STS

Scope includes Science, Technology and Safety

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Life begins in Fife

When we heard, some time ago, of plans by the University of Edinburgh to demolish our present abode, St. Mary's Land, it kind of concentrated our minds on looking for new premises. After innumerable false dawns we came to the conclusion that alternative accommodation in Edinburgh and the Lothians was either affordable or conveniently situated, but never both.

Therefore you may have heard that SSERC plan to move across the Firth of Forth to new premises at Unit 2, South Pitreavie Business Park, in the Royal Burgh of Dunfermline, which resides in the Kingdom of Fife (KY11 8UB). We were pleased to accept a lease from Fife Council for the premises you see above.

We have been able to customise the interior to suit our requirements and can now offer an environment, for our staff and associated projects, which is both pleasant and versatile. Downstairs we have a large Wet Lab, Clean Lab and Dry Lab, which have been fitted out by ESA McIntosh, a well-respected Kirkcaldy company that designs and manufactures educational furniture. The older of you may remember the excellent work they did at our previous Edinburgh premises at Bernard Terrace. Upstairs, we have most of the administrative offices as well as a large Meeting Room.

We are just 5-10 minutes walk from Rosyth railway station and at the end of the A823(M) spur off Junction 2 of the M90 motorway. Pitreavie Court is only 30 minutes by car from Edinburgh, less than an hour from Glasgow, 2 hours from Aberdeen and less than 3 hours from Inverness.

We would encourage advisers, council officers, teachers and technicians to seek us out. A phone call beforehand would make sure we're in and the kettle is boiled! Come and see what can be done for you at the new SSERC premises.

STOP PRESS NEWS - we hope to be moved to our new abode by the end of March 2006.

Prism experiments

After Newton's famous prism experiment was voted one of the top ten most beautiful experiments in science, we had to retry it and let you know what we found. In doing so, we discovered LSD.

Introduction

Every teacher of science has surely done the normal demonstration of splitting white light into a spectrum. Many will do this every year, and perhaps several times over with different classes. Given that it is one of the most commonly done experiments, it might seem so simple to do. Indeed, as a mark of this ordinariness, no-one has asked me about it in my 24 years at SSERC – until, that is, the recent Physics Summer Schools and IOP Stirling Meeting. There, teachers saw a spectrum produced with a white Lumiled source and prism in a SSERC experiment and commented: "That's a better spectrum than I've ever been able to produce. However do you do that?" That's one reason for writing about it. Another was the result of a poll conducted by the American philosopher and historian of science, Robert Crease, of readers of the journal *Physics World*, in which he is a regular columnist. Crease asked his readers to let him know which experiments they thought were particularly beautiful. (The question presupposes that beauty can be found in science or an experiment, but it seems that no one has disagreed with the presumptions.) The finding that an experiment by Newton with prisms was in their top ten is the second reason for writing about experiments with them.

So this article is about a very ordinary set of experiments and will show how spectra of great beauty can be made. The key is in knowing the role played by each of the optical parts. The highlight is the experiment Newton called his *experimentum crucis*.[1] Knowing that the experiment is not at all easy, Newton went at some length to give instructions on how it should be done. This is a third reason for writing this piece. And then there is LSD …

How to get a spectrum

White light from an intense lamp illuminates a vertical slit, which becomes the source in the optical system (Fig. 1). A converging lens focuses the image of the slit on a temporary screen, *C*, placed at about the same distance from the lens (700 mm) as the spectrum will eventually be. A 60° prism is placed in the radiation and turned to get the angle of minimum deviation. The spectrum on screen *AB* is also an image of the slit, extended by the dispersion of the colours. The prism and perhaps the other optical elements are placed on an A1-sized sheet of white card to show the rays of dispersed light.

The lamp is sited level with, or just slightly above, the working plane, giving the desired effects. With some types of lamp, for instance the Compact Light Source (Harris, B6H76839, £112), the working plane has to be elevated to make allowance for the size of the lamp housing. We therefore made a prism table from an A1-sized sheet of MDF (839 x 592 mm) resting horizontally on separate supports at a height of about 100 mm above the benchtop (Fig. 2). A sheet of white A1 card sits on the table on which the coloured rays from the prism are cast. Another white card is placed vertically along one side to show the spectrum.

1 In spite of the experiment's Latin title – it means the crux or crucial experiment - it is noteworthy that Newton's *Opticks* was written in English – unlike his other magnum opus *Principia*.

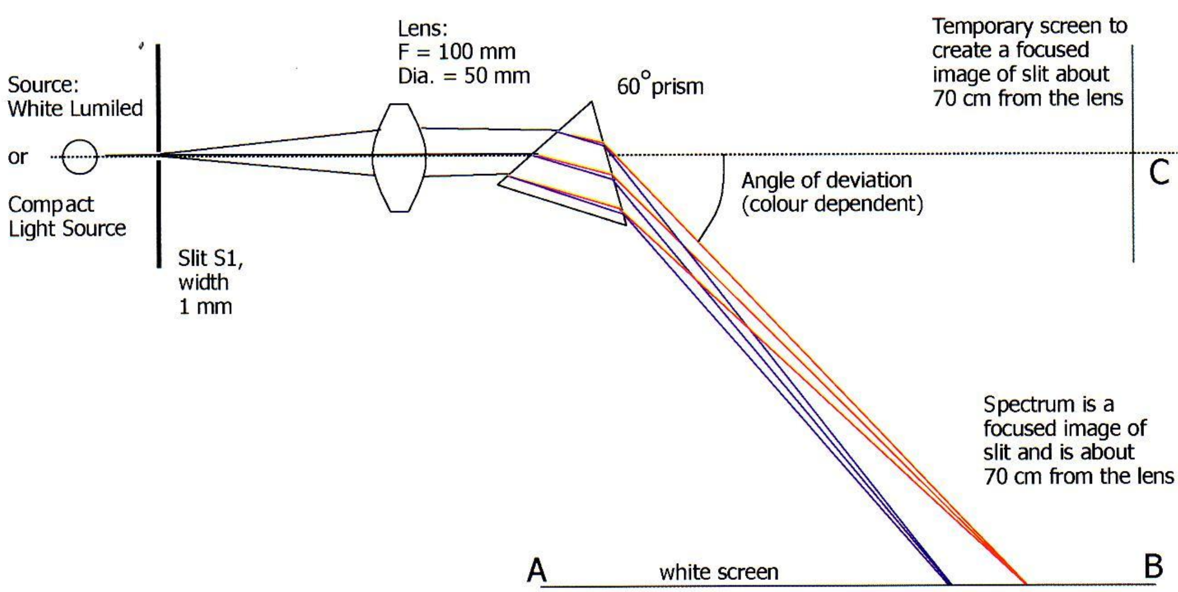


Figure 1 *Producing a spectrum with a prism: Ray diagram and the optical parts. Procedure: (1) With prism removed and a temporary screen at C adjust the lens to get a sharp image of slit S1 at C. (2) With prism in place, rotate the prism until the spectrum is as far towards B as possible, such that the angle of deviation is a minimum.*

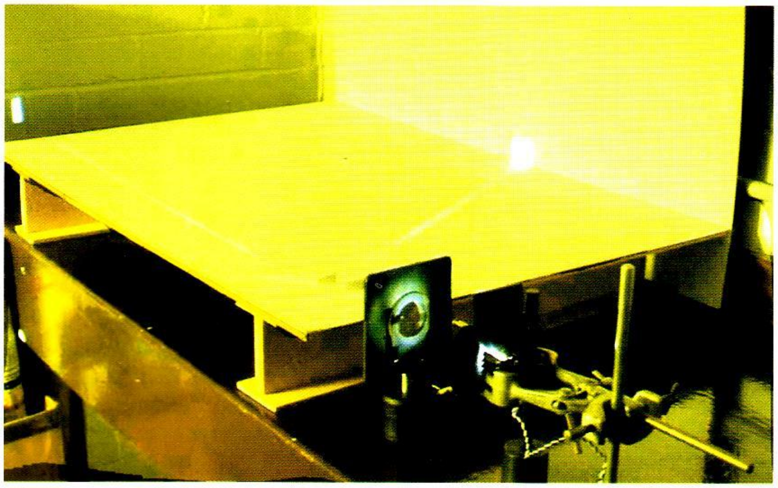


Figure 2 *The prism table with white, A1-sized card showing rays of light.*

The light source should be white with a significant blue-violet element. The new 1 W white Lumiled with optics is excellent for this job. Being physic-ally small, it can be operated on the worktop, there then being no need for a prism table. The radiation emitted by this source has a circular cross-section of about 12 mm in diameter and is roughly collimated, diverging only a little. Another suitable source is the *Compact Light Source*, which has a 12 V, 100 W quartz halogen lamp inside a large, rect-angular box. This needs to be used with a prism table because of its physical size.

The slit should be mounted vertically right in front of the light source. The best width is 1.0 mm, rather smaller than the width on some raybox slits (commonly 1.5 mm). If the slit width is wider than 1.0 mm, there is too much overlapping of colours resulting in the centre of the spectrum appearing as yellow and cyan, or even white, the green having merged with red and blue.

In fact the quality of the spectrum is a pragmatic compromise. The choice of lens (f = 100 mm) and image distance (700 mm) results in the slit's image being 6 mm wide at *C* (Fig. 1). The orthogonally transverse width[2] of the rays at screen *AB* is 50 mm, so, whilst there is some overlapping of colours, the amount does not noticeably spoil the spectrum. You would get greater colour purity with either a narrower slit or longer focal length of lens, but the colours would be less bright.

Our compromise depends on (1) the focal length of the lens, (2) the width of slit and (3) the refractive index *n* of the prism glass (Table 1) (Fig. 3 - opposite). For best results, so that all of the colours are vividly bright and well dispersed to be readily distinguishable, the slit width should be narrow (1.0 mm) and the refractive index high (1.7). We found that if the refractive index of the prism glass is only 1.5, as is the case with crown

2 The oblique width of the spectrum as seen at *AB* is about 60 mm with an SF-18 prism.

Prism glass	Slit width (1.0 mm)	Slit width (1.5 mm)
SF-18 glass, n = 1.7	Colours well spread out. The best results.	Slight overlapping noticed.
Flint glass, n = 1.6	Colours fairly well spread out.	Colours merge giving red-yellow-white-cyan-violet
Crown glass, n = 1.5	Colours merge giving red-yellow-white-cyan-violet	Colours merge giving red-yellow-white-blue. The poorest result.

Table 1 *The dispersion of colours in a spectrum is improved by having a narrow slit and high refractive index.*

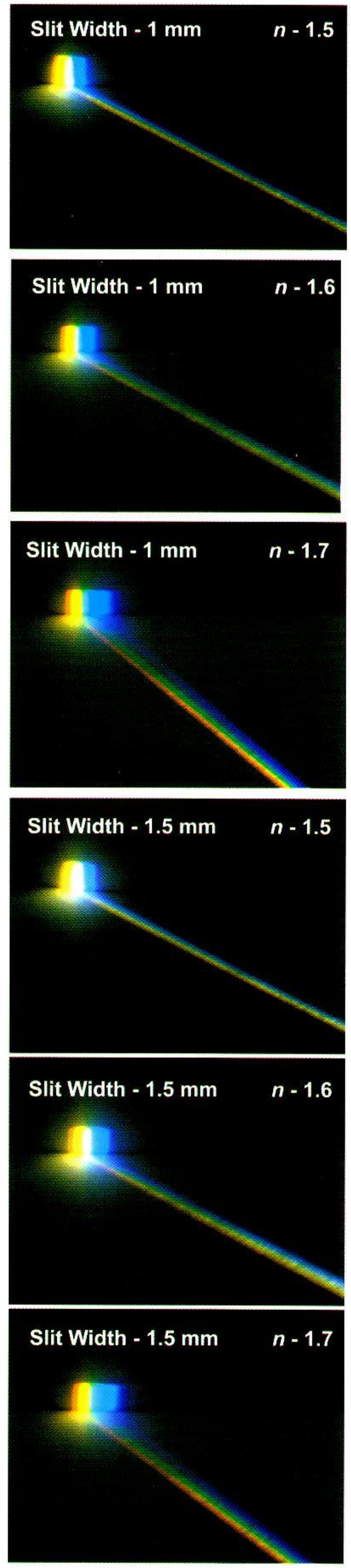


Figure 3 *Sets of spectra with various slit widths and refractive indices.*

glass, and the slit width is 1.5 mm, then there is so much overlapping of colours that the centre of the spectrum is white. We therefore recommend getting an expensive prism in SF-18 glass for a demonstration experiment.

The crucial experiment

Light is focused on a second slit, S2, placed about 100 mm from screen *AB* such that the path length from the lens to S2 is about 600 mm. Only one colour is transmitted through S2 (Fig. 4). When a second prism – an inexpensive crown-glass one is fine - is placed in this narrow beam (which is, of course, the refracted radiation of the first prism), no additional colours are produced (Fig. 5). What you see with the first prism is all you get. Refraction does not produce colours by magic. The experiment shows that it does not alter the nature of light. The colours seen are seen to come from the decomposition of white light. Thus white light, or sunlight, is a mixture of rays of different colours.

Please note that there are several other prism experiments requiring the use of two 60° prisms of the same refractive index:

1. If the second prism is placed in the refracted radiation from the first one, the colours can be recombined causing them to mix. This results in white light.
2. If the second prism is placed next to the first prism on the prism table, both with the same orientation, then when the experimenter looks through it at the spectrum on the screen, the colours have recombined producing white. What the viewer sees is a vertical white line.

Beauty in science

"Is science beautiful?" That was the question put by Crease. A well-made spectrum is indeed beautiful. But beautiful effects are superficial. And many scientific effects would not be beautiful to look at. Many experimental scientists work by guddling around in the laboratory, trying one thing after another. The more practised the experimenter, the more artful becomes his craft. This would seem to have been the way with Newton as he played with his prisms and lenses in an upstairs' room of his mother's house. He clearly got a thrill from solving the problem of the formation of the spectrum – the idea that it is an image of the slit extended by the spreading out of colours. He was also excited by seeing that what he had found out about the refraction of sunlight could be shown by one demonstration, the *experimentum crucis*. And from what he had discovered, he was able to explain the formation of the rainbow, and he was able to apply his knowledge in the design and construction of optical instruments. If there is beauty in science then it is because of the sequence of events, the artfulness of the work and the thought processes as much as anything.

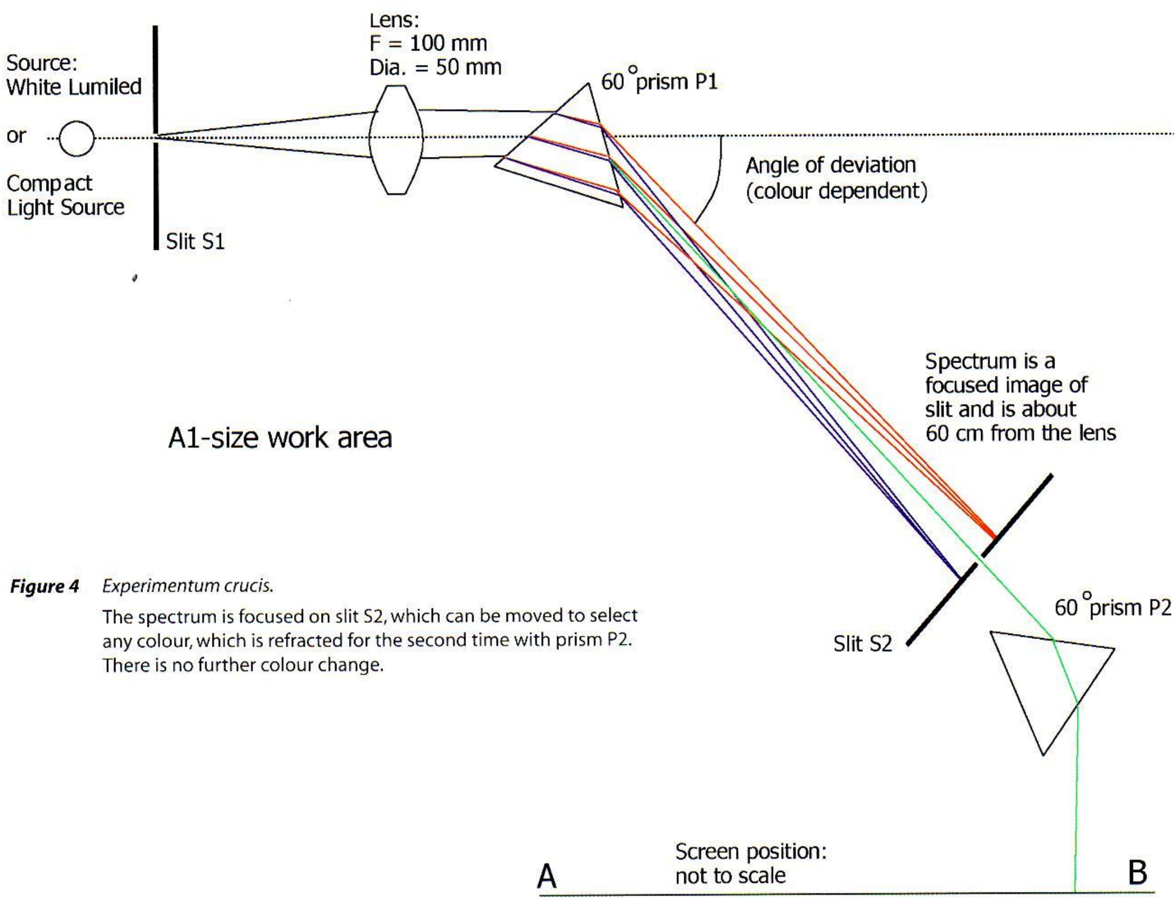


Figure 4 *Experimentum crucis.*

The spectrum is focused on slit S2, which can be moved to select any colour, which is refracted for the second time with prism P2. There is no further colour change.

Optical part specification	Supplier, part number, price, comment
Slit, 1.0 mm width	Philip Harris, B6G98647, £2.29 for 5, B6A44222, £2.74 for mixed set
Prism, high refractive index	SF-18 glass, n=1.722, Edmund, T43-498, £63.07 Flint glass, n=1.620, Leybold, 465 32, £28.74
Lens, focal length about 100 mm	This should be a cylindrical lens if working on the benchtop, but can be a spherical lens (50 mm diameter) if using a prism table.
Light source: white 1 W Lumiled	Lumiled Luxeon 1W Star with Optic (Low Dome Batwing) Enhanced-White LXH-NWE8, RS, 467-7519, £10.49. See Bulletin 212 for circuit diagram.
Light source alternative: Compact Light Source	Griffin, XGH-600-M, £207.50, Philip Harris, B6H76839, £112

Table 2 *List of optical parts*

The *Experimentum crucis*

An *experimentum crucis* is the crucial experiment or telling demonstration that makes a critical point. It gives irrefutable evidence of how things are.

We know quite a lot about how Newton worked. 1665 and 1666 were plague years. Newton, then a young Cambridge scholar, was forced to return to his mother's house in Lincolnshire, where he pursued his scientific studies in solitary confinement. He learnt much about optics from playing around with prisms and lenses. There is a lesson for us from that. We should allow children to play with apparatus. From play, we get a tacit understanding of how things are. It is an aid to sensory perception and the formulation of concepts. And it is from play that great thoughts sometimes emerge.

Some years later (1972) Newton wrote a discourse on light and colours which he sent to the Royal Society. The Society published it. It was his first scientific publication. This letter is regarded by historians of science as the prototype of the scientific paper. It contained practical details of his experiments, letting others see and copy what he had done, and gave his findings, letting them be argued over and confirmed or disagreed with. In presenting science in an open, non-dogmatic way and looking for, and getting, a disputatious response, it set the way that science has been conducted ever since.

In playing around with prisms, Newton had come to realize that what he had found out on

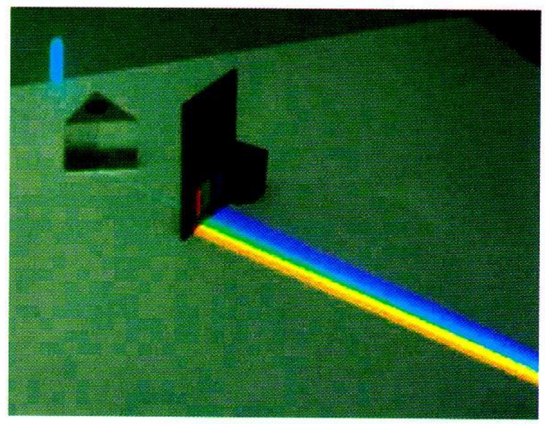


Figure 5 *Experimentum crucis.* Photograph of a second refraction.

light and colour could be shown with one telling experiment. At that time, prisms were thought to colour light by staining, as if, indeed, by magic. Indeed the word 'spectrum' was invented by Newton as a testimony of old beliefs; it comes from 'spectre', a ghostly apparition. In the *experimentum crucis*, light was refracted a second time, showing that refraction sifts rather than stains light and, in Newton's words, that "light does not change colour when it is refracted". Therefore it was evident that sunlight, or white light, had been decomposed into rays of different colours.

Further reading

Crease, R.P., *The prism and the pendulum: The ten most beautiful experiments in science*, Random House, 2003, ISBN 1-4000-6131-8.

Experimenting with LSD and a prism

Here are novel ways of recombining colours to get white light and making a brilliant, rainbow-coloured arc.

LSD is new – and not what you may think it is. More of a material than a gadget, the acronym stands for *light shaping diffuser*. If you think of a ground glass diffuser and its effect on light transmitted through it, LSD acts in a related sort of fashion. But more cleverly. It mixes light in the sense of diffusing it, but confines the diffused light within a well-defined beam that can be circular or elliptical in cross section. Depending on its specification, it will shape light into a narrow or broad beam either with no divergence or lots of divergence. As a result it is a superb tool for optical engineering.

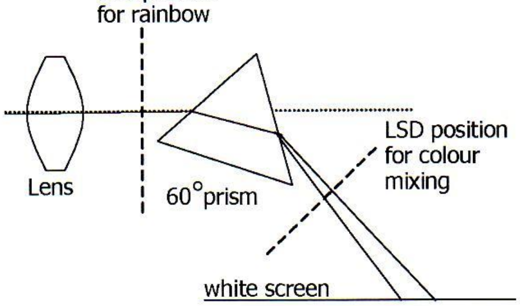


Figure 1 *Positions of LSD with respect to the prism and other optical elements to get the effects shown in Figures 2-5.*

For instance, suppose you were to use a prism to disperse white light into a spectrum from red to violet (Fig. 1). Then place the LSD in the dispersed beam creating zero divergence across the spectrum but lots of divergence perpendicular to it. This spreads out the spectrum vertically into a vertical spectral ribbon (Fig. 2). Now rotate the LSD, causing the spectrum to rotate to an oblique line. The more it turns, the more the colours mix producing white in its middle with outer fringes of red and violet (Fig. 3). After being turned through 90 degrees all of the colours become completely mixed and you see a horizontal band of white (Fig. 4). It is therefore a very nifty improvement on Newton's famous experiment where he split white light into a spectrum with one prism and recombined the colours with, some-times, a second prism, and, other times, a lens, to create white light again.

If the LSD is then placed in front of the prism such that the white light entering the prism has been shaped to be a diverging vertical ribbon, the light undergoes two rotations: (1) about a horizontal axis on passing through the LSD; and (2) about a vertical axis on passing through the prism. The outcome is an arc like a rainbow - the most brilliantly vivid rainbow I have ever seen generated artificially (Fig. 5).

In physical form, LSD is a plastic sheet one surface of which has the topography of computer-generated lumps and humps shaped to control the directions in which light is diffused - hence its name (Light Shaping Diffuser). It's not cheap, but SSERC has bought in some sheets of the stuff and cut it down to size for fitment within a 35 mm slide holder for convenient use by schools. We are selling these small bits at £4 a piece, roughly the same price as a low-cost ground glass diffuser. We think that it's a bargain. LSD is the sort of stuff that up until now you will never have wanted because nothing like it ever existed, but once you start playing with it, you realize how useful it is and it becomes indispensable. We can supply you with two types of LSD (Table 1).

Light-shaping nature of LSD	Spec.	Function	Suggested uses
Elliptical cross-section beam	40° x 0.5°	Generates a narrow wedge of diffuse light radiating from the LSD through an arc of 80°	Mixing a spectrum to produce white light. Artificial rainbow.
Round cross-section beam	10°	Generates a 20° cone of diffuse radiation diverging from the LSD	Directional diffuser. Cleans up LED radiation for colour mixing and other experiments.

Table 1 *Types of LSD stocked by SSERC. Supplied in 35 mm slide holder at £4 a piece.*

Figure 2 *Ribbon spectrum created with 40° x 0.5° LSD set up in the refracted radiation. The LSD's plane is vertical and orthogonal to the radiation.*

Figure 3 *Rotation of LSD in a vertical plane about a horizontal axis causes the spectrum to turn, mixing the colours. The central part has become white.*

Figure 4 *Further rotation of the LSD results in all of the spectral colours mixing, producing white.*

The artificial bow is the result of placing the LSD in the white light before it enters the prism. The upper part of the arc has lost its circularity because it has been cast on a plane screen.

Figure 5 *The artificial bow*

Other rainbows can be made by placing LSD after the prism and turning the plane of the LSD to an oblique orientation with respect to the optical radiation. It is possible to make a bow that circles back down to the horizon.

An Oscillating Reaction

Introduction

This oscillating reaction is known as the Briggs-Rauscher (BR) reaction.

The mechanism is very complex and involves iodide ions and iodine molecules. The species HOI is formed in one reaction and consumed in another. As its concentration rises and falls, it triggers oscillations in the I^- and I_2 concentrations. It is thought that the colourless solution arises when I_2 is low and I^- is high; it is yellow when I_2 is high and I^- is low; and blue when I_2 and I^- concentrations are both high (when both are high they form pentaiodide ions which gives rise to the blue complex with starch).

The reaction can be used in S2 to show changes in appearance due to chemical reactions (5-14 Guidelines, Science, Target ES-F3.2, Changing Materials, Level E; in Standard Grade, Intermediate 1 and 2 to show chemical reactions and in Higher to show a reversible reaction. It also makes an eye-catching demonstration for an open evening/parents' night and has the advantage of not depending on expensive transition metal catalysts for it to work. The oscillations can last for about 5 minutes.

What you will need

Chemicals

hydrogen peroxide solution, 100 vol.
manganese(II) sulphate mono-hydrate
sulphuric acid, 0.1M
potassium iodate
malonic acid
starch, soluble
distilled water

Figure 1 *Oscillating reaction shown at the start and the two colours evident when the reaction starts to oscillate.*

Equipment

conical flasks, 4 x 250 ml
measuring cylinders, 3 x 50 cm^3
stirring rod or magnetic stirrer with follower
balance (0.1 g resolution)

Preparation of solutions

Forget the complex recipes you may have seen elsewhere and follow this simplified one which we know works well. Always use distilled water as the chloride ions in tap water can interfere with the reaction.

Solution 1 - Weigh out 4.3 g of potassium iodate (OXIDISING, IRRITANT, HARMFUL) and dissolve in 100 cm^3 of 0.1M sulphuric acid (IRRITANT) in one of the conical flasks.

Solution 2 - Prepare 100 cm^3 of a 0.1% solution of soluble starch.

Weigh out 1.5 g malonic acid (OXIDISING, IRRITANT, HARMFUL) and 0.4 g magnesium sulphate and dissolve these in the cold starch solution.

Solution 3 - Prepare a solution of hydrogen peroxide by diluting 30 cm^3 of 100 volume hydrogen peroxide (CORROSIVE) to a total volume of 100 cm^3 with distilled water.

The demonstration

Measure out 50 cm^3 of each solution (1 to 3) in three separate measuring cylinders. Add them to a 250 cm^3 conical flask and stir with a stirring rod or magnetic stirrer. Once the solutions are mixed thoroughly, ask the students/observers to describe and record what happens and when.

Note - The preparation of the solutions and reaction should be done in a well-ventilated lab.

After the reactions have oscillated back and forth the solution remains as a blue-black mixture with the smell of iodine. Occasionally some purple fumes of iodine can be seen (HARMFUL & DANGEROUS FOR THE ENVIRONMENT). Care should therefore be taken if the demonstration is scaled up.

It is also possible to scale the reaction down. We have successfully used 30 cm^3 "disposable" universal plastic containers for 5 cm^3 portions of each of the three solutions. This allows the reaction to be carried out by individual students. Make sure the universal container has a screw cap to avoid spillage. Once shaken, the container can be placed on the bench and the oscillations studied dfor up to 5 minutes.

Invisible Writing

Introduction

There are many recipes for invisible ink. Unfortunately, most do not produce ink that is colourless, or convincingly 'invisible'. The following recipe uses everyday household chemicals and has the advantage over the more commonly touted versions in that the 'ink' really is invisible.

It is an excellent visual and fun demonstration for S2 Earth & Space – Changing Materials Level F.

For the chemistry courses, it can be used to show a colour change in a chemical reaction in Unit 1(ii) of the Intermediate 2 course, Unit 1(b) of the Access 3/Intermediate 1 course and in Unit 1 of the Standard Grade course.

Due to the toxic nature of aspirin and iron tablets (see below), the solutions should be made up by a technician. The bottles should be labelled as 'Ink solution' and 'Developer solution'. Dispense the 'ink' in quantities of 4-5 cm^3 (equivalent to approximately one dissolved aspirin tablet).

Equipment

measuring cylinder, 100 cm^3
beaker, 100 cm^3
beaker, 250 cm^3
mortar and pestle
filter paper
atomising bottles, 60 cm^3 - available from Scientific Chemicals - code BDP160020 at a cost of £21.85 pk10)
small 60 cm^3 screw top bottle
stirring rod
small paintbrushes
balance

Chemicals

Aspirin 'ink' solution
washing soda crystals (or sodium carbonate)
aspirin tablets, 300 mg
deionised water

Iron 'developer' solution
iron supplement tablets (must be ferrous sulphate type, 200 mg).
white vinegar
thin household bleach

The aspirin and iron tablets were purchased from *Boots* at a cost of £0.75 and £1.69 respectively. Washing soda and vinegar were purchased from *Asda* at a cost of £0.51/g and £0.47/500 cm^3 respectively.

Preparation of solutions

Aspirin ink

Add 2 g of aspirin capsules (about 7) and 5 g of washing soda to 30 cm^3 of de-ionised water.

Dissolve, with stirring, for approximately 1 hour and transfer to a jar. It can be used immediately. It lasts for up to a week.

Iron developer

Mix 2 g crushed iron capsules (about 10) with 125 cm^3 of white vinegar and stir to dissolve. Wearing rubber or plastic gloves and indirect vent goggles add 2.5 cm^3 of household bleach (Irritant). The solution should turn dark orange.

Transfer to an atomising spray bottle. This will keep for at least 2 months.

Pupil Experiment

Using a paintbrush write a message onto a piece of filter paper and leave to dry. A hairdryer can be used to speed up the drying process.

Place a newspaper behind the filter paper to absorb any excess solution. Spray the dried filter paper **lightly** with the developer solution and watch the message appear. Do not over soak the filter paper, as the message will blur.

Figure 1 *Equipment and chemicals for invisible writing*

Substance	Hazard	Control Measures
Household Bleach	Irritant solution. In contact with acids, or on heating, the toxic gas chlorine is evolved. Inhalation of chlorine is destructive to all mucous tissue.	Wear rubber or plastic gloves and indirect vent goggles. Open carefully as pressure may have built up. Do not warm.

Table 1 *Hazard and control measures*

Additional Safety Notes

Aspirin - The medical use of aspirin is already banned for under-12s, and guidance by the National Pharmacy Association in 2002[1] further advised that aspirin should NOT be given to children under 16 years, unless specifically on the advice of a doctor. This is due to a risk of Reye's syndrome, a rare condition that causes brain swelling and damage to the liver.

Iron supplement – Swallowing of iron tablets by children can be toxic if taken in large enough quantities[2]. The 10 tablets mentioned above could contain 600 mg of elemental iron. A lethal dose is estimated at between 180 and 300 mg per kg of body weight although serious effects[3] can occur at dosages over 60 mg per kg. The effects of iron toxicity are more severe in younger children but are dangerous to all age groups[4].

References

1. National Pharmacy Association press release, 2002.
www.npa.co.uk/publications/pressreleases/2002/nov.html
2. www.portfolio.mvm.ed.ac.uk/studentwebs/session2/group29/irontox.htm
3. Iron (pp133-137), Lithium (pp141-143), Mercury (pp148-149). In: Proudfoot AT. Acute poisoning: diagnosis and management. 2nd ed. Oxford: Butterworth-Heinemann; 1993.
4. Chapter 16: Acute metallic poisonings. In: Matthew J, Lawson AAH. Treatment of common acute poisonings. 4th ed. Edinburgh: Churchill Livingstone; 1979. pp129-138.

Chemiluminescence (cool light)

Introduction

Many chemical reactions, such as a candle burning, produce both light and heat.

It is rare for a chemical reaction to produce light without heat. A 'cool light' such as this can come from chemiluminescent reactions. A special, and perhaps familiar type of chemiluminescent reaction, which occurs in living organisms such as fireflies, is called bioluminescence.

The following chemiluminescent reaction uses luminol (3-amino-phthalhydrazide) solution and gives a blue glow that will last for several minutes. Luminol can be purchased from various suppliers (see below). Although it may appear expensive, only tiny quantities are required for each demonstration.

Chemicals

luminol
sodium hydroxide solution, 1.25M
hydrogen peroxide solution, 10 vol.
potassium hexacyanoferrate(III)
deionised or distilled water

Equipment

beakers, 2 x 250 cm^3
measuring cylinder, 250 cm^3
conical flask, 250 cm^3
filter funnel, glass
tubing, clear plastic (2 metres of silicon tubing of int. diameter 5 mm)
- The use of odd shaped vessels and curly tubes adds to the fun and interest. Ensure the plastic tube will drain any solution into the large flask without airlocks.
bottle, 2 litre plastic drinks
retort stand, bosshead & clamp

Preparation

To be carried out in the light

Dissolve 0.02 g of luminol in a little 1.25M aqueous sodium hydroxide CORROSIVE) solution and then dilute to 200 cm^3 with deionised or distilled water. This solution should be freshly prepared each time.

Prepare 3 x 0.45 g portions of potassium hexacyanoferrate(III) pre-weighed in small containers. This will give you enough for three tries.

Measure 180 cm^3 of the luminol solution into a 250 cm^3 beaker and 18 cm^3 of the 10 volume hydrogen peroxide solution into a second beaker. Add the potassium hexacyanoferrate(III) to the hydrogen peroxide in the second beaker and stir until dissolved.

Figure 1 *The expensive hi-tech (not!) apparatus. Blue dye illustrates the path the chemicals take*

To be carried out in the dark

Allow some minutes for the eyes to become adjusted and the pupils widened.

Slowly pour the luminol and the hydrogen peroxide/potassium hexacyanoferrate(III) mixture into the filter funnel simultaneously. They will react to give a blue glow that spirals down the tubing into the collecting flask.

Suppliers of luminol - Scientific & Chemical Supplies (1 g, LU005, £6.33), Griffin (1 g, A/3150/43, £9.53), (5 g, A/3150/44, £30.66) and Philip Harris (5 g, B6A68925, £33.43)

Disposal - Dilute the products of the reaction with copious amounts of water and flush to waste.

Chemicals, Hazards & Control Measures
Luminol powder **Hazards** May be harmful by inhalation, ingestion or skin absorption. May cause irritation. Avoid contact with eyes. **Control Measures** Avoid raising dust. Wear gloves and indirect vent goggles.
Hydrogen peroxide **Hazards** At 10 volume the solution still has the potential to irritate the skin, eyes & respiratory system. If preparing from higher concentrations of solution (e.g. 100 volume), the solution and vapour is corrosive, causing burns to eyes, lungs, mouth and skin. 20 to 50 volume is classed as irritant. **Control Measures** When using 100 volume hydrogen peroxide wear nitrile gloves and indirect vent goggles.
Sodium hydroxide **Hazards** Concentrated sodium hydroxide solution and solid are strongly corrosive. Very harmful if swallowed. Extremely dangerous to eyes. **Control Measures** For solutions of 0.5M and above wear indirect vent goggles and gloves.
Potassium hexacyanoferrate(III)-3-water **Hazards** Dangerous if heated or in contact with concentrated acids since it emits very toxic fumes of hydrogen cyanide and even with dilute acids if heated. Low oral toxicity since the cyano groupings are firmly bound. Irritating to eyes and skin. Dangerous if heated to decomposition. **Control Measures** Use eye protection and wear rubber or plastic gloves.

Table 1 *Chemicals, Hazards and Control Measures*

An aid to filtering protoplasts – the Buchanan filter

Introduction

This filtration method has been developed in support of the SAPS (Science & Plants for Schools) protocol *Protoplast isolation*. See the SAPS website for further details :-

http://www-saps.plantsci.cam.ac.uk/docs/protofusion.pdf

Protoplasts are cells which have had their cell wall removed, usually by digestion with the enzymes cellulase and pectinase.

Digestion is usually carried out after incubation in an osmoticum (a solution of higher concentration than the cell contents which causes the cells to plasmolyse).

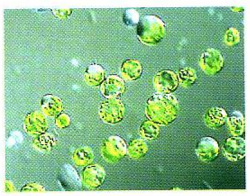


Figure 1 *Plant protoplasts*

This makes the cell walls easier to digest. Debris is filtered and/or centrifuged out of the suspension and the protoplasts are then centrifuged to form a pellet.

Protoplasts can be isolated from a range of plant tissues: leaves, stems, roots, flowers, anthers and even pollen.

Plant cell protoplasts are an important research tool, and, in school, present an interesting way of studying plant cell structure.

Buchanan filter

With this filter there is no need for the usual messy, untidy, waterproof sticky tape. 'Buchanan' comes from the name of our esteemed Technical Adviser - Ian Buchanan.

1. Cut the stem off a small plastic filter funnel (Fig. 2).

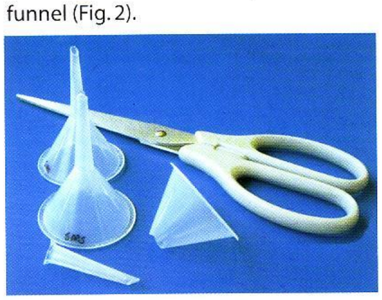


Figure 2 *Equipment required*

2. Use either a small glass or plastic filter funnel and a square of 60 μm mesh approx 60 mm square (Fig.3).

3. Push the 60 μm mesh square into the filter funnel (Fig.3).

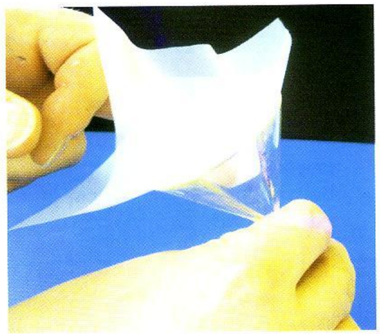


Figure 3 *Placing the mesh square in a glass filter funnel. Push down.*

4. Take the cut filter funnel and fit it on top of the mesh (Figs. 4 & 5).

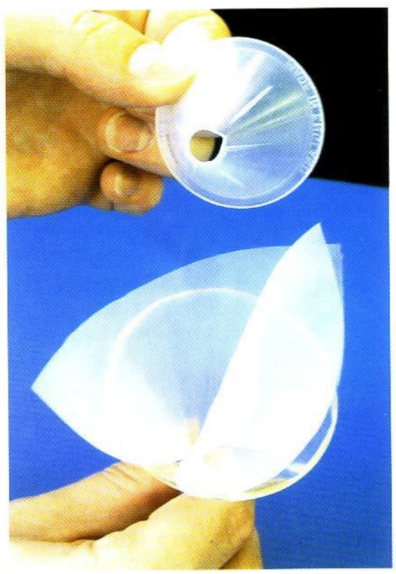


Figure 4 *Cut plastic filter funnel inserted*

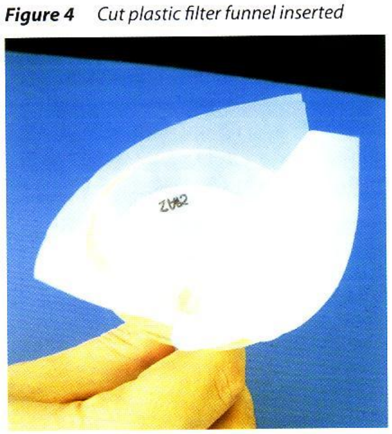


Figure 5 *Cut filter funnel in place*

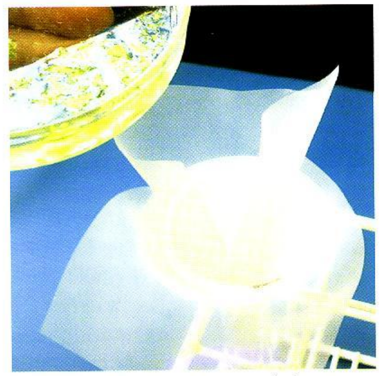


Figure 6 *Buchanan filter - ready for use*

Figure 7 *Protoplasts being filtered*

Use of Prestige Medical Automatic Autoclaves for media sterilisation

It has been brought to our attention that the Griffin education catalogue 2005/2006 states that Prestige Medical autoclaves are not suitable for media sterilisation. The range of automatic Prestige Medical autoclaves offered by Griffin and other suppliers do, however, provide effective steam sterilisation for educational microbiological work. While the temperature used (126°C) may damage certain constituents in some types of media, the types of media generally used for microbiological work in schools will not be adversely affected. Similarly, for disposal there is a fixed sterilisation cycle but this should generally pose no significant problems for school based work. Prestige Medical autoclaves are easy and convenient to use for both sterilising most media and disposal of microbiological waste. We thus continue to recommend their use in schools for these purposes. The taller model with the extended body is particularly useful.

Environmental Measurement

Market Survey - Inexpensive 'Eco-meters' (light, temperature and humidity)

Supplier & Description	Product Code	Price (£)	Notes
Scientific & Technical			
Soil pH meter	SOT 180 010	9.42	includes separate thermometer
Soil moisture meter	SOT 180 020	9.42	includes separate thermometer
Plant, light and moisture meter	SOT 180 030	12.80	-
Tenax Soil pH meter	SOT 060 010	14.35	pH 3.5 - pH 9.0 doesn't need batteries
Tenax light and moisture meter	SOT 070 010	14.35	dual range doesn't need batteries
Soil Meter 3 in 1 mini	SOT 130 010	7.93	soil moisture, light pH
Soil Moisture Meter Mini	SOT 130 020	6.05	soil moisture only
Soil pH mini	SOT 130 030	6.05	soil pH only
Philip Harris			
Soil pH meter	B6A63812	17.91	cf. Scientific & Chemical range
Light and moisture meter	B6A63824	23.00	as above
Combination pH, light and moisture	B6H71430	12.82	cf. Sci&Chem SOT 130 010
Soil moisture meter	B6A63800	21.17	
Griffin			
Soil pH meter	TUB-510-300B	12.40	
Soil moisture meter	TUB-510-310V	12.40	
Plant, light and moisture meter	TUB-510-320S	15.50	
Light and moisture meter	YUB-500-G	22.60	

Table 1 *Market Survey - Inexpensive 'Eco-meters' (light, temperature and humidity)*

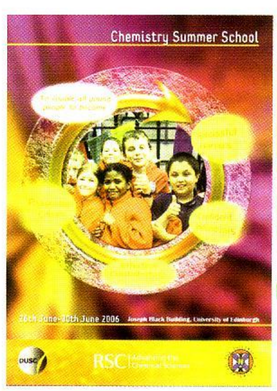
Many of the less expensive instruments can be found locally in DIY outlets (B&Q, Homebase) and Garden Centres. From these sources they tend to be even less expensive than the catalogue prices quoted here. These cheaper options are, as you would expect, not very accurate. A more expensive, but potentially more flexible option for the longer term, is the purchase of a simple datalogger such as LogIT Explorer or a Data Harvest Easy Sense Logger. Each of these costs about £170 including some sensors and software.

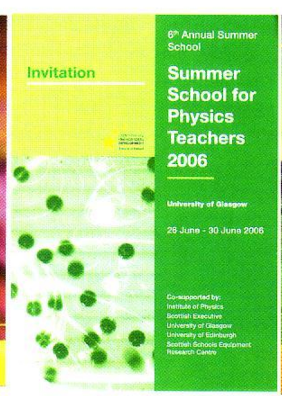
Summer Schools 2006

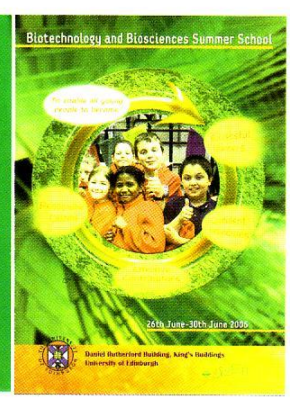
The Chemistry, Physics and Biotechnology Summer Schools will all take place on 26-30th June 2006. The Physics one will take place in the University of Glasgow this year. The other two will use the University of Edinburgh, as in the past. Each cost £190 if you book early enough.

Look out for the brochures and booking forms which have been sent to all schools in Scotland.

Contact SSERC for further details.







Revised lab safety guide

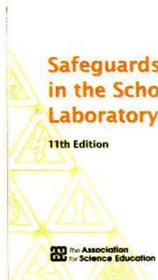
Safeguards in the School Laboratory, 11th Edition (2006), ASE, ISBN 0 86357 408 4

A new edition, the eleventh, of this hugely important little guide '*Safeguards in the School Laboratory*' (affectionately known as *Safeguards*) was published at the beginning of 2006 by the Association for Science Education (ASE). Its importance comes from the many jobs it does so well – an introduction to safety for the new teacher; a primer for the experienced hand; a daily reference for all. Its scope covers the school subject areas of biology, chemistry and physics. It also includes general matters like insurance, training, legislation, management, good practice, fire precautions, storage and first aid.

Need a set of laboratory rules? Here is one place that you will find them. What should staff do while waiting for a first-aider? The advice is provided. What preparations should be made to deal with spillages? Turn to 15.9. All of this advice can be found on SSERC's *SafetyNet CD* (free copy to each school in membership of SSERC), although some may find this alternative source of information to be handy.

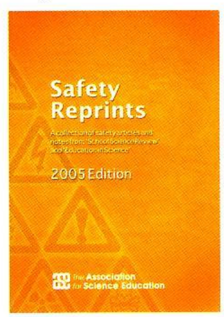
On every page is sound advice, for topics ranging from the commonplace to the peculiar. Every science department should have a copy; every science teacher should be dipping into it every other week. Non-chemists should read the chemistry bits. Indeed everyone should read those parts that lie outwith their own subject specialism.

Safeguards takes its name from the Safeguards in Science Committee, an ASE service group. SSERC was represented on the task group that revised *Safeguards*. However, some may feel that *Safeguards* does not fully represent the best advice from SSERC on every matter. It is, after all, a document which aims to serve the UK. The way that the differences between Scottish and non-Scottish affairs is handled in this publication is quite fair. For instance we differ from ASE over voltage limits, on which we take the view that limits should tally with expert advice. The outcome is a compromise reflecting the judgement of the Committee.



In spite of a few differences, we are pleased to endorse *Safeguards* as the best little guide to lab safety available.

So what's different from the Tenth Edition? Concerned that many teachers have become too safety-conscious, often to the extent that safety has become an impediment to practical work, the ASE would like to convey a toned-down message. Safety measures are needed for moral, ethical and legal reasons; but should not generally prevent pupils from doing experiments, or teachers from demonstrating more spectacular versions. Therefore the text has been recast to give as much encouragement as it can to lab work.



Then there are many detailed improvements. The law as it applies to school science is better understood. Although accidents and incidents are uncommon in any school, when they do happen, the results of what occurred, what the causes were, and how the events were handled, presents us with many lessons. The Safeguards' Committee has had another decade's set of events to learn from. So although much of the original text remains, there are many changes, mostly small, but expressing the collective wisdom of the writing team.

Companion publications

Despite having 142 pages, *Safeguards* calls itself a booklet, signalling to readers that its scope is limited to the bare essentials. It has many references to other sources of information, including ASE and SSERC publications. One companion ASE publication, now in its third edition, dated 2001, is *Topics in Safety*, about twice as large as *Safeguards* and more scholarly in tone. Another companion, newly revised, is *Safety Reprints*, a collection of safety articles and notes from *School Science Review* and *Education in Science*. This 200 page A4-sized document is well indexed, with its assortment of articles grouped into eight categories.

Safety Reprints is a most useful compilation of accidents and incidents that have occurred in the last thirty years. Many of the articles are quite punchy, particularly the one on mercury thermometers. To counter the myth of a ban, evidence and calculations are presented which leads to the conclusion, "if a thousand thermometers had been broken in the laboratory and no steps at all taken to clear them up or prevent evaporation, then there could be a problem". Enough said.

Safeguards in the School Laboratory and *Topics in Safety* are available for sale to SSERC Members at £12 and £17.50 respectively, inclusive of postage. *Safety Reprints* is available through ASE Booksales.

Publications

Safeguards in the School Laboratory, 11th Edition (2006), ASE, ISBN 0 86357 408 4 (£12)

Topics in Safety, 3rd Edition (2001), ASE, ISBN 0 86357 316 9 (£17.50)

Safety Reprints, 2005 Edition (2006), ASE, ISBN 0 86357 409 2

SafetyNet CD, 2006 Edition, SSERC - due for publication in the near future. Free copy to each school, currently in membership of SSERC.