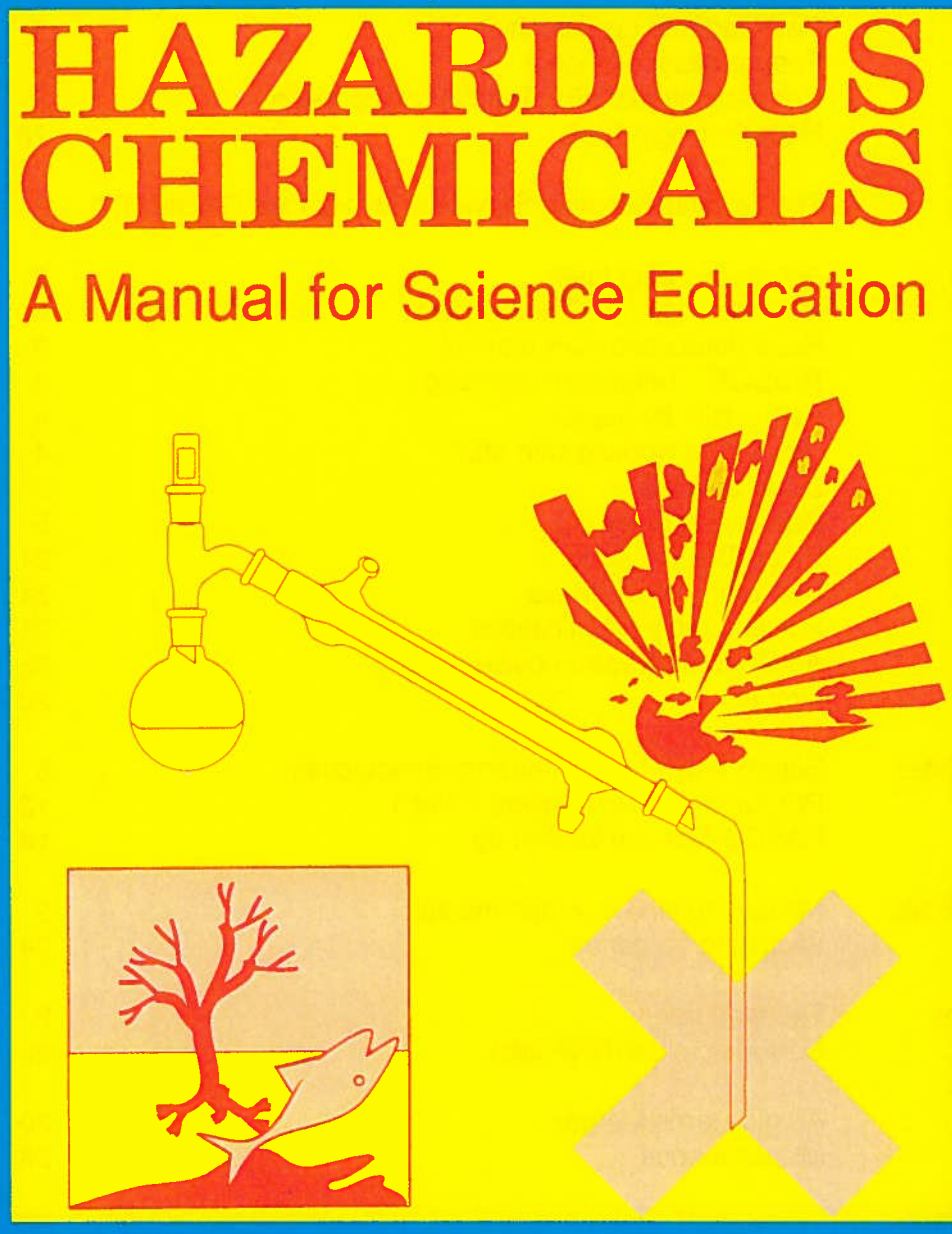
SCOTTISH SCHOOLS EQUIPMENT RESEARCH CENTRE

HAZARDOUS CHEMICALS

A Manual for Science Education



Science & Technology Bulletin

For: Teachers and Technicians in Technical Subjects and the Sciences

ISSN 0267-7474
Number 192

Autumn 1997

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Typeset by SSERC in Trinity and Homerton using Computer Concepts *Impression Publisher* DTP software, Acorn *!Draw* and 4Mation's *Vector*. The line drawings were originated in SSERC or compiled from elements of the *SSERC Graphics Library* by Ian Birrell and Jim Jamieson. Editor : John Richardson. Authors and sub-editors : Ian Birrell, Ian Buchanan, Allen Cochrane, Jim Jamieson. Technical support : Marjorie Hamilton and Graeme Paterson. Circulation manager : Anne White.

NEWS AND COMMENT

We have the technology!

And, now not only but also - the anoraks! As promised in Bulletin 190 we hereby announce our e-mail thingy :

sserc@mhie.ac.uk

We are piloting pages on a Web site also - see Address List inside rear cover. If you wish to contact us by e-mail you best hurry up before we learn to do what nearly everyone else seems to us to do with electronic mail - ignore it!

No, we didn't mean that last bit. Fairly soon electronic communication may be just about the only game in town. We are already involved in "SOLSN" which stands for "Science on Line Support Network". SOLSN is at present only a pilot project - a feasibility study with a restricted number of schools taking part. For more detail both on this pilot network and on broader aspects of the potential educational uses of the *Superhighway* or the National Grid for Learning see the article by Stuart Robertson HMI in the enclosed copy of "Scottish Science Issues".

Dates for the diary

The dates for a number of Scottish science education gatherings in 1998 have already been announced. Indeed the venue for the 1999 ASE Scotland shindig is Aberdeen - already. These folk are getting far too professional and efficient for our taste (but then our preference for the Organic Slovenly school of management is weel kent). The key 1998 dates and places are :

ASE Scotland Annual Meeting : 6-8th March 1998 Forte Posthouse and Park Mains High School, Erskine.

Institute of Biology : Third Annual Education Meeting Thursday 14th May 1998 : University of Stirling.

Institute of Physics 24th Annual Education Meeting Thursday 21 May 1998 : University of Stirling then followed by a two day Physics Update - Conference Centre Heriot Watt University on 22nd and 23rd May.

Royal Society of Chemistry National Meeting for Teachers : Thursday 21 May at the University of St.Andrew's.

Again, further details including the names and addresses of the relevant contacts are to be found in the enclosed copy of SSI. For convenience the latter are listed also on the inside rear cover. A copy of the programme and a booking form for the 1998 ASE Scotland are also enlosed herein.

The 1997 AGM of the Technology Teachers' Association (TTA) is imminent as this edition goes to press. As far as we know, the date and venue for the 1998 meeting have yet to be set. When they are to hand we shall announce them also in a Bulletin issue.

Micromouse

No - not a nutritionally challenged scion of a famous former member of the Scottish and Lions' front rows but the IEE[1], TEP[2] and University of Manchester annual robotic competition to be staged in June 1998. The aim of the exercise is to design and make a self-contained robotic device capable of negotiating a maze and then to progressively develop its ability to compete in achieving the shortest possible time to the maze centre. The main competition has three classes or categories : Teenage, Intermediate and Advanced. A Technical Information Pack with basic design data is available at £5.75.

Running alongside the main championship will be a Schools' Micromouse Competition organised by the IEE. A free Teacher's Resource Pack is available to interested schools who should contact Rose Pride at the IEE (see Address List, inside rear cover).

1. IEE - Institution of Electrical Engineers
2. TEP - Technology Enhancement Programme

Postgraduate opportunities

Research opportunities in technological education are now offered by the Robert Clark Centre for Technological Education within the University of Glasgow. PhD or MSc degrees may be pursued on a full or part time research and thesis basis and scholarships may be applied for. Entry requirements are a good degree (First or Upper Second) in technology or related disciplines, education, psychology or sociology etc. Further details are available from Dr Gordon Doughty at the Robert Clark Centre (see Address List).

Hazardous Chemicals manual

The new STS/SSERC Hazardous Chemicals Manual for Science Education is now available for purchase. For details of prices, and our other conditions of sale, please see the Safety Notes section of this bulletin.

Festive season closure

Please note that SSERC will close over the Christmas and Hogmanay period with effect from 13.00 h on Wednesday 24th December and re-open for business on the morning of Monday 5th January, 1998.

Guest article

Gregor Steele (alias Phil Harrass, Private Inspector) was given an honourable mention in the Technicians' News bit of the last issue of the Bulletin. He then kindly sent us copies of some of his other TESS pieces relevant to science and technology. One of which we are now, with his and the TESS's permission, reprinting (over).

The Special Teaching Service

Phil Harrass Private HMI

I'd called in at Royal Terrace ostensibly to find out whether the Special Teaching Service, the GTC's covert operations division, had any work for me. Finding no one who could help, I decided to visit *Q* in the basement.

I liked the short tempered, old ex-science technician and he didn't seem to mind my company so long as I didn't look like damaging any of the devices he'd invented to make life easier for teachers.

"Ah, morning Harrass," he said. "Been abducted by aliens again recently?" "Keep quiet about that, I said. "You're the only one who knows. What's this?" I pointed to a white metal cabinet with an LED display and some push buttons on it.

"It's a microwave toilet roll tube sterilizer," he said. "Means the children can still use them for making things without getting worms or gastro-enteritis." I moved on. "And this? Some sort of weighing machine?"

"It's an 'I speak your appraisal' unit. You stand on it, type in your targets for the coming year and it talks, then produces a print out." "Can it really assess a guy?" "Of course not, but it has one advantage over conversational appraisal. Watch." He put an old packing case on the machine, flipped the top of a control stick and pressed a red button. The case shot through a hatch in the ceiling. "This method actually gets rid of the bad ones," he said, briefly displaying his rare smile.

"Who presses the red button?" I asked. He did not answer but led me to a console with a whole bank of red buttons, each with a name under it. "This is a Foul Air Reduction Terminal," *Q* explained.

"If a teacher has trouble with a persistently flatulent pupil he can push one of these switches and activate an electronic sparker under the seat..." "Stop!" I yelled. "I've heard enough! "Have you nothing to show me that isn't violent or scatological?"

Q pursed his lips. "There's this," he said, indicating a tall cupboard. He opened it up. Inside was what looked like a shop dummy dressed in black shoes, grey trousers, a blue shirt with matching tie and a grey sports jacket. "It's obviously supposed to be a physics teacher," I said. "but what's it for?"

"It's our latest aid for the 5-14 Environmental Studies programme," *Q* replied. "It uses the same speech chip as the appraisal machine but it's had a lot of phrases fed into it to help primary teachers with science. "How do you turn it on?" "Pull his tie."

I did so. The robot physics teacher clicked and whirred as it tilted its head downwards and raised a finger. "*Ach, listen hen,"* it said, *"just leave it to us at the big school. We'll tell you what they need to know for doing science in first year.*"

It's hard to talk when your jaw is on the bottom deck but I tried. "What the h. . . use is that?" I pulled the tie again. "*It's important you lassies who've never done science don't go filling your weans' heads with nonsense*" said the robot physics teacher.

"Oh, it's not a teaching aid," *Q* shook his head vigorously. "It's a stress relief device. It's got a detachable head and comes complete with a baseball bat." I joined in the headshaking. "Time to get out of Denver," I sighed, waving without looking back.

Acknowledgements

We are very grateful to Gregor and to Willis Pickard, Editor of the Times Educational Supplement Scotland (TESS) for granting copyright clearance. A slightly shorter version of the piece first appeared in Gregor's TESS column. Given the change of educational climate he not surprisingly gave up his Phil Harrass alter ego for a while. He still has a fortnightly slot in the Scots bit of TESS. This, especially for starting the Friday (or Monday) cheering up process, is always worth a read. And, recently Phil Harrass HMI has come out of retirement.

When he isn't being Phil Harrass HMI, or a somewhat less covert columnist, Gregor Steele teaches -physics - among other things. He tells us that the above piece was partly inspired by a visit he paid as a PGCE student to SSERC's old Broughton Street premises. We particularly like the 5-14 Environmental Studies references. So, be warned - secondary scientists (especially yous physicists). If the tie fits, better watch out for the bats. And, no, we are not about to run any kind of competition along the lines of "Identify the real-life Q".

* * *

SAFETY NOTES

Accessible plug fuses

All types of moulded 13 A plug will have a fuse which, because it is accessible, can be tampered with. In this respect they are unlike 13 A plugs that are wired by hand. The fuse in most types of conventional plug can only be reached by removing the plug top. These fuses are thus not readily tamperable with.

Because much new electrical equipment is now fitted with moulded 13 A plugs, there is a risk that children may remove the fuse, or replace one fuse type with another, or substitute some other conductor into the fuse carrier.

We have had a report from a single school that this sort of abuse often takes place. This report indicated that one child had learned from another. The habit may spread.

In discussing this problem with a major manufacturer, however, we are relieved to learn that no one else has reported this problem. It may be that this habituated form of abuse is isolated to a small number of, schools. If a school should be affected significantly by this problem, there are two ways of prevention, neither of them being other than a nuisance in themselves :

- replacing the moulded plug with a conventional hand-wired plug that does not have an accessible fuse; or
- gluing the fuse permanently into the fuse carrier in the moulded plug.

The latter, fairly drastic, action should only be taken if experience indicates that the fuse is unlikely to blow. Once a fuse carrier has been fixed by glue, the entire plug has to be replaced if it subsequently blows.

Polarity fault on IEC connectors

We have been notified by Renfrewshire Council School Technician Service that, out of a sample of 14 detachable mains cords, they have found 5 which had wrongly wired IEC connectors, i.e. reverse polarity live and neutral. These faults originated at the place of manufacture. None of the cord sets has a recognisable manufacturer. Most are thought to be aged. They seem to originate from different places. We do not know if this fault condition often occurs having never previously come across it. And the HSE electrical inspector we wrote to had not heard of this fault either. We have followed it up by testing about 40 other cord sets. None of our sample was faulty. However another council has tested a relatively small number and found one cord set with reverse polarity.

In reacting to the problem we recommend that, at the next sensible opportunity, each cord set should be tested for correct polarity. Such a test should be made either with a portable appliance tester that has this facility, or with the continuity function of a multimeter. If anyone doing this test is in any doubt, please contact the Centre and we will be pleased to advise. An appropriate time for conducting the test would be the occasion of the next routine periodic inspection or test of equipment.

There is also potentially a polarity fault in every 13 A moulded plug. We have discussed this with an equipment manufacturer and learn that checks are not carried out by his company. In other words the manufacturer trusts that the maker of moulded plugs gets the polarity right. We, the users, trust so too. Because we have no evidence of polarity faults in moulded plugs, we do not at this stage think that you should carry out checks on them too. In our own equipment proofing tests, we routinely do check the polarity of moulded plugs. None have yet been wrong.

* * *

Hazardous Chemicals Manual

The SSERC Hazardous Chemicals Manual for Science Education is now on sale. The price to schools in Scottish Authorities which are currently in membership will be £50 per copy for one to five copies with a 10% discount on orders for six or more per order (some Councils or schools having declared an interest in purchasing multiple copies).

In addition the privileges of membership will include a degree of copyright waiver within any purchasing institution. FE College members and other Scottish subscribers will enjoy the same terms.

The price to non-members will be £120 per copy with no discounts and strict copyright conditions. All buyers will be given the opportunity to register their interest in receiving updates. Again members will be offered a special rate for this service.

* * *

RIDDOR : Telephone reporting

If you are in school management it may be your responsibility to report accidents at school under RIDDOR '95 (Reporting of Injuries, Diseases and Dangerous Occurrences Regulation).

Now reporting is even easier. There's no form filling; the paperwork is done for you. All you have to do is call the Scottish Accident Report Line Direct which has been set up by HSE with the support of COSLA (see inside rear cover for the number). Whilst there is no form filling with this new method of reporting, it remains essential to make a written report for your own school's records as soon after the event as possible. Furthermore the responsible person is required by Regulation 7 of RIDDOR to keep records of particulars specified in Schedules of the Regulations.

* * *

SAFETY NOTES

Farm visits by school pupils

Authoritative advice to teachers on farm visits by school parties has been prepared by, and is available from, The Scottish Farm and Countryside Trust (see inside rear cover for address). The Trust has published a six page A4 leaflet on guidelines for teachers on farm visits. Other publications and a video relating to farm visits are listed below.

Preventing Accidents to Children in Agriculture, which is the HSE ACoP (Approved Code of Practice) on this subject, is currently being revised. Whereas the existing Code is very prescriptive, we understand that the new version is much less so. It describes the goals to be achieved through risk assessment and management, whilst also providing specific and detailed advice. Copies of *Proposals for the revision of the Agriculture (Prevention of Accidents to Children) Regulations 1958 and Approved Code of Practice* CD 121 are available free from HSE Books.

Other useful and relevant references are :

Never at rest, a farm safety video for pupils, teachers and farmers. (It is recommended that the video is viewed to ascertain suitability before showing to pupils.) Available on free loan to schools only from : FCL Vision.

Accidents to children, AS 10 HSE (free publication)

Preventing accidents to children in agriculture Approved Code of Practice, HSC
ISBN 0 11 883997 7

Zoonoses in agriculture, Agriculture Information Sheet No. 2, HSE (free publication)

Teaching Pack Farm Safe ABC, SRJ Distribution (produced by the HSE)

Risks from working with Medium Density Fibreboard (MDF)

Following recent press stories about working with MDF we contacted the HSE to find out whether the advice we had been providing on the subject is still sound. We are reassured to find that it is; although it should be noted also that HSE has been reported as embarking on a two year study into the problem.

Machine working MDF does generate a lot of fine dust. There must be effective control measures in place to reduce the aerial dust concentration to as low a level as possible below the exposure limit. Another hazard is the possible evolution of methanal (formaldehyde). We understand that the HSE have investigated the level of methanal vapour in the air during the machining of MDF. To date they have found that levels were well below currently acceptable occupational limits in the UK.

Pending the reporting of the HSE review here is our interim advice, in the formulation of which we have consulted with the Employment Medical Advisory Service of the HSE and with our sister organisation CLEAPSS.

1. Provided that normal suitable and sufficient control measures are taken, the risk from using, handling, or working with MDF board in schools or colleges is unlikely to be great.
2. Working with MDF board with machine tools such as saws, routers or sanders, or even hand sanding, creates a lot of dust, the finer parts of which are respirable. Therefore effective local exhaust ventilation (LEV) must be provided and used.
3. The MEL for respirable dusts is 5 mg/m^3 and levels must be kept below this concentration. No ill effects have been demonstrated in people whose exposure is kept below this level when working with MDF board.
4. Because the best of LEV fails to capture all of the dust, people in the workplace must wear a disposable mask which conforms to FFP2S (the standard for disposable masks). See for example the RS catalogue, stock no. 406-903.
5. Methanal (Formaldehyde) levels are thought currently to be a problem only in the manufacture of MDF boards and therefore not of concern in schools.

   It is also considered by HSE that methanal is unlikely to be evolved during sawing, sanding or routing unless very unusually high temperatures are reached.

   Methanal vapour levels are also seen by HSE and others as unlikely to rise to an unacceptable level during the storage of MDF boards unless they are heated in a room without ventilation or in the event of a serious fault in their actual manufacture.
6. Small scale work such as drilling or sawing by hand or small amounts of drilling on a pillar drill is unlikely to raise a significant amount of dust. No special protective measures are needed if the scale of work is small and of relatively short duration - other than providing good, natural ventilation and cleaning the work area and work piece with a damp cloth.

* * *

SAFETY NOTES

Laser pointers

It was clear, even several years ago, that miniature laser products using semiconductor diode lasers would become widely available at low cost. This was one of the underlying reasons for SOEID's commissioning us to research and draft Circular 7/95 [1] on controlling the use of lasers in Scottish schools and in non-advanced work for FE.

The first instance reported to us of a child bringing a laser pointer into a school was in January 1996, not long after Circular 7/95 had been published. We had several more reports last session and by this October, we were getting such reports on a regular basis. Matters came to a head with growing numbers of accounts in the press of children using lasers as toys, and much worse.

We contacted NRPB, the government agency responsible for advising on dangerous radiations. They relayed our and their concern to the DTI, who, as a result of this and other similar approaches, have instructed Trading Standards Officers to pursue, with a view to prosecution under the General Product Safety Regulations 1994, any vendor of a Class 3B laser product to a member of the general public.

We also contacted the City of Edinburgh Trading Standards Office. They responded immediately by impounding laser products from city stores, which they took to Heriot Watt University for testing. What they found was disturbing. Typically the product packaging was marked Laser Class 2; the laser device was marked Class 3A; but the tests revealed that the device itself was a Class 3B laser. The labelling was found to be unreliable. Most of the products on sale were shown from testing to be Class 3B. NRPB have also tested laser products from High Street shops and confirm this finding.

Confusingly, in the way laser products are marked, there is an inconsistency between the American and European systems of classification. Some lasers denoted as 3A in the USA are classed as 3B in Europe. However we understand that both systems are consistent with their definitions of Class 2 products. We have the assurance of NRPB that no Class 2 product has been found to be wrongly classified - apart from the mis-labelling of packages found by Trading Standards Officers.

At the time of writing this note, it looks as though neither Class 3A nor 3B products will remain on the general consumer market much longer. NRPB have recommended to the DTI that laser pointers for public sale should be restricted to Class 2 only. In the opinion of NRPB they do not need to be more powerful than that for normal audio-visual applications. From Press Reports in Scotland, the NRPB's recommendations would seem to have the backing of the relevant Scottish Office Minister.

We would like to thank the many schools who contacted us about this problem. We trust that the action being taken by the authorities will be sufficient to control such misuse of lasers. However it would be comforting to know that even the sale of Class 2 lasers was to be restricted to *bona fide* users. The controls in Scottish schools would seem to be appropriate and sufficient. The SOEID Circular [1] makes its clear that the use of lasers for educational purposes in Scottish schools and in non-advanced FE is restricted to Class 1 and 2 devices.

1. Circular No: 7/95 *Guidance on the use of lasers in laboratory work in schools and colleges of education, and in non-advanced work in further education establishments*, SOEID, 1995.

Dangerous fuses

We have been informed that Trading Standards officers have identified that 13 A fuses manufactured in China and labelled PMS may explode under overload conditions. This may shatter the plug-top, or blow it out of its socket. These fuses are currently on sale within the UK for use in 13 A plug-tops, fused spurs and other electrical equipment and do not comply with BS1362.

We understand that PMS fuses supplied over two years ago were manufactured in the UK, comply with all British Standards and are not implicated by this warning. They can be identified by a dog tooth pattern printed on the ceramic part of the fuse near the metal end cap, or a trade mark consisting of a circle with the letter *A* inside it immediately after the BS1362 label.

We further understand that it is only 13 A rated fuses that fail to comply with BS1362. No problems have been found with 3 A or 5 A rated PMS fuses.

Action

Schools should check 13 A fused equipment, including spur outlets and stocks of fuses, as soon as practicable. Since the majority of portable appliances should be fitted with 3 A or 5 A rated fuses, only relatively few items need be so inspected. The sensible action would be to include these checks during routine portable appliance testing, which may incur some delay.

For further help on the recognition of the dangerous fuse type, please contact the Director of the Centre.

EQUIPMENT NOTES

SUPER! WOW! NEAT! AMAZING! SPECTACULAR!

These are the words that Educational Innovations Inc. use to describe their products. We thought we would have a look for ourselves.

Educational Innovations Inc. is a US mail order company specializing in inexpensive, wacky, science materials for jazzing up a lesson or demonstration. It provides out-of-the ordinary stuff that standard suppliers might not stock.

Soda bottle science, centre of gravity kit, Stirling engine, gyro ring, memory wire, world's simplest motor, catalytic combustor, piezo popper kit and a singing pipe - have they been looking through old SSERC Bulletins?

Other stuff includes wind bags (us again!), solar bags, gro-beasts and water absorbing polymers, water gel crystals, a levitation top, thermochromic paper, crystal garden set, Cartesian divers, polarizing filters, plastic mirrors, a marbling kit, chemical lightsticks, polyethylene pipettes and a Kelvin water drop electrostatic generator.

There is material for science clubs, technology projects and science experiments. It's up to you, the teacher, to capture a child's imagination! Here is stuff to help.

The catalogue has four pages on *Nitinol Memory Wire* projects. Pliable at room temperature, if heated above a transition temperature the wire hardens and assumes a previously set shape. One application is *Muscle Wire*. This contracts about 5% in length when heated. When cooled under tension it returns to its original length. The technique can be employed as the propellant, or prime mover, in dynamic models. Construction projects applying *Muscle Wire* include a model butterfly that flaps its wings, an airplane launcher, mouse-trap car and egg dropper.

We bought a few products to try for ourselves. Each had accompanying notes, which we found to be generally sufficient. Here is what we got.

Windbag

The package consists of four tubes of lightweight, coloured polythene, each tube being over two metres long and 20 cm in diameter. The question presented is, "How many breaths does it take to inflate the tube - assuming one end is sealed?"

There is an easy way to do it, of course. But it can wait until many in the class are red in the face and out of puff.

The obvious, but wrong, way to inflate the windbag is to seal the polythene to your lips as if you were blowing up a balloon. Then all of the air entering the bag has to pass through your lungs. This takes lots of breaths.

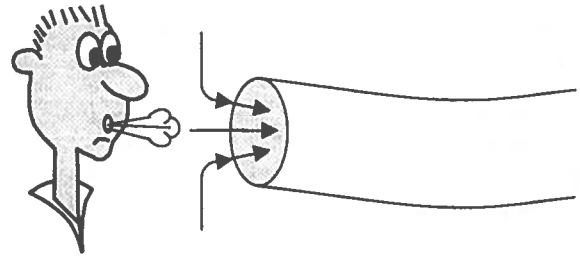


Figure 1 How to inflate a Windbag.

The nifty way, thanks to Bernoulli, is to keep your mouth several inches distant from the opening of the bag. One big breath, and the whole bag inflates. Because the fast moving airstream is at a lower pressure than the surrounding air mass, a lot of extraneous air gets dragged into the airflow (Fig. 1). Provided you can sustain the exhaled breath for about 10 seconds, this is sufficient for full inflation.

Solar Bag

The Solar Bag is a tube of extra-lightweight black plastic, 50 feet long and 2 feet in diameter. It should be used outdoors on a finely cut, grass playing field, or a grit-free, tarred or metalled surface. Having first tied one end, it is partially inflated by running with the other end held open. If the bag is sealed and left in bright sunlight, it starts to float after about five minutes. It works best on a cool sunny morning.

If the mass and volume of the bag are measured, along with ambient air temperature and time to float, you should be able to estimate the solar constant - the power per square metre of incident solar energy.

In a simpler context, with a junior class, it is an effective demonstration of solar heating and the expansion of air with temperature.

Astro-Blaster

Four balls of a lightweight plastic material are threaded on a rod. When dropped on a hard surface, the top ball can rebound to a height equal to about five times the original drop (Fig. 2).

We tried it out in a stairwell. If dropped 2 m, the top ball was projected to a height of 10 m. From what height should it be dropped to escape to outer space?

cont./over

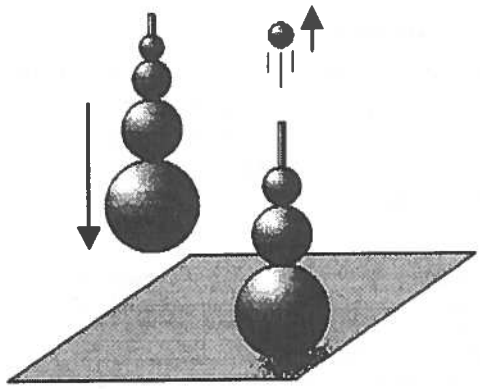


Figure 2 The top ball of the Astro-Blaster rebounds to five times the height dropped.

There is an astrophysical analogy. During the creation of a supernova, matter collapses in on itself before bursting apart. The outermost thin layer of matter is accelerated to extremely high speeds, creating cosmic rays that spread throughout the galaxy.

Choositz Decision Balls

These are two black balls, about 36 mm in diameter, and identical in appearance. When dropped from the same height on to a hard surface, one rebounds to almost the same height while the other just stops dead with hardly a perceptible bounce (Fig. 3).

The bouncy ball shows a near perfect elastic collision. It's often referred to as a *super ball*. Being made of polyneoprene, it has polymer chains with numerous cross links between neighbouring chains. Because of these cross links, there is very little rotational or translational movement of the chains. Thus the energy of a fall cannot easily be converted into heat. To conserve energy at an impact, the molecules move but return immediately then to their original position.

The other ball is made from polynorbornene. A molecule of this has a 5-membered ring as part of the chain structure. Having lots of degrees of freedom, most of the energy on impact is transformed into heat. Thus there is no bounce.

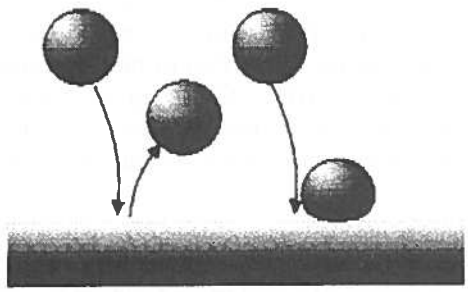


Figure 3 Choositz Decision Balls - one rebounds like a *superball*, the other stops dead.

Smashing steel sphere demo kit

If you smash together two steel ball bearings, enough heat is generated to char a piece of paper held between them (Fig. 4). Of course, you need a large pair of spheres for this - the ones in the kit are 50 mm in diameter and 0.5 kg in weight!

It's frightening even to think of!

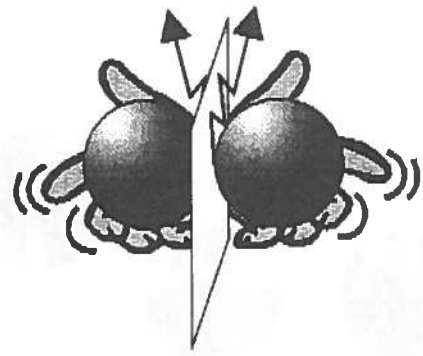


Figure 4 Paper chars.

Multi-fibre ribbon

This has been devised to test the effects of dyes on fabric materials. The ribbon has been woven from thirteen different fibre materials (acetate, cotton, Dacron, nylon, silk, viscose, wool, etc.), each 7 mm wide with an overall width of 100 mm.

If the ribbon is soaked in a dye, each material stains differently. This may be used to match dyes with materials, or as a test for identifying either a dye or a material.

The ribbon is a yard in length. One yard of ribbon can be cut into one hundred strips, giving plenty of bits for testing.

Other related kits include dyes (#SM-6B), unlabelled fabrics (#SM-6C) and a kit with dyes and fabrics (#SM-6D).

Touch-it heat-sensitive periodic tables

A periodic table printed on an A5 sheet of thermo-chromic paper. Each pack contains thirty sheets.

Ultraviolet Detecting Beads

These beads contain a pigment which is sensitive to ultraviolet radiation. In the absence of UV, the beads are white. Turn on the UV and the beads colour - wan shades of pink or peach indoors in the subdued daylight of a Scottish winter, but vibrant reds, purples, or oranges, of an American summer sunshine.

You get about 240 beads per packet - sufficient for several necklaces or bracelets.

Inverting Pop Tops

If this small wooden top is spun, it starts to precess until the heavier, domed end is lifted, which causes the top to invert (Fig. 5).

Jearl Walker described this action in the October 1979 issue of *Scientific American* : "The motion appears to violate the law of conservation of energy because the top seems to raise its centre of mass (which is the spherical section) without outside help".

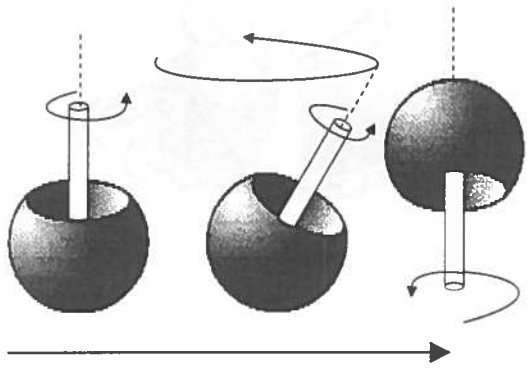


Figure 5 Spinning top precesses, then inverts.

How to purchase

Order codes and prices of items described are listed below. A shipping and handling charge for exporting the goods to the UK is charged. Communication with Educational Innovations by fax or e-mail is advised for speed of response.

Windbag (pack of 4)	#WIN-600	$4.75
Solar Bag	#SLR-200	$11.95
Astro-Blaster	#SS-17	$3.95
Choositz Decision Balls (set of 2)	#SS-3	$6.25
Smashing Steel Sphere Kit (2 balls)	#HS-8	$23.75
Multi-fibre Ribbon (1 yard)	#SM-6	$6.95
Multi-fibre dyes (5 pairs)	#SM-6B	$9.95
Multi-fibre Unknowns (10 pieces)	#SM-6C	$16.75
Touch-it Periodic Table (30 x A4 size)	#LC-3	$8.50
Ultraviolet Detecting Beads (240)	#UV-ast	$6.95
Inverting Pop Tops (bag of 5)	#SS-8	$5.00

TECHNICAL TIP

The lead tree

Thanks are due to Kenneth Johnstone of Our Lady's High in Motherwell for reminding us of an old, but still interesting, chemical idea. Demonstrating displacement of metals and redox reactions may be made topical for the festive season. In this reaction the zinc supplies electrons to reduce the lead(II) ions.

$$Zn_{(s)} \longrightarrow Zn^{2+}_{(aq)} + 2e^-$$

$$2e^- + Pb^{2+}_{(aq)} \longrightarrow Pb_{(s)}$$

Instead of using a bit of granulated zinc or wee piece of zinc foil cut a sheet of zinc in the shape of a Christmas tree and 'plant' it in the bottom of a beaker or old gas jar with a dod of Blu-tak before covering it with a solution of lead nitrate (12 g in 100 cm^3 of water). The zinc is soon coated with a furry grey layer and then with silvery plates of lead. This takes about half an hour and looks more impressive if the lights are switched out and the demonstration is illuminated from the side. Should Christmas be past try using a Snowman shape instead.

It is of course worth showing the other type of tree formed by the dendritic growth when a piece of zinc is placed in a lead nitrate solution. To show the role of electrons the dendritic tree can also be formed with a battery as the source of such electrons.

Hazards and control measures

Lead salts are toxic by inhalation or by contact with skin. Avoid handling the solid or solution. Wear gloves.

Disposal

Test the remaining solution for the presence of lead ions by addition of dilute sulphuric acid. Add excess of the acid and separate the precipitate of lead sulphate which forms. Mix the lead sulphate with 50 parts of sand and place in ordinary domestic refuse.

* * *

Stop-press

Congratulations!

To James (Jim) Johnston, ubiquitous Secretary of the Technology Teachers Association, one time Editor of TTA News and much loved Principal Teacher at Springburn Academy in Glasgow. James has been named as Technology Teacher of the Year by the Institution of Electrical Engineering (IEE). The award was made in recognition of the excellent work Jim does, not only with his own students but with national and international agencies.

Look out for the next issue of the IEE's educational journal - *Electronics Education* - which will carry a complimentary copy of a card game designed by students at Springburn. The IEE have produced a pop-up version of this and are distributing it free of charge.

TECHNICAL ARTICLE

Measuring lead in water and soil

A simple method for use in the field is described. This requires little more than a small supply of the reagent, a set of stoppered test tubes and some bits of paint colour charts. Concentrations in the range of a few parts per million are easily measured.

Dr. S. O'Donnell of Holycross High School, Hamilton, first showed us the basics of this method several years ago [1]. Later, articles by pupils and staff at Framwellgate School in Durham [2] described variations on much the same procedures. The main modification introduced by ourselves has been the replacement of the solvents used by the previous two authors. In our small scale method, butyl ethanoate has replaced the ozone unfriendly trichloromethane (and Category 3 carcinogen) or 1,1,1-trichloroethane used in earlier procedures.

Background

The method employs a visual comparison of the colours produced when dithizone reagent is added to a sample with those produced on its addition to lead solutions of known concentration. Essentially, the concentration of the sample in ppm is read off by matching the colour with that of one of the standards. Once the calibration chart has been made in the laboratory the measurements can be carried out on site by pupils from S2/3 upwards. Alternatively soil samples can be labelled and brought back to the lab for a more efficient means of extraction by a variety of reagents, eg warming with 1M nitric acid. This procedure is thus different from the more usual colorimetric determination of lead where an excess of dithizone reagent is present. The intensity of the pink colour is then proportional to the concentration of the lead ions.

Lead in the environment

Lead ions are readily precipitated and hence lead is usually found in waters only in extremely low concentrations, but higher concentrations may be found close to the source. The weathering of old paints containing lead (the yellow lines on our streets can be lead chromate), the combustion of fossil fuels, especially leaded fuels for car engines; all can add to surface deposition.

Spoil from mining can add considerably to the lead content of soils locally. It is very interesting for pupils to collect soil samples along lines in a field and analyse them for lead content. This would be a nice example of how geochemists find veins of lead ore.

Lead is ubiquitous and many soils will contain between 15 and 25 ppm in areas which have not been polluted. Where there has been much deposition from the atmosphere the levels in the top few cm will be greater than the local 'background' levels. Usually the concentrations below a depth of 5 cm are fairly constant. Background levels vary with locality; any results greater than about four times the background can be taken to indicate pollution or the presence of a source of lead nearby.

Principle

Dithizone is a green dye. A solution of it in an organic solvent (traditionally CCl_4 or even $CHCl_3$!) extracts several metal ions, including lead(II), from alkaline aqueous solutions to form red coloured complexes. Being covalent, these complexes are very soluble in organic solvents and are readily extracted into them. Dithizone forms such coloured complexes with several metal ions according to the equation:

$$M^{n+}_{(aq)} + n\,H_2Dz \;\text{(green)} \quad <=====> \quad M(Hdz)_n \;\text{(red or orange)} + nH^+_{(aq)}$$

Raising the pH removes H^+ ions and favours the formation of the metal dithizonate. The stability constants vary with the metal ion.

$$K_{st} = \frac{[M(HDz)_n]\,[H^+_{(aq)}]^n}{[M^{n+}_{(aq)}]\,[H_2Dz]^n}$$

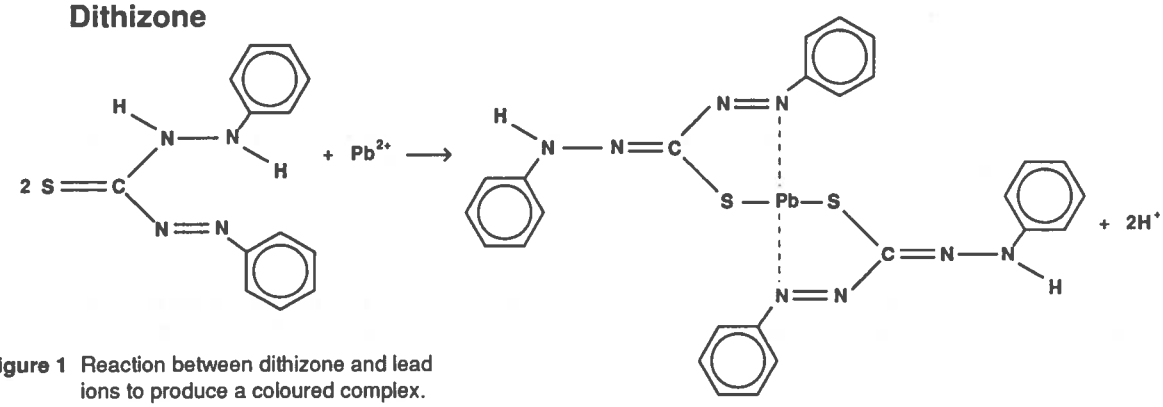


Figure 1 Reaction between dithizone and lead ions to produce a coloured complex.

The higher the stability constant of the metal complex of the above reaction (K_{st}) the lower will be the pH at which the dithizonate complex can still manage to form to an appreciable extent. Thus there is a lower pH limit for each metal ion, below which it is incompletely converted into its dithizonate complex. Raising the pH by one unit has the same effect on the position of equilibrium as increasing the concentration of the reagent by a factor of 10. However, there is also an upper pH limit above which the complex cannot form because of its hydrolysis by hydroxyl ions to hydroxometal ions. Thus it is possible to separate two metal ions in solution if there is no overlap in the pH ranges in which they form stable dithizonates.

Specificity

The reagent can be made reasonably specific for lead by choice of pH (citrate buffer close to 9 is used) and by incorporation of the amine, *tetren*, into the reagent. This acts as a masking agent for Cu(II), Hg(II), Cd, Co and Zn. The citrate present as buffer will also have some masking ability for Sb(III), Be, Cr(III) and Fe(III). Most analytical procedures also include the addition of 10% potassium cyanide solution as a masking agent to prevent a number of particular ions (Cd, Zn, Hg, Cu and Ag) from reacting with the dithizone. Whilst cyanide is excellent as such a masking agent, we recommend that it be omitted.

Method

As noted above, in colorimetry the dithizone reagent is present in large excess. This is so that all of the lead(II) ions are converted to coloured dithizonate complex. Here, in this present method, the amounts of lead and reagent taken are close to the stoichiometric ratios. Thus, when a low concentration of Pb^{2+} is added to the reagent, some of the pink complex is formed, but the majority species is the unreacted green reagent. What you see will be a grey green (formed by the mixture of a little pink and a lot of green). In the second standards tube, where the concentration of Pb^{2+} is a little higher, the ratio of pink to green increases and the colour of the mixture moves towards a grey/pink. In the next standards tube the pinkiness of the grey is greater and in the last tube there is an excess of Pb^{2+} so that all of the green reagent has been reacted leaving a definite pink colour.

Recipes, hazard data, and the preventive and protective measures resulting from risk assessment are appended to the article as technical notes. However the high sensitivity of this reaction can cause specific problems. It is easy to pick up enough lead from benches, glassware, stoppers and even your fingers to give a positive test. Pipette tips should not be placed on benches. Everything has to be scrupulously clean and the dithizone should be purchased in reagent form. All test tubes with stoppers should filled with a little of the dithizone reagent and then shaken. The reagent solution is discarded and the rinsing with fresh batches of reagent is repeated until a yellow or pink colour no longer forms. All reagent bottles, apart from the standards bottles should be similarly treated.

Preparation of colour chart

Add 1 cm^3 of lead solutions of known concentrations :

(0, 1, 2, 3, 4, 5, 6, and 8 ppm)

to 8 small test tubes (75 x 12 mm). To each lead solution add in turn 1 cm^3 of the reagent followed by 1 cm^3 of buffer solution and 1 drop of tetren solution (Figure 2).

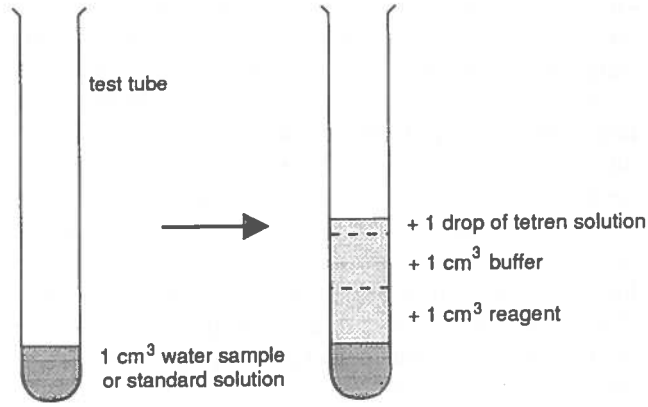


Figure 2

Cork and shake for 20 seconds, then observe the colour produced. It is important to note that different batches of dithizone will produce slightly different colours for the same concentrations. You can however produce a bespoke calibration for your own batch of dithizone. The range of colours formed should approximate to the sequence shown as Table 1 below.

[Pb] (ppm)	0	1	2	3	4	5	6	8
Colour	dark green	dark green	green with a hint of grey	grey with hint of green	grey	grey with a hint of pink	pink	pink/red

Table 1 Approximate relationship between lead concentration and the colours or tints of resultant dithizone and dithizone/Pb complexes. A white card held behind or fastened to the test tube rack makes the colours much easier to see.

Unfortunately these standards fade in a matter of hours. A useful trick therefore is to make your own colours versus concentration chart by cutting out pieces of paint shade cards which match reasonably closely the colour of the solvent layer in the tubes. These can then be pasted together to make a key which looks like that provided by manufacturers of universal pH papers. You can have fun, for example, with Dulux shade cards for *Whisper Grey* or Crown's *Sea Jade* and *November Pink*! Similar shades are on offer under less, or more, exotic names from other paint manufacturers. A more artistic alternative is to use crayons. Note that dithizone is of variable purity. Different batches will not necessarily produce the same colours. A calibrated set of shade cards should prove consistent when used with any one batch of the dye.

To estimate the concentration of lead in an 'unknown', put your sample through the same process and see which shade produces a match. This should give you an estimate of its lead concentration. In practice, it is best if you end up with a colour for the sample lying somewhere in the middle of the range. Two simple tricks will help to achieve that.

For example, should you end up with a green colour as your first result, then simply add another 1 cm^3 of sample and shake. If need be, repeat the process until you obtain a mid range colour and then divide the result by the total number of 1 cm^3 aliquots used. On the other hand the sample may yield immediately a red or pink colour. This means it may be off the top of the 0 - 8 ppm scale. The obvious answer is to further dilute the sample a known number of times and repeat the measurement, multiplying up the result by the number of dilutions. Water samples which may well contain high concentrations of lead are those close to mining spoil or that carried through lead pipes if the water is soft. Taking samples at or just below junctions of tributaries in a stream can often find a source of lead, possibly lead ore.

Extraction from soils

Published methods suggested for use in the field include simply shaking a spatula-ful of the soil sample with the buffer, reagent and tetren. Obviously this method is less accurate than O'Donnell's [1] and the efficiency of extraction of the lead may be lower also (*see also next column). However it could be useful for comparative studies. Alternatively, soil samples should be brought back to school and dried in an oven at 70° C for 24 hours. O'Donnell recommends heating a 1 g sample for 1 hour with 1M nitric acid to extract all soluble metals, then adding 1 g of sodium sulphite (beware sulphur dioxide evolution) to the hot liquid which is then stirred, filtered and made up to 100 cm^3 with distilled water.

Extension to Zn

If the same method is used, but with the 10% tetren solution replaced by a 10% solution of triene or triethylenetetramine ($H_2N\text{-}CH_2\text{-}CH_2\text{-}NH\text{-}CH_2)_2$, then lead and zinc are determined together.

Zinc standards can be prepared in exactly the same way. 0.110 g of zinc sulphate-7-water made up to 250 cm^3 gives a solution containing 100 ppm Zn.

References

1. *Heavy metal prospecting*: S. O' Donnell, Science Activities, vol 13, No 6. Nov/Dec 1976.
2. *The Pollution Detectives, Part III, Roadside lead pollution*: Phil Sanderson, School Science Review, Dec 1989.

Appendix : Technical and safety notes

Reagents

Dithizone : 0.1 g dissolved in 100 cm^3 of butyl ethanoate. This solution will last 3 months if kept in the dark. The working solution is made up freshly when required by diluting 1cm^3 of this stock solution to 50 cm^3 for a working solution. Protect from light by covering with foil. With a flashpoint of 22° C butyl ethanoate just escapes being labelled highly flammable. Label *Flammable*.

Citrate buffer : 11.0 g of citric acid (AR grade) and 2.0 g hydroxyammonium chloride (AR grade) are dissolved in the minimum of deionised water and adjusted to pH 9 by careful addition of 880 ammonia (CORROSIVE). This solution should be placed in a separating funnel and shaken with dithizone reagent to remove any traces of lead in the buffer. Discard any yellow or pink solution and repeat with new portions of dithizone reagent until it remains clear. Discard that last portion too and make up to 250 cm^3.

Tetren : $(H_2N\text{-}CH_2\text{-}CH_2\text{-}NH\text{-}CH_2\text{-}CH_2)_2NH$. *(or tetraethylene-pentamine)* 10% aqueous solution is used. Dissolve 25 cm^3 in distilled water and make up to 250 cm^3 with more distilled water. Label *Corrosive, Sensitiser*.

Lead standards : 0.160 g of lead(II) nitrate dissolved in 1 litre gives 100 ppm. Dilute this solution 10 fold by placing 100 cm^3 in a 1 litre flask and making up to the mark

*The test normally uses extracts from soil, but standards can be made up in water. It is probably most convenient to assume an efficiency of extraction from soil of 100%, but to remember that it will almost certainly be less than this. The extraction efficiency tends to be similar for any one soil type and so comparative studies can be done.

Health and safety information

Dithizone : Harmful by ingestion or if inhaled as dust to which only the person preparing solution is at risk. Handle carefully to avoid raising dust. *Butyl ethanoate* : b.p. 125° C is not too volatile. Flammable; very low toxicity and only harmful if ingested in very large quantities; irritates skin and eyes.
Citrate buffer : irritating to skin and eyes. *Hydroxyammonium chloride* severely irritates the eyes and is harmful by ingestion and inhalation. *Ammonia* used to prepare it is corrosive.
Tetren (or triene) : cause burns; harmful if swallowed or in contact with skin; may cause skin sensitisation.
Lead nitrate : harmful by ingestion and inhalation. Lead nitrate is crystalline and it is easy to avoid formation of aerosols. Pupils need to handle only very weak solutions - 10 ppm or less.

Control measures : Wear eye protection and gloves. Avoid sources of ignition. This should be easy in the field. Avoid skin contact with reagents and wash off any spillages on the skin.

* * *

TECHNICAL ARTICLE

Programmable controllers - Part 1

The article is based on a student teacher's personal account of the use of a programmable controller - the BASIC Stamp - for learning and teaching in school or college technology courses. A brief overview is also provided of the features of a small selection of similar devices currently on the market.

This article has been prepared by abstracting and editing material from a Final Year Project Report for the Scottish BTechEd[1] qualification. That report was written and presented by *Robin McChesney* who was at the time a student at St Andrew's College of Education, University of Glasgow. Robin's project was concerned largely with identifying a useful and inexpensive resource to aid the presentation of the topic on programmable control systems within Higher Grade Technological Studies. Application of this type of controller should also be of interest to those Scottish teachers looking towards 'Higher Still' Courses, with particular reference to Engineering 1 and 2.

Why use microcontrollers?

Three Chip Plus equipment made by UNILAB, is widely used in schools to teach some of the concepts germane to programming in machine code and assembly language. Also used for this purpose are somewhat dated technologies such as earlier models of Acorn micro-computers in the BBC and Master series with largely outmoded 6502 processors, associated machine code and assembly language. After observing the use of such equipment and techniques in schools the author was moved to try a different approach to teaching such concepts in courses of study for Technological Studies. Previous experience in a University laboratory had included the use of IBM or compatible microcomputers to program a '6805' microprocessor, produced by Motorola, for control purposes. With the application of IBM platforms and clones increasing rapidly in schools, there seemed to be a need to examine more closely the educational uses of such programmable controllers.

Which controller?

Whilst searching for suitable equipment the BASIC Stamp was 'discovered'. This is a programmable micro-controller which uses a BASIC type language, hence its name. The form of BASIC utilised is a high level computer language which is relatively easy to understand and learn. With simple training and experience you can progress to understanding an instruction set which at the outset looks more like alphabet soup. Information on the BASIC Stamp is readily viewed on the Internet under at least two heading (where it was first stumbled upon).

1. BTechEd - Bachelor of Technology Education

The BASIC Stamp is cheap, reliable, flexible and - unlike 6502 based devices - is representative of current technology. It can act as a small computer. There are presently three physical versions, with two of these sharing the same basic specifications but differing in the way they are packaged. The first version is called *BASIC Stamp 1 (BS1-IC)*, the second not unreasonably is *BASIC Stamp 2 (BS2-IC)*. The third version is the *School Stamp* with the same specification as BS2 but with a different physical layout intended for use in schools.

What can it do ?

The processor can be programmed to control voltage levels on its 8 pins, each of which can be programmed to act either as inputs or outputs. These pins can also be programmed to change status during the running of the program. This means that the Stamp can be used as an output control unit. It can thus be programmed in this stand-alone mode to operate many forms of electrical or electronic devices eg LEDs, buzzers, motors (dc or stepper), relays and switches etc. It can also accept input and process signals from an equally wide range of other devices such as sensors (light, temperature etc.), external switches or a keyboard such as that of a microcomputer.

To what use was it put?

It was used for a fairly standard, possibly clichéd, task oft suggested for projects in Technological Studies viz. - the emulation of traffic lights using LEDs. Fourth year pupils at Bishopbriggs High school, Glasgow were invited to join a short lunch time course on the operation of the BASIC Stamp. The result after three weeks - four and half hours actual learning and teaching time, was that a fairly complex program had been written to operate LEDs as traffic lights. If this does not seem much to show for those hours here is a list of the specific tasks undertaken.

- ✔ learning about the structure within the microcontroller;
- ✔ using the software package (DOS style quite like QBASIC on PCs) and using delays in programs;
- ✔ fault finding on breadboard;
- ✔ using simple routines to flash an LED;
- ✔ emulation of disco lights - very enjoyable;
- ✔ emulation of simple traffic light routine;
- ✔ emulation of more complex traffic light routines and
- ✔ setting up and packing away equipment properly.

Results of the project

It was concluded from this overall evaluation that there is significant educational potential for this type of equipment. Microcontrollers may be of such use far beyond the Secondary Technology Department. It is felt that, with refinement, the Stamp controller could have a place in primary schools. Indeed the TEP project has produced a cased version intended for the primary market[1].

For now, the report author's preference lies firmly with the BASIC Stamp. It is relatively cheap and easy to use. As part of this particular project it was used successfully with boards from Unilab's *3 Chip Plus* range. So his advice is not to throw out your 3 Chip Plus boards just yet, but to instead buy a BASIC Stamp PLC or two to advance and complement their use.

Other benefits

Because the software runs on microcomputers (PCs or compatibles) individual control programs can be archived on hard discs but transferred to floppies for individual operations or tasks. Wouldn't this be handy for school open days? Additionally Stamp has many other 'oven-ready' features in its full instruction list (which is available on the Internet). Example programs and instruction manuals can be downloaded therefrom for reference or inspection.

Overview

The reasons given by Robin for choosing the BASIC Stamp 2 - marketed by Parallax Inc. - for his particular purposes included : the relatively gentle learning curve involved, its use of a high level language, (a modified form of BASIC), the technical support available and the price. A rough and ready comparative survey is appended as Table 1 below. This summarises the major features of a number of such PLCs. Note that the opinions expressed are based mainly on those of the report's author as well as school usage of just some of the devices. Such opinions do not necessarily in every detail reflect those of SSERC.

Some of the traffic light routines written by his own students are included in Robin's final project report. For a somewhat more technical description of the Stamp and for a documented program for another application - a reaction timer - see the companion article to this which is planned for Bulletin 193.

The future

With the changes planned as part of *Higher Still*, the BASIC Stamp appears to be a real contender for use in teaching Control Systems in Higher Grade Technological Studies. Robin McChesney and staff at SSERC are keen to develop more learning and teaching materials for the BASIC Stamp. If anyone is interested in this work - collaboratively or otherwise - Robin can be contacted through SSERC.

Name of device	Maker/ supplier	Price (incl VAT) £	Mode of operation	Ease of use	Specific advantages and Verdict
Pic Microcontroller	Arizona Microchip	154.49	Programmable micro-controller with compiler software for PCs and compatibles.	Requires knowledge of specific language and needs external circuitry.	Support from High Street electronics stores and via the Internet. ***Rejected : too steep a learning curve.***
Programmable Logic Device	E&L Instruments	450.00	Performs logic design and simulation using a mixture of PC software and hard wired circuits.	Designed more for industrial type training exercises. Has comprehensive documen-tation but learning curve is apparently very steep.	Because of industrial type spec. may put students in good stead for more 'realistic' situations in employment. ***Rejected - too expensive for the purposes of this project.***
FXO Mini Programmable Logic Controller	E&L and Mitsubishi	910.00	Programmed in object-oriented software on a PC. Programs then transferred to the PLC.	Intended "for the classroom" Learning strategies somewhat involved but still claimed to be "Intuitive".	PLC as applied in industry. ***Rejected : too expensive for this school based project.***
BASIC Stamp	Parallax Inc.	142.17	Programming on a DOS based compiler. Programs can then be transferred to the microcontroller which can act 'stand-alone'.	Manageable learning curve which will particularly suit schools and non-advanced FE courses.	Good customer and technical support available via Internet. Range of accessories at added cost available. ***Selected : gentle learning curve, add-ons, price.***
Schools' Stamp	TEP[1]	131.60	Programming and other features as BASIC Stamp.	As above plus easy replace-ment of on-board microchips.	***Close second to BASIC Stamp but support as yet not as good.***
Bit by Bit Controller	TEP	18.80	Stand alone unit which is programmed by switches. Uses same PLC as above but in a metal case etc.	Simple instructions and easy to use (potentially even at the Primary level). Question marks over hardware reliability.	No access needed to a computer for programming the device. ***Rejected for the purposes of this secondary project too simple, too large and reliability not yet proven.***

[1]TEP - Technology Enhancement Programme

TABLE 1 - Brief market survey of Programmable Controllers for educational applications

EQUIPMENT NOTES

PASCO Science Workshop

Science Workshop can turn your PC or Mac into a virtual instrument for capturing and analysing experimental data. In this test report we take a critical look at the system - the software, the *500* Interface and force and motion sensors.

PASCO manufacture three data logging computer interfaces and associated software, *Science Workshop*. This review considers the *500* Interface, a mid-range interface, compatible with both Macintosh and Windows.

There is a wide range of sensors in the system. We have looked at their performance by testing two types, Force and Motion. The findings from this small sample are indicative of the performance of the whole range.

The software includes the main *Science Workshop* program, five tutorials and a library of over one hundred experiments. One on impulse is reviewed. This uses the force and motion sensors. With the former we obtain a measurement of impulse from a force-time transient during a collision. With the latter we get a value for the change of momentum. By looking for agreement from these two derived values we are able to assess whether the system is nothing more than a Flash Harry - and an expensive one at that! Or does it provide accurate quantitative values with which the laws of nature may be interpreted?

Specifications

The *500* Interface plugs into the serial port (PC) or modem port (Macintosh) and runs at 19.2 kbaud.

Crystal-controlled timebase - ±0.01% accuracy

Analogue inputs - three analogue channels
- A: Differential input, 2 MΩ impedance, gain = 1 or 10
- B: Single ended input, 200 kΩ impedance, gain = 1 or 10
- C: Single ended input, 200 kΩ impedance, gain = 1
- ADC: 12-bit conversion
- Tolerance (±10 V range): ±0.02 V + 0.1% of reading
- Resolution (±10 V range): 5 mV (±1 V range): 0.5 mV
- Analogue sampling rates:
  - 500 samples/sec continuous mode maximum providing real-time display
  - 20,000 samples/sec burst mode providing after-the-event display

Digital inputs - two digital I/O channels
- Resolution: 0.1 ms

Data logging mode -
- Battery operation for logging remote from computer
- 50 KB data storage buffer
- Multiple data runs are appended to buffer

Power supply - 9 V @ 500 mA d.c.

Macintosh Computer requirements -
- System 7.0 or later and Color Quickdraw

Windows Computer requirements -
- Windows 3.1 or later
- 1 MB RAM available

500 Interface hardware

The *500* Interface has five input channels - three bipolar analogue to digital converters, and two digital. It plugs directly into the serial port of a PC, or modem port of a Mac, and requires a 9V AC mains adapter (supplied) or four AA batteries (not supplied).

The hardware specification has been tested and found to be an honest reflection of the instrument's performance.

The analogue channel tolerance is ±20 mV + 0.1% of the reading. The standard input range is ±10 V. Except for low values, the uncertainty of any measurement is less than 1% of the reading. This is a marked improvement on the performance of the voltage scale of a typical oscilloscope.

The analogue channels have a top speed of 20,000 samples a second. This gave the fastest rise and fall times of 50 μs each. The bandwidth is about 7 kHz. This is much lower than is found on a typical analogue oscilloscope, but twice as fast as the next fastest interface on the UK educational market and it is comparable to the bandwidth found on some digital storage oscilloscopes. At 7 kHz, this bandwidth is sufficient for capturing low to mid frequency audio signals, but will not resolve high frequency audio, or ultrasound.

The input impedance of analogue channel A is over one megohm, which is the standard oscilloscope value. Channels B and C have a nominal impedance of only 200 kΩ. This is rather low and users may find that it sometimes distorts signals they are trying to measure. However in practice, because analogue inputs are likely be used mainly with PASCO sensors compatible with this impedance, the relatively low value may not be significant.

The time-base accuracy was tested. Being limited by bandwidth, pulses with a period of 0.1 ms or less were indeterminable. All other longer pulse periods had negligible error, showing that the specified 0.01% accuracy held for periods greater than 0.1 ms.

Whilst the fastest sample rate is 20 kHz, not all sensors can log data at this rate. The maximum sample rate for some sensors is 10 kHz. Real time displays are not possible for sample rates over 500 Hz.

Multiple channels can be logged simultaneously, but problems occur at high sample rates. If two or more channels both try to sample at 10 kHz, the interface does not always collect data reliably.

The *500* Interface has a remote logging facility; the Interface can be configured by the computer, then disconnected. This means that experiments do not necessarily need to be set up in the vicinity of a computer.

Software

We installed the *Science Workshop* software in a Toshiba Notebook 210CS with 16 MB RAM running at 120 MHz with Windows 95. The installation was simple and problem free.

The system is basically 'plug and play', which is to say that *Science Workshop* automatically recognizes which computer port the interface is connected to and what interface type (*300*, *500*, or *700*) is being used. Sensor settings are easy to configure. Data can be presented in the appropriate SI units and displayed graphically, or in a table, or in either a large digital or analogue display.

The software and interface are easy to use in conjunction with support material, *Laboratory Activities*, supplied with *Science Workshop*. Each experiment is written clearly in detail, with pre-configured *Science Workshop* files. *Laboratory Activities* is supplied in two formats, electronic and printed. Both provide the same information.

However when we stepped outside of *Laboratory Activities* and tried to perform our own experiments we found that configuring *Science Workshop* to carry out a set task was initially quite difficult. Although the controls are easy to operate, and although there is a lot of suitable ancillary equipment to work with, the procedure is complex. Partly it is selecting an appropriate sensor for the application. Partly it is assembling unfamiliar apparatus and conducting the experiment in a way that doesn't introduce side effects. Partly too it is choosing a software configuration that works. This can be likened to tuning an engine. It comes down to thoughtfulness, practice and experience. PASCO recommend that new users should get training. We agree with that.

Collected data can be displayed in different forms via pre-programmed calculations. For instance the motion sensor can analyse then display the results as position, velocity and acceleration. It is possible to configure the sysytem to perform user defined calculations. For example data collected from the motion sensor could be converted into the derived quantity, momentum, and tabulated, graphed, or displayed digitally, in the SI unit.

If the oscilloscope display is selected, *Science Workshop* behaves as if it were a digital storage scope with a fairly impressive specification. However whereas the user can vary the sweep speed over many ranges, only two, true, voltage settings are provided - direct and x10 (see specifications). However there is fine resolution because of the 12-bit processing and the system provides virtual gain settings jumping in the usual 1, 2, 5 steps across several decade ranges from 1 mV/div. to 5 V/div. In this respect its specification is less good than would be found on an actual oscilloscope.

Science Workshop windows

Graphs - Sets up a graph window for displaying data points
- Plots in real time up to 500 samples/second
- Scales axes in SI units under user's directions
- Up to three traces can be shown on a single display
- Inputs may be plotted against time, or one input may be plotted against another input

Graph Toolbox - contains the following tools for analysing graphical data in the graph window :
- *Statistics* : Sets aside a screen area for giving the parameters of a mathematical function fitting data points in the graph window and showing a statistical analysis of data
- *Smart Cursor* : Gives coordinates for any point on a graph
- *Select-a-Region* : Magnifies any selected region of a graph for closer examination
- *Auto-scale* : Automatically scales plots so all data points are visible
- *Graph Display* : Changes display options
- *New Plot* : Adds a new plot to the graph window

Tables - Sets up a window for tabulating data
- *Columns* : User can add further columns to the table window
- *Time indexing* : Displays the time value against the set of measured values in each row of the table
- *Statistics* : Calculates the minimum, maximum, mean and standard deviation for each column of data

Oscilloscope - Sets up a window which acts like the screen display of a triple trace storage oscilloscope
- *Sweep speeds* : Up to 0.05 ms/division
- *Sampling rate* : Up to 20 kHz for a single channel (with an effective bandwidth of 7 kHz)
- *X-Y mode* : For displaying voltage versus voltage phase relationships

Analogue and digital displays - Sets up windows for displaying measured values in large digits, or as a large meter display with a pointer indicating the value. SI units shown.

Curve fitting - The user can select from six curve fitting options either a straight line or curve that best fits the data shown on the Graph Display window. A mathematical description of the curve is provided.

Experiment calculator - The user can rescale the data either with his own functions or with selecting from 23 built-in scientific functions. For instance distance versus time data can be rescaled to provide a plot of velocity or momentum versus time.

Experiment Notes - The Experiment Notes window may be used to provide the user with information about an experiment or apparatus.
- *Experimental procedures* : Step-by-step procedure given for each experiment. This can be amended by the teacher to fit local conditions.
- *Lab Notebook* : Students can use the Notes window to prepare notes which can then be exported to a word processor for their lab report.

Spectrum analyser - Sets up a window for displaying a frequency distribution obtained from performing an FFT on the recorded data. Useful for analysing the frequency content of an audio signal. May clearly show the fundamental frequency and its harmonics.

The graph and oscilloscope displays have a smart cursor - mouse controlled cross hairs - that show the *x* and *y* co-ordinates to a high degree of accuracy. The graph and table displays also allow statistical functions to be performed, such as mean, standard deviation, integration and curve fit.

The frequency content of a signal can be investigated using the spectrum analyser facility. This works effectively up to about 7 kHz.

Data can be exported from *Science Workshop* files into other packages. Tabulated data is in the form of .TXT files; graphical data is in .WMF files (Windows Metafile). For instance tabulated data can be transferred to MS *Excel* for processing in a spreadsheet, or for statistical analysis. It can also be transferred into a specialised maths/science package for further analysis or graphing. Graphs, tables, or notes prepared in *Science Workshop* can be transferred to a word processing package such as MS *Word* for the production of lab reports or teaching materials.

Although *Science Workshop* was almost trouble free, the software occasionally crashed. This was associated with sampling data at a very high rate, or with typing in experimental notes, where there is a problem with word wrapping. These crashes led to a second problem in that a number of temporary files were found to be produced. In the normal run of events, these temporary files are created to hold data, then are deleted automatically when the system shuts down in a controlled way. However if the system crashes, these files are left. Directories had to be cleaned out on a regular basis.

Speaking to other users, we understand that system crashes are infrequent, or even non-existent.

Documentation

Science Workshop is very well documented. It comes with detailed manuals, subdivided into four sections : Equipment List, Textbook Cross-References, Laboratory Activities and Teachers Guides. There are manuals for different subject areas : Introductory Physics (22), Physics (60), Chemistry (33), Biology (18), General Science (30) and Maths (20). The number of experiments in each is indicated in brackets.

The Equipment List shows what is needed for each of the Laboratory Activities. Textbook Cross References relates each experiment to relevant chapters in American textbooks. The Laboratory Activities are very detailed and give explicit instructions for use by students. They cover theory, procedure and analysis. The Teachers Guides have notes, sample data and answers to questions asked in the Laboratory Activities.

Also included in the software are libraries of pre-configured *Science Workshop* documents and MS *Word* versions of Laboratory Activities for each experiment. But *Science Workshop* doesn't have on screen Help files.

Sensors

The range of sensors covers many science disciplines. Traditionally PASCO has been a manufacturer of physics apparatus. However they have extended their interest into other subject areas and now make sensors for biology, chemistry and environmental science as well as for physics. The current sensor range is shown in the text box below.

Sensors may either be bought individually, or in groups, which PASCO calls *Bundles*. There are currently seven bundles available, each related to different subject areas. A bundle also includes an interface, software and manuals. The catalogue should be consulted for details.

Force Sensor

The *Force Sensor* (CI-6537) has a wide operating range of ±50 N. Bipolarity indicates that it may be used for compressive or tensile forces. The transducer is a strain gauge. The sensing actuator is a threaded socket into which different attachments may be screwed. The one attachment supplied with the *Force Sensor* is a hook. We recommend that you supplement this by purchasing the *Accessory Bracket with Bumpers* (CI-6545), which includes spring, magnetic and rubber bumpers, and a clay cup for inelastic collisions.

The *Force Sensor* can be used for static or dynamic forces. For instance it can support a suspended static load, or vibrating loaded spring. It can be fitted to a PASCO dynamics cart to study the force of impact during collisions, or it may be mounted securely on the *Accessory Bracket* at the end of a cart track.

The quoted resolution of the force sensor is ±0.03 N. Since the capacity of the force sensor is quoted as being 50 N, the resolution of 0.03 N is 3 parts in 5000, or 1 part in 1667. This ties in with the ADC's 11-bit resolution of 1 part in 2024, there being a twelfth bit for the polarity sign.

PASCO sensors

Motion
Rotary Motion
Smart Pulley
Photogate
Free Fall Adapter
Laser switch
Nuclear
Beta Gamma Nuclear
G-M Tube
Force (±50 N)
Student Force sensor
Light
High-Sensitivity Light
Current
Voltage
Magnetic Field Strength
Sound
Acceleration
Low Pressure
Absolute Pressure
Differential Pressure
Flow rate
Barometer
Relative Humidity
Heart Rate
EKG
Respiration Rate
Temperature (-5°C to +105°C)
Temp. (-200°C to +200°C)
Temp. (-200°C to +400°C)
Temp. (-200°C to +1000°C)
Colorimeter
pH
Ion-Selective Electrode Ampl.
Calcium-Selective Electrode
Fluoride-Selective Electrode
Chloride-Selective Electrode
Potassium-Selective Electrd.
Sodium-Selective Electrode
Nitrate-Selective Electrode
Lead-Selective Electrode
Conductivity
Dissolved Oxygen

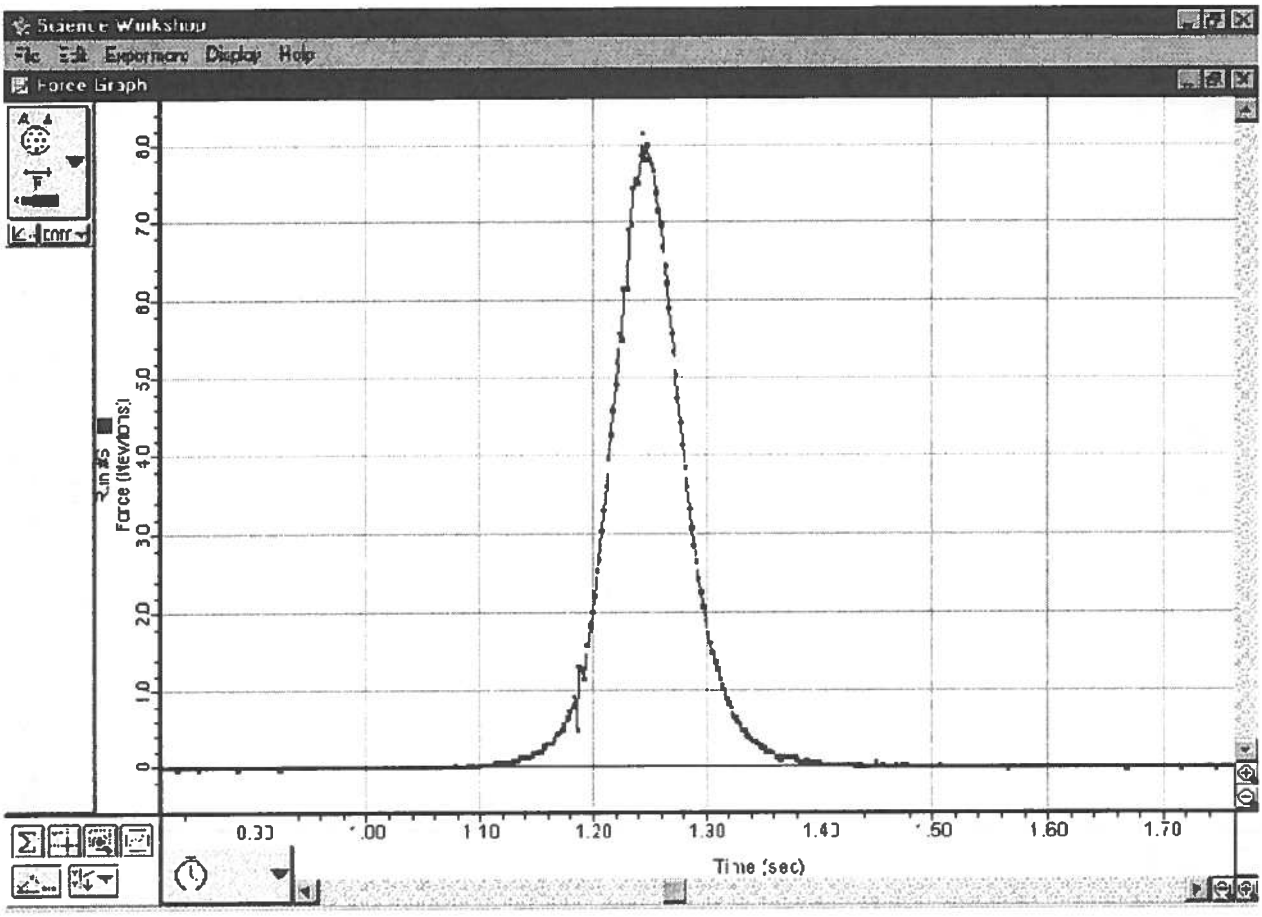


Figure 1 Force-time transient obtained when a PASCO dynamics cart collided with, and rebounded off, the Force Sensor. Magnetic bumpers were in use.

PASCO do not specify the uncertainty tolerance. That may be the right approach with an educational product because it pushes the teacher or students into questioning what a reading actually means. We found the tolerance for ourselves by hanging the sensor vertically from a rigid support and suspending a set of known masses.

Separate calibrations were done for two decade ranges of force, 0 to 5 N and 0 to 50 N. The tests were redone six weeks later to examine stability.

There are four points to note resulting from this.

1. Whereas the *500* Interface has a specified tolerance, none of the sensors that connect to it, such as the force sensor reviewed here, have tolerances specified.
2. If meaningful results are wanted, the user must calibrate the sensor before use. The result of a calibration is given here. However, this is for just one sensor and gives no indication of the tolerance deviance over a range of force sensors.
3. In our case, the sensitivity is out by around 2%. Fitting a linear line through the origin and through calibrated points gives a gradient that is 1.017 ±0.006 for 0 to 5 N, or 1.019 ±0.001 for 0 to 50 N. After applying this correction the tolerance of a reading is ±0.05 N to a 95% confidence limit. This value is not much greater than the 0.03 N resolution.
4. The sensor is fairly stable over time, but the uncertainties have been found to drift.

PASCO *Motion Sensor*

The position of a single object is measured by ultrasound echolocation. The only quoted specification of the *Motion Sensor* is its range - between 0.42 m and 10 m. Neither the resolution nor the uncertainty in a reading is specified.

Because the maximum sample rate of the *Motion Sensor* is 150 Hz, it can track the position of a fast moving object. It can therefore be used in a wide range of mechanics experiments. It does not suffer from the narrow field of applications that applies to some other types of ultrasound motion sensors.

The accuracy of measurement to a range of 2 m has been assessed. We find that its sensitivity is true and that readings are subject to a random uncertainty of ±5 mm to a 95% confidence limit.

The uncertainty of derived quantities, velocity, acceleration or momentum, may then be worked out by calculation. Because the timebase has a tolerance of 0.01%, uncertainties in periods of time may be ignored.

The sensor should be calibrated each time it is used to allow for temperature, relative humidity or air pressure.

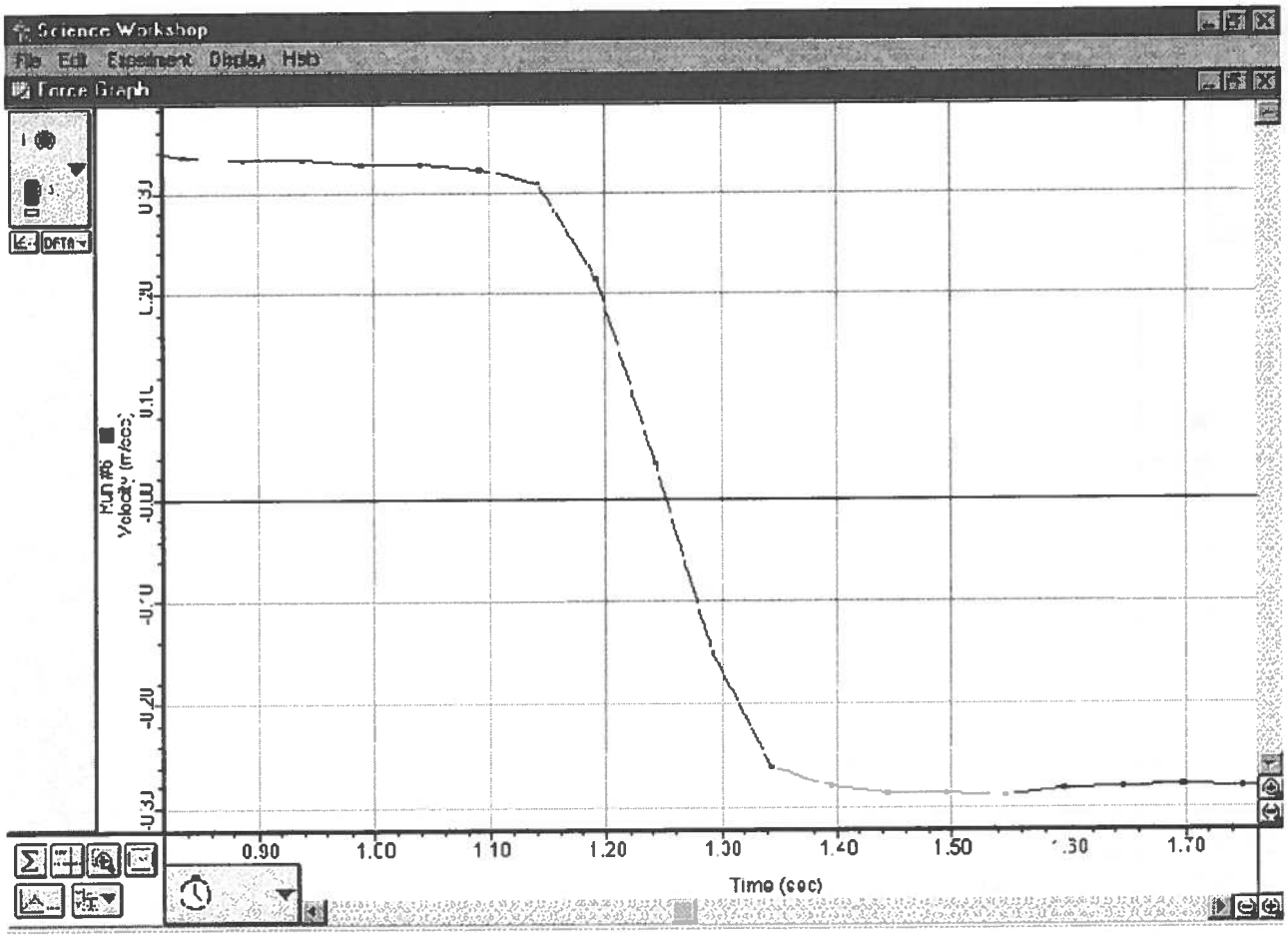


Figure 2 Change of velocity, as recorded by the Motion Sensor, of a dynamics cart rebounding off a magnetic bumper fitted to the Force Sensor.

Impulse Experiments

Well, the proof of the pudding is in the eating! Here, PASCO sensors and the *500* Interface are used to perform an impulse experiment. We want to see whether

$$I = \int F.dt = m.\Delta v = \Delta p$$

where I = impulse, F = force, dt = time increment, m = mass, Δv = velocity change and Δp = momentum change.

The experiment file *P14_coll.sws* from *Science Workshop* is used here, with the dynamics cart and track. The interface sample rate is set at 500 Hz for the force sensor, and 20 Hz for the motion sensor.

Added to the 0.5 kg cart was a 0.5 kg mass, making the total mass of the cart nominally 1 kg. This was done to increase the impulse and to decrease relative resistance factors. The track was levelled using a spirit level, ensuring that the results would not be affected by gravity.

The force sensor was fastened to the end of the cart track using the *Accessory Bracket*. To minimise any movement of the force sensor or track during collision, the force sensor and end of track were positioned against a wooden block weighted and clamped to the table. To obtain a good collision, with a low maximum force and a reasonable collision time, the neodymium magnetic bumper was used with the force sensor. There were corresponding magnets in the cart.

The results were initially unsatisfactory due to movement of the *Accessory Bracket*. The reason for this was that initially the bracket had been fastened to the cart track with the washerless set of bolts provided. Presumably there had been an imperceptible movement of the force sensor which marred the simplicity of the dynamical system. When the first set of bolts were replaced with a set with washers, we got satisfactory results.

Graphical displays of the force-time transient and velocity change of the cart are shown (Figs. 1 and 2). The values taken directly from the graphs, without any correcting, are :

$I = \int F.dt = 0.604$ N s

$v_i = 0.332$ m s^{-1}
$v_f = -0.288$ m s^{-1} => $\Delta v = 0.620$ m s^{-1}

$m = 0.993$ kg => $\Delta p = 0.616$ kg m s^{-1}

A difference as low as 2% is encouraging. However there are corrections to apply to both values and uncertainties should be found.

The Velocity Graph (Fig. 2) shows that there is a deceleration due to friction. The actual velocity before the collision v_i can be found more precisely by extrapolating a best fit line from the upper linear region of the graph to the collision peak (i.e. when the cart velocity is zero). A similar extrapolation for the lower part of the graph yields a corrected value of v_f also. Microsoft *Excel* was used for this analysis[1]. Linear fits were made to data preceeding and following the impact. This gave us the best values for the extrapolated velocities and values for uncertainty due to the random scatter of data about the best-fit lines.

We already know that the motion sensor has a random error of 5 mm. The collision occurs about 1 m from the motion sensor, so this corresponds to an uncertainty of 5 mm s^{-1} in velocity. The uncertainty of the extrapolated values is ±6 mm s^{-1}. This gives a combined uncertainty of ±8 mm s^{-1} (to 95% confidence) in each velocity.

From this we can work out a corrected value for the change of momentum :

v_i = 0.328 ±0.008 m s^{-1}

v_f = -0.298 ±0.008 m s^{-1}

=> Δv = 0.626 ±0.011 m s^{-1}

m = 0.993 kg => Δp = 0.622 ±0.011 Ns

The uncorrected value of impulse given in the preceding column is an integration over the whole graph. By reducing the part integrated to the region of the collision, the new integral is 0.606 N s.

The force sensor has a systematic error of -1.017%, hence the impulse value needs a +1.017% correction. The corrected value for impulse is 0.616 N s.

The standard deviation in a measured value of force due to random uncertainties is ±0.05 N to a 95% confidence limit. If calculated as a percentage over the average force F_{av} acting over the collision period Δt, this uncertainty can be applied, as a percentage, directly to the value of impulse.

The average force acting over the collision period :

$F_{av} = I / \Delta t$

$\Delta t = 0.20$ s => $F_{av} = 0.616 / 0.20 = 3.1$ N

Uncertainty in force : ±0.05 N (95% confidence)

0.05 N is 1.6% of F_{av}

=> 1.6% of 0.616 N s = 0.010 N s

Thus, I = 0.616 ±0.010 N s (95% confidence)

From the distribution graphs (Fig. 3), it is clear that there is agreement between the corrected values for the change of momentum and impulse.

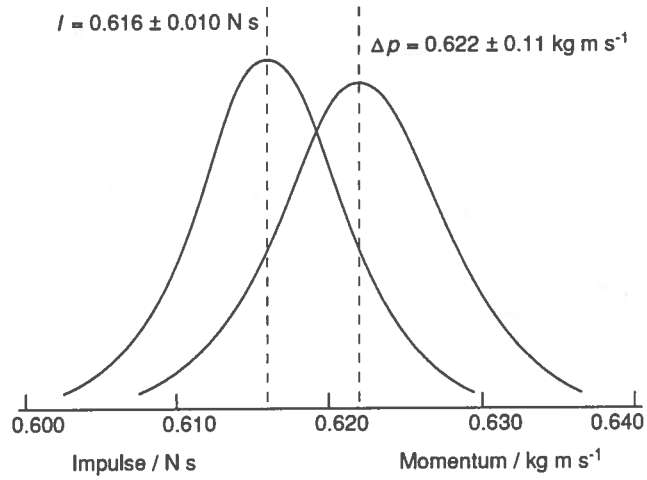


Figure 3 Distribution functions for derived values of impulse and change of momentum.

Summary : PASCO Science Workshop

- The whole package is very adaptable and easy to use; it performs well and can be configured to suit almost any experiment.
- The system includes a wide range good quality sensors for Biology, Chemistry, Environmental Science and Physics.
- The range of other equipment is extensive. It is compatible with a wide selection of high quality, basic apparatus. Note that there is really no point in providing IT equipment without also providing good quality, basic equipment - it would be like offering butter without bread.
- The *500* Interface has a good technical specification, with which its technical performance complies.
- It has a remote logging facility.
- It can operate as a storage oscilloscope.
- The sensors calibrate in actual SI units.
- High accuracy results are obtainable.
- There are many useful functions to aid analysis, such as the statistical functions and spectrum analyser.
- There is excellent on-screen support and documentation.
- There are large displays for demonstrations.
- It is a cross-platform system; data may be shifted between a Macintosh and Windows compatible computer - dependent on system type.
- Files may be exported to other packages.
- Teachers can amend files and students can make notes.
- *Science Workshop* is very general purpose - such as an oscilloscope is - thus allowing it to be used in a wide range of applications. However there are also application specific programs which simplify its use in certain laboratory experiments. Thus it meets the needs of an experimenter who wants a general purpose instrument and also the teacher who wants an application specific device or package.
- With the *500* Interface, it is specifically suited to physics education because of its fastish sampling rate and other features.
  - The 7 kHz bandwidth is limiting, but not immoderately so.
  - For a new user, setting up user defined experiments can be complex. Teacher training is recommended.
  - The software crashed a number of times at high sample rates, or when typing in experiment notes.
  - These crashes produce a number of temporary files, which the user should clean out of memory afterwards.

Range and prices

There are three interfaces in the Science Workshop range : 300, 500 and 700. Any of these may be purchased as a single item. This purchase also includes software, manuals, connectors, etc. However most customers buy a Science Workshop Bundle comprising of an interface, group of sensors, Science Workshop software, experiment library on disk, student workbook and storage box. The top of the range 700 interface is included in two of the Bundles, Economy Physics and Standard Physics. The 500 Interface reviewed here is included with all of the other Bundles.

Science Workshop is cross platform, running on a Macintosh or Windows-compatible computer (do check with PASCO on system specifications).

Acknowledgement

The benchwork required to test the hardware and software and collect experimental data was performed by a summer vacation student, Stevaan Hall, who is now in his final year at The University of Edinburgh doing Mathematical Physics.

Science Workshop prices

Science Workshop 300 Interface	CI-6665A	£237
Science Workshop 500 Interface	CI-6765A	£378
Science Workshop 700 Interface	CI-6565A	£750
Introductory Physics Bundle	CI-6681B	£1015
Economy Physics Bundle	CI-6661C	£1340
Standard Physics Bundle	CI-6662C	£2313
Biology Bundle	CI-6676B	£993
Chemistry Bundle	CI-6670B	£871
General Science Bundle	CI-6696B	£969
Math and Science Bundle	CI-6785	£824
Force Sensor (±50 N)	CI-6537	£185
Accessory Bracket with Bumpers	CI-6545	£63
Motion Sensor	CI-6529	£114

TRADE NEWS

Arnold and Harris merge

It has been announced that Philip Harris and NES Arnold have merged to form a large, new company. However, the two original company names will be retained, with NES Arnold catering largely for the Primary school market and Secondary school stationery, Art, Textiles and General supplies. Philip Harris will continue to serve the needs of science in Primary, Secondary schools and Colleges.

In many respects, schools will not experience significant changes in their choice of science resources but, from now on, there will not be a separate science catalogue from NES Arnold Scientific. Instead, selected items from the NES Arnold range of equipment will be incorporated into the Philip Harris catalogue.

NES Arnold schedule users will be pleased to hear that the prices therein will remain fixed until April, 1998, after which date a new Philip Harris schedule will be delivered to all relevant NES and Harris customers.

* * *

TECHNICAL TIP

Corroding clips

It been brought to our attention by NCBE that some users of the *SAPS/NCBE DNA* kits may be following an older and now incorrect recipe for the buffer used for the gel electrophoresis tank. This results in the crocodile clips corroding fairly rapidly. There may also be staining on the gel.

The correct recipe is given below. This is for 1 litre of a stock solution at x10 concentration which should keep indefinitely at room temperature. Obviously, quantities may be scaled down if need be. To 700 cm^3 of distilled or deionised water in a 1.5 or 2 litre flask add :

1 g sodium hydroxide
108 g tris base
55 g boric acid
7.4 g of EDTA (which must be the disodium salt)

Stir to dissolve and add more distilled or deionised water to make up to I litre

* * *

SAFETY NOTES

Smart Box Interface

We have come across a fault condition in a batch of Smart Box Computer Interfaces manufactured by Economatics throughout most of 1993 and in the early part of 1994. The fault can occur on units fitted with a toroidal type of isolating transformer. Serial numbers of the Smart Boxes fitted with the toroidal transformer in question are :

101320 - 101419
101520 - 101619
101621 - 101695
101746 - 101820
102504 - 102843
103506 - 103538
103601 - 103864
103931 - 103996

The toroidal transformer has two primary windings connected in series. This connection is made via a pair of lengthy red and black leads joined with an open ended, insulated, crimp connector. We understand that the assembly instructions were to dress the leads around the back of the transformer body, thereby trapping them between the transformer and the enclosure, thus restricting movement. However on the Interface we examined the leads had worked loose and had become flying leads. Recessed 1 mm within the open crimp connector is a hazardous live conductor at 115 V a.c. Because this can touch internal circuitry, the flying lead is hazardous.

Checks need only be made on units with serial numbers listed. If the leads at risk are insecure, then the crimp connectior should be covered with heat shrink sleeving, which will insulate the connection. The leads should be fastened to other supply leads to the transformer with cable ties. This work should only be done by a competent person.

* * *

Edu-Elequip apparatus

We have been sent information by a school indicating that a type of cord grip employed by Edu-Elequip is ineffective. Edu-Elequip manufactured a range of electrical laboratory apparatus such as power supplies, amplifier and signal generator. So far as we are aware, they went out of business in the late 1980s. The fault in question is known to occur on the Power Unit TL51, but other equipment may be affected.

The mains cord is ducted into the enclosure through a cable gland. A strain relief device is fitted inside the enclosure immediately after this cable gland. Because too large a cord grip has been used, Edu-Elequip had increased the girth of the cord by wrapping it round with insulating tape. However because this tape slides off, the cord grip can become ineffective.

An effective cord grip should prevent two types of movement : there should neither be significant translational movement, nor rotational movement. This can only be provided by fitting a cable gland designed to provide strain relief. For instance the M13 threaded cable gland from RS Components (544-011) is generally suitable. We find that it is preferable to fit this component with its large locking nut inside the enclosure to prevent it being slackened off by children.

We know of another problem with Edu-Elequip equipment. Around 1985 the company sent us apparatus for testing that had been fitted with a detachable mains cord. This connected to the enclosure with a mini-Bulgin plug and socket. It raised quite a separate hazard because other manufacturers employ the same connector for detachable extra low voltage devices such as 24 V soldering irons. The juxtaposition of both types of equipment is dangerous because the connectors could get muddled [1].

1. *Ambiguous connectors : 3-pin Bulgins* SSERC 1993 Bulletin 176, 7.

* * *

Power supply modifications

We have been contacted by Unilab concerning a Power Supply Module being offered for sale by Rapid Electronics. The module is designed to be fitted inside the enclosure of the host power supply. Drawing power from the a.c. low voltage supply of the host, it supplies the user with a regulated 5 V outlet at 1 A.

We have examined the last two issues of the Rapid catalogue, but have failed to find this product listed therein. However, being aware that Rapid are agents for power supplies made by Electrosound, we looked at a 1995 edition of that company's catalogue and found the parasite.

The module's 5 V outlet is a ½" jack socket, which, as many readers are well aware, is see through. Thus the modification, once fitted, would seem to provide your pupils with access to the interior of the host apparatus through this non-captive socket. This could well be a dangerous fitting.

Unilab have provided us with the following points:

1. They had no knowledge of this modification until it had been brought to their attention by a customer and consequently had not given any approval for it.
2. They would be reluctant to authorize any form of third party modification for their equipment.
3. Any user modification would invalidate the 12 month warranty, assurance of compliance with safety requirements and CE conformity which their products carry. Nor could they take responsibility for damage or injury resulting from unauthorised use of, or modifications to, their products.

Addendum : Klystron Power Supply

In a recent Bulletin issue [1] we reported on the cause of an electric shock and recommended control measures to prevent an event like this from recurring. Unfortunately it slipped our attention that the Klystron Power Supply (Unilab 042.871) enclosure has a series of 9 mm diameter apertures through some of which a pupil fooling around with a probe could touch an internal conductor from which he might get a shock.

Some other aged, items of mains equipment from Unilab have similar enclosures with overlarge apertures in the black, thermosetting plastic base. The following notes refer to all such equipment.

If we take a risk assessment approach, and having no record of any accident or incident relating to these overlarge apertures, the risk of harm is very slight. Each school should assess whether it would be safe for children in different classes or year groups to work with this apparatus. If behavioural problems with electrical apparatus never occur, then it may be reasonable to permit pupils in Standard Grade classes and above to handle this apparatus. If such equipment is occasionally misused, then work by pupils in Standard Grade, or even Higher Grade classes, should be prohibited.

However continued use by teachers in demonstration experiments would seem to be tolerable. In some instances it may be possible to replace the original case with an unperforated one. Three sizes of such a case type are stocked by Unilab :

090.010	Case, 203 x 152 x 59 mm	£2.98
090.011	Case, 152 x 97 x 59 mm	£1.99
090.012	Case, 76 x 51 x 31 mm	£1.70

The person undertaking such work would need to be competent and under supervision as appropriate. It would be necessary to make an aperture for cord entry and fit a strain relief device. Depending on the level of competence of the technician, the finished work should be inspected and tested by a second competent person.

It should also be considered whether it may be safer and more cost-effective simply to dispose of this aged equipment and replace it with a modern equivalent that meets present day standards of construction.

1. *Accident report : Unilab Klystron Power Supply 042.871* SSERC 1997 Bulletin 190 8.

First aid

On behalf of some Councils, Allen Cochrane here at SSERC has recently been looking at the problem of the scale of provision of trained first-aiders. The results of his work are currently out for consultation. Meantime :

Should untrained persons attempt to give first aid?

The question is addressed in a newly published leaflet from the HSE [1]. This gives official advice on basic first aid for untrained people to use in an emergency. Matters discussed include action to be taken on encountering unconscious persons, treatment for wounds and bleeding, treatment for minor injuries, suspected broken bones, burns, eye injuries and special hazards such as electrical and gassing accidents. There is also advice on illness at work.

The leaflet emphasises that it is not intended to be a substitute for effective training. The need to *send for help without delay* is repeatedly emphasised. However the leaflet also implicitly recognises that even untrained persons have a duty of care towards the casualty. If there is no trained first aider immediately available, then it may well be appropriate for an untrained person to give emergency aid.

Are any remedial measures to be taken forthwith?

This is a topic which has been considered, in recent years, by a number of educational agencies notably our sister organisation CLEAPSS and the Association for Science Education (ASE). We have included a summary of the resultant advice in our own Hazardous Chemicals Manual for Science Education [2, 3]. A copy of the relevant page is reproduced on the page opposite.

Can I be sued for performing basic life support?

A consultant anaesthetist Dr M E Ward writing in the British Heart Foundation *Heartstart* magazine *ABC* [4] replies that in order to be sued it is necessary to prove negligence, assault, or trespass. His explanation is given in the context of health care workers. From this we can draw inferences in the context of education service employees.

Neither assault nor trespass would arise unless life support was given either to a casualty who was clearly not in need of it, or who had refused consent for treatment of this kind. Three criteria must be met for a negligence suit to succeed: that you owe a duty of care to the recipient (he/she was a pupil and you were acting *in loco parentis*); that there was a breach of that duty of care (that you did not act properly); and finally that damage was caused as a result of the breach of duty. Dr Ward concludes, "It is unlikely that a negligence suit would succeed unless your actions are so far outside the norm as to be seen as foolish".

But a person untrained in first-aid has no norm on which to judge and might thus act in a foolish manner. Doing nothing could be a greater wrong because, trained or untrained, we all have a duty of care toward any casualty. It would seem that, in the end, the dilemma may only be resolved properly by the provision of adequate numbers of trained first-aiders.

1. *Basic advice on first aid at work* IND(G) 215L HSE 1997.
2. *Hazardous chemical manual for science* SSERC 1997.
3. *Safeguards in the School Laboratory*, ASE, 10th Edition, 1996.
4. *Your questions answered ABC Heartstart* British Heart Foundation 1997 5.

IMMEDIATE REMEDIAL MEASURES

What Science Staff should do while waiting for a First Aider

Chemical splashes in the eye
Immediately wash the eye with running water for at least 10 minutes, **and for much longer in the case of alkalis.** The flow should be slow and the eyelids should be held back. Afterwards the casualty should be taken to hospital (and, for alkalis, irrigation continued during the journey).

Chemical splashes on the skin
Wash the skin for 5 minutes or until all traces of the chemical have disappeared. Remove clothing as necessary. If the chemical adheres to the skin, wash gently with soap.

Chemical splashes in the mouth, perhaps swallowed
Do no more than wash the casualty's mouth. Do NOT induce vomiting. After any treatment by the first aider, the casualty should be taken to hospital.

Burns
Cool under gently running water until first aid arrives.

Toxic gas
Sit the casualty down in fresh air.

Hair on fire
Smother with cloth.

Clothing on fire
Smother by laying the casualty on the ground, flames on top. Spread a thick cloth or garment on top if necessary. A fire blanket is ideal but only use if very close by.

Electric shock
Taking care for your own safety, break contact by switching off or pulling out the plug. If it is necessary to move the casualty clear, use a broom handle or wooden window pole or wear rubber gloves. If the casualty is unconscious, check that the airways are clear and that the casualty is breathing and has a pulse. If so place the casualty in the recovery position. If the casualty is not breathing but has a pulse artificial respiration is essential. If there is no breathing or pulse, call an ambulance and begin Cardio-Pulmonary Resuscitation.

Severe cuts
Lower the casualty to the floor and raise the wound as high as possible. Get the casualty to apply pressure on or as close to the cut as possible, using fingers, a pad of cloth or better, a sterile dressing.
If the casualty is unable to do so, apply pressure yourself, but protect yourself from contamination by blood if at all possible. Leave any embedded large bodies and press around them.

Asthma attack
Asthmatic pupils will have been trained in what to do. Allow them access to their medication and permit them to take appropriate steps.

From the SSERC Hazardous Chemicals Manual for Science Education wherein it is reproduced by the kind permission of ASE and CLEAPSS from the ASE booklet : *Safeguards in the School Laboratory*

TECHNICAL ARTICLE

Switched-on genes

A simplified protocol is described for demonstrating the induction of the enzyme ß-galactosidase in strains of the bacterium *Escherichia coli.*

The core protocol to be described results from another co-operative venture between teachers, the Science and Plants for Schools (SAPS) Project, and SSERC (see Acknowledgements and also the article : *Phosphatase enzymes in Plants* in Bulletin 191 p.6 et seq.).

The remainder of this page provides more detail for teachers and technicians. The next three pages or so are intended for student use or as materials on which to base such materials. Appended are : technical information on recipes, sources of reagents etc. and acknowledgements.

Background

Curricular Enzyme induction is included as a topic both in current Scottish biology syllabuses and in the Arrangements documents for the Higher Still programme (eg see Biology: Higher Course, Unit 3: *Control and Regulation* and related topics in Advanced Higher Biology Unit 3: *Biotechnology).*

Theoretical The disaccharide lactose is found in milk but not in many other environments. Whilst young mammals can usually produce enzymes (loosely termed 'lactases') to hydrolyse lactose into its constituent monosaccharide hexoses - galactose and glucose - some higher organisms cannot. In addition some humans - *lactose intolerant individuals* - are effectively allergic to lactose in their diet and thus cannot eat many everyday dairy products. However a wide range of micro-organisms can produce lactases (eg ß-galactosidase) and are thus capable of using lactose as a substrate.

For example, the yeast *Kluveromyces lactis* produces the enzyme quite readily and is used to convert dairy products into lactose-free forms either suitable for lactose-intolerant individuals or for incorporation into frozen foodstuffs. Other well known lactose utilisers include the yoghurt bacteria such as the various *Lactobacilli sp.*

Several of these types of micro-organisms were possibly only uncontrolled contaminants of milk until harnessed by humans to produce useful, fermented dairy products. It is not surprising then to find that many, if not most, of the strains of *Kluveromyces lactis,* or of *Lactobacillus* species, available to schools, on exposure to a lactose medium seem capable of ß-galactosidase production with little or no induction period. Given the relatively narrow distribution of lactose as a substrate it is equally unsurprising that whilst other micro-organisms are capable of ß-galactosidase production the gene initiating the process is not permanently switched on but is controlled by exposure to the substrate itself.

Demonstrating ß-galactosidase action

A useful introduction to an investigation of gene control is first to develop some understanding of the action of the enzyme itself - leaving aside how it may also be switched on or off by genetic mechanisms. Both NCBE (National Centre for Biotechnology Education) and the Scottish Biotechnology Education Project (SBEP) have protocols for simply demonstrating ß-galactosidase action on milk, other lactose containing substrates or their analogues. The enzyme source for these practicals can be an organism, such as *Kluveromyces lactis*, or the enzyme itself. Both are sold by NCBE. As part of their courses NCBE and Marjorie Smith of SBEP each provide methods for investigations using these. This article aims to develop further work based on such investigations.

The lac operon

The *lac* region of the chromosome of the bacterium *Escherichia coli* is probably the best known, most closely understood, example of the genetic mechanics of enzyme control. An account pitched at a level for Higher Biology students is given opposite together with a reference to a text by Torrance.

Our account is however much simplified in that it only mentions the switching of a single gene. We know that at least four meaningful sequences of DNA (*genes* if you wish) are involved in encoding the three functional polypeptide structures involved in ß-galactosidase production and its subsequent accumulation in the cell.

The Y gene specifies the structure for a permease enzyme allowing retention of ß-galactosidase in the cell.

The Z gene specifies the amino acid sequence for the enzyme itself.

A third gene - the i gene - is a regulator which controls the synthesis of a diffusible product thought to act on a fourth (O) gene, the operator gene.

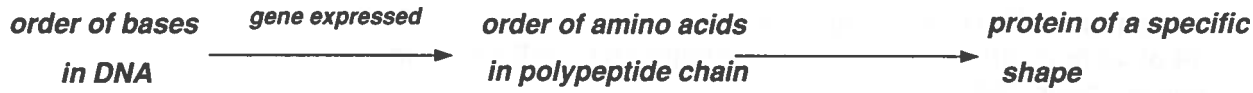
The i gene thus regulates the synthesis of the two structural genes Y and Z

In far more complex practicals than that described here, one can demonstrate the entire mechanism using four different strains of *E.coli.* These are genetically : $i^+Z^+Y^+$; $i^+Z^-Y^+$; $i^-Z^+Y^+$ and $i^+Z^+Y^-$. *E.coli* strains known as EM7, EM8, EM9 and EM10 are of these genotypes.

Here, we stick to either one or another of just two strains. The activity only demonstrates enzyme induction by lactose by incubating in the presence of a coloured, synthetic analogue of the sugar as substrate.

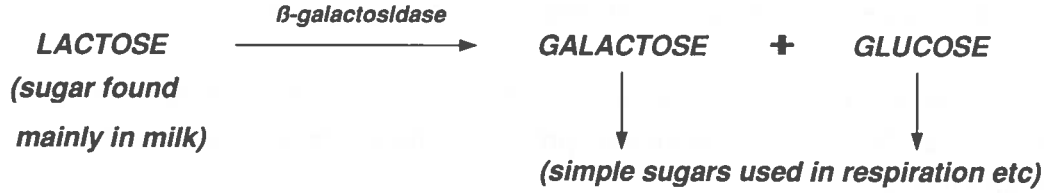
Introduction and background

Genes are effectively composed of meaningful sequences of bases within DNA. The order of these bases is a code for the sequence of amino acids in a polypeptide chain. The detail of that sequence of amino acids, among other factors, will in turn determine the way in that the peptide chain folds or otherwise transforms from a linear sequence into a three dimensional structure or compound which we call a protein. When a gene is expressed - synthesising the protein which it encodes for - the organic structure which results is capable of carrying out a specific function. For example the resulting protein may be an enzyme which can catalyse certain biochemical reactions.



Protein synthesis is an energy requiring process. Some enzymes do not have to be always present in cells. It may then be of advantage to the survival of an organism if such enzymes were only made when the substrate upon which they act is present. Suppose an organism were able to control its genes and only switch them on when the enzymes for which they hold the code are required.

The bacterium *Escherichia coli* (*E. coli*) can break down lactose (a sugar found mainly in milk) into its two sub-units, ie glucose and galactose. But, to use lactose the appropriate gene must be active in order to encode RNA and bring about the synthesis of the enzyme ß-galactosidase :



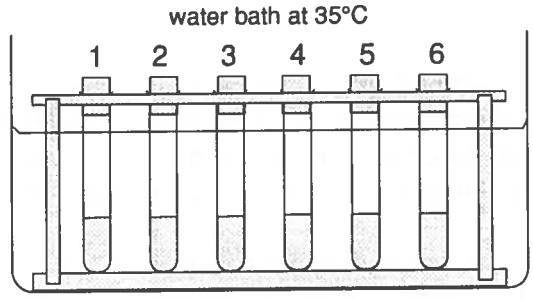
Although lactose is found in milk it is otherwise far from common. It would confer no advantage to *E.coli* were the gene for ß-galactosidase to be permanently switched on. Energy efficiencies are possible if *E.coli* activates appropriate DNA sequence(s) only when lactose is present and there is a requirement for ß-galactosidase. The suggestion that organisms could switch particular DNA sequences on and off was made in the 1960s by two scientists, Jacob and Monod. They also outlined a possible mechanism. These ideas became known as *The Jacob-Monod Hypothesis*. For a more detailed explanation please refer to your teacher or consult a text such as Torrance's *Higher Biology* pages 141-142.

In the activities which follow (overleaf) you will use as the substrate a compound known as ONPG or ortho-nitrophenyl-ß-galactopyranoside. This is a synthetic substitute for lactose. In its initial state it is colourless. It is however broken down by ß-galactosidase into the simple sugar galactose and a another compound (o-nitrophenol) which in alkaline solution is yellow . The intensity of the yellow colour, from the ortho-nitrophenol, will then give us a measure of activity for ß-galactosidase.

Level 3 Work. Use good microbiology laboratory practice throughout. See 'Strathclyde' Code or local variant thereof as a source of results of model risk assessments. The only E.coli *strains allowable for the exercise are either K12 or B.*

Collect

Six test tubes and rack; marker pen;
0.1 M sodium phosphate buffer > 30 cm^3
5 or 10 cm^3 disposable syringe;
2 x 1 cm^3 sterile pipettes with filler (or micropipettor and tips from SSERC);
methylbenzene (toluene) - small quantity;
dropper pipette; Parafilm or stoppers for tubes;
ONPG solution (must be freshly made up);
disinfectant and discard jar;
24 or 48 hr culture of *Escherichia coli* (either K12 or B strain) in nutrient broth WITHOUT added lactose
24 or 48 hr culture of *Escherichia coli* (either K12 or B strain) in nutrient broth WITH added lactose
ß-galactosidase in solution



Method

1. Wipe down the bench with disinfectant.
2. Label the test tubes 1 to 6.
3. Add 5 cm^3 sodium phosphate buffer solution to each tube.
4. Add 5 drops of methylbenzene (toluene) [HARMFUL, HIGHLY FLAMMABLE] to each tube. This helps speed up the formation of any yellow colour.
5. Aseptically transfer 1 cm^3 of the *E.coli* in the nutrient broth WITHOUT added lactose to tubes 1 and 2. Observe good laboratory practice in discarding pipettes or in dealing with any spillage etc.
6. Again using aseptic technique transfer 1 cm^3 of the *E.coli* in nutrient broth WITH added lactose (0.1 g per 10 cm^3 of broth) to tubes 3 and 4.
7. Add 1 cm^3 of the solution of the enzyme ß-galactosidase to tubes 5 and 6.
8. Add 1 cm^3 of the ONPG solution to each of tubes 1,3 and 5.
9. Stopper each tube or cover tube mouth with Parafilm and shake gently to mix and distribute the ONPG.
10. Place all six tubes in a suitable rack in a water bath at 35°C.

(continued / opposite)

Results

These may be semi-quantitative in that you should note which tubes develop a yellow colour, the order in which that occurs, and those tubes which do not develop any yellow colour within an hour or so. If a colorimeter is available, a more quantitative presentation of the results will be possible. The intensity of any yellow colour may be measured every 10 minutes. Select a 420 nm filter. Use the appropriate matching, even-numbered, tubes as blanks with which to zero the colorimeter for each reading. Plot the results, as % transmission or absorbance, against time.

Questions and further ideas

1. Explain :
   (a) The timing of the appearance of the yellow colour in tube 5.
   (b) The difference in time for the yellow colour to appear in tube 3.
   (c) Any observed differences in the speed of formation of the yellow colour between tubes 1 and 3.
   (d) Why, if tube 1 is retained, a deep yellow colour will eventually appear.

2. Re-arrange the following table to match up each of the terms with a function or meaning.

Term	*Function/Meaning*
repressor molecule	When activated makes a specific protein.
regulator gene	If present, this combines with the repressor molecule thus allowing the operator gene to switch on the structural gene.
inducer	Made by the regulator gene and combines with the operator gene preventing it switching on the structural gene.
structural gene	Can be switched off by the repressor molecule. If repressor molecule is combined with an inducer, it is switched on activating the gene coding for the specific protein.
operator gene	Makes the repressor molecule.

3. Design and carry out further investigations on the effect of different carbohydrate substrates, both singly and together (in pairs say) on the pattern of growth in a bacterial culture.

Technical details

ONPG - Sigma Aldrich Cat.N1127, 1 g £9.70. (0.04 g in 10 cm^3 sodium phosphate sol'n. Make up ONPG fresh each time).

Sodium phosphate - Na_2HPO_4 ie dibasic, anhydrous, adjust to pH8 with dilute HCl;

ß-galactosidase - NCBE (Novo Lactozyme from yeast, £12.50 for 100 cm^3) or Sigma Aldrich G2513.

E. coli (K12 strain [B strain works well also]) - eg Harris Biological (K12 - Cat. H50650/8 £5.99)

Acknowledgements

The simplified protocols described above were suggested by a number of earlier accounts, most notably :

1. Sambrook, J. et al., *Molecular Cloning : A Laboratory Manual*, 2nd Edition, Cold Spring Harbor Laboratory, Vol. 3, 1989.
2. MacLean, N., in *Laboratory Manual of Cell Biology*, Editors: Hall, D.O. and Hawkins, S.E., English Universities Press, 1975.
3. Cappucino, J.G. and Sherman N., *Microbiology : A Laboratory Manual*, Addison Wesley, 1983.

The work was very much a co-operative exercise and acknowledgements are also due to *Roger MacAndrew*, then with the Scottish SAPS project now at Queensferry High who did much of the work; *Marjorie Smith* (SBEP and Dollar Academy); *John Rennie* of George Watson's College and, not least, *Ian Gilmour* of Currie High School, who first started this particular hare.

BIOTECHOLOGY NEWS

Scottish Biotechnology Project

The Scottish CCC has now circulated its second short newsletter giving an update on progress to date with the Scottish Biotechnology Education (SBE) Project. Among the items mentioned are a resource pack to support Revised Higher Biology. These will be made available as part of the project's programme of training courses. Also planned is a Summer school in the week beginning 29th June 1998 at Edinburgh University. To note your interest please contact Marjorie Smith (SBE Development Officer - see Address List, inside rear cover).

"What's what in Biotechnology?"

With a recent Newsletter, the NCBE at Reading recently circulated a useful Briefing Paper produced by the European Federation of Biotechnology. This provides a 4 page glossary of biotechnological terms with definitions, answers to common questions etc. If you didn't get a copy then you should be able to obtain one by writing to the Secretary of the EFB Task Group on Public Perceptions - see our Address List.

Additional organisms and techniques

A number of groups are beginning to look at possible revisions and updating of educational codes of practice for microbiology. It will however be some time before any such group will report. In the meantime you may have noticed that either we or other agencies have mentioned or suggested some micro-organisms for educational use which, apparently, are not on any of the quasi-official lists. (cont. next col.)

Organisms : Those of you who have read the various codes carefully will be aware that such lists were never meant to be either exhaustive or exclusive. It always was intended that the use of other organisms be left open and that their acceptance for any specific educational application would be dependent on the results of risk assessments.

Two organisms in particular have had a lot of mentions of late. Both are used for protocols by NCBE and in work developed within the SBE Project. These are both non-pathogenic yeast type organisms viz : *Kluveromyces lactis* and *Phaffia rhodozyma*. Since both are not only non-pathogenic but also widely used in the food industry, in our view they are perfectly acceptable for use in Scottish schools. Given suitable and simple controls they could even be used for Level 1 work at 5-14.

Technique : On SBEP training courses, teachers may be supplied with a freeze dried culture of *Phaffia rhodozyma* in a glass ampoule. Again this is something the older codes rule out in their normal or standard procedures. However, with suitable training and a good set of instructions there is no reason why teachers or technicians can't handle such cultures perfectly safely. Marjorie Smith has written such a short set of instructions. We have other good examples - notably from the National Collection of Industrial and Marine Bacteria. Copies can be supplied on request.

TRADE NEWS

Remember Charles Frank, Moncrieff the glassmakers, W B Nicolson, or Rollo Industries? In case you don't, they were all Scottish manufacturers of science apparatus, the end of a tradition of instrument makers going back to the eighteenth century. Sign of the times? This issue's *Trade News* has information about several new products made in Scotland by young Scottish companies - djb microtech, Crocodile Clips, and ScienceSoft.

djb Microtech

Maths Tools for Schools is a new djb product, which has been designed to let pupils explore mathematical data and functions. Data may be entered into a table from the keyboard. The data may then be graphed and analysed. Graphs can be super-posed, coordinates and gradients of any points found and areas calculated. There is also a curve fitting feature selecting from the standard curves studied in Higher Maths. The equation can also be shown.

It is only available for Macintosh computers with System 7 and 2 MB available RAM. The cost is £25.50 for a single user licence, or £36 for a site licence.

Time, Speed and Acceleration (TSA) is another new djb product. It is a microcontroller based instrument for the Physics Lab. At £93.50, we believe it undercuts much or all of the competition. With just three pushbutton controls, it is simple to operate. Instructions and readings, in SI units, are displayed on a two line alphanumeric LCD display.

Timing is triggered by electrical inputs from light gates or peripheral switches. Two switch types are available - manual, for reaction timing, and sonic, for speed of sound measurement for which, with a resolution of just 10 μs, you don't need yards of benchspace!

The *TSA* can be battery powered, or from an LT supply. If supplied by battery, we understand that a single PP3 can power the TSA for over 10 hours, indicating that extensive outdoor investigations can be carried out. Prices are as follows :

Time, Speed and Acceleration	£93.50
Light Gate Receiver	£14.45
Light Gate Source	£7.95
Reaction Timer Switches (per pair)	£7.99
Sound Switch (per pair)	£28.40

* * *

Crocodile Clips

Crocodile Clips is a software package allowing circuits to be constructed from its library of components. These virtual circuits simulate the actual ones they pretend to be. Bulbs light or fuse, depending on judgement, or lack of it, or just pure luck! Values of current and potential at different circuit places can be indicated. A graphical display can be included to show time varying events. This may either show continually repeating effects such as a.c., or one-offs such as voltage transients. Thus the display simulates either an oscilloscope, or a datalogger.

This popular package has recently been updated to include mechanical components. *Crocodile Clips 3*, as the new release is called, now allows the creation of electro-mechanical designs. An animated display shows how components interact. The new components include gears, chain drive, rack and pinion, springs, generator, motor, solenoid, flywheel and microswitch. Values of forces and torques may be displayed. Another new feature is a sound synthesizer, allowing the simulation of musical systems.

There are versions for Windows and Macintosh. Licences cost £70, or £150 (Single, or 5-User). Licensees of version 2.0 are charged £49 to upgrade to version 3.0.

* * *

Sciencesoft Calculator

Whereas the scope of *Maths Tools for Schools* (see opposite) sits squarely within the bounds of the Higher Grade syllabuses, *Sciencesoft Calculator* has wider application, being used by industry and higher education. However it may also find application in schools because it is not too intimidating. In fact it has no more than the standard functions you would expect to find on the typical scientific calculator - and how ordinary and commonplace is that! - along with a graphing facility.

Where it scores over its ubiquitous little namesake (i.e. the scientific calculator) is that the user may perform calculations, analyse data and plot graphs in the Windows environment of a computer display. This allows the user to get high quality printouts, or to incorporate data and graphs with lab reports.

Sciencesoft Calculator is not a spreadsheet. It adopts a minimalist approach to data analysis by providing just two columns for data. This is in recognition of the vast amount of time that engineers reportedly often waste on programming spreadsheets.

Data can be imported from elsewhere for analysis. Thus its main application would seem to be analysing data collected electronically by dataloggers, or manually from direct reading instruments, then retransporting the worked data into a word processing package for a finished lab report.

The cost of a single user package is £59. There is only a PC version.

* * *

Exploring Space

The *Exploring Space* slide set has been put together by Dr James More (PT Physics, Glenwood HS) and is published by Armagh Planetarium at £15. The thirty slides of the solar system and beyond are supported by detailed notes for teachers.

The curricular relevance is *Earth in Space*, a key feature of the 5-14 Environmental Studies guidelines. The notes have been designed to assist teaching to the following content at the P7-S2 Broad Stage :

> Major features of the Universe and details of the solar system
>
> Knowledge from space exploration

The aim of the notes is to encourage the active participation of pupils in discussing the slides rather than presenting a collection of facts which will not be retained and could be researched by the pupils themselves.

* * *

Pumps and pipettors - again!

Pi-pumps : We have found some more sources of inexpensive Pi-pump pipette fillers. These are available in three sizes from either *Refer Scientific* in Aberdeen or *React Scientific* of Troon (see Address List inside rear cover). All three types are the same price from either supplier and the code numbers etc are as follows :

Capacity (cm^3)	*Code no.*	*Price each* (£)
0 - 2	R622	5.75
0 - 10	R623	5.75
0 - 25	R624	5.75

Micro-pipettors : We have also located an excellent source of inexpensive micro-pipettors in three capacity ranges. Such devices are required more and more as microbiology, biotechnology and smaller scale, more environmentally friendly, chemistry teaching become increasingly important.

To date, a major drawback to school or non-advanced use in FE has been price. More upmarket micropipettors are commonly well over the £100 mark each. We have now managed to buy in a number of each of three sizes of micropipettors for sale to schools at a very competitive price - £16.00 each. See Items 849 to 851 inclusive in our Equipment Offers listings. We shall also make available packs of replacement tips for each size of pipettor (see Items 852 to 854 inclusive).

* * *

Equipment Offers

Items are arranged by similarity of application, or for other reasons, and not by stock number sequence. Often the item number serves only for stock identification by us in making up orders. Newer stock items are underlined, so as to be more easily seen.

VAT : The prices quoted do not include VAT. However it is added to every customer's order. Local authority establishments will be able to reclaim this input VAT.

Postage : Postage and, where necessary, packing, will be charged for.

It is therefore best not to send cash with an order, but wait for us to bill you. Official orders may be used.

Please try and ask for at least £10 worth of goods because the administrative costs of handling orders are significant.

Don't send cash with orders

We repeat, please do not send payment with your order. Wait until you receive our advice note upon which payment may be made. This saves unnecessary complications e.g. when items are out of stock, failure to make provision for VAT, or if a delivery charge needs to be made. Items of equivalent value may be deducted from your order to balance any shortfall.

Motors

778 Stepper motor, Philips MB11, been stored in damp conditions but unused and retested. 4 phase, 12 V d.c., 100 mA per coil, 120 Ω coil per phase, step angle 7.5°, with 7 mm x 2 mm dia. output shaft. Dimensions 21 mm x 46 mm dia. on oval mounting plate with 2 fixing holes, diam. 3 mm, pitch 42 mm, at 56 mm centres. Circuit diagram supplied. £2.50

755 Pulley wheel kit comprising:
- plastic pulley wheel, 30 mm dia., with deep V-notch to fit 4 mm dia. shaft,
- two M4 grub screws to secure pulley wheel,
- Allen key for grub screws, and
- 3 mm to 4 mm axle adaptor.

The whole making up a kit devised for SSERC tacho-generators with 3 mm shafts.
Specially supplied to SSERC by Unilab. £1.25

848 Motor, 12 V d.c., no load current 2 A at 12 V and 1.5 A at 5 V. Min. no load starting voltage, 2 V, min no load running voltage 0.8 V. 64 X 37 mm dia., shaft, 11 X 3 mm dia. £2.50

614 Miniature motor, 3 V to 6 V d.c., no load current 220 mA at 9600 r.p.m. and 3 V, stall torque 110 mN m, dims. 30 mm x 24 mm dia., shaft 10 mm x 2 mm dia. 45p

593 Miniature motor, 1.5 V to 3 V d.c., no load current 350 mA at 14800 r.p.m. and 3 V, stall torque 50 mN m, dims. 25 mm x 21 mm dia., shaft 8 mm x 2 mm dia. 30p

739 Miniature motor, 1.5 V d.c., dimensions 23 mm x 15 mm dia., shaft 8 mm x 1.7 mm dia. 25p

621 Miniature motor, 1.5 V to 3 V d.c., open construction, ideal for demonstration, dimensions 19 x 9 x 18 mm, eight tooth pinion on output shaft. 25p

838 Motor, solar, 12 mm long by 25 mm dia., shaft 6 x 2mm dia. (see also Item 838 - solar cell) £1.70

732 Motor with gear box, high torque, 1.5 V to 12 V d.c., 125 r.p.m. at 12 V, dimensions 40 x 40 x 28 mm, shaft 10 mm x 3 mm dia. with key. Suitable for driving buggies, conveyor belt, or any other mechanism requiring a slow drive £6.00

773 Tachometer (ex equipment) £2.25

811 Worm and gear for use with miniature motors, 34 : 1 reduction ratio plastic worm and gear wheel. 35p

378 Encoder disk, 15 slots, stainless steel, 30 mm dia. with 4 mm dia. fixing hole. 80p

642 Encoder disk, 30 slots, stainless steel, 30 mm dia. with 4 mm dia. fixing hole. 80p

772 Encoder disk, 4-bit Gray code, stainless steel, 81.28 mm dia., 3 mm fixing hole, slots sized to register with components mounted on 0.1" stripboard. Applications: shaft position sensing, wind direction indicator.
For related electronic circuitry see Bulletin 146. £3.00

Precision motor stock

785 Precision motor with optical shaft encoder, 0.25 to 24 V d.c., no load current and speed 9 mA and 6,600 r.p.m. at 24 V, stall torque 23 mNm, 9 segments. Overall body length including shaft encoder 59 mm, dia. 23 mm with output shaft 20 x 3 mm dia. Back EMF constant 3.6 V/1000 r.p.m. Suggested application - tachogenerator. Data on shaft encoder section available on application. £15

787 Precision motor with attached gearbox, 0.15 to 12 V d.c. With a supply of 3 V, the no load current is 25 mA and the output shaft turns at ca. 20 r.p.m. Gearbox ratio 1 : 365. Overall body length including gearbox 43.5 mm and diameter 16 mm. Output shaft 6 x 3 mm dia. with flat side to maximum depth of 0.3 mm along outer 5 mm length of shaft. Application - any system where a very slow angular velocity is required. £15

836 Motor mounts, plastic push-fit with self adhesive base pad, suitable for SSERC motors 593 & 614, pk of 10 £1.95

Miscellaneous items

801 Propeller, 3 blade, to fit 2 mm shaft, 62 long. (Replaces Item 791at lower cost). 35p

792 Propeller kit with 10 hubs and 20 blades for making 2 or 3 bladed propellers. 130 mm diameter. Accepts either 2 mm or 3 mm shafts. £3.40

790 Buzzer, 3 V. 55p

827 Buzzer, 6 V. 55p

629 Dual tone buzzer with flashing light back in stock 55p

846 Sound module, includes 'melody' chip and Piezo transducer. £1.00

710 Sonic switch and motor assembly. First sound starts the motor, a second reverses the direction of rotation, a third sound stops the motor. Driven by 4 AA cells (not supplied). 85p

715 Pressure gauge, ca. 40 mm o.d. case, 25 mm deep and 33 mm dia. dial reading 0 to 4 bar (i.e. above atmospheric). With rear fitting for $^1/_8$" BSP. Suitable for use as indicator for pneumatic circuits in Technological Studies. 75p

165 Bimetallic strip, length 10 cm;
high expansivity metal: Ni/Cr/Fe - 22/3/75
low expansivity metal: Ni/Fe - 36/64 (invar) 15p

166 Ditto, but 30 cm length. 40p

385 Pressure switch, operable by water or air pressure. Rated 15 A, 250 V (low voltage operation therefore possible). Dimensions 2" x 3" dia. 65p

758 Loudspeaker, 8 Ω, 0.5 W, 66 mm dia. 50p

771 Neodymium magnet, 13.5 mm dia. x 3.5 mm thick. £1.30

837 Ring magnet, 40 mm o.d., 22 mm i.d. 35p

815 Ceramic block magnets, random polarisation, 19 x 19 x 5 mm. 15p

823 Ceramic block magnets, poles at ends, 10 x 6 x 22 mm. 12p

824 Ceramic block magnets, poles on faces, 25 x 19 x 6 mm. 35p

825 Forehead temperature measuring strips 50p

745 Sub-miniature microphone insert (ex James Bond?), dia. 9 mm, overall depth 5 mm, solder pad connections. 40p

723 Microswitch, miniature, SPDT, lever operated. 40p

354 Reed switch, SPST, 46 mm long overall, fits RS reed operating coil Type 3. 10p

847 Rocker switches, panel mounting, (mixed stock). 15p

738 Relay, 6 V coil, DPDT, contacts rated 3 A, 24 V d.c. or 110 V a.c. 75p

774 Solenoid, 12 V, stroke length 30 mm, spring not provided. £2.25

742 Key switch, 8 pole changeover. 40p

382 Wafer switch, rotary, 6 pole, 8 way. 70p

688 Croc clip, miniature, insulated, red. 5p

759 Ditto, black. 5p

788 Crocodile clip leads, assorted colours, insulated croc. clip at each end, 360 mm long. £1.35

809 Wire ended lamp, 3 V 10p

741 LES lamp, 6 V. 15p
770 ditto, but 12 V. 15p
789 MES lamp, 3.5 V, 0.3 A 9p
690 MES lamp, 6 V, 150 mA. 9p
691 MES battenholder. 20p

692 Battery holder, C-type cell, holds 4 cells, PP3 outlet. 20p

730 Battery holder, AA-type cell, holds 4 cells, PP3 outlet. 20p

845 Battery holder, holds two C-type cells, PP3 outlet. 20p

835 Battery holder, AA-type cell, holds 2 cells, PP3 outlet. 15p

729 Battery connector, PP3 type, snap-on press-stud, also suitable for items 692 and 730. 5p

724 Dual in line (DIL) sockets, 8 way. 5p

760 DIL sockets, 14 way. 7p

826 DIL sockets, 16 way. 8p

808 Electrodes for making lemon or other fruit cells etc. 1 pair, comprising 1 of copper, 1 of zinc, each approx. 60 mm square, per pair 50p

716 3-core cable with heat resisting silicone rubber insulation, 0.75 mm² conductors, can be used to re-wire soldering irons as per Safety Notes, Bulletin 166. Per metre. £1.35

756 Silicone coated, braided glass sleeving, yellow, 2.5 mm dia., gives both heat and electrical insulation to conductors (e.g. for autoclave rewiring). Price per metre. 55p

714 Sign "Radioactive substance" to BS spec., 145 x 105 mm, semi-rigid plastic material. Suitable for labelling a radioactive materials store. With pictogram and legend. £2.70

763 Sign "DANGER, Electric shock risk" to BS spec., rigid plastic, 200 x 150 mm. £2.70

764 Sign "DANGER, Laser hazard" to BS spec., rigid plastic, 200 x 150 mm. £2.70

727 Hose clamp, clamping diameter from 8 mm to 90 mm, 101 uses - securing hose to metal pipe, tree to stake, joining wooden battens for blueing, etc. 30p

731 Re-usable cable ties, length 90 mm, width 2 mm, 50 per pack. 12p

752 Shandon chromatography solvent trough. £1.00

805 Condenser lens, bi-convex, 200 mm focal length, 75 mm dia. Crown glass. £12.50

806 Condenser lens, plano-convex, 150 mm focal length, 75 mm dia. Crown glass. £12.50

Components - resistors

420 resistors, 5% tolerance, ¼ W : Per 10. 6p
1R5, 4R7, 5R6, 6R8, 8R2, 10R, 15R, 22R, 33R, 47R, 56R, 68R, 82R, 100R, 120R, 150R, 180R, 220R, 270R, 330R, 390R, 470R, 560R, 680R, 820R, 1K0, 1K2, 1K5, 1K8, 2K2, 2K7, 3K3, 3K9, 4K7, 5K6, 6K8, 8K2, 10K, 12K, 15K, 18K, 22K, 27K, 33K, 39K, 47K, 56K, 68K, 82K, 100K, 150K, 220K, 330K, 390K, 470K, 680K, 1M0, 1M5, 2M2, 4M7, 10M.

421 DIL resistor networks, following values available: 62R. 1K0, 6K8, 10K, 20K, 150K. Per 10. 30p

BP100 Precision Helipots, Beckman, mainly 10 turn. 10p-50p

Components - capacitors

813 Capacitors, polystyrene: 4p
180 pF, 220 pF, 330 pF, 560 pF, 1000 pF, 2400 pF, 3000 pF, 3300 pF, 3900 pF & 4700 pF

695 Capacitors, tantalum,
15 µF 10 V, 47 µF 6.3 V. 1p

696 Capacitors, polycarbonate,
10 nF, 220 nF, 1 µF, 2.2 µF. 2p

697 Capacitor, polyester, 15 nF 63 V. 1p

698 Capacitors, electrolytic,
1 µF 25 V, 2.2 µF 63 V, 10 µF 35 V. 1p

358 Capacitor, electrolytic, 28 µF, 400 V. £1.00

Components - semiconductors

807 Schools' Chip Set, designed by Edinburgh University, comprises the 4 chips and prototype board.
Schools in members EAs, subscriber schools £4.00
FE colleges in membership of SSERC £10.00

Edinburgh University support material :
Volume 1 : Teaching Support Material (+£2 p&p). £4.50
Volume 2 : Laboratory Work (+£2 p&p). £5.00

322 Germanium diodes 8p

701 Transistor, BC184, NPN Si, low power. 4p

702 Transistor, BC214, PNP Si, low power. 4p

717 Triac, Z0105DT, 0.8 A, low power. 5p

725 MC74HC139N dual 2 to 4 line decoders/multiplexers 5p

699 MC14015BCP dual 4-stage shift register. 5p

711 Voltage regulator, 6.2 V, 100 mA, pre-cut leads. 10p

Sensors

615 Thermocouple wire, Type K, 0.5 mm dia., 1 m of each type supplied: Chromel (Ni Cr) and Alumel (Ni Al); for making thermocouples, see Bulletins 158 and 165. £2.20

640 Disk thermistor, (substitute type) resistance of 15 kΩ at 25°C, β = 4200 K. Means of accurate usage described in Bulletin 162. 30p

641 Precision R-T curve matched thermistor, resistance of 3000 Ω at 25°C, tolerance ±0.2°C, R-T characteristics supplied. Means of accurate usage described in Bulletin 162. £3.00

718 Pyroelectric infrared sensor, single element, Philips RPY101, spectral response 6.5 µm to >14 µm, recommended blanking frequency range of 0.1 Hz to 20 Hz. The sensor is sealed in a low profile TO39 can with a window optically coated to filter out wavelengths below 6.5 µm. Data sheet supplied. For application see SG Physics Technical Guide, Vol.2, pp 34-5. 50p

503 Kynar film, unscreened, 28 µm thick, surface area 12 x 30 mm, no connecting leads. £1.00p

504 Copper foil with conductive adhesive backing, makes pads for unscreened Kynar film to which connecting leads may be soldered. Priced per inch. 15p

506 Resistor, 1 gigohm, ¼ W. £1.40

Opto-electronic devices

838 Solar cell, 100 x 60 mm, 3.75 V per cell max. £2.10

507 Optical fibre, plastic, single strand, 1 mm dia. Applications described in Bulletin 140 and SG Physics Technical Guide Vol.1. Priced per metre. 50p

508 LEDs, 3 mm, red. Price per 10. 50p
761 Ditto, yellow. Per 10. 60p
762 Ditto, green. Per 10. 60p

New - economy variable volume micropipettors

Of slimline profile, these micropipettors are fully autoclavable (121° C max.). They have a nominal accuracy of ± 1.75%. Supplied with spare O-ring and lubricant. Tip ejector swivels, thus pipettors are suitable for either left- or right handed users. Colour coded bodies for ease of identification. Supplied with two tips and stocks of spare tips available. Three sizes :

849 micropipettor, 1 cm^3, range 100 to 1000 µl £16.00
850 micropipettor, 5 cm^3, range 500 to 5000 µl £16.00
851 micropipettor, 10 cm^3, range 1000 to 10,000 µl £16.00

Replacement tips in packs of 25 tips :

852 replacement tips for 1 cm^3 micropipettor, pack. £1.50
852 replacement tips for 5 cm^3 micropipettor, pack. £1.70
852 replacement tips for 10 cm^3 micropipettor, pack. £2.15

Items not for posting

All of the following items are only available to callers because of our difficulties in packing and posting glassware and chemicals. We will of course hold items for a reasonable period of time to enable you to arrange an uplift.

Glassware, chemicals etc.

664 Flat bottom round flask, 500 ml. 50p

768 Sodium lamp, low pressure, 35 W. Notes on method of control available on application. 85p

810 Watch glasses, assorted sizes 20p

712 Smoke pellets. For testing local exhaust ventilation (LEV) - fume cupboards and extractor fans : large, 50p, small, 40p

* * *

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Email: sserc@mhie.ac.uk.
Web site: http://www.stgeorges-school.demon.co.uk/SSERC/

Aldrich, The Old Brickyard, New Road, Gillingham, Dorset, SP8 4JL. FREE PHONE: 0800 717181,
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Tel: 01334 463856.

Dr Wilson Flood, 68 Rowanbank Road, Dumfries, DG1 4QE.
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