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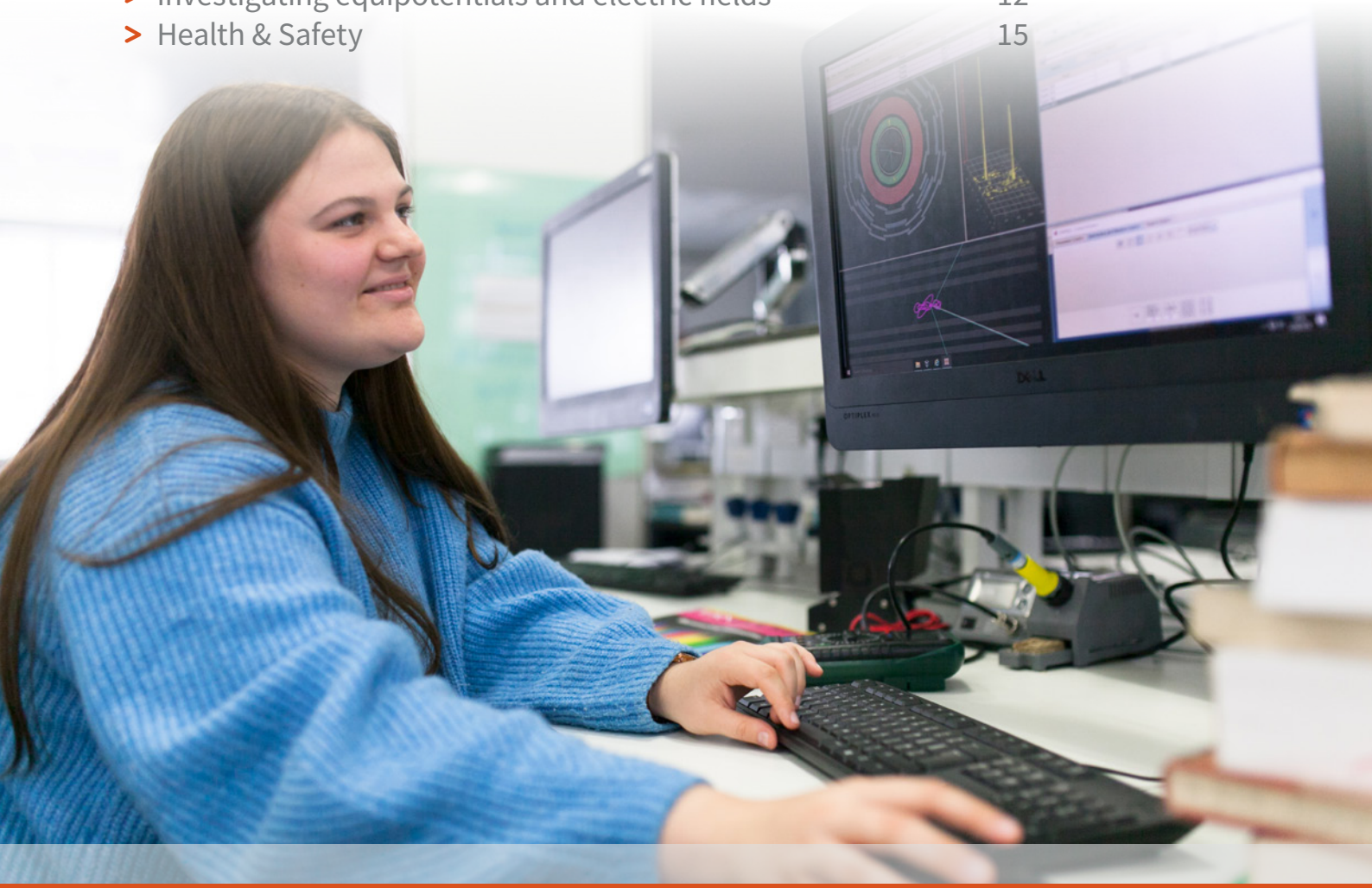
STEM bulletin

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



Make 'space' for partnership working

At SSERC, we are always looking for new and exciting partnerships and we are equally delighted when potential partnerships provide the opportunity to bring together a range of products and services from the SSERC portfolio. Our evolving partnership with the Aero Space Scientific Educational Trust (ASSET) does just that in so many ways including complementing our role as ESERO Space Champion UK space education office | STEM.

Here is what ASSET have to say about our partnership potential:
'The team at ASSET are delighted to have formed an inspirational partnership with SSERC. At ASSET we are passionate about STEM education and have delivered a number of exciting projects to inspire and engage young people specifically in aeronautics and space exploration.

From inside our immersive mobile 'Cosmos Planetarium' we have reached hundreds of schools across the country and worked with primary and secondary age pupils; as well as supporting a number of young carers and their families. We have created and provided 1000 unique Space@Home packs to young carers and remote families and will be augmenting Deep Space Diaries with outreach sessions to local schools to celebrate the exciting James Webb Telescope launch.

In 2018 we completed a "Build-a-Plane" project with Kinross High School and will begin construction of a second plane at Strathallan School in 2022. We will also run the Scottish School's Air Race Challenge in 2022 inviting schools across the country to take part in an aeronautics and engineering competition.

Driven by our evolving STEM Outreach Programme, ASSET's ultimate goal is to open an aerospace Discovery Centre in Perth and Kinross. With support and training from SSERC we plan to embed the Young STEM Leader Award scheme into our work with young people

UK esero EUROPEAN SPACE EDUCATION RESOURCE OFFICE
A collaboration between ESA & national partners

to facilitate the development of STEM engagement and potential STEM related careers. We also hope to further develop our curriculum supported programme in our future Discovery Centre leveraging the expertise and knowledge of our SSERC associates.

We are grateful to SSERC for the opportunity to work collaboratively and look forward to sharing our skills and knowledge to support and inspire educators in potential professional learning sessions and training in astronomy and aeronautics.'

As the SSERC/ASSET partnership develops we look forward to incorporating the Young STEM Leader Programme, the STEM Ambassadors in Scotland Programme and our professional learning opportunities for education practitioners into a cohesive programme of activities and experiences that bring together the expertise, knowledge, skills and enthusiasm of both partners; ultimately to the benefit of Scotland's learners. Watch this 'space' for partnership updates. <<

For more information about ASSET
- Website Aero Space Kinross
- Social Media: @aerospacekinross
- Website Cosmos Planetarium

ASSET AERO SPACE SCIENTIFIC EDUCATIONAL TRUST
AERO SPACE KINROSS
COSMOS PLANETARIUM

For more information about any of SSERC's portfolio of STEM Engagement products and services
- STEM Engagement - SSERC
- Professional Learning - SSERC
- Advisory Service - SSERC

Investing in Volunteers

SSERC manages the STEM Ambassador programme in Scotland via the STEM Ambassador in Scotland hub based at our HQ.

The STEM Ambassadors in Scotland Hub has been awarded Investing in Volunteers Accreditation by Volunteer Scotland. Investing in Volunteers is the UK quality standard for good practice in volunteer management and recognises organisations making outstanding contributions within the voluntary sector.

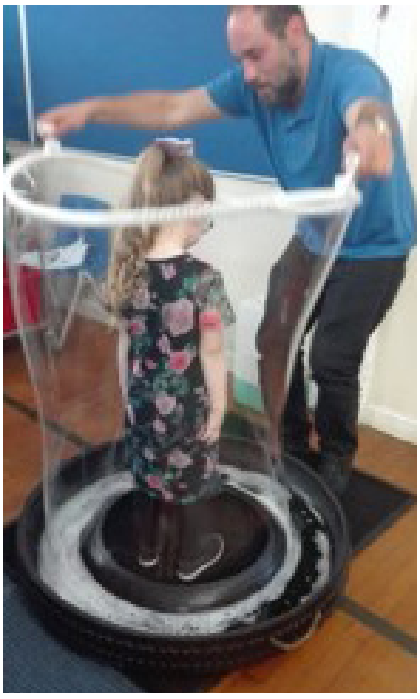
The Hub began working towards this accreditation in 2020, self-evaluating against the Investing in Volunteers Indicators such as processes, policies, diversity, recruitment, safety, recognition and support. Working with STEM Learning, an in-depth analysis was carried out to examine the UK-wide policies, processes, and documentation and those local to the Scottish Hub. Where required, new policies and amendments were developed in consultation with STEM Learning to ensure improvements would be implemented for all the STEM Ambassador Hubs, ultimately for the benefit of all STEM Ambassadors.

Progressing to the Accreditation stage, the STEM Ambassadors in Scotland Hub team and additional members of the wider SSERC team were interviewed by an external Assessor as part of the in-depth review. In September 2021, 77 STEM Ambassadors were interviewed by the Assessor, with additional Ambassadors completing online questionnaires. Volunteers interviewed were from a wide age range and socioeconomic backgrounds. The Assessor saw evidence of diversity in relation to

age, ethnicity, and geographical inclusion with volunteers from Scotland. 98% of survey respondents agreed that the organisation is open to involving volunteers from a wide range of backgrounds. Volunteers interviewed said they felt well supported and were clear about how to access support, saying, "I find it very rewarding to get the support, very positive, gives me confidence".

The Assessor's report recommending full accreditation was received at the end of October and highlighted that “volunteers clearly understood why they were integral to the organisation, stating their reasons for getting involved, which closely aligned with the aims of the organisation.”

Alastair MacGregor, Chief Executive Officer, SSERC, said: “Receiving this recognition affirms our commitment to providing a positive and supportive volunteer experience for STEM Ambassadors. Our volunteers are crucial to bringing STEM subjects to life through real-life experiences. It is vital that they enjoy a fulfilling and rewarding experience in return. We are immensely proud of this achievement and is a testament to the hard work, professionalism and enthusiasm of the STEM Ambassador in Scotland Hub team.” <<



STEM Ambassadors in Scotland Week

The Scottish STEM Ambassadors Hub are delighted to announce the return of STEM Ambassadors in Scotland Week. After a resounding success last year, this year it is back even bigger and better than before. Running from Monday 31 January to Sunday 6 February this is an opportunity to celebrate STEM in Scotland and find out a little more about what STEM Ambassadors can do for you.

There are lots of opportunities for you and your school or class to get involved, both in advance and during the week, full details of everything that will be featured can be found in the Teachers Handbook on our website.

Here are just some of the activities that will run throughout the week.

Careers Carnival

STEM Ambassadors from various sectors will be running online presentations and Q&A session. Secondary teachers and students are invited to tune in live or watch the recorded sessions at a time that suits you.

Each ambassador will detail what their role involves and the study and career path that led them to where they are now.

Hear from ambassadors in the following industries:

- Construction
- Forestry and Aquaculture
- Research
- Renewable Energy
- Technology and Digital

Scottish researchers blogs

Scientific research is the cornerstone of improved knowledge and leading innovation, and Scotland is home to many amazing researchers like Elaine Duncan.

Elaine is a 1st year PhD student at THE University of Glasgow who is carrying out research in the hope of developing an animal-free model to be used in the treatment of type 2 diabetes.

Read her full story and others throughout the week at www.stemambassadors.scot/saisweek.

Twitter takeover

Follow us on twitter at @ScotSTEMAmb and not only will you keep up to date with all our news but throughout STEM Ambassadors in Scotland Week you will hear from a host of fascinating ambassadors as they take over our twitter to share their stories.

Elaine Duncan

Starting on Monday the 31st when Marine Conservation Societies Scotland, Conservation Officer - Catherine Gemmell will be discussing all things marine litter.

This is a chance for you and your students to interact online and ask our ambassadors what you want to know.

Want to know more?

If you would like to get involved, register your interest here and we will be in touch.

Missed it?

Don't worry all resources will be available for you to access after the event at www.stemambassadors.scot/saisweek. <<

Nuffield Research Placements and ESERO-UK Space Champion

SSERC has a new STEM Enrichment Partnership with STEM Learning, providing Nuffield Research Placements and ESERO-UK Space Champion related activities in Scotland.

Nuffield Research Placements provide engaging, hands-on research projects, where S5 pupils can make a meaningful contribution towards the work of a host organisation through a well-supervised but independent research collaboration.

What is a Nuffield Research Placement?

- **When?**
  Summer holidays after pupils have completed S5.
- **How long?**
  4-6 weeks in total. This includes independent study ahead of 2-3 weeks for the real-world placement collaboration activities.
- **What?**
  A well-supervised but independent placement relating to an area of science, quantitative social science, computing, technology, engineering or maths - or a combination!
- **Cost?**
  Students can take part in a placement at no cost. Travel costs are reimbursed and students may be eligible to receive a £200 bursary.
- **Where?**
  Placements take place in a variety of locations including offices, museums, research centres, laboratories or fieldwork settings.
- **More information?**
  Go to www.stem.org.uk/nuffield-research-placements or attend one of our teacher information sessions during January 2022.

One million interactions

This is an initiative to attract more young people into STEM and the space industry. STEM Ambassadors can deliver successful interactions with young people, inspiring and encouraging the next generation of space professionals.

The UK Space Agency, ESERO UK, STEM Ambassadors and The Careers and Enterprise Company have pledged to deliver one million interactions per year with young people to emphasize 'space' as a context for teaching the curriculum.

Request a STEM Ambassador today to deliver a space themed activity!

one million interactions

ESERO-UK Space Champion

As an ESERO-UK Space Champion, SSERC aims to support the space sector by inspiring more young people, particularly those from under-represented groups, to pursue space-related studies and careers post-16. Through inspirational activities and opportunities inside and outside the classroom, SSERC and STEM Ambassadors can increase young people's STEM aspirations, engagement, and achievement to develop an understanding of the importance of the space sector in their lives. <<

UK esero

digitalXtra fund enabling digital creativity across Scotland

Digital Xtra Fund provides financial assistance and support for extracurricular digital skills initiatives which can be used as an avenue to deliver and enrich the Young STEM Leader Programme and the STEM Ambassador Programme.

Digital Xtra Fund was launched in 2016 to help boost the interest of young people in computing and technology through extracurricular activities. In March 2017, the Fund became a Scottish Charitable Incorporated Organisation (SCIO) enabling it to partner with a wide range of industry partners. Over the years, the charity has supported various tech initiatives which teach young people skills such as computational thinking, coding, robotics, cyber skills, and data science while also highlighting the future career opportunities these skills provide. The aim is to inspire the next generation of developers, designers and digital leaders to understand and create with technology, rather than simply using it.

Digital Xtra Fund is backed by businesses, government, and individuals with a common will to help young people succeed in a digital world - the goal is for every young person in Scotland to have access to inspiring and meaningful digital tech activities. The Fund's aims are to:

- Enable high-quality, exciting digital skills activities across the country;
- Inspire young people to understand, create, and innovate with technology, not simply consume it;
- Engage industry partners with supported initiatives giving industry experts and young people an opportunity to connect in informal and creative settings.

The model is very straightforward – the Fund works with their partners to identify, finance, and assist extracurricular tech initiatives across the country. Current partners include AWS, Baillie Gifford, CGI, Chroma Ventures (4J Studios), JP Morgan, Scottish Government, and Skills Development Scotland (SDS) as well as Accenture, BT, Cirrus Logic, Fujitsu, Incremental Group, Micro:bit Educational Foundation, ScotlandIS and Skyscanner.

Since its inception, the Fund has awarded 102 grants totalling £725,000 helping schools and educational organisations engage nearly 45,000 young people including recently awarding 22 grants to help schools and organisations engage another 7,292 young people during the 2021/22 academic year.

An announcement about the next round of grant awards (Round VII) - for initiatives delivered during the 2022/23 academic year - will be forthcoming shortly. Grants will be available for schools and organisations who encourage young people (aged 16 and under) to learn digital skills through high quality, extracurricular activities. For more details about how to apply for the fund, check the link: https://www.digitalxtrafund.scot/apply/.

The Fund welcomes applications from UK-registered companies, charities, chartered bodies, local authorities, schools, colleges, or universities actively involved in the provision of computing education or digital technology related activities, especially for

audiences from excluded groups or backgrounds (such as pupils from areas of high deprivation and/or rural isolation, girls and young women and/or minority groups). Eligible organisations can apply for grants from a minimum of £500 to a maximum of £5,000. Whether you are just starting out with a new coding club or planning to participate in global competitions such as FIRST® LEGO® League or the VEX Robotics Competition, Digital Xtra Fund is keen to support any exciting and stimulating extracurricular activities that appeal to the young people.

Digital Xtra Fund also encourages applicants to incorporate programmes such as Young STEM Leader Programme as part of the proposed initiative. And to help contextualise the skills being learned, applicants would also benefit from involving the STEM Ambassador Programme as they can provide positive role models, first-hand examples, guidance, and support during the project.

For more information and updates, please follow Digital Xtra Fund on:

- Twitter
- Facebook
- LinkedIn

Or sign up to their newsletter on the website here. <<

Microbiology for BGE

At SSERC, we are continuing to build a range of practical resources aimed at CfE Level 3 and 4 experiences and outcomes for Science. In September, we launched our microscopy resource "Our World Through A Lens" [1], supporting practical opportunities to explore the structure and variety of cells - *SCN3-13a* (Figure 1).

In November, "Investigating Micro-organisms" [2] was released and outlines three experimental opportunities to explore *SCN3-13b*, looking at different types of micro-organisms and how their growth can be controlled (Figure 2).

Good Microbiological Laboratory Practice

"Investigating Micro-organisms" covers the health and safety aspects of the three experiments explored in this investigation, reinforcing the importance of good microbiological laboratory practice in all classrooms working with micro-organisms.
A general principle is that all microbiological materials, cultures, media, environmental samples, etc., from whatever source should be treated as though they were a potential source of pathogens. All teachers/technicians working with micro-organisms should be familiar with SSERC's Code of Practice for Safety in Microbiology [3].

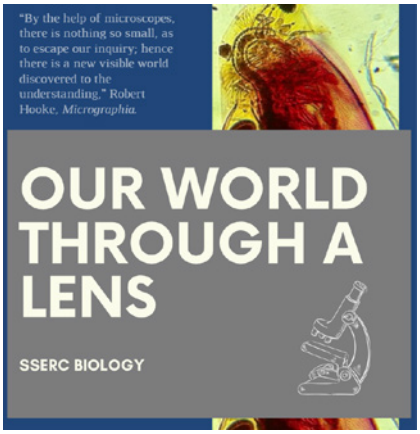


Figure 1 - Our World Through a Lens – a resource to support microscopy techniques in the classroom (many suitable for *SCN3-13a*).

Throughout the three experiments, control measures to reduce the risk of contamination of the operator (e.g. pupil), others, cultures and surroundings must be highlighted and reinforced. These measures include hand-washing, before and after working with micro-organisms; cleaning the workspace with a recommended disinfectant (e.g. 1% hypochlorite solution) before and after use; and the application of aseptic techniques during the experiment (Figure 3).

All teachers delivering the experiments outlined in this resource should be trained (e.g. this could be achieved in-house) in dealing with a small-scale spill and should feel competent in the microbiological techniques explored. The practical techniques outlined in the investigation vary in levels of technical challenge, while all being classed as Level 2 activities according to SSERC's Code of Practice; teachers should assess whether their learners can safely perform the experiments. Finally, to carry out these experiments in your school, our guidance states that your school should have a technician who has completed the SSERC Level 3 Safety in Microbiology course [4].

The experiments

All three experiments are supported by both written and video step-by-step guides [5]. The first experiment outlines how to safely carry out an environmental swab, incorporating

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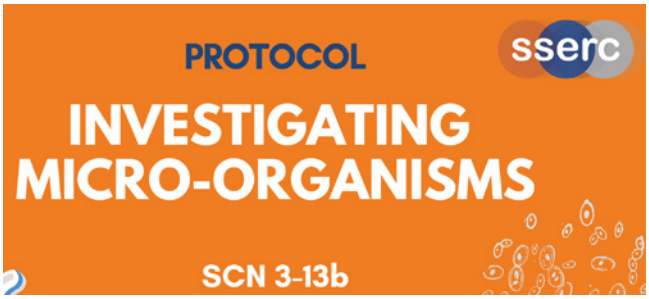

Figure 2 - Investigating micro-organisms, a resource providing practical work to support *SCN3-13b*.

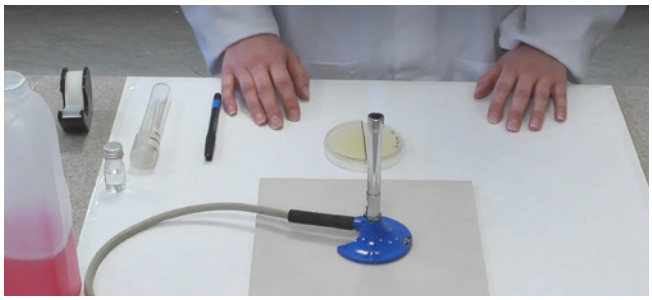

Figure 3 - Preparing your workspace for microbiological work.

aseptic techniques such as the pinkie-palm technique (Figure 4) and flaming the neck of a bottle. In class, this experiment is often met with learner requests like “can we swab the toilet seat?”, “can I sample my face?”, “what about the bottom of my shoe?”. Our resources support you in how to identify a safe sampling location.

The second experiment requires learners to produce a lawn plate of *Saccharomyces cerevisiae* and then, aseptically, transfer a filter paper disc coated with anti-fungal medication (Figure 5). Learners will assess the inhibition of fungal growth, as observed by the zone of clearance around the filter paper disc following a period of incubation.

Reflecting on the safety of this experiment, the use of *Saccharomyces cerevisiae* as the micro-organism here is important since a sample of a liquid culture must be transferred to an agar plate. If this was a bacterial sample, the activity would be classified as a Level 3 task and could not be carried out by anyone other than an S6 pupil supervised by a Level 3-trained member of staff. Working with *Saccharomyces cerevisiae* keeps this experiment at Level 2. However, it is important that all teachers carrying out this experiment are competent in dealing with a small-scale spill [6]. This could be achieved by running an after-school, in-house professional learning event led by your Level 3-trained Science Technician.

The final experiment illustrates how to carry out a vital stain of *Saccharomyces cerevisiae* and observe cells using microscopy. A live sample of the yeast culture is added to a microscope slide and a coverslip is placed on top of the culture. To stain the cells, blotting paper is used to draw neutral red stain from one side of the coverslip to the other

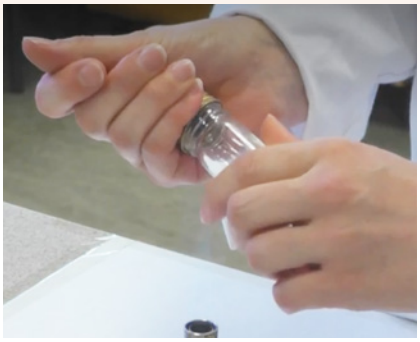

Figure 4 - The pinkie-palm technique is an important technique to share with learners to reduce the risk of contamination.

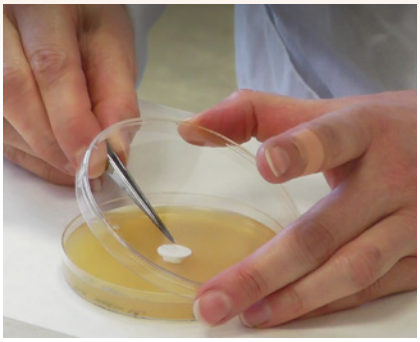

Figure 5 - Investigating the effect of an anti-fungal medication on the inhibition of *Saccharomyces cerevisiae* growth.

(Figure 6). This procedure prevents the cells from being washed off the slide. After a short period of time, living yeast cells will appear red/pink under the microscope.

Through these series of experiments, young people can investigate the different types of micro-organisms around them and how their growth can be controlled. Importantly, they will develop a range of safe microbiological laboratory techniques and skills that highlight the potential hazards associated with micro-organisms.

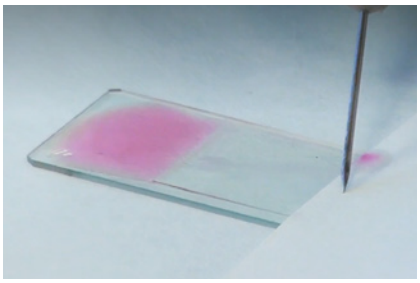

Figure 6 - Vital stain of S. cerevisiae to assess cell viability.

Further opportunities for training

SSERC have now developed two online, self-study courses, focused on safe microbiological laboratory practice [7, 8]. “Microbiology for the Classroom” is aimed at Secondary Science Teachers while “Introduction to Safety in Microbiology” is aimed at School Technicians. You can enrol for free and complete these at your own pace. <<

References

[1] SSERC (2021), Our world through a lens, available at https://sserccltd-my.sharepoint.com/:b:/g/personal/enquiries_sserc_scot/Efj_qrvRqaVIl5C916lro1IBeGFIw1aEfKvRKo-DD4pChA?e=tT9Ee6.

[2] SSERC (2021), Investigating micro-organisms, available at https://sserccltd-my.sharepoint.com/:b:/g/personal/enquiries_sserc_scot/EXLu9q9D8KtJmjHPz-KbCDYBHEZwRMno32YoCFeSo6JneQ?e=RfjZ8g.

[3] SSERC (2018), Safety in Microbiology: A Code of Practice for Scottish schools and colleges, available at https://www.sserc.org.uk/wp-content/uploads/2018/06/SSERC-Safety_in_Microbiology_Code_of_Practice.pdf.

[4] SSERC, Safety in Microbiology Course, Professional Learning Calendar, available at https://www.sserc.org.uk/professional-learning/technicians-pl/35349-2-3/.

[5] SSERC, SSERC TV YouTube Playlist, available at https://youtube.com/playlist?list=PLVez4VOGTRM-LUlrs0LTOq63x0h1fI5y5.

[6] SSERC, Micro Techniques Microbiological Spill, SSERC TV, available at https://youtu.be/aOehBjCIXXI.

[7] SSERC, Microbiology for the Classroom, self-study course, available at https://onlinelearning.sserc.org.uk/.

[8] SSERC, Introduction to Safety in Microbiology, self-study course, available at https://onlinelearning.sserc.org.uk/.

SSERC professional learning courses

We offer professional learning events for teachers in both the primary and secondary sectors and for school technicians. Many of our events receive funding from the ENTHUSE Bursary scheme or from the Scottish Government. For many courses, bursaries will help towards covering course costs and allow us to provide delegates with resources to support learning and teaching back in their schools. Face-to-face courses will take place at SSERC with appropriate COVID-19 mitigations and social distancing in place.

Courses available for online booking include:

COURSE NAME	RESIDENTIAL?	DATES	CLOSING DATE	SECTOR
Bio SSERC Meet – Outdoor Learning	Online	27 January 2022	26 January 2022	Secondary Biology
TechMeet	Online	27 January 2022	26 January 2022	Secondary Technicians
Bio SSERC Meet	Online	17 February 2022	16 February 2022	Secondary Biology
TechMeet	Online	24 February 2022	23 February 2022	Secondary Technicians
***Wood Turning**	Face-to-face	24-25 February 2022	7 January 2022	Secondary Technology
***Chemistry for Advanced Higher**	Face-to-face	24-25 February 2022	7 January 2022	Secondary Chemistry
Working with Radioactive Sources	Online	1 & 8 March 2022	28 January 2022	Secondary H&S
Electrical Safety and PAT Testing	Face-to-face	2-3 March 2022	28 January 2022	Secondary Technicians
Safe Use of Fixed Workshop Machinery	Face-to-face	9-10 March 2022	28 January 2022	Secondary Technicians
Chemical Handling	Face-to-face	9-10 March 2022	28 January 2022	Secondary Technicians
Bio SSERC Meet	Online	17 March 2022	16 March 2022	Secondary Biology
TechMeet	Online	24 March 2022	23 March 2022	Secondary Technicians
***Centre Lathe Turning**	Face-to-face	24-25 March 2022	18 February 2022	Secondary Technology
***Safety in Microbiology**	Face-to-face	29-31 March 2022	18 February 2022	Secondary Technicians
Physics Self Study Courses	Self-study	31 March 2022	28 February 2022	Secondary Physics
H&S Self Study Courses	Self-study	31 March 2022	28 February 2022	Secondary H&S
***Safety in Microbiology**	Face-to-face	27-29 April 2022	4 March 2022	Secondary Technicians
***Welding Skills**	Face-to-face	9-10 May 2022	18 March 2022	Secondary Technology
Bio SSERC Meet	Online	19 May 2022	18 May 2022	Secondary Biology
***Welding Skills**	Face-to-face	23-24 May 2022	18 April 2022	Secondary Technology
***Physics Summer School**	Face-to-face	25-28 May 2022	18 April 2022	Secondary Physics
***Chemistry Summer School**	Face-to-face	14-16 June 2022	6 May 2022	Secondary Chemistry
***Biology Summer School**	Face-to-face	21-23 June 2022	13 May 2022	Secondary Biology

*This course attracts ENTHUSE funding which offsets the course fee.

Please check our website pages at **https://www.sserc.org.uk/professional-learning/calendar/** for the most up-to-date details on our professional learning calendar. **Courses are subject to change or cancellation due to COVID-19.**

Home and dry - drying agents in organic chemistry

Many organic compounds contain trace amounts of water, particularly if prepared on site. In many cases, this is not a problem: anhydrous ethanol, for instance, is rarely used in schools due to its expense.

Ethanol is an interesting example. As is well known from whisky production, ethanol is separated from water by distillation. However, a mixture of ethanol and water forms an azeotrope (a constant boiling point mixture) that boils below the boiling point of ethanol. It contains 95.6% ethanol and its lower boiling point means that it is impossible to get purer ethanol than this by simple distillation.

Despite saying that the presence of water is not usually a problem, there are times when it can cause issues. We came across one of these recently.

The problem with preparing ethyl ethanoate

Following a standard preparation of the ester, ethyl ethanoate, we encountered problems at the final distillation stage. Whilst the literature states that the boiling point range should be 74-79°C we discovered that the main bulk of the liquid was coming off between 69-74°C. A search of the literature showed that formation of azeotropes in the preparation of ethyl ethanoate is a known problem [1] and results in the pure ester being isolated in a low yield. In fact there is a range of azeotropes formed:

- water-ethyl ethanoate bp 70.4°C;
- ethanol-ethyl ethanoate bp 71.8°C;
- water-ethanol-ethyl ethanoate bp 70.1°C.

The first step to minimise the problems in this case is to minimise the formation of azeotropes by removing any excess alcohol and water.

Figure 1 - If there is no water in the liquid, your drying agent will remain as fine grains – like this sodium sulphate.

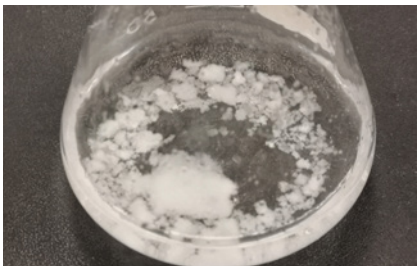

Figure 2 - If there is some water in the liquid, the drying agent will clump together like this.

In our experimental procedure the reaction mixture was first washed with saturated sodium carbonate to neutralise any acid present. A saturated calcium chloride solution was then added to remove excess ethanol. Finally the extract was dried with a drying agent to remove any water before the final distillation.

Common drying agents are anhydrous inorganic salts that acquire waters of hydration when exposed to moist air or a wet solution. Vogel [2] has advice on drying agents (and indeed much else) a suitable drying agent:

- must not react with the organic compound;
- should have a rapid action and an effective drying capacity;
- should not dissolve appreciably;
- should be as economical as possible;
- should have no catalytic effect in promoting chemical reactions of the organic compound such as polymerisation;
- a large excess should be avoided to keep adsorption losses down to a minimum.

The procedure we were following suggested using anhydrous calcium chloride as a drying agent, however we decided to use anhydrous sodium sulphate.

Being unaware at the time of the problem with azeotropes we suspected that the problem lay with our choice of drying agent and decided to investigate a range of agents to find the best one to remove water from ethyl ethanoate.

We tested 4 common drying agents that would be normally found in a school chemical store:

- anhydrous sodium sulphate (Na_2SO_4)
- anhydrous magnesium sulphate ($MgSO_4$)
- anhydrous calcium chloride ($CaCl_2$)
- anhydrous potassium carbonate (K_2CO_3)

The standard method for using drying agents is as follows.

It is preferable to have the wet solvent in a flask.

1) Start by adding a small portion of drying agent to the flask and swirling (Figure 1 and 2). *Water causes the drying agent to clump into larger particles (and sometimes stick to the glass).* >>

Figure 3 - Wet solution now dried.

2) Add further portions of drying agent until the swirling just shows some particles of the original size swirling round as well as the larger clumps (Figure 3).
You will need to leave the solvent standing on the drying agent for a while to allow the water all to be absorbed.
3) Decant or filter the solvent to remove the drying agent.

Once we had dried the solvent, it was then distilled. For these results see Table 1.

Drying agent (all anhydrous)	% original volume collected below 74°C
Na_2SO_4	32-40
$MgSO_4$	12-15
K_2CO_3	3-9
$CaCl_2$	0

Table 1

So in this particular case it is clear that we made an error in thinking that the drying agent made little if any difference. Calcium chloride is clearly the best and much better than the sodium sulphate we used.

Drying agents more generally

A summary of the properties of the four drying agents is shown in Table 2 [3].

Suitable drying agents [4]

While there are exceptions, general guidance on suitable drying agents can be found Table 3.

Calcium Chloride is a very good drying agent for a wide variety of solvents. It is generally not suitable for compounds containing hydroxy groups, amino groups and carbonyl groups though there are exceptions – such as ethyl ethanoate.

Substance	Capacity	Speed	Intensity
Calcium Chloride	High	Medium	High
Magnesium sulphate	High	High	Medium
Potassium carbonate	Medium	Medium	Medium
Sodium sulphate	High	Low	Low

Table 2 - Capacity refers to the numbers of moles of water that the drying agent can bind. Speed is self-explanatory. Intensity refers to the 'dryness' of the final solution.

Class of compounds to be dried	Recommended drying agent
Alkane, alkyl halides	$MgSO_4$, $CaCl_2$
Aromatic hydrocarbons, ethers	$MgSO_4$, $CaCl_2$
Aldehydes, ketones	Na_2SO_4, $MgSO_4$, K_2CO_3
Esters	Na_2SO_4, $MgSO_4$, K_2CO_3, $CaCl_2$ (not all esters)
Alcohols	$MgSO_4$, K_2CO_3
Amines	K_2CO_3
Acidic compounds	Na_2SO_4, $MgSO_4$

Table 3

Magnesium sulphate is suitable for drying most organic compounds. It works well in solvents like diethyl ether, but not as well for ethyl ethanoate. It is more rapid (partly because it comes as a very fine powder with a large surface area) and more effective than sodium sulphate.

Potassium Carbonate is often used to dry basic solutions containing amines. It cannot be used to dry acidic compounds.

Sodium Sulphate has a very high capacity, but drying is inefficient and slower compared to magnesium sulphate. It is very efficient in ethereal solutions.

Other drying agents

Calcium sulphate is a generally good drying agent but it does not have a high capacity, which makes it useless for very wet solutions.

Potassium hydroxide can be used in place of potassium carbonate but it is significantly more corrosive.

Concentrated sulphuric acid and **phosphorous pentoxide** are both acidic drying agents that are mainly used in desiccators and not in direct contact with the solution since they are very aggressive reagents.

Molecular sieves are alumino-silicates with a three-dimensional network with different pore sizes. They have to be activated prior use but also can be regenerated quite straightforwardly by heating.

Sodium - sodium wire (or similar small pieces) can be used to remove water from solvents by reacting with it. There are obvious hazards associated with this method and it should be avoided unless there is no other option.

Drying gases

These pose a different (though related) challenge. Further information can be found on the SSERC website. <<

References

[1] EC Wagner, E.C. (1950), Ethyl Formate, n-Propyl Formate, and n-Propyl Ethanoate Journal of Chemical Education 27 (5), **245**.
[2] Arthur Vogel - Textbook of Practical Organic Chemistry.
[3] University of Calgary – Organic Laboratory Techniques 7 – Drying Agents, available at http://www.chem.ucalgary.ca/courses/351/laboratory/drying%20agents.pdf.
[4] UCLA - Drying agents, available at https://www.chem.ucla.edu/~bacher/Specialtopics/Drying%20Agents.html

Investigating equipotentials and electric fields

Advanced Higher Physics requires knowledge of electric field patterns around single point charges, a system of charges and in a uniform electric field. This practical enables students to become familiar with the relationship between electric field lines and lines of equipotential. The equipotential surfaces around a point charge and between two parallel plates are marked out. The potential gradient and hence the electric field strength between a set of parallel plates can then be found as can the relationship between the electric potential and distance from a point charge. It is very straightforward, requires little apparatus and is safe. It is a simple practical exercise that will enhance understanding.

Investigating the equipotential surfaces between two parallel plates

The apparatus required is a multimeter, a 1.5 V cell, some graph paper, a black conductive bag [1] cut into a strip approximately 5 cm x 10 cm, and a set square. Set up the apparatus as shown in Figure 1.

Connect one bulldog clip to the negative terminal of the cell. Connect the negative terminal of the multimeter to the negative terminal of the cell. The negative terminal is 0 V.

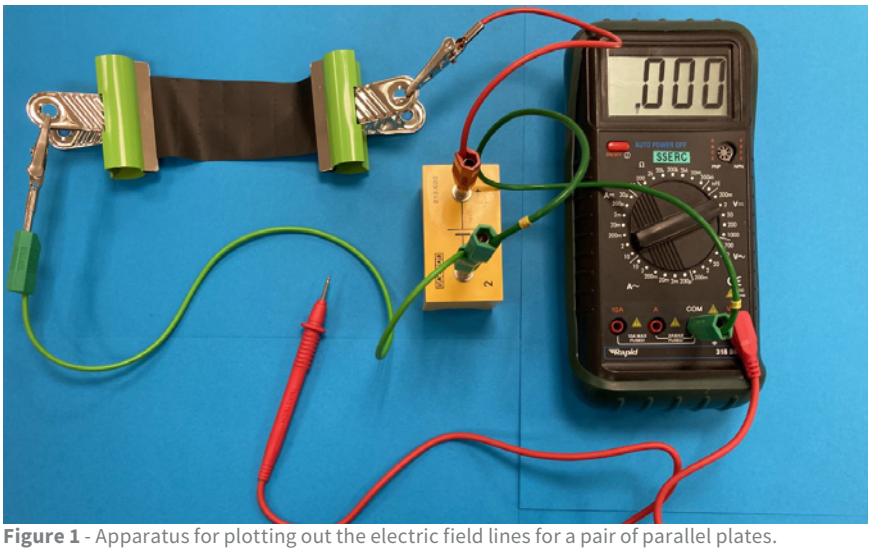

Figure 1 - Apparatus for plotting out the electric field lines for a pair of parallel plates.

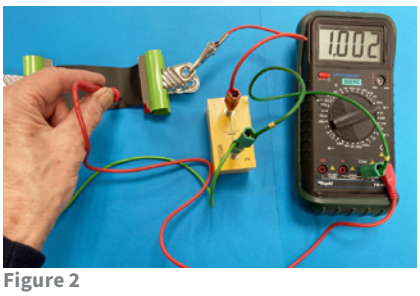

Figure 2

Figure 3 - The lines of equipotential are drawn out by the parallel lines of dots made by the probe making out points at the same potential.

Connect the positive terminal of the cell to the other bulldog clip. Connect the positive terminal of the multimeter to a flying lead. Set the multimeter to read 2 V maximum and switch on. Take the flying lead and 1 cm from the 0 V bulldog clip, note the reading on the voltmeter and mark the position by pressing down on the black polythene, see Figure 2.

Record the position of 4 more points having the same potential as the initial point. Move the flying lead to 2 cm from the bulldog clip and note the reading. As before record the position of 4 more points with the same potential. Repeat up to 8 cm. The results are shown in Figure 3.

The lines are clearly parallel to the edge of the bulldog clips. Students could sketch out the equipotential lines and add the electric field lines, after reminding them no work is done when moving over an equipotential surface. The electric field lines must therefore be at 90° to the lines of equipotential. This is an excellent formative assessment exercise. It checks basic understanding of the concepts associated with electric field lines and equipotential surfaces. A graph can be plotted of the potential difference against distance from the 0 V bulldog clip, see Figure 4.

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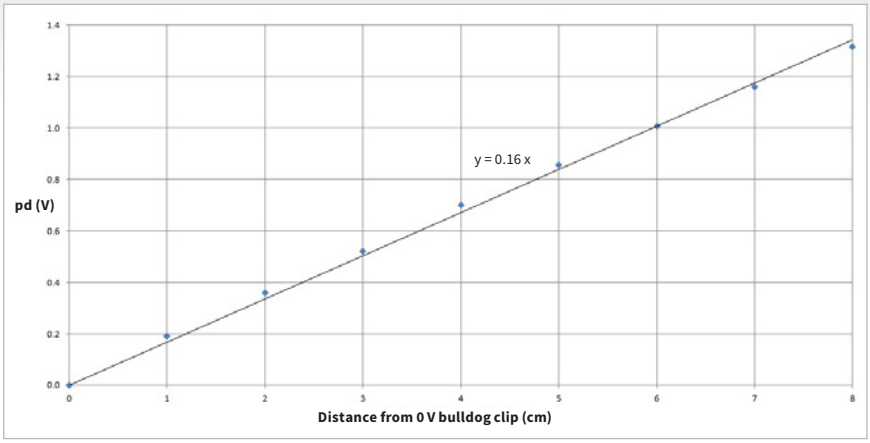


Figure 4

This gives a straight-line graph showing V α d. Students could be asked what the gradient of the graph gives. Again, this is good reinforcement of basic knowledge since the electric field strength between a pair of parallel plates is equal to the potential gradient V/d, the gradient of the graph.

The equipotential lines around a point charge

If circular symmetry is required, an embroidery hoop or a Petri dish can be used to give this. The apparatus required is shown in Figure 5.

Draw round the Petri dish. Cut out a circle with a radius about 2 cm larger than that of the Petri dish. Stick double sided sticky tape to the side of the petri dish. Cut two strips of aluminium foil, one the width of the Petri dish and one twice the width of the Petri dish and both at least 4 cm longer than its circumference. Stick the strip of aluminium that is the width of the Petri Dish to the sides of the Petri dish so each end of the foil can be made into a connecting wire, see Figure 6. Place the Petri dish on top of the circular piece of conducting material. Centre the Petri dish so the centre of the circle of conducting material is over the centre of the Petri dish, see Figure 7. To keep the conductive material in place stick small pieces, 5 mm square, of double-sided sticky tape to the aluminium foil. Stick the conducting material to these points. Take the wider second strip of aluminium foil and place it round the Petri dish as before so there is a connecting wire. Hold this piece of aluminium in place using an elastic band. Fold the extra width over the elastic band. This gives electrical connection to both sides of the conducting material (Figure 8). If an embroidery hoop is used, each hoop needs to be covered with aluminium foil and the foil needs to be longer than the hoop to enable a good electrical connection to be made as with the Petri dish. The circle of conductive material is then stretched between the hoops and the top hoop is then tightened to hold the material taut. >>

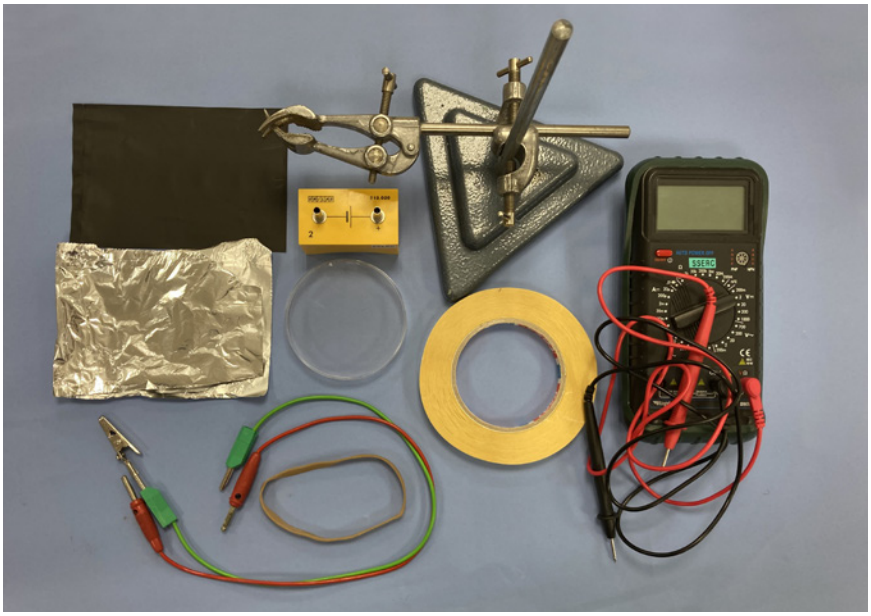


Figure 5


Figure 6

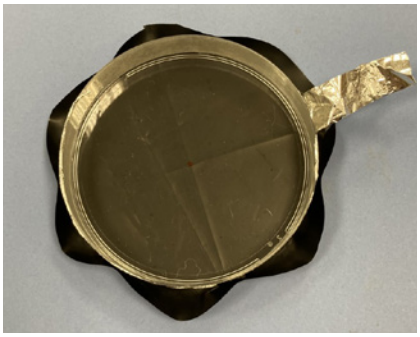


Figure 7

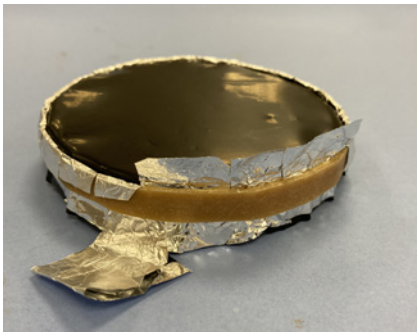


Figure 8

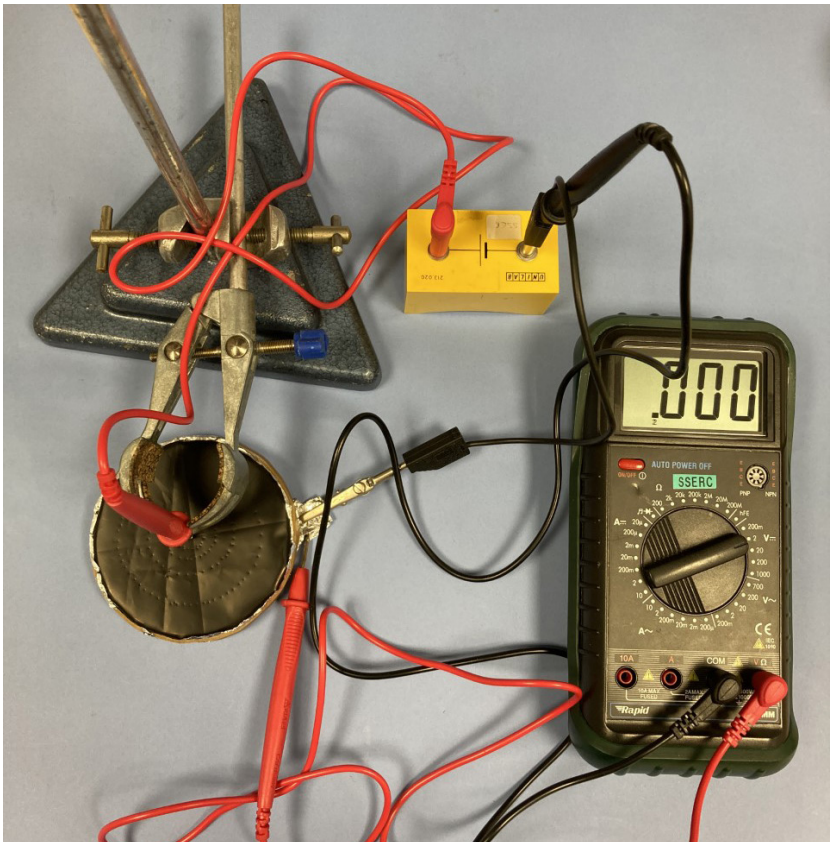


Figure 9

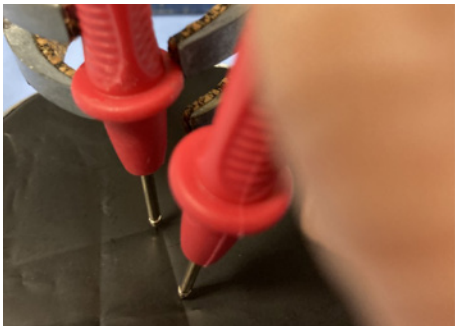


Figure 10

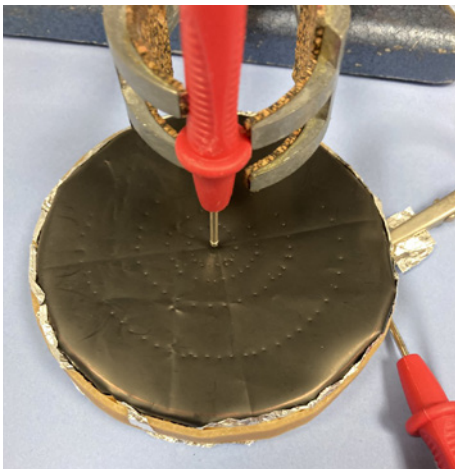


Figure 11

Set up the apparatus as shown in Figure 9. Take the positive probe and record points equipotential for a value of 0.7 V if using a 1.5 V cell. Repeat for values of 0.5 V, 0.3 V, 0.1 V. Then do just a few points for 0.6 V, 0.4 V and 0.2 V. The resulting equipotential lines are drawn out by the dots. The lines of equipotential are concentric circles (Figure 10).

The lines for regular intervals of potential get more widely spaced, showing the relationship between potential and distance from a point charge is not linear (Figure 11). Plotting a graph of voltage against distance from the source gives a curve, see Figure 12. A curve fit for a power can be tried using Excel. To one significant figure this gives $V \propto d^{-1}$, as expected. As before the electric field lines can be drawn. This gives the electric field around a point charge. <<

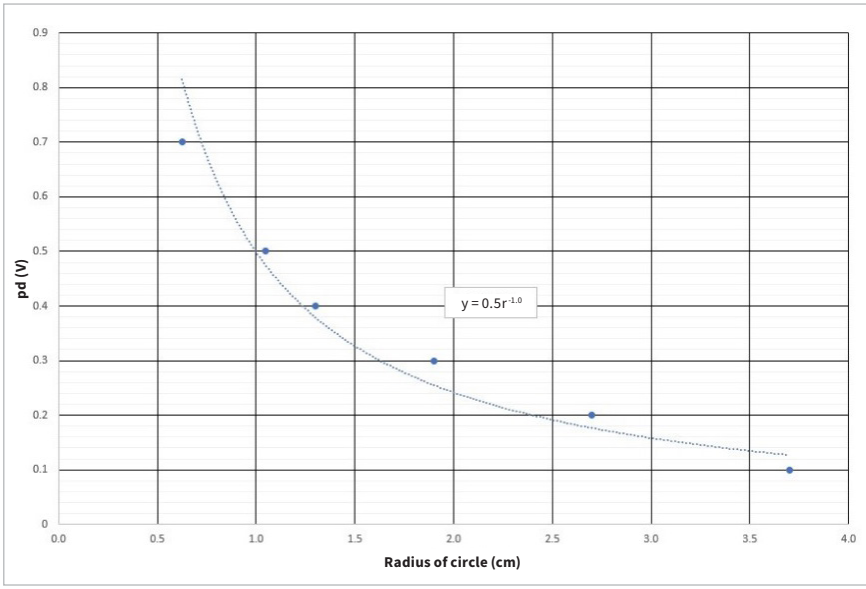


Figure 12

Reference

[1] Conductive bags are available from https://uk.farnell.com/multicomp/006-0003f/conductive-bag-101-6mm-x-152-4mm/dp/1687804

SSERC RPA Service

At the turn of the century, the Ionising Radiation Regulations 1999 stipulated that an employer who had employees who worked with certain types of radioactive materials had to consult with a Radiation Protection Adviser (RPA). The materials held by schools to teach the properties of ionising radiation fell into this category. RPAs had to hold a qualification recognised by the Health and Safety Executive. To gain such a qualification, the would-be RPA had to demonstrate good theoretical knowledge and a track record of giving advice on radiation protection over a period of time. With great foresight, the SSERC physics specialist at that time, having had extensive experience in offering advice, applied for and gained RPA accreditation. This meant that local authorities and member independent schools had automatic access to an RPA as part of their SSERC membership, a significant benefit in terms of cost and convenience.

People retire and move on, but the SSERC RPA service continues. Working with other members of the physics team, the RPA answers queries, develops guidance, runs courses and, where necessary, makes visits to ensure that work with ionising radiation is carried out safely and in compliance with the law, in a way that is not unnecessarily onerous. The current RPA is Gregor Steele.


Evelyn Lee

We would like you to meet the latest member of the Radiation Protection team – Evelyn Lee. Evelyn has a degree in physics and has been a technician at SSERC for a number of years. She has supported radioactivity courses and has had a role in in-house radiation protection. She is now training to be a Radiation Protection Adviser. You will see her at courses and she will be answering many of your queries going forward. She also wrote the risk assessments mentioned elsewhere in this bulletin, and the bulletin article itself.

You can contact SSERC for radiation protection advice using rpa@sserc.scot <<

Electrical Safety and PAT update

New equipment Class II (FE)

The article is taken from the first issue of The Stem Technician, published three times a year, it's a technician specific bulletin you can find here.

The IET 5th edition In-service Inspection and Testing of Electrical Equipment code of practice has introduced a new equipment classification. Class II (Functional Earth). This new classification is to distinguish items that are considered for electrical safety to fulfil the requirements for Class II, but for functional reasons require a connection to earth.

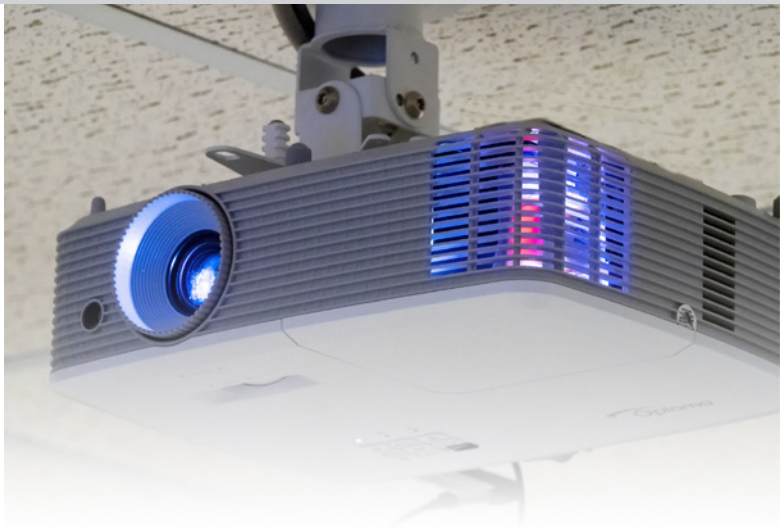
This means the item will be double insulated but will have a connection to earth on the mains side. In the past such items may have been referred to as Class I Hybrid.

The most common examples of these are switch mode power supplies which are used in a variety of applications especially in IT equipment such as laptop power supplies/chargers.

The symbol for Class II (FE) is shown on the right. Some older equipment with this type of supply arrangement may be marked as ITE (Information Technology Equipment).

When testing and inspecting such equipment, for electrical safety, they should be treated as any other Class II item. <<

Mercury in projector bulbs



Data projectors are ubiquitous in classrooms and many other places around schools and colleges.

There are three main types: LED, Laser and Lamp. The oldest type, and the most likely to be found in schools are the lamp type. The bulbs in these contain mercury vapour at high temperature (when operating) and very high pressure.

While in general these are perfectly safe, as the mercury is contained within the glass, we have heard reports of the bulbs exploding and consequently releasing their contents into the room.

Before we consider any health effects, it is a good idea to look at ways in which you can reduce the likelihood of this sort of bulb failure.

There are various factors that can extend a bulb's life: avoiding overheating, keeping the fan etc dust free, not switching on and off rapidly but as far as avoiding breakage or explosion, there is one thing that is particularly important.

Make sure not to touch the bulbs with bare hands when inserting or changing them: wear gloves instead.
The bulb has an internal pressure of up to 250 atm at about 1300° Celsius and the greasy spots can lead to uneven temperature across the glass surface, internal tension, and eventual cracking or explosion.

So, whether you did this or not, if your bulb explodes, what is the danger?

There is not much mercury in a bulb – around 30mg – but this is still a significant amount.

Inhalation

The main hazard comes from inhalation of mercury vapour. The workplace exposure level (WEL) for mercury vapour is extremely low (0.02 mg/m³ over 8h). Assuming all the 30 mg is vapourised and spread evenly over the lab even a large lab would produce a concentration of around 0.1 mg/m³ (though this is without allowing for ventilation).

Without measurement it is impossible to get accurate figures but some factors affecting the level could be.

Positives

- Not all the mercury vapour will escape into the room: some (maybe most) will be deposited on the glass shards and the surfaces of the projector.
- Ventilation will remove the contaminated air fairly rapidly.
- At the time of writing, face coverings are widespread in laboratories and provide some slight extra protection. It is to be hoped, though, that this situation will not last for long so the risk will be slightly higher.

Negatives

- Vapour will not be dispersed evenly so near the projector the concentration will be higher.
- It could be that the fan in the projector disperses it more or blows it in a particular direction.

Depending on the nature of the bulb, the lamp housing and the projector design, differing amounts of mercury vapour will be ejected.

In any case, in case of such an explosion the room should be evacuated to allow the ventilation to clear the vapour from the air – an hour should be plenty of time in a normal laboratory with its 5 air changes per hour.

>>

Skin contact

Not all the mercury vapour in the room will be removed by ventilation. A significant amount will condense onto the surfaces.

Here, if no action is taken, it can be picked up by hands and clothing.

The amount of mercury will be small so there is no need for a complete deep-clean of the room but any bench/table tops within a few metres of the projector along with stools/chairs should be wiped down with damp paper towels or tissues. These should be "double bagged" and kept for disposal as possible mercury containing waste.

It would be prudent to arrange for a good cleaning of floors and any other surfaces near the projector as well. But the highest amount of mercury condensate will be on the projector itself. The projector should be cleaned as thoroughly as possible (it will probably need to be demounted for this) and any tissues etc bagged for disposal as above.

It should be noted that this has happened and perhaps a sticker put on the outside of the projector to make sure that whenever it is being handled, people wear gloves to do so.

Some perspective

While the above might sound alarming, any level of exposure is going to be very low. It is worth remembering that we are all constantly exposed to mercury in the environment, albeit at low levels: the CDC in America suggests about 3.5 micrograms (µg) of mercury per day for an adult of average weight.

If for any reason there is reason to suspect anyone has had a larger exposure – perhaps the vapour is vented directly at an individual, symptoms of mercury poisoning include the following:

- Breathlessness
- Coughing
- A tightening or burning sensation in the chest
- Shaking tremors
- Feeling nervous and irritable

This is extremely unlikely to be an issue but if there is concern about exposure, the levels of mercury in the body can be diagnosed by a blood or urine test via the medical services. So anyone concerned should be encouraged to contact their GP. <<

SSERC Health & Safety poster

Whatever your job, your employer must tell you how to work safely. In turn, you must follow your employer's guidance. When it comes to safety in practical work in STEM subjects, your employer will expect you to follow SSERC guidance. There are a few exceptions when an employer adds additional measures over and above those specified by SSERC, but this is rare. If you are a regular Bulletin reader or have ever been on a SSERC health and safety course, you will know this.

To help get the message across to all employees working in this area, you can now download a poster from SSERC [1].

The poster reminds readers that employers expect them to follow SSERC advice and highlights how this advice can be accessed. The advice is free, save for some courses which, though they must be paid for, are subsidised. The poster could be downloaded and printed out, for display in staff bases, prep rooms or classrooms as you see fit. We hope that you will see this as an effective way of reminding colleagues of the guidance they should be following and of how to access that guidance. <<

Reference

[1] https://www.sserc.org.uk/health-safety/h_s-poster/

Working with radioactive sources - risk assessment

The task of risk assessment can often be viewed in a negative light, however here at SSERC we prefer to think of it as a positive process that leads to making exciting and interesting practical work possible and safe.

Radioactivity is an area of the curriculum that particularly benefits from practical work. On a recent SSERC course we had a teacher comment that they find radioactivity difficult to teach because you cannot see it. Practical work in this area really helps to make it more engaging, tangible and accessible. You might not be able to see the actual radioactive decay however you can see and hear the effects of it. There is nothing more mesmerising than watching tracks appear in a cloud chamber (Figure 1) and the spark counter (Figure 2) is impressively visual.

Not to mention that hearing one click on the GM tube counter represents a single atom event, there are very few other times a learner will experience that! When a topic is seemingly abstract, it is all the more important to convince learners of the science you are teaching them with actual experimentation rather than just telling them or using a simulation which is unlikely to make it seem anymore real. We are keen that no school is put off from doing practical work in a particular area because of the requirement to risk assess it and recognise that radiation risk assessment can be seen as particularly daunting. This is why, as part of providing RPA services for Scottish schools, we aim to provide as much assistance with it as possible.

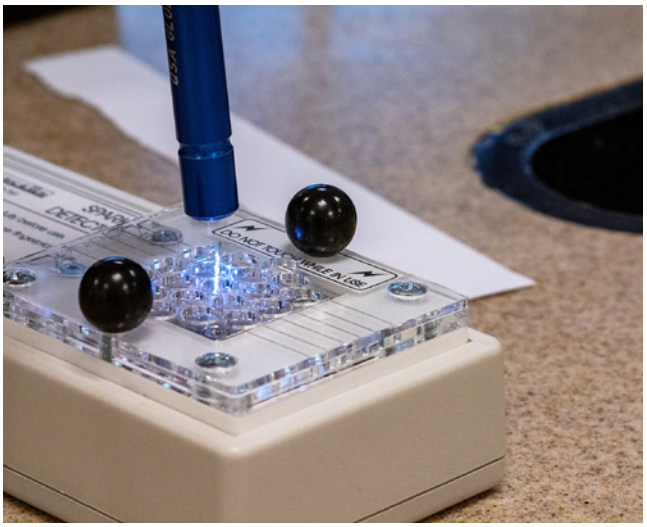


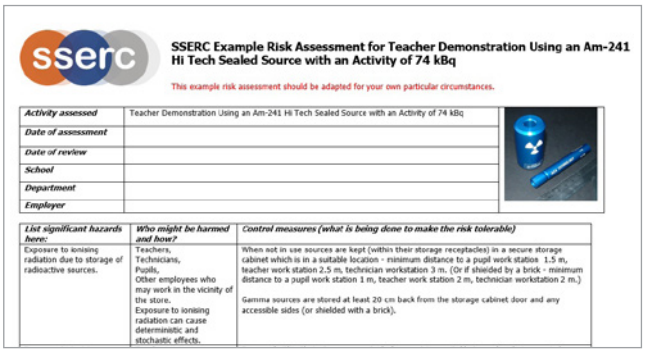
Figure 2 - The spark counter in action.

Figure 1 - Tracks in a cloud chamber.

Before any radioactive source is approved for use in schools it goes through what is known as a prior risk assessment. This looks at its safety and suitability for use in schools. A prior risk assessment evaluates a variety of factors about the source, for example its construction, and it considers the dose received by those in its vicinity not only during standard operation of the source but also in situations where there is an accident or improper use, in some cases it even goes as far as considering the environmental impact. These prior risk assessments are of course necessary and useful. However, they do contain a lot of highly detailed information which isn't needed for normal school use of radioactive sources.

Until recently we provided these prior risk assessments on the SSERC website to aid schools with writing their own risk assessments for working with radioactive sources. After a recent review we decided that we could take this a step further and create example operational radiation risk assessments which focus on the information and control measures that need to be considered by the user when performing standard demonstrations with radioactive sources.

When producing these risk assessments, the relevant sections of the code of practice associated with the ionising radiation regulations have been consulted to ensure they cover what is legally required of a radiation risk assessment (RRA). The most important outcome of an RRA (and also a legal requirement) is to limit radiation exposure as far as is practical to all those in the vicinity of a radioactive source. This will be achieved by following the control measures set out in our user risk assessments. >>



SSERC Example Risk Assessment for Teacher Demonstration Using an Am-241 Hi Tech Sealed Source with an Activity of 74 kBq

This example risk assessment should be adapted for your own particular circumstances.

Activity assessed	Teacher Demonstration Using an Am-241 Hi Tech Sealed Source with an Activity of 74 kBq
Date of assessment	
Date of review	
School	
Department	
Employer	

List significant hazards here:	*Who might be harmed and how?*	*Control measures (what is being done to make the risk tolerable)*
Exposure to ionising radiation due to storage of radioactive sources.	Teachers, Technicians, Pupils, Other employees who may work in the vicinity of the store. Exposure to ionising radiation can cause deterministic and stochastic effects.	When not in use sources are kept (within their storage receptacles) in a secure storage cabinet which is in a suitable location - minimum distance to a pupil work station 1.5 m, teacher work station 2.5 m, technician workstation 3 m. (Or if shielded by a brick - minimum distance to a pupil work station 1 m, teacher work station 2 m, technician workstation 2 m.) Gamma sources are stored at least 20 cm back from the storage cabinet door and any accessible sides (or shielded with a brick).

Figure 3 - Example risk assessment.

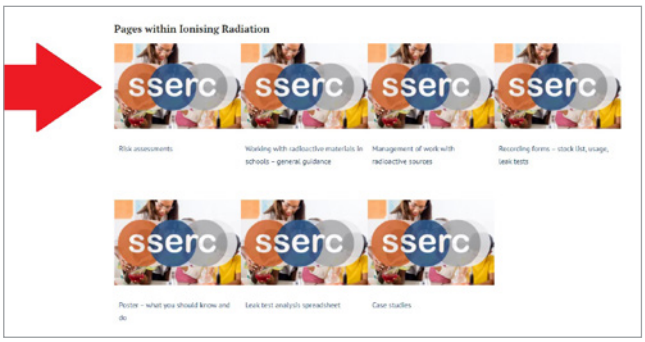


Figure 4 - Ionising Radiation web page.

These user risk assessments have been created using what HSE used to refer to as the 'five steps' approach. Therefore, they should be in a format which is familiar to you (Figure 3) and this also ensures that not only do they satisfy the requirements for a RRA but they also form a complete risk assessment.

Part of this five-step process is to implement the findings from a risk assessment. Performing a risk assessment is only useful if the control measures identified in it are communicated clearly to the users. As such we have also produced some example 'operating procedures' documents to provide you with an idea of how you might want to disseminate the information within the risk assessments.

Both these new user risk assessments and example operating procedures can be found by logging in to our website and visiting the ionising radiation pages (Figure 4) of our health and safety section [1].

We are in the process of providing risk assessments for all the main radioactive sources permitted for use in Scottish schools and the standard demonstrations involving them. If you wish to perform an experiment out with this scope, please first ensure you are using a permitted source and the activity you wish to carry out is justified. If in doubt, contact us [2]. You will then need to create a risk assessment specific to this experiment, however the user risk assessments provided by us should still help and further advice can be provided by us if required. Likewise, these user risk assessments produced by us only cover teacher demonstrations. Students under 16 must not work with radioactive sources. Students aged 16 and over may work with sources so long as there are no under 16s in the same room, they are supervised, they have received appropriate training and a separate risk assessment specific to this has been carried out. Again, we can provide support with producing this type of risk assessment if required.

Finally, it must be stressed that although we have tried to provide as much assistance with this process as possible, the user risk assessments and operating procedures produced by us are generic as circumstances will vary from school to school. Therefore, it is vitally important that schools read through these and adapt them for their own situation. It is also essential that all users of radioactive sources within a school are aware of the corresponding risk assessments and the control measures within them that they must put into action – this should be covered in the training provided to them prior to using the sources and the information on control measures made easily accessible, for example in operating procedure documents. These risk assessments, as with all risk assessments, should also be reviewed at appropriate intervals to ensure that they are still fit for purpose.

Next time your risk assessments are up for review please consult this updated area of our website to ensure your own risk assessments contain all the information required. Or if you are new to owning radioactive sources or considering purchasing them, please be assured that there is plenty of support available for putting your risk assessments in place along with full guidance on all areas of working with radioactive sources in schools. So- there is nothing to stop you and your classes enjoying the wonder and enhanced learning of practical work with radioactive sources in a safe way. <<

References

[1] https://www.sserc.org.uk/health-safety/physics-health-safety/ionising-radiation
[2] Email: rpa@sserc.scot

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