uk/events/ase-scotland-conference-2019

Compressors and the Pressure Systems Safety Regulations

"Our CDT department has a compressor. I've heard that the science department has to have its pressure systems tested every year. Is it the same with compressors?" This enquiry was recently emailed to SSERC following our article on the Pressure Systems Safety Regulations (PSSR) that we published in Bulletin 259. We reckoned that the sender would not be alone in wanting to know the answer.

Model steam engines, pressure cookers and autoclaves may be used in a science department and all require annual tests according to PSSR. Some compressors do and others don't. Why the differences? Firstly, all the pressure vessels mentioned in the science context generate steam. This means that the regulations requiring a formal inspection apply. Whether or not a compressor needs an inspection depends on the energy the system is capable of storing. Physicists will tell you that the energy in a pressure system can be calculated from pressure times volume. These same physicists will doubtless be horrified that HSE guidance eschews SI units in favour of bar for pressure and litres for volume.

To work out whether a compressor requires a regular formal inspection, do this:

- Find out the volume of the receiver tank in litres;
- Find the maximum operating pressure in bar;
- Multiply them together.

If the answer is not more than 250 bar litres, no formal inspection is necessary. If it is greater than 250 bar litres, the system must undergo a formal inspection that follows a written scheme of examination. Note that some compressors do not have a receiver tank. They do not require to be inspected. Volume and pressure can be found from manufacturers' data.

For example, a compressor with a 50 litre receiver tank with a maximum pressure of 10 bar would need inspecting because 50 x 10 = 500, well above 250.

However, SSERC's compressor (Figure 1), with its 15 litre tank and a maximum pressure of 8 bar, wouldn't because 15 x 8 = 120, comfortably less than 250.

This article refers solely to inspections required under PSSR. Other inspections will be necessary, for example a PAT test. Equipment should be in good condition and inspected visually before use and, of course, a risk assessment should be carried out for any activity using a compressor. <<

Figure 1 - SSERC's compressor.

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