SSERC Bulletin

Ideas and inspiration supporting science and technology for all Local Authorities

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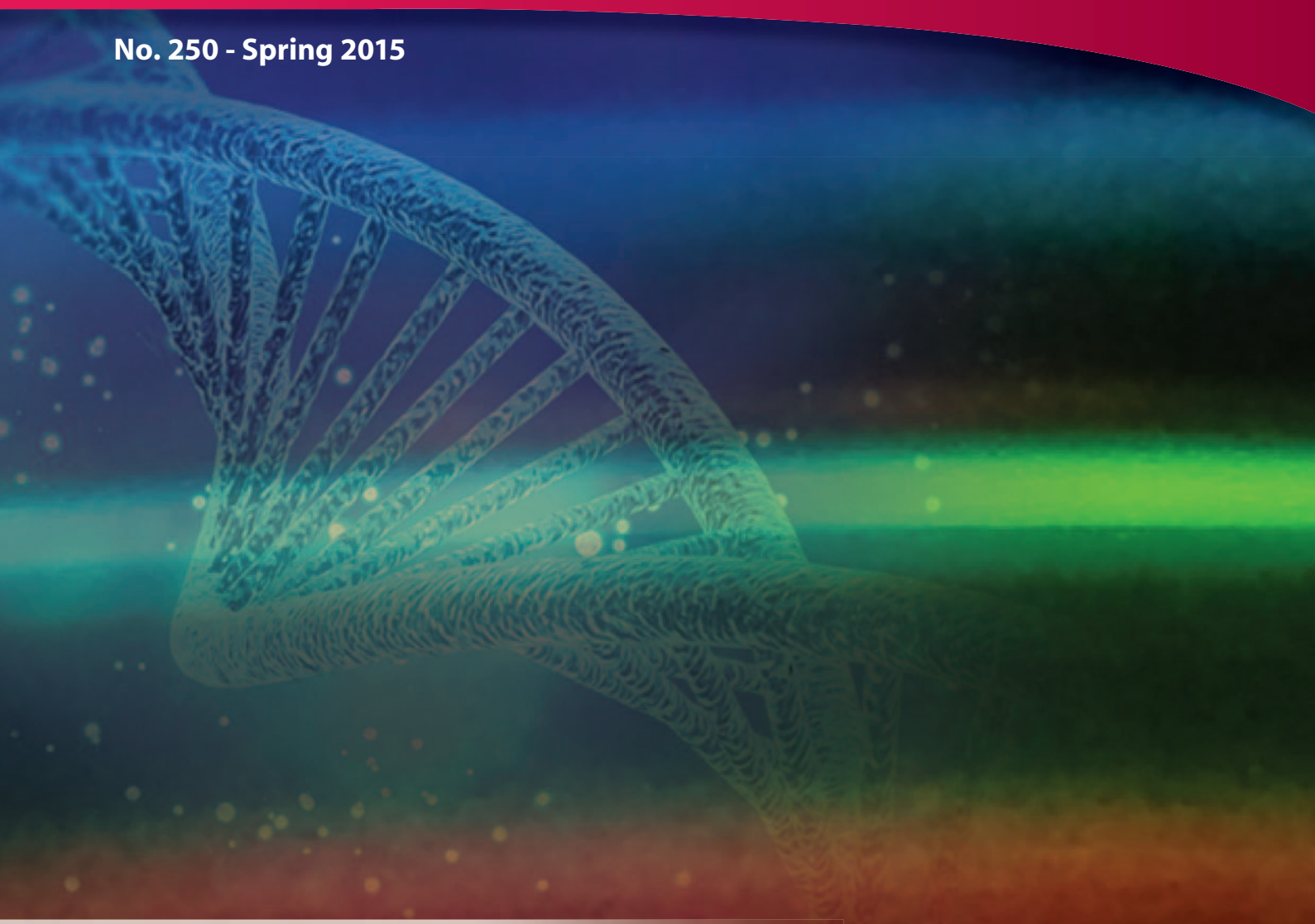

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Violet laser diode

In Bulletin 229 we rejoiced that at last an inexpensive Class 2 green laser diode module (LDM) was available [1]. The eye is particularly sensitive to green light, hence a green laser looks particularly bright. What is more, the laser in question had automatic power control - a negative feedback system monitors the output of the laser, ensuring that it never creeps above the 1 mW limit of a Class 2 device.

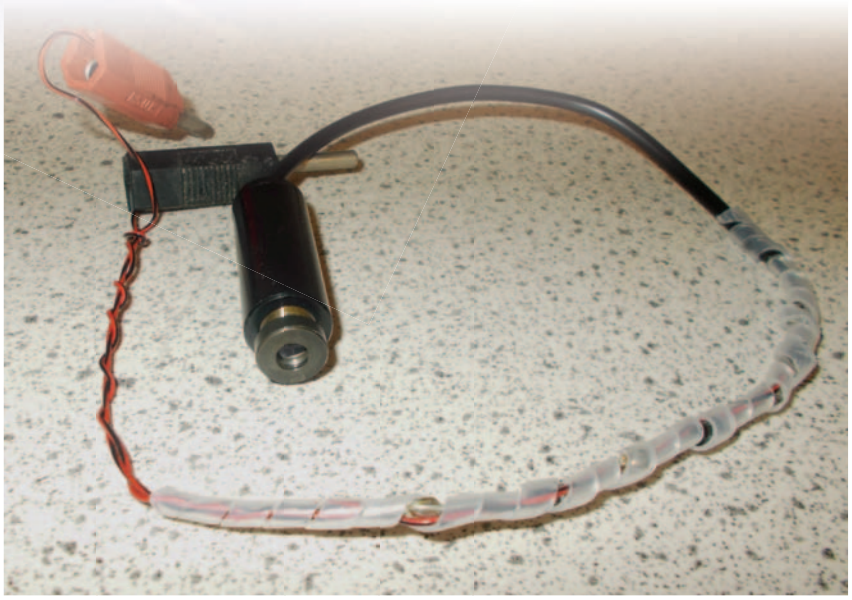


Figure 1 *- The violet LDM with chain of diodes.*

Now we have at last been able to buy a violet laser diode module (405 nm). As with the green unit, our violet LDM had automatic power control and came from the same reputable company, Roithner Lasertechnik in Vienna. Its part number is RLDD405-1-3 (Figure 1). Like most LDMs, its beam is polarised and the plane of polarisation remains stable with time, something that cannot be said for some school helium-neon lasers.

The cost was around €70, including postage. This is significantly more expensive than a violet laser pointer that you could buy online. Please don't be tempted by the latter.

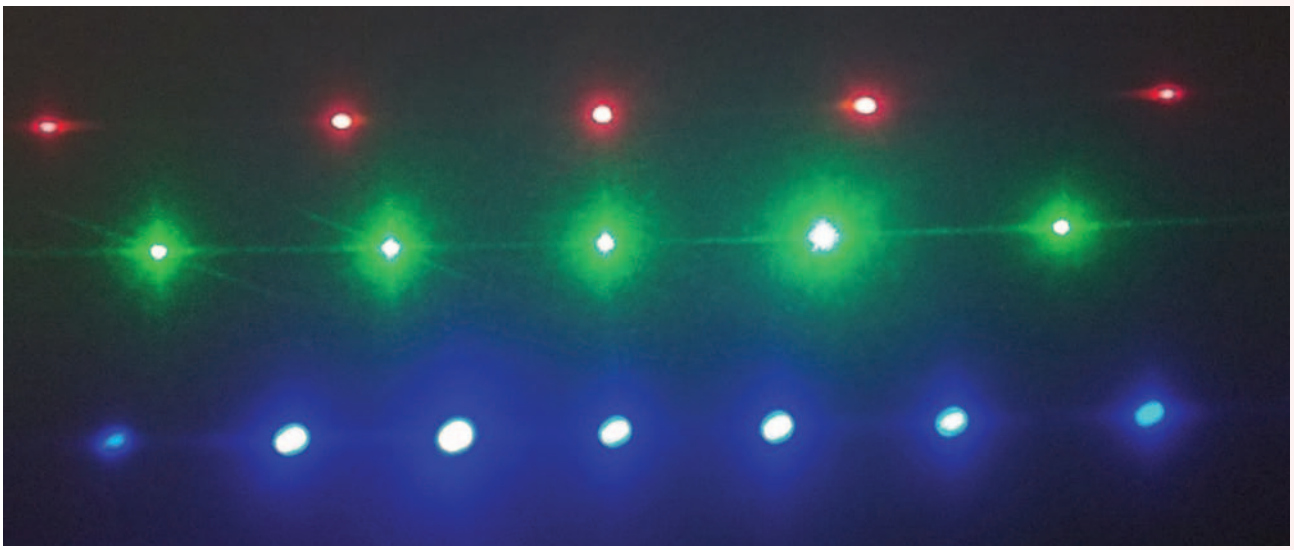


Figure 2*- Interference pattern from red, green and violet lasers, using a diffraction grating. Ethics prevented us from Photoshopping away the outermost violet fringes, but if you cover them with your fingers, the effect you're trying to show is more pronounced.*

Figure 3 *- Fluorescence in tonic water.*

We are quite convinced about the reasons for not using laser pointers for experiments. You can read more in our guide to Optical Radiation in the Health and Safety section of our website, Physics subject area [2]. Just in case we were being draconian, we bought a violet pointer from eBay. It was labelled as Class 2, but proved to be twice as powerful as it ought to be.

The LDM (Figure 1) runs from a 3 V supply. We felt that a 5 V supply was more likely to be available and so we soldered a chain of three IN4001 diodes, each of which drops the voltage by about 0.7 V, in series with it. The circuit is the same as that in Bulletin 229. If you did not want to do this, you could run the module from two 1.5 V batteries.

So why would you want a violet laser if you already had a red and or a green one? It is tempting to state glibly that you can never have too many lasers. As well as being able to use your lasers with a grating to compare the fringe spacing of the interference pattern when different wavelengths are used (Figure 2), this light is energetic enough to cause fluorescence in certain substances.

One of these is tonic water. Figure 3 shows fluorescence in tonic water from violet light that has passed through a diffraction grating.

You can also make some quite lovely total internal reflection patterns in tonic water, but do look out for stray beams - use beam stops where appropriate.

If you look at Figure 2, the violet light appears blue. This is because the paper screen we shone the beams on to contained fluorescing "optical brighteners". This gave us an idea. Could we colour mix red, green and violet (fluorescing to blue) laser light to give white? We used a similar set up to that used in the laser colour mixing article in the aforementioned Bulletin 229 - Light-Shaping Diffuser to spread the beams, and polarisers to adjust the brightness. A strategically-placed plastic dinosaur created some interesting shadows as shown in Figure 4.

We will finish with a question: Laser light is highly monochromatic. Would you expect the light from fluorescence to be so too?

Figure 4 *- Lasers and dinosaurs, the perfect combination.*

References

[1] http://www.sserc.org.uk/images/Bulletins/229/229_Complete.pdf.
[2] http://www.sserc.org.uk/index.php/health-safety/health-a-safety-home136/optical-radiation-safe-use81.

Renewables and Higher Physics - the Bananarama

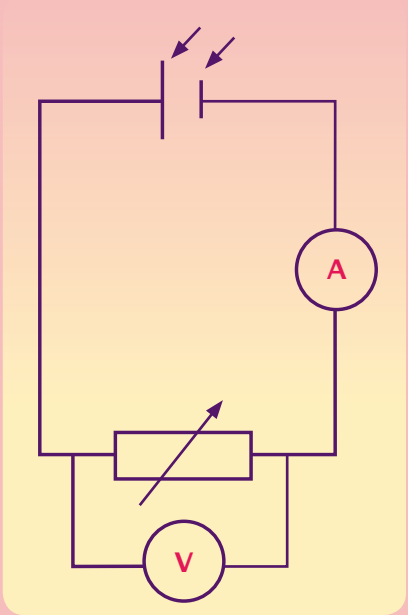


Figure 1 *- Circuit used.*

There is now a Researching Physics exemplar on Renewables. This has had a mixed reception. Some teachers, with no option but to teach N5 and Higher in the same class, welcome the option of a topic that is appropriate to both levels. Others, who have perhaps investigated solar cells and wind turbines at BGE, question whether the work is sufficiently challenging for Higher. Thus was born the Bananarama Conjecture, *It ain't what you do, it's the way that you do it*, after the 1982 song featuring the girl band of that name [1].

Mentioning the Bananarama Conjecture may raise a smile amongst some teachers of a certain age at Researching Physics professional learning events, but concerns about levels of challenge deserve more than a jokey soundbite. We therefore set out to do some unambiguously Higher level experiments on solar cells. The exemplar is quite clear that it is the power output rather than voltage that should be investigated. Load matching and maximum power transfer are mentioned in the Electricity half unit at Higher, so the following approach was taken. A solar cell was wired up in series with an ammeter and variable load resistor, across which a voltmeter was connected (Figure 1).

A desk lamp was placed directly above the solar cell. With the light level remaining constant, V and I were measured for different values of load resistance *R*. The experiment was repeated with dimmer light, mimicking one of Scotland's cruel summers.

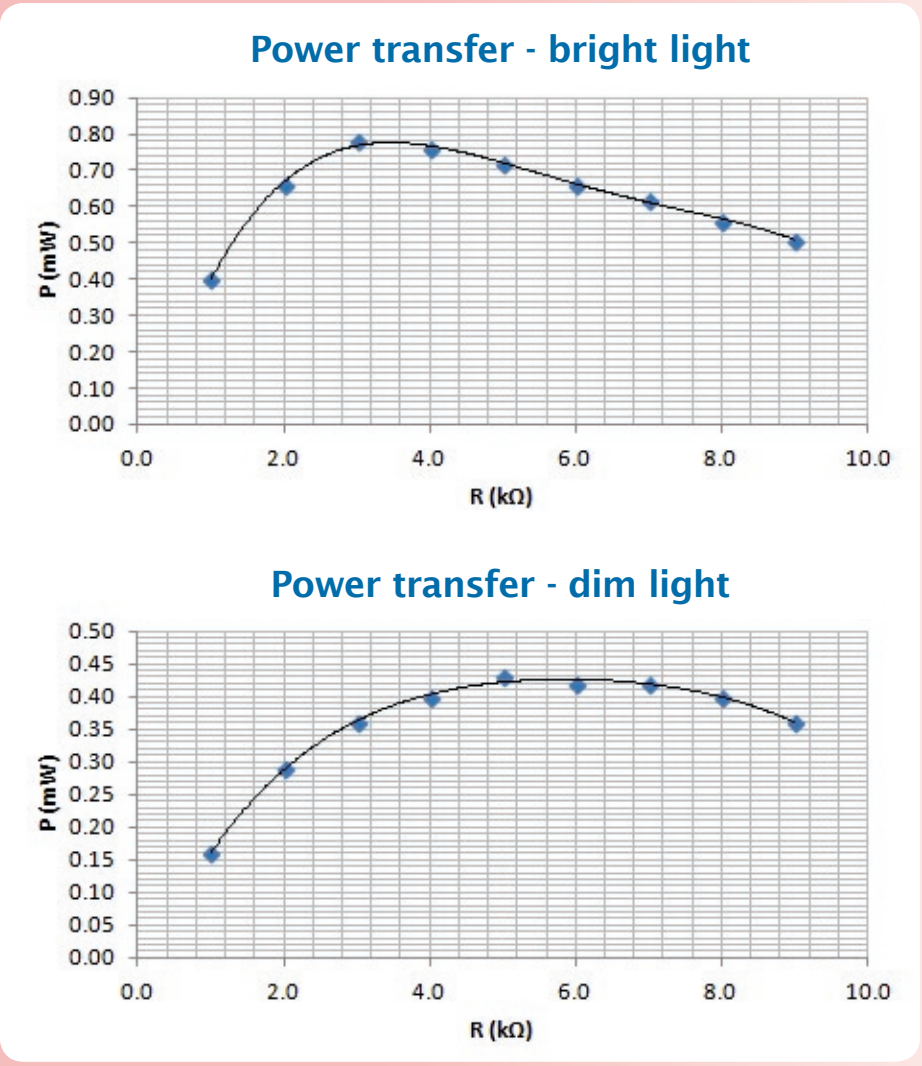


Figure 2 *- These graphs seem to be really saying something.*

Conjecture

The results are shown in Figure 2.

As expected, the power transferred to the load resistor peaks at a certain value of *R*, which theory tells us happens when the internal resistance of the solar cell and the load resistances are equal. If this is the case, then the internal resistance has increased as the light falling on the solar cell has decreased.

A Researching Physics investigation might then result in a series of power transfer curves, each for, say, a different angle of tilt of the cell. A graph could then be drawn of maximum power transferred versus angle. Conventional wisdom states that Researching Physics investigations are generally unsuitable for Outcome 1 write-ups. This is almost certainly correct. However, a single power transfer experiment could well form the basis for such a report.

Notes

We used a DJB Decade Resistance Board [2] with an unbranded solar cell. At low light levels, the highest resistance available from the board was just enough for us to be able to identify the peak power. We have, however, heard from teachers who tried the experiment using solar cells whose internal resistances were significantly lower than that of our cell. They agree that we can unambiguously (hey hey) kiss goodbye to doubts that this is not a suitable investigation at Higher.

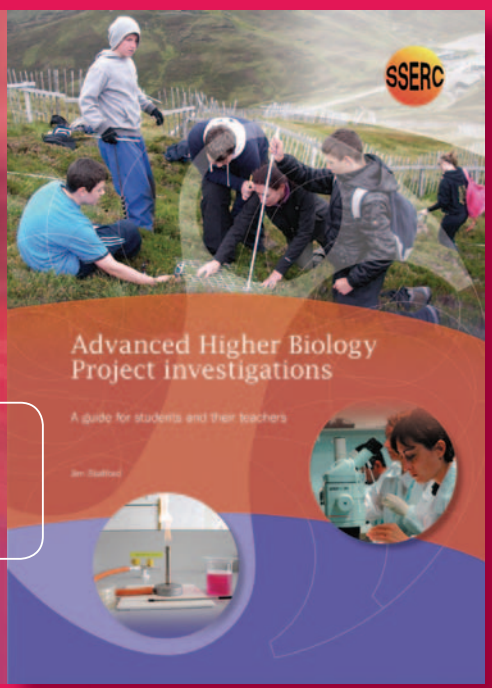
References

[1] The song was actually released by The Fun Boy Three, with Bananarama supplying the backing.

[2] http://www.djb.co.uk/ppe_decade_resistance.html.

Coming soon ...

We are pleased to let you know that SSERC will shortly be publishing a new guide entitled 'Advanced Higher Biology Project investigations'.



Copies of the guide will be made available through the SSERC website.

The guide has been written by Jim Stafford who is a Senior Associate with SSERC. Previously Jim has been a Principal Teacher of Biology, a Local Authority Science Adviser and Quality Improvement Officer.

Iain Hunter (Executive Dean of Science at the University of Strathclyde, in his foreword to the Guide, writes *'This Guide, from SSERC, fills a much-needed gap for both student and teacher. It provides generic guidance and support for both. It will be invaluable in detuning the anxiety of the Investigation, and enhancing the student experience and attainment'.*

Demonstration corner

FLAME COLOURS

This demonstration has had a bit of a bad press, particularly in the United States, as a result of it being carried out on too large a scale without due care and attention. However, as long as the method described below is used, the risks are minimal.

Flame tests are simple methods of identifying, qualitatively, the presence of certain elements. The method works because each element has a particular emission spectrum and while not all are suitable, there is a range of metal salts that can be easily identified in the school laboratory due to their characteristic colours.

There are many different methods of showing flame tests, quite a few of which are suitable for pupils. The advantage of this method is that it allows demonstration of a range of colours simultaneously rather than one after the other.

The flame that produces the colour is provided by burning methanol. Methanol is used because it has an almost colourless flame. Ethanol can be used but is not quite as good as the flame has a bit more colour to it.

What you will need

- A series of borosilicate glass watch glasses or small petri dishes (or evaporating dishes).
- Samples of solid salts, preferably chlorides: barium, calcium, copper lithium, potassium, sodium and strontium.
- Methanol.
- A 3 cm^3 Pasteur pipette (or small syringe or measuring cylinder).
- Heatproof mats.

What you do

Preparation

1) Lay out your heatproof mats and arrange the watch glasses (or other containers).
2) Place about 1 g (a small spatulaful) of your salts into the containers you are using; a different one in each.
3) Use a Pasteur pipette to put 3 cm^3 of methanol on top of each pile of salt.
4) Put the lid back on the methanol bottle and remove it to a safe distance.

The demonstration

1) Ensure the audience is standing 1 m back from the bench. The amounts of methanol are small but in case of spillage, the burning liquid could run across the table.
2) Use a Bunsen burner lighter or a lit splint to light each of the containers of methanol. (Be careful, the flame is all but transparent to start with and very hard to see.)
3) Dim the lights - if you haven't already. After a few seconds, the flames will start to take on the characteristic colours of the ions.
4) Within about 1 minute, the flames will have died down as the methanol is burned.

NB. If you want to repeat the experiment, either wait until the current containers are completely cooled or use fresh ones. If you use the same ones, there is no need to add more salt.

Do NOT under any circumstances add methanol to hot or still burning vessels.

Mobile phone spectroscope

Spectroscopy is an important analytical tool in several areas of science. In the classroom, however, spectroscopy is not used as much as we would like due to the relatively high cost of the equipment.

In 2008, a design for a simple, home-made spectroscope made out of card and using a section from a CD or DVD as the diffraction grating was published. (A version can be found on the SSERC website [1]). It is cheap and works reasonably well.

Recently, however, we have come across a variation of this design that can be attached to a webcam or to a phone or tablet, allowing the spectra to be captured and analysed.

Background

A diffraction grating is an optical device with a structure which splits light into several beams travelling in different directions. They can do so either by reflection or transmission. The directions of these beams depends on the spacing of the grating and the wavelength of the light. If you shine white light on a diffraction grating, the grating will cause the white light to spread out into a spectrum.

Figure 1 *- DVD layers.*

In a CD or DVD, the tracks containing the data spiral in to the centre, resulting in an array of parallel lines which can work as a diffraction grating. This is what produces the array of colours you see when you look at the reflections in a CD or DVD (Figure 1).

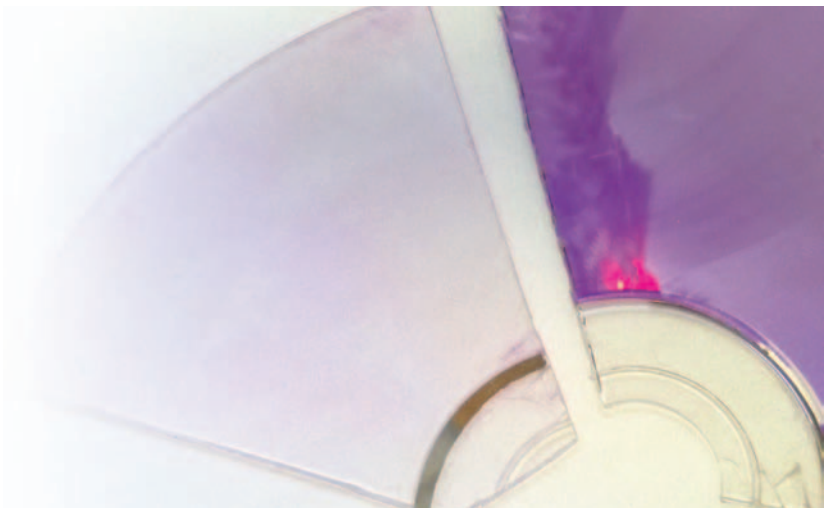


Figure 2 *- Cleaning the dye.*

Making the spectroscope

The design here (the first one at least) was developed by the Public Laboratory for Open Technology and Science (www.publiclab.org).

1) Preparing the diffraction grating

You will need a recordable DVD (DVD-R).

Cut the DVD-R into halves or quarters with a pair of scissors and then you should be able to get a fingernail in and separate it into two layers: the metallic layer with the label on and a clear plastic layer with a purple sheen. (Figure 1) You need the clear layer. Try to handle the surface as little as possible to avoid marking it.

You can remove the purple colouring using some ethanol (methylated spirit works well) and cotton wool (Figure 2).

Cut a piece from the edge of the now clear plastic, approximately 1 cm x 1 cm. This is your diffraction grating.

2) Getting and preparing the template

You can find the template on the publiclab website [2] (Figure 3).

You need to print this out onto black card: card so it is stiff enough and black to reduce internal reflection. You might think printing black lines onto black card is a daft thing to do but it is still possible to see the design clearly enough to cut it out.

Cut round the outside, scissors are probably easiest.

Use a scalpel or sharp craft knife to cut out the square (top right of the diagram) where the grating goes. Then use the scalpel/knife to cut a narrow slit (lower left of the diagram) - the narrower the better.

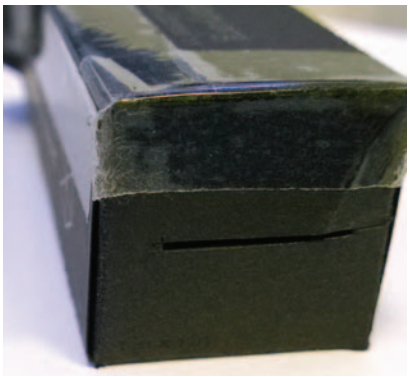


Figure 4 *- The slit.*

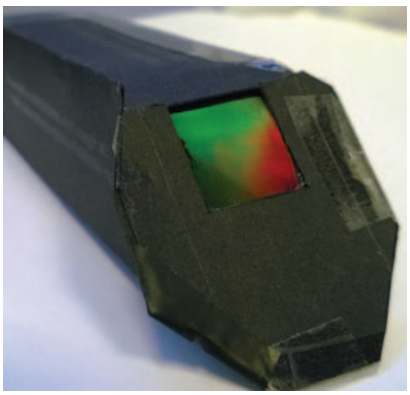


Figure 5 *- The diffraction grating.*

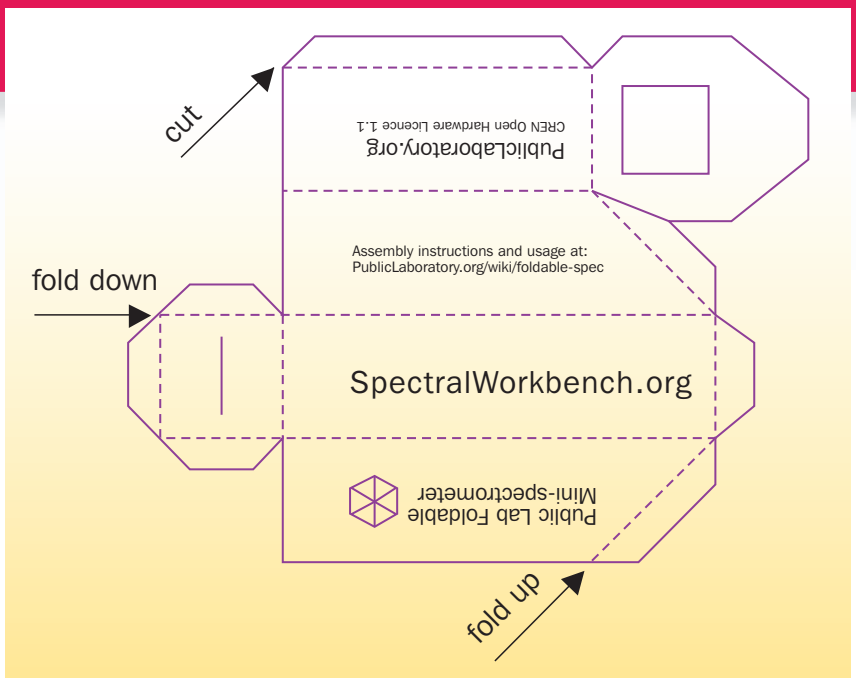


Figure 3 *- The template.*

3) Assembling the spectrometer

Use tape or glue to fix your 1 cm x 1 cm piece of diffraction grating on the inside of the 'door', over the square hole you cut out for it. The lines need to be horizontal so make sure that the edge of the DVD-R is at the top or bottom rather than to one side. Then fold the device as shown in the diagram and tape or glue it shut (tape is probably easier and black electrical tape is best).

You will now have a rectangular box, approximately 10 cm long with a slit at one end (Figure 4) and a slope at the other end with a window containing the diffraction grating (Figure 5).

4) Attaching the spectrometer to your phone

You can simply do this using tape (again, black electrical tape is best). Launch the camera app. Place the 'window' with the diffraction grating against the lens, check that you are getting a pattern and then tape it in place. This is a bit tricky with an iPhone as the camera lens is stuck away in the top left hand corner. It is possible, however, to get it in place with a bit of care.

Once in place, launch the camera app (if you closed it) and then you can point it at various light sources and get photographs of their spectra (Figures 7, 8 & 9).

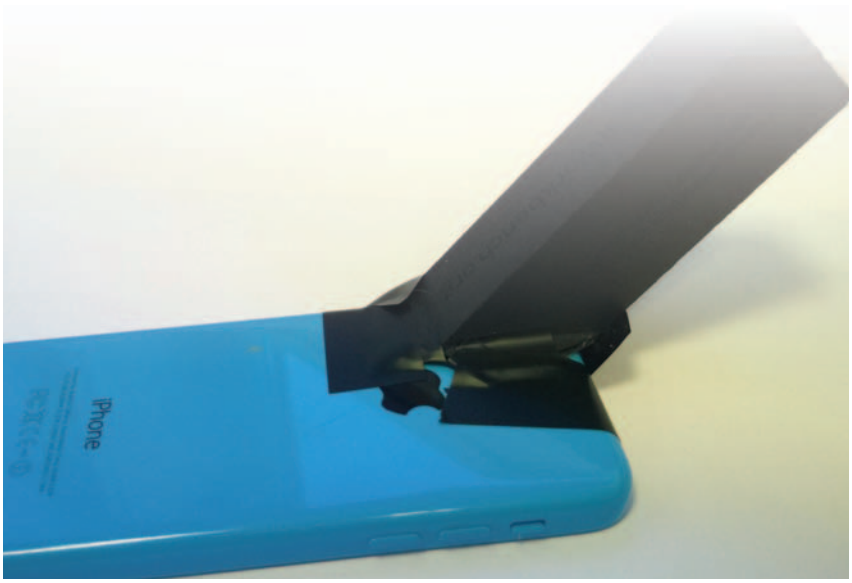


Figure 6 *- Spectrometer attached to an iPhone.*

5) Tips and Improvements

The device works pretty well and it is possible to get some decent pictures of spectra. It is, however, a bit fragile.

It is possible to improve the construction by using a piece of plastic tubing as the body. 19 mm plumbing overflow pipe is ideal. You can cut it easily with a hacksaw and use a file or craft knife to smooth it off (Figure 10). The pipe is white so you will need to either spray paint it black on the inside or line the inside with black paper or card.

It is easy to cut card for the ends and if you make a series of cuts round the edge, you can fold it down and tape it.

You need to make sure that you tape the spectrometer to your phone well - you want to make sure that there is no light leaking in as that will decrease the contrast of your image.

Resolution - at present the resolution is not quite good enough to separate the two sodium bands. A narrower slit does improve resolution but then it also reduces the light level which is not good for photography.

Once you have your photographed spectrum, you can then analyse it. This aspect will be covered in a future issue of the Bulletin.

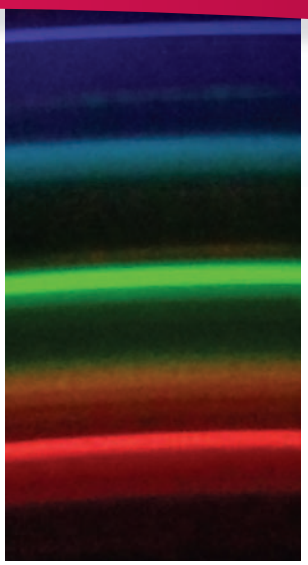


Figure 7 *- Spectrum of a compact fluorescent lamp.*

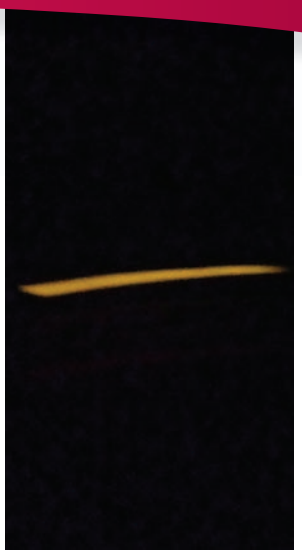


Figure 8 *- Spectrum from a sodium flame test.*

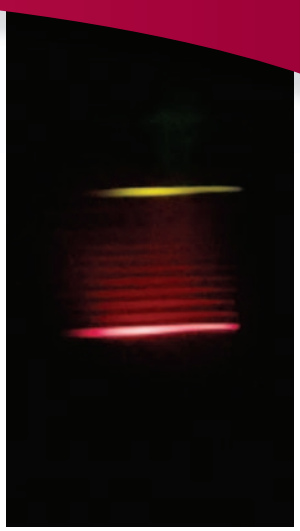


Figure 9 *- Spectrum from a strontium flame test.*

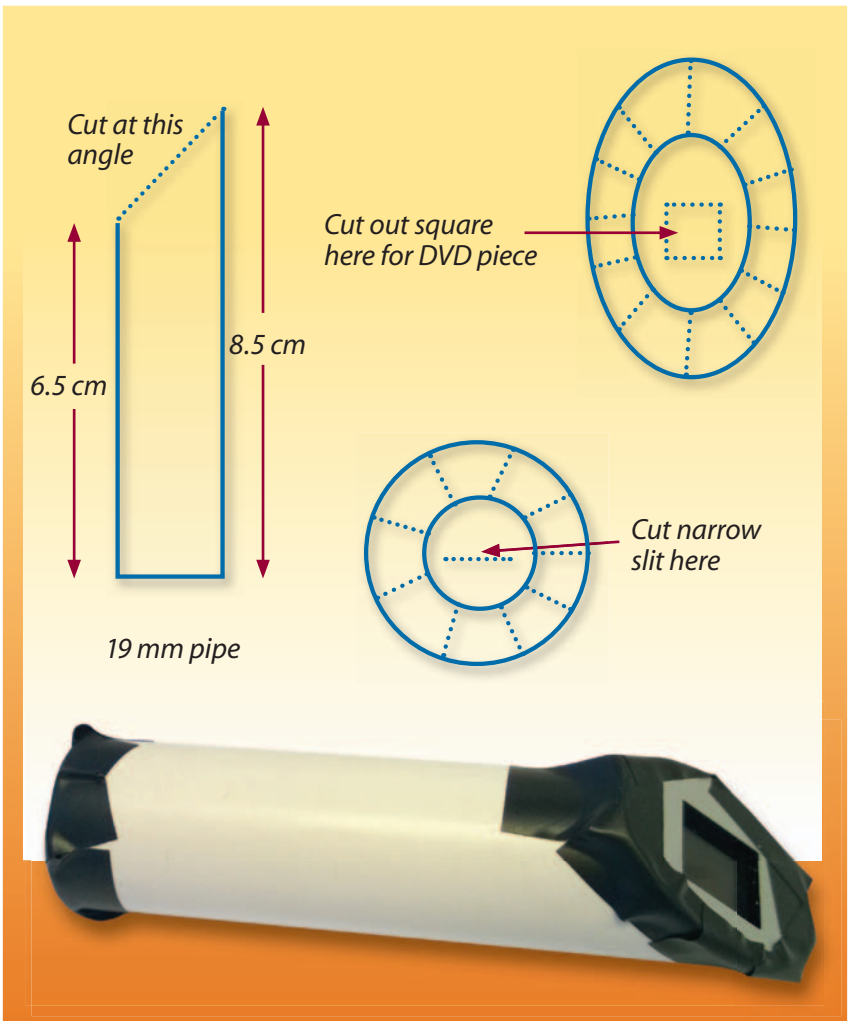


Figure 10 *- Using pipe instead of card.*

References

[1] http://www.sserc.org.uk/index.php/advanced-higher-revised/inorganic-and-physical-chemistry/3074-dvd-spectroscope.

[2] http://publiclab.org/sites/default/files/8.5x11mini-spec3.8.pdf.

Society of Biology Teacher Network (Scotland)

The Society of Biology, the leading professional body for biologists in the United Kingdom, has recently launched its Teacher Network in Scotland.

The stated mission for the network is:

Building on, and supported by SYNAPSE, our mission as the Society of Biology Teacher Network in Scotland is to support the professional development of Biology teaching community colleagues by providing more opportunities for links and experiences with Higher Education and life sciences research and to act as a voice for the Biology teaching community in Scotland.

Four coordinators who will start working from February 1st 2015 have been appointed:

- Andrew Johnston
- Marjorie Smith
- Claire McCartney
- Gillian Davis

The key role of the four co-ordinators will be to help the Society sustain the Network and ensure that it is responsive to the needs of teachers. The coordinators will also support the management, and further development of, the SYNAPSE mailing list. Each co-ordinator would also take on responsibility, with the assistance of the Society, for organising one regional event/meeting per term covering an aspect of current interest to the membership in their region.

Initial enquiries can be directed to: the Director of Education and Training, Rachel Lambert-Forsyth, rachellambertforsyth@societyofbiology.org

Working

Changes to the legislation that controls the way work with DNA is regulated, and the increasing availability of DNA practical work for schools makes a review of the guidance for experimental work with DNA in schools appropriate at this time.

The relevant pieces of legislation are: *Genetically Modified Organisms (Contained Use) Regulations (2014)* [1], *Human Tissue (Scotland) Act (2006)* [2], and the *Data Protection Act (1998)* [3]. This legislation governs the release of genetically modified organisms, consent for the use of human tissue (in this case learners' own DNA) and the use of personal information. Although the prime purpose of this legislation is not to regulate practical laboratory work in schools, such work still falls under the legislation and schools must comply with it. Nor does this legislation regulate safe working with DNA in school laboratories, that is governed by the *Health and Safety etc. Act (1974)* [4] and its associated regulations. The good news in all of this is that by following the guidance for *DNA Technology* in the SSERC Code of Practice *Materials of Living Origin - Educational Use (2012)* [5], schools will be able to comply with all of the legislation mentioned above.

The genetically modified organisms regulations do not regulate the techniques of genetic modification; they regulate the use of the genetically modified organisms produced. Work with genetically modified organisms can only be carried out in premises registered with the relevant authority (typically the Health and Safety Executive) and may require a Genetic Modification Safety Committee to be set up to oversee and control the work. This would appear to put such work beyond the scope of most schools. However, genetic modification is officially defined as 'the alteration of genetic material (DNA or RNA) of an organism by means that could not occur naturally through mating and/or recombination' [1]. This allows some work with microorganisms (typically bacteria) to be exempt from these requirements. For example, the 'transformation' of *E. coli* strain K-12 with pGLO plasmid DNA may be carried out in schools. 'Self cloning' experiments where antibiotic containing plasmids are transferred between strains of *E. coli* K-12 may also be carried out in schools. In both these instances the 'transformed' or 'self cloned' bacteria must be destroyed by autoclaving after completion of the practical work. Such protocols usually

with DNA

involve the incubation of *E. coli* K-12 at 37°C, a permitted exception to the general guidance on incubation temperatures in the SSERC Code of Practice *Safety in Microbiology* [6]. When looking for kits or protocols for microbial transformation experiments it is best to avoid sources from the USA or the web which may not comply with European, UK and Scottish legislation. SSERC is happy to provide advice on such protocols.

Human DNA can be extracted from cheek cells using the sampling procedures in the SSERC Code of Practice *Materials of Living Origin - Educational Use (2012)* [5]. Human DNA, suitable for use in schools, may also be available from molecular biology and school suppliers. The Human Tissue (Scotland) Act requires that informed consent is obtained from learners where they analyse samples of their own DNA. Although DNA sequencing in schools may be some way off, the amplification of DNA fragments by PCR may well be possible. Informed consent requires that learners should understand the purpose for which the DNA is being sampled and the implications for any issues that may arise from the analysis. Such consent must be voluntary and, as with any activity that involves learners as the subject of an experiment or investigation, they must not feel under any pressure to participate. Care must be exercised that the results of any such analysis do not reveal information about family relationships or other sensitive information such as disease susceptibility or sex chromosomes. In principle this is no different from the care and sensitivity that teachers exercise in the observation of inherited traits during genetics lessons. It is a case of avoiding inadvertently carrying out genetic or phenotypic testing which may reveal such sensitive information. In practice, teachers are often expert at surrounding such work with sufficient cautionary caveats such as experimental error and unknown genetic effects to alleviate such concerns.

Image courtesy of Ponsulak at FreeDigitalPhotos.net.

Practical work with learners' own DNA may also raise data protection concerns. Activities should ensure that any personal genetic information can be kept private to the individual concerned. Where class results are collated they should be done so anonymously in a way that is not reversible. Learners should be advised of the risks of revealing personal information through, for example, social media where a third party may make use of it. Again this is an area where teachers are often skilled at avoiding the inappropriate disclosure of personal information by learners.

Good laboratory practice should be observed when working with DNA and care must be taken to ensure that hazards from electrical equipment, buffers, stains for DNA etc., are understood and the risk of harm is adequately controlled. DNA itself can generally be regarded as not constituting a hazard. However, full length viral DNA that may be infectious in its own right or DNA extracted from calf thymus (which may harbour the infectious agent for transmissible spongiform encephalopathies) must not be used. Kiwi fruit (often used as a source for extracting DNA) is a potential allergen and should be avoided where known allergies exist; onion can be a suitable alternative source of DNA.

Further more detailed advice on the health and safety of working with DNA can be found in the revised (2014) Chapter 16 of *Topics in Safety* published by ASE [7].

References

[1] Genetically Modified Organisms (Contained Use) Regulations (2014), http://www.legislation.gov.uk/uksi/2014/1663/contents/made (accessed September 2014).
[2] Human Tissue (Scotland) Act (2006), http://www.legislation.gov.uk/asp/2006/4/contents (accessed September 2014).
[3] Data Protection Act (1998), http://www.legislation.gov.uk/ukpga/1998/29/contents (accessed September 2014).
[4] Health and Safety etc. Act (1974), http://www.legislation.gov.uk/ukpga/1974/37/contents (accessed September 2014).
[5] Materials of Living Origin - Educational Use, SSERC (2012), http://www.sserc.org.uk/images/Publications/Biology/SSERC-Materials_of_Living_Origin_Code_of_Practice.pdf.
[6] Safety in Microbiology, SSERC (2012), http://www.sserc.org.uk/images/Publications/Biology/SSERC-Safety_in_Microbiology_Code_of_Practice.pdf.
[7] Topic 16: Working with DNA, Topics in Safety, ASE (2014), http://www.ncbe.reading.ac.uk/NCBE/materials/microbiology/PDF/DNASafety.pdf.

Whole school risk assessments

SSERC has worked with Aberdeenshire Council to create some whole school risk assessments for nursery, primary and secondary schools. These are now on our website under *Health and safety > Whole school Guidance > Risk Assessments - whole school.*

A model risk assessment (RA) is no use unless you:

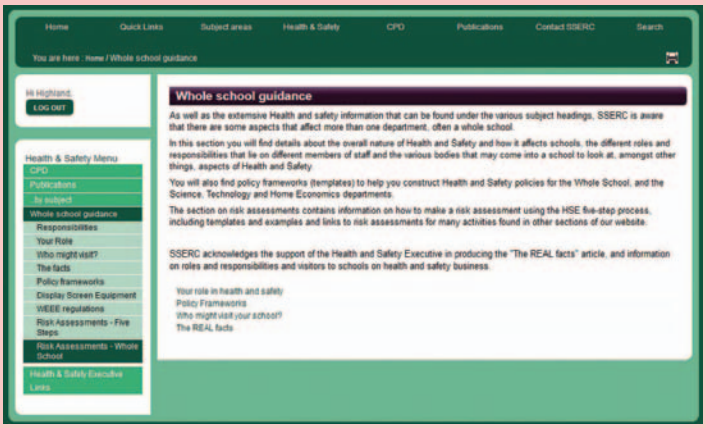
- Read it and modify it according to your own circumstances.
- Pass on information to users (pupils, teachers, support staff).

With respect to modifying the risk assessment according to your own circumstances, it is likely that rather than adding additional control measures, you will remove ones that don't apply. The model risk assessments have to cover all ages and abilities. Take the example of the litter-picking one. For younger children, it is entirely appropriate that somebody should check the area for broken glass and dog mess. For older students, they can simply be warned to avoid it or be instructed on how to deal with it safely.

When tailoring a risk assessment, consider:

- Who will be involved in the activity? What are their ages, abilities and behaviours?
- Where will the activity take place? Do you have the same facilities mentioned in the model RA?
- What resources are available for the activity? Do you have the equipment described in the model RA?

We strongly advise that you don't simply leave a risk assessment unmodified, thinking that it might be a bit over the top but at least it covers everything. Our experience with science risk assessments is that if hazards that are trivial for a particular age group are included, users become frustrated at what they rightly see as unnecessary measures. This can lead to health and safety not being taken seriously and a focus on the trivial can lead to big issues being overlooked.



Risk assessments and protocols

Some risk assessments refer to other documents designated as "protocols". This is to avoid extensive duplication. Rather than include the same manual handling advice in several risk assessments, for example, these risk assessments simply make reference to a manual handling protocol. Please note that the SSERC website www.sserc.org.uk has extensive information on health and safety in science and technical classes. This is referred to, but not duplicated, within the whole school risk assessments.

And finally...

Aim to be risk aware, not risk averse. If you want to do something, there's usually a safe way to do it.

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