SCOTTISH SCHOOLS EQUIPMENT RESEARCH CENTRE
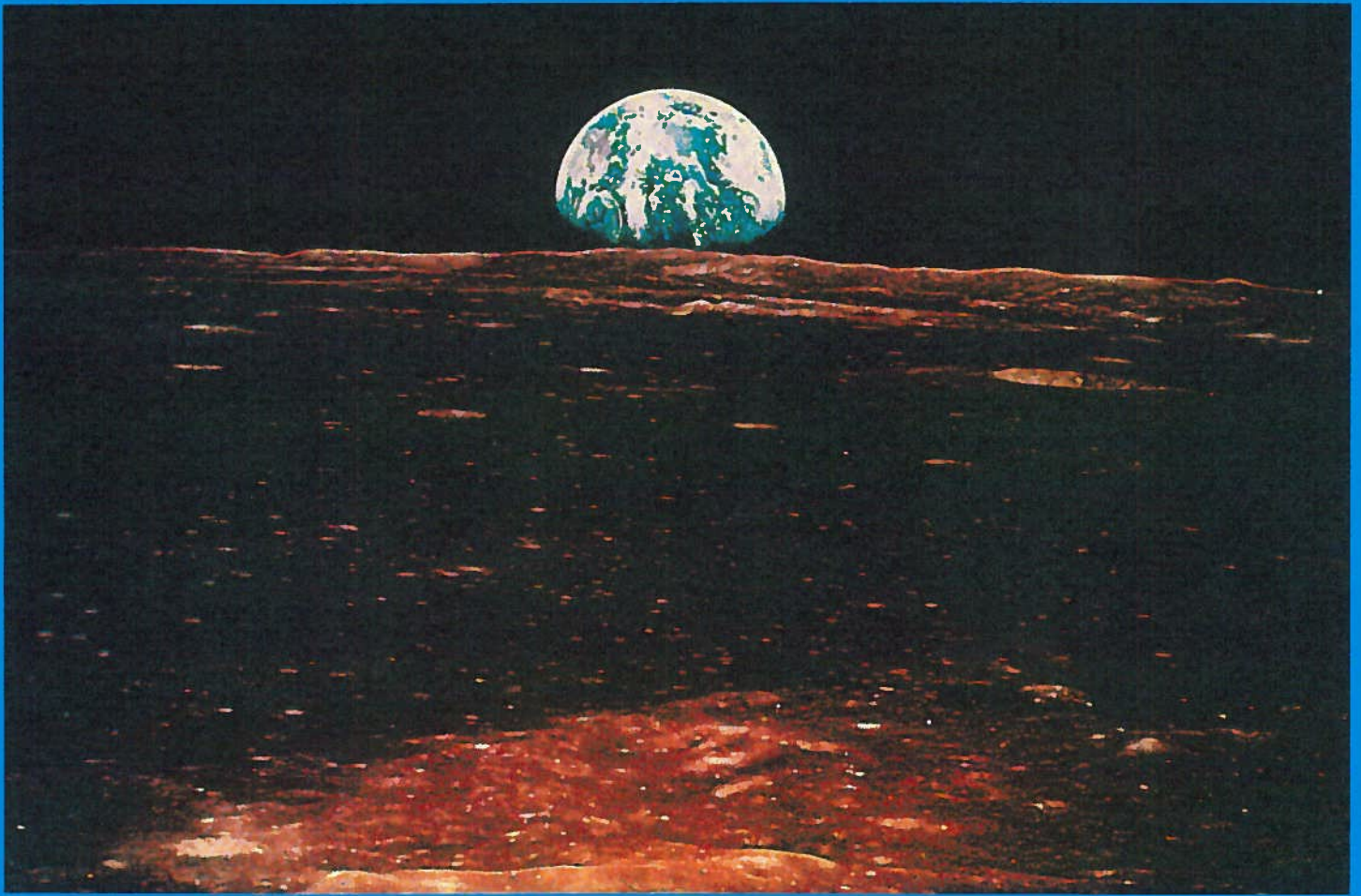

Science & Technology Bulletin

For: Teachers and Technicians in Technical Subjects and the Sciences

Science and Technology Bulletin

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INTRODUCTION

Waffly, only slightly rude, bits

We apologise for the late appearance of this issue - lot of stuff happening, innit[1]? Familiar, as well as feeble to most teachers and technicians, I know! That, as you all also well know, doesn't stop it being true. There's been a lot with which to deal lately. We have had to beaver away at a number of tasks other than this Bulletin. The chips and shavings from all of that beavering soon should be flying your way. (What we have to do these days to avoid mixing the odd metaphor).

We have been very busy also just keeping up with the orders for our Hazardous Chemicals Manual - for which highly esteemed custom, not to mention the cash - many thanks. An electronic, interactive, version of the manual is nearing completion, with sample CDs about to be *burned* for trials. How times have changed. In the first great information technology revolution - called "print" apparently - it could be more or less the other way about. These days it seems that you can cause all sorts of monopolistic mayhem and get away with nothing more than a Belgian confectionery facial. As they might have said in my young day : "Custard pies are for Wimps". They could at least have pulled down his menus and disabled his scroll bar.

Press any key to continue - $

1. "Stuff" - universal pronoun of the young and "innit" useful combined verb and object.

Staffy bits

It is some years since last we listed the names, posts and various specialisms of the SSERC staff team. We have had a few requests recently to repeat the exercise. This is so that when you 'phone, fax, e-mail or write in quaint old-fashioned joined-up writing, you know to whom to address different types of enquiry.

Ian Birrell, Development Officer : ICT including graphics libraries and other SSERCsoft products; data logging etc and chemistry.

Ian Buchanan, Senior Associate : technology education, 5-14 environmental studies, technician support.

Allen Cochrane, Senior Associate : chemical education, health and safety, especially occupational hygiene, fume cupboards, other LEV and chemical safety generally.

Marjorie Hamilton, Technical Officer : technical support for chemistry and biology including biotechnology.

Jim Jamieson, Senior Associate : physics, electronics, equipment testing, health and safety, especially physical agents including radiological protection.

Graeme Paterson, Technical Officer : electronics, testing, repairs, troubleshooting, electrical safety, sales etc

John Richardson, Executive Director : general policy, other boring bits - occasionally - biology, biotechnology.

Anne White, Administrator & Circulation Manager : general administration, invoices and accounts (everything really).

Baldricky bits

Readers will not know it but SSERC has a cunning plan. We try to have a rolling three year Service Development Programme. But, with the upheaval of local government re-organisation, it rolled away and hid under a filing cabinet as we scrambled for survival. By then the cunning plan had come to lean heavily on what the drollsters in the team christened "achievable priorities". These were all the tasks we had managed to get done the previous year. This was known as the rolling backwards programme.

Now, things are more stable financially. Bar one or two, most councils now are in membership of SSERC. Some still outwith the club at the time of writing have announced their intention to join or re-join for the 1998-99 financial year. It is time to dust off the cunning plan and modify it in the light of consultation with folk that matter - chiefly yourselves.

To that end we have inserted into this Bulletin issue an evaluation questionnaire. This looks long, but it is of a simple *tick the box* or *circle the letter* format and we judge that it should not take too much of your valuable time to complete. As an added incentive (ie smallish bribe) those who eschew anonymity will have their completed form put into a prize draw. The owners of the first three forms out of the hat will each get a cheap, tatty but useful prize. We may be silly but, be warned that even we will be alive to the possibilities for cheating with photocopied forms, pupil slave labour etc. So scam us no scams! Please try to return your forms a.s.a.p. We can then attempt to change the service as necessary to better meet the needs of clients. That way we may all yet get our very own turnip.

Jollies and hoolies

Just some reminders that it's not too late to book up for several of the professional gatherings due to be held in the coming Summer term viz :

> Institute of Biology. Third Education Meeting. Thursday 14th May at the University of Stirling.
>
> Institute of Physics. Annual Education Meeting Thursday 21st May, University of Stirling and a two day "Update" meeting 22nd and 23rd May at the Conference Centre, Heriot Watt University.
>
> Royal Society of Chemistry. National Meeting for Teachers. Thursday 21st May at St. Andrews University.
>
> Biotechnology Summer School. confirmed for the week beginning 29th June, Edinburgh University.

For details of contacts for each of the above listed events see the Address List, inside rear cover of this issue.

Tenth Science Festival

At the time of writing, the official programme for the tenth Edinburgh International Science Festival had just been released. As usual, the schools' programme begins earlier and may well be underway as this issue goes to press. The festival proper takes place from the 4th through to the 19th of April.

As in previous years, the programme has a number of themes covering topics as diverse as "Full Up" on the science of food, "New Technology", "Ageing", "Explorers", "Health Matters", "Outer Space" and "Water". So there should be something, as they say, for everyone. There will also be both a Science Book Festival and a Film Festival running concurrently with the main body of the programme.

For further information, programmes and bookings see the information in the Address List, inside rear cover of this bulletin issue.

More for technicians

Following on from the project on S/NVQs for technicians in education, which was managed by the Association for Science Education, is another initiative. This aims to develop a framework for a modern apprenticeship scheme for technicians. It has been set up under the auspices of ST+M (The Science, Technology and Mathematics Council). The Project Leader is Dr Colette Baird who earlier looked after the S/NVQ project for ASE. The Steering Group only held its first meeting in mid January of this year. We shall try to keep Scottish technicians and other interested readers informed as the project progresses.

Non-tabloid papers from POST

The Parliamentary Office of Science and Technology publishes some well written and educationally useful reports on contemporary issues. Many of the reports proper are probably too long and too dear for use in schools or colleges by busy, poor, teachers. POST Report Summaries however are a different matter. Teachers may well find them extremely useful in better informing students on matters currently the subjects of scientific and public debate. We have recently obtained another three titles and can thoroughly recommend them as useful background to currently controversial issues. (next col.)

They are POST Technical Report 103, October 1997 : *BSE and CJD Update*, POST Report Summary 104, October 1997 : *Safer Eating : Microbiological Food Poisoning and its Prevention* and POST note 109, January 1998, *Health Risks and Mobile Phones* (which evaluates evidence, if any, for harmful effects from radio frequencies). The first two look particularly useful as sources of tables, graphs and charts for interpretation exercises. They provide good examples of how multi-dimensional scientific problems may prove and the importance of exercising judgement or adopting precautionary approaches.

SSERC is negotiating copyright clearance for some of these report summaries. We could then make photocopies available to interested teachers. But if your school is on-line then you can access summaries at the POST Web site.

http://www.parliament.uk/post/home/htm

Summaries may also be downloaded using Adobe Acrobat (available, if need be, as a plug-in at the site).

CV tips

The Net and Web also have their more entertaining uses. We have obtained via anarchic e-mail some gaffes to avoid in your next job application. Before anyone sends us bahookey-clenched complaints : We know - none are PC, not even remotely compatible. Look on the bright side - that, at least and for once, is not Bill Gates' fault.

CV and covering letter phrases to avoid :

It best for employers that I not work with people.

I'm a perfectionist and rarely if if ever forget details.

Finished my PGCE eighth in my class of ten.

Please don't misconstrue my 4 teaching posts to date as job-hopping. I have never voluntarily left a post.

References : None. I have left a complete trail of destruction.

Marital status : Often   Children : Various

Reason for leaving : The school insisted that all teachers got to work by 8.30 h every term-time morning. I just could not work under such unreasonably demanding conditions.

I felt that she made me a scapegoat, just like my previous three headteachers.

I may sometimes procrastinate especially if a task is unpleasant.

We also have some phrases which we all might love to use in appraisal reports (probably on the person above us in the perceived hierarchy) but daren't. Watch this space!

Health warning

We've heard rumours that impressionable readers may think that all the 'stuff' on the opening pages of Bulletins is meant always to be taken seriously. We apologise both to them and, just to be on the safe side, to Alan Clark - the latter just in case someone might think any part of these pieces have been lifted from his diaries, real or otherwise.

To be serious for a sentence or so : It is a sad fact that - although the wonders of modern medical science allow many vital human components to be replaced when faulty or worn out - it is not yet possible to transplant a sense of humour. Among my many recurring nightmares, is the one wherein only the po-faced ever get to be cloned.

Meantime, stay, hip!

Managing risk assessment

Strategies are suggested for the implementation of measures to control risks in science departments.

Enquiries have been received of late indicating that many teachers, technicians and advisers would welcome clarification of the requirements of risk management in science education. A brief treatment is given here. Further advice is available from the Centre.

Risk assessment

This is better seen as a process or activity rather than a thing. Unfortunately, it is now too often being used to describe a piece of paper - often a pre-printed or standard form (a proforma). Such forms do have a place, but need firmly to be kept therein.

The risk assessment process involves : identification of hazards (sources of danger or potential harm); looking then at the details of the activity so as to assess the probability of that harm being realised in those actual circumstances, together with the severity of the possible consequences. Decisions can then be made on appropriate ways to remove or minimise any risks so assessed. Use of an instrument such as a standard proforma is but one approach to obtaining the results of a risk assessment. It isn't necessarily the best nor the most efficient way.

The major interest must lie in avoiding any harm (preventive measures). Failing that, or in addition, we should also be interested in sensible measures to ameliorate the consequences of incidents which do occur (protective measures). The keys are to : identify such preventive and protective measures as simply and quickly as possible; communicate them to end users by the shortest and most effective routes.

Another principle, which thoughtless form-filling may obscure, is that efforts devoted both to the process of risk assessment, and to preventive or protective measures, must be commensurate with the risks. Also germane are HSE's own repeated statements that it is perfectly proper to ignore trivial risks and for employers and employees to bring to bear previous knowledge, experience and training when assessing, then controlling, any significant risks.

COSHH precedents

Not long after the COSHH[1] Regulations were promulgated, the Health and Safety Commission's Education Service Advisory Committee published a booklet "COSHH Guidance for Schools". Copies went out to most EAs and schools in the UK. It was this guidance that established the principles of *simple* and *general* (also known now as *model*) assessments for science education.

[1] Control of Substances Hazardous to Health Regulations, 1989 and 1994.

Simple assessments: These use the information provided, by the supplier of a substance, as Risk and Safety Phrases on the label, safety data sheets or hazard and other data in the SSERC HazChem Manual [1]. If heeding such advice be sufficient to control the risks, then one need do nothing more. The other test of a simple assessment as to its "suitability and sufficiency" is that this process can be repeated any time the substance is so used. Such simple assessments then bring the added bonus that they need not be recorded (despite what others may say). A moment's thought would reveal what nonsenses might otherwise result. This notion of a simple assessment and of controlling risks through labelling or its equivalent clearly has potential outwith COSHH.

Model assessments: Here authoritative sources of advice on preventive and protective measures are used as though they were the results of risk assessments, which of course very often they are. Employers (EAs or Governors) need formally to adopt such sources and convey that action to their employees. So long as the process about to be undertaken doesn't differ significantly from that described by the model then the same measures should suffice to control the risks.

Novel assessments: This is where a proforma may prove useful - for projects, open ended investigations or new and complex activities [eg see ref.6]. Even then, once a procedure has been broken down into individual steps - preparing reagents, extraction, separation, analysis etc. it may well be found that each of these is already covered by an existing model assessment. So long as there are no significant differences of, for example, scale or method then one may adopt the same measures to control the risk.

Assessment summary: The emphasis must lie always in removing or controlling risks. The risk assessment is a means to ends never an end in itself. What matters is that sensible preventive and protective measures are identified and that these are then communicated to and acted upon by the end users. The use, wherever sensible, of the results of simple and model assessments may avoid unnecessary and disproportionate effort by hard pressed teachers and technicians. These principles, established earlier under COSHH are just as useful and applicable to more recent legislation, such as the Management Regulations and the associated 1992 legislation (the so-called 'Six-Pack') all of which last year came fully into force.

Sources of model assessments

A short list is appended as part of the bibliography for this article. Some may require interpretation. Other sources such as the Hazardous Chemicals Manual or the Code of Practice on Microbiology should be straight-

forward to use. They clearly spell out the steps which are needed to remove or mimise risks. Collections of risk assessment results (sometimes called *risk assessment logs* see below) are also available.

Communicating controls

As already emphasised, this is critical to any risk assessment based approach to health and safety management. It may not be effectively achieved if the sole tactic adopted is handing people thick files of 'risk assessment' proforma. Such files may be looked at once and then left to gather dust on a shelf. As recent legal cases have clearly demonstrated, preventive and protective measures are not only to be identified but also used. As our American cousins are wont to say *You gotta walk the talk!* The best place to remind everyone of measures to control risks is at the point of use.

In school science, apart from procedural measures - such as substituting materials, changing methods or scale etc - there is a fairly restricted range of other controls which sensibly may be used. These include the use of a fume cupboard or safety screens, the wearing of eye protection (a fairly high priority, given accident histories), or the use of gloves. Controls for physical agents such as electricity or radiation also tend to be procedural as well as engineered. Biohazards can be managed through a combination of a careful choice of living materials, or material of living origin, for educational applications and appropriate methods of handling such materials.

Annotation : Once sources of model assessment results are identified (and adopted formally by the employer) a useful way to proceed is to annotate point-of-use texts such as pupil worksheets, workcards or teachers' schemes of work. Note that the legislation only requires that the "significant findings" of the assessment be recorded. What goes on the learning and teaching materials are the measures needed to control the risk(s). Be succinct and don't exaggerate trivial risks. Try to avoid the largely meaningless, unhelpful markings such as the general warning triangles, exclamation marks and *Take care!* messages seen on some published texts. Do not obscure the main messages with repetitious minor warnings. Stick to useful phrases based firmly and closely on the advice resulting from the model assessments such as :

Wear eye protection. Use a fume cupboard. 25 V max.

Oral and other ways : Workcards, worksheets or pupil texts are not used in every science department. Where they are in use, it is probably not for all of the time. Annotation needs then to be of a learning and teaching plan or a similar document held by the teacher. Preventive and protective measures may be conveyed to pupils orally. The annotated document then serves as a reminder to the teacher and is a record that a model assessment has been consulted and its recommendations are available at the point of use (and, trustfully, are being followed).

Traditionally, science teachers have focused attention on keeping pupils safe - what happens at the bench. It is important to remember that health and safety legislation is employment law. It's as much about the health and safety of teachers, technicians and cleaners as it is about that of pupils. One way to inform fellow employees is by passing on an actual copy of the risk assessment results. For example, a copy of the relevant part(s) - showing uses and control measures - of a page or pages from a relevant source. Examples would be the Hazardous Chemicals Manual, a CLEAPSS Hazcard, or a SSERC Practical (or Technical) Guide left out with the apparatus for a teacher demonstration. Similarly a request to a technician, for the preparation of a particular reagent say, could be accompanied by a reference to entries (or copies thereof) in the Manual. Yet another ploy is to label chemicals or apparatus with restricted uses or other instructions.

Other model assessment results : The strategies outlined above are used not only by ourselves but are broadly endorsed both by ASE and our sister organisation CLEAPSS School Science Service. Several Scottish EAs, also have adopted similar sources as results of model assessments. In addition a number of the previous Regional Councils also compiled, and through the Science Advisers' Group exchanged, *Risk Assessment Logs*. These collated and presented - in tabular form - sets of control measures taken from authoritative sources. They were tied into various published courses or other curricular materials at different levels and for a range of science subjects (S1/S2, Standard Grade, Higher etc).

Such logs have their uses. Indeed recently we have been compiling one or two of our own for popular S1/S2 publications. For example at the request of a number of schools and councils we recently have been working on *Spotlight Science*. Books 7 and 8 have been audited for adequacy of safety advice. Much of the advice in the Teachers Guides is in fact accurate and adequate. In a few places it has had to be augmented or amended to take account of Scottish practices and policies. Watch the Bulletin for news of their availability.

Our sister organisation, CLEAPSS, has also been issuing risk assessment guidance along similar lines. Such logs of risk assessments may usefully be kept on file (one copy) as evidence that the significant risks have been considered.

Such matters cannot however rest at that point. As advised earlier, it is usually more effective and efficient to transfer just the preventive and protective measures to point-of-use text or schemes of work.

Authors' and publishers' duties : Of course, in an ideal world, authors, publishers and curriculum development agencies would always produce materials which carried complete and adequate health and safety advice.

Integration of such information into learning, teaching and course management has to be the ultimate aim. That is something we have stressed several times before in these pages and, over the years, in our courses on health and safety management. We all have to remember to keep pushing hard to make it happen.

Phasing

For a number of reasons, it may be that in some departments the procedures suggested above have been neglected. A major difficulty then is that auditing and annotating all of the science learning and teaching materials at once, becomes a huge and daunting task.

Our advice is - don't try. The sensible and obvious approach is to tackle the job on a term by term, topic by topic, or even a week by week basis. The overall task may also be split up and delegated to different staff members (see opposite).

Review and policies

The findings from risk assessments need to be kept under review. This is necessary when :

- an accident or near miss suggests that the preventive or protective measures may be inadequate;

- the employer, SSERC, or ASE issue changed advice, warnings etc;

- conditions or circumstances change (eg an experienced technician is replaced by a trainee);

- there are changes to the entire course.

A Health and Safety Management policy for the sciences as a whole is one way to help cope with the need for risk assessment. Among other things, such a policy document should include arrangements to divide up courses and delegate specialised risk management tasks to appropriate staff.

Arrangements are also needed for risk assessments for projects or novel activities (SSERC can help with these and also offers appropriate training on both risk assessment and policy formulation).

A policy is most useful when it is operational. It should spell out lines of communication, delegate tasks and responsibilities and reference suitable sources of risk assessment findings which have been adopted by the employer.

References : Sources of model risk assessment results :

1. *Hazardous Chemicals : A Manual for Science Education*, STS/ SSERC, 1997. ISBN 0 9531776 0 2.

2. *Safeguards in the School Laboratory*, ASE, 10th Edition, 1996, ISBN 0 86357 250 2. [By means of marginal references indicates Scottish sources such back issues of SSERC Bulletins etc].

3. *Safety in Microbiology : A code of practice for schools and non-advanced further education* (and Post-16 supplement), Strathclyde Regional Council, 1989 and 1991.

4. *Materials of Living Origin in Schools : A Code of Practice*, Strathclyde Regional Council, 1995.

For Primary Science and Technology and relevant also to S1/S2 :

5. *Be safe!* Scottish Edition, 1995, ASE, ISBN 0 86357 234 0.

For project work and investigations :

6. *Preparing COSHH Risk Assessments for Project Work in Schools*, SSERC, 1991.

In addition, over the years SSERC Bulletins, SOEID Circulars and ASE publications have dealt with a range of risks from physical agents such as electricity, ionising and non-ionising radiations (eg lasers) etc. SSERC has published risk management protocols for many of these risks from physical agents. Prior to Scottish Local Government re-organisation the Scottish Science Advisers' Group exchanged collections of risk assessment results as "Risk Assessment Logs".

COMMENT - Animals in schools

We have have been sent a copy of a letter on this subject which, we understand, was issued by a Council Education Department. It went to all Principal Teachers of Biology in that council area. This letter confirmed an Education Committee's decision that it should have a complete ban on keeping :

"animals, fish and invertebrates" [sic] in schools.

We have been invited by a number of parties to comment on this policy. This is a delicate matter since the Council in question is one of a minority of Scottish EAs not currently in membership of the SSERC consortium. There is however, one statement in the letter which, in our experience and considered professional view, quite clearly sits ill with the true picture of wider practice and opinion.

> ". . the Council's position on this issue has drawn support from throughout Britain. This includes teachers and academics."

It is vital that elected members, officers and teachers in other Councils do not take that statement at face value. It may well be that the decision has received some support (although we aren't told precisely from where or whom). It is also true that the decision has attracted the strongest opposition and, so far private, criticism, from the relevant professional associations and learned societies.

We are led to believe that a joint public statement is under active consideration. Many professionals find the arguments in the relevant report unconvincing and the conclusions ill-founded. If husbandry and practice have not always been of a satisfactory standard in that authority, then time and effort may have been better spent on improving the situation. A complete ban, imposed on each and every school, regardless of individual standards of husbandry or educational practice, is ill-advised.

The logical conclusion of such an illogical process is that since we cannot absolutely guarantee the highest standards of husbandry in each household, or on every farm then no-one, however well they do it, should keep any animal of any kind. One cannot see the animal welfare organisations, for example the SSPCA, ever supporting such a policy. That would be completely to deny their own *raison d'être*.

The whole matter was more properly and sensibly dealt with in the *Strathclyde Education Department Code of Practice* [1], which was adopted by so many other Scottish Councils. Would that all had the good sense to take that course rather than, as some may suspect in this case, be taken for a ride.

Reference

1. *Materials of Living Origin in Schools : A Code of Practice*, Strathclyde Regional Council, 1995.

Mobile stands for videos and monitors

An accident history with some types of monitor stands and trolleys has been brought to our attention. There have been incidents and near misses in schools when large screen monitors or TVs have fallen off stands or where an unstable trolley has toppled. In those authority areas where these incidents took place steps have been taken to:

● purchase and use only video related furniture designed and made to the appropriate British Standard;

● securely fix monitors to stands or shelving etc;

● introduce procedural controls as to how and by whom, transportable monitors are to be moved around schools.

Standards : The matter is complicated because of an apparent clash between two different, both apparently relevant, British Standards : There is BS 5873 [1] dealing with educational furniture (specifically Part 3 thereof), to which some manufacturers and suppliers are claiming compliance for their trolleys - including trolleys used as transportable video stands.

There is, however, another Standard which deals more specifically with televisions and monitors used in education. This is BS 7429 [2], which covers not only the TV or monitor itself but, in considering safety aspects (Specification : Section 4), treats any combination with a moveable stand or a trolley (which it terms a "mobile stand") as a whole.

Unfortunately, there are some trolleys being sold as mobile monitor and video stands which comply only with the requirements of BS 5873. These are adequate for use as trolleys, but may not be acceptably safe in use as mobile video and monitor stands. They do not comply with some important provisions of BS 7429. There is also the possibility, therefore, of breaches of the Provision and Use of Work Equipment Regulations and, or, the Manual Handling Regulations (both 1992).

In practice meeting the requirements of BS 7429 means fixing a monitor or TV in such a way that neither its electrical nor mechanical integrity is compromised. Nor must mounting a TV or monitor on a mobile stand reduce the overall stability of the assembly as whole.

This may prove difficult where a trolley has been designed mainly with BS 5873 in mind. Such a trolley may not have provision for securing the TV or monitor and that may be difficult to add subsequently.

Solutions : Purpose built mobile stands to BS 7429 are available from specialist suppliers either as kits or in completed form. One such supplier is *Unicol Engineering.* As yet, we have not been able to evaluate any of their relevant products. Purpose built stands can be relatively

expensive at over £200 each even in kit form. This perhaps explains why some schools have preferred trolleys from more general educational suppliers.

There is an affordable device on the market which can be added both to shelves or mobile stands to secure TVs, monitors and video recorders (the last more for security than safety purposes). It is widely in use in some Scottish EAs. This device is the *Security Guardclamp* from *Delta Dynamics.* It is available in four sizes to suit different cabinet widths and the newer versions have a tilt adjustment to accommodate the sloping surfaces typically found on modern equipment. Each Guardclamp assembly costs about £30. The clamp does not penetrate the cabinet of the TV or monitor and in this respect is claimed to comply with both BSI and BEAB (British Electrotechnical Approvals Board) requirements. Note that incompetent DIY fixings which penetrate TV cabinets have an accident history (electric shocks from external parts which became live).

Operational problems : BS 7429 makes specific points about transporting TVs and related equipment between floors in multi-storey buildings. It recommends that where there isn't a suitable lift, equipment be provided on a scale which makes inter-floor transfer unnecessary in "normal circumstances". Where transfer of such equipment up or down stairs is unavoidable, then it is to be dis-assembled and transported as separate component parts. Dis-assembly and subsequent re-assembly are to be carried out only by "authorised persons".

There may be serious financial and operational implications for councils and schools who have not yet addressed these problems. British Standards, in themselves, are not legally binding. They have however been effectively much strengthened by recent sets of secondary legislation. Clearly, there is a need for some schools and educational managers to carefully review current practices. For example, a number of EAs have already issued instructions that pupils are not to handle monitor stands nor transport them from room to room. In not a few schools this may cause real operational difficulties, not least because it could conflict with a standing requirement that teachers are not to leave their classes unattended.

References :
1. BS 5873 : *Educational Furniture,* Part 3. Specification for strength and stability of tables for educational institutions. BSI, 1995.
2. BS 7429 : 1991 *Specification for Television receivers and monitors for use in education and training,* BSI 1991.

Dynamics experiments with a digital camera

Continuous motion can be monitored in the laboratory, or even outdoors, by capturing images with a digital camera and downloading the data in real-time to a PC for immediate analysis.

Strobe photography

Strobe photography, once popular, now seems little practised in physics labs. In principle it remains a valuable and worthy method. With it, you can watch continuously the movement of a body, or group of bodies, getting data for either qualitative or quantitative analysis. Unlike some other methods, it does not impede, or in any way disturb, the dynamic system being observed. Some interactions, like bat on ball, cannot be monitored in any other way. Others, such as the projectile, can be followed by other means, but at the cost of great repetitive effort. The photographic method is much the best. Thus by eschewing photographic methods, we physics teachers have lost the capacity to study many types of motion.

It may be worth reflecting on reasons for this decline. Some have little to do with practical work - like the difficulty of obtaining Polaroid film for obsolete cameras, or the absence of questions on strobe photography in national examinations. Typically, experiments with strobe photography were done as teacher demonstrations. These may have become less frequent with more individualized learning. Perhaps a deeper reason was the complexity of analysing the film. Scaling up from the photographic image to the actual dimensions, then processing data composed of complex decimal values rather than integers, with division by fractions to convert from displacement to velocity, came to be seen as too difficult. It was certainly long-winded. Another reason was the skill required in taking a good strobe photograph, which took much care and practice. Factors included whether to use a flashing strobe, or motorized strobe disk, the strobe frequency, the disk aperture, and the amount of blackout.

While strobe photography was declining, other methods were advancing and now supersede it. Signals from a light gate are able to give, through electronic processing, direct readings of speed and acceleration. Whereas that only provides spot readings, rectilinear motion can be monitored continuously with ultrasound echolocation, providing the experimenter with graphs of displacement, velocity and acceleration versus time.

This article describes modern photographic methods that are a distinct improvement on strobe photography. Some years ago [1] we discussed the use of capturing images with a camcorder, and playing back image by image using the still frame mode of a playback machine. But the analysis is still quite awkward with this method.

Far better, it seems, is using a digital camera which can transfer data directly to a computer for automated analysis. To be effective in a school laboratory, the system must be capable of capturing at least ten frames a second. Rapid improvements in optoelectronics now have brought inexpensive systems operating at this rate.

Systems that might be observed by this method include projectile motion, a moving body reaching terminal velocity, linear air track collisions and sports activities. Outdoor photography would be possible with either a portable computer, or digital camcorder.

Digital photography

In our search for suitable systems for the video analysis of experiments, we set the following criteria:

- Minimum frame rate of 10 frames per second (fps)
- Low cost
- Ease of use
- Equipment must interface with a PC to allow analysis
- Monochrome images are adequate

Of the three possible systems outlined below, we were only able to try out the first, running *QuickCam* on a PC. The other two reports are based on technical specifications and discussions with company representatives.

VideoPoint, a video analysis software package, is an important part of each of the following systems. It is separately described in the article following on from this one.

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┌─────────────┐    ┌─────────────┐    ┌─────────────┐
│ Connectix   │    │ trmoov.exe  │    │ VideoPoint  │
│ QuickCam    │──> │ file        │──> │ video       │
│ digital camera│  │ converter   │    │ analyser    │
└─────────────┘    └─────────────┘    └─────────────┘
              ┌──────────────────┐
              │ PC only- not Mac │
              └──────────────────┘
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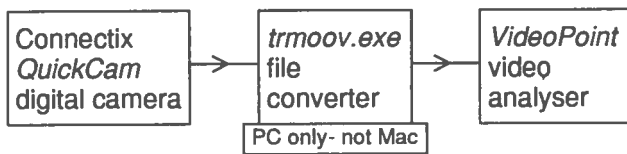
Connectix *QuickCam* is a digital camera with a 640 x 480 pixel charge coupled device (CCD) sensor. By manually adjusting the lens, the camera can focus on distances from "1 inch to infinity".

There are software versions for PC and Macintosh; we tried out the PC version. *QuickCam* is plug and play, i.e. just plug the camera into the computer, install the software and it is all ready to go. Pull-down menus make the software quite easy to use. Training is not really needed, but some time would have to be spent learning what to do.

The PC version's software supplied by Connectix includes *QuickMovie* for making movie sequences in a *Video for Windows* format, and *QuickPict* for taking stills in *JPEG*, bitmap, or *TIFF* formats.

When capturing a movie sequence, image size is dependent on frame rate. If the latter is fast, the system is only able to compose quite a small image, taking up about an eighth of the full screen display perhaps. The user thus has to learn to optimise the operation for each specific task.

The *QuickCam* is available from Technomatic in two versions. The monochrome version costs £60 and the colour one £130 (excluding VAT). Each requires a keyboard port for power and a parallel port for data transfer. An adaptor is supplied for the keyboard port connection.

The program *trmoov.exe* converts files from *Video for Windows* format to *QuickTime for Windows* format. It is available free from the web site :

http://www.lsw.com/videopoint.

Quicktime is the standard video format for Macintosh, so no conversion is necessary for that platform.

VideoPoint is a video analysis software package available from Instruments Direct Limited, who are the UK agents for PASCO Scientific. It costs £167 (order code SE-7473).

Minimum PC requirements (*QuickCam*) :

486 running Windows 3.1 with 8MB RAM and 1.5MB free memory on hard drive.

Minimum Mac requirements (*QuickCam*) :

LC running system 7.1 with 8MB RAM and 2MB free memory on hard drive.

Minimum PC requirements (*VideoPoint*) :

386 running Windows 3.1 with 3MB RAM and 1MB free memory on hard drive.

Minimum Mac requirements (*VideoPoint*) :

LC running system 7.0 with 1.5MB RAM and 1MB free memory on hard drive.

Method with PC

- Open up *QuickMovie* and set it to record greyscale images (unless colour is necessary).

- Adjust image quality (can be set to low, medium or high), frame size and shape, and frame rate until the best balance is obtained.

- Record footage, ensuring that no frames are 'dropped' (the computer doesn't store the frames) - a warning message will appear if this occurs. If frames are dropped, adjustments to size, quality and rate must be made.

- Save the file with either *Cinepak Radius* or *Intel Indeo* compression (any other forms of compression will not be compatible with the *VideoPoint* software). The file is saved in *Video for Windows* format.

- Using the conversion program *trmoov.exe*, convert the file from *Video for Windows* to *QuickTime for Windows* format. Note again that this is not required for the Macintosh version.

- Open up the *QuickTime* version in *VideoPoint* for analysis.

The best image sizes and frame rates that we obtained were (for 256 greyscale images set at low quality):

100 x 100 pixels	30 frames per second
130 x 130 pixels	25 fps
160 x 160 pixels	20 fps
200 x 200 pixels	15 fps
200 x 200 pixels	10 fps

This system has its good points:

- It is cheap.
- It is easy to install and use.

It also has some bad points:

- Editing is not possible.
- Variables (i.e. image size, quality and frame rate) must be carefully chosen to eliminate or minimise dropped frames.
- Size and quality is sacrificed for speed.
- Repeated frames (where one frame occurs identically twice consecutively) can occur.

```
┌──────────┐       ┌──────────────┐       ┌──────────────┐
│ Video    │  ──▶  │ Video capture│  ──▶  │ VideoPoint   │
│ source   │       │ card         │       │ video        │
│          │       │ e.g. ELViS III│      │ analyser     │
└──────────┘       └──────────────┘       └──────────────┘
```
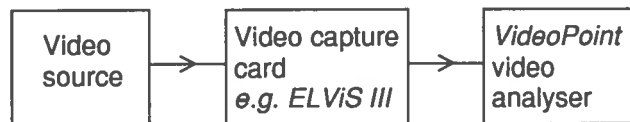
Any standard video source can be used, e.g. a video camera or a VCR. It is assumed here that such a source is already available. One suitable source is the CCD camera *Flexcam*, at £900 from Philip Harris (Y90740/9). Another suitable CCD camera is the *OS25* from Optimum Vision Limited for £250.

The video capture card *ELViS III* is available from Vision Dynamics for £450. It is compatible with any PC running Windows or DOS and comes with appropriate software. *ELViS III* connects directly into a PC desktop's motherboard.

There are other video cards available, although many are quite expensive. Video capture cards come under various other descriptions, e.g. 'frame grabber' or 'video digitising card'. In principle, these all have the same function, i.e. to convert analogue video input to digital video, but each card will boast slightly different features. It is important that the digital output is in a compression format compatible with *VideoPoint*, e.g. *Cinepak Codec*, *Apple Video Codec*, *JPEG Codec*, *Indeo Codec*.

The good points of this system are:

• Reasonable quality images and good frame rates should be obtained.

• Editing is possible.

The bad points of this system are:

• The quality of the images might not be as high as would be liked. If the video input is not of high quality, the digital version will not be of high quality either. It is likely also that quality is lost in the digitisation process.

```
┌──────────┐       ┌──────────┐       ┌──────────────┐
│ JVC Digital│ ──▶ │ Editing  │  ──▶  │ VideoPoint   │
│ Camcorder │      │ process  │       │ video        │
│          │       │          │       │ analyser     │
└──────────┘       └──────────┘       └──────────────┘
```

The JVC *Digital Camcorder* costs around £1800, and is available from, though not exclusive to, Brian Reece Scientific Limited. This is small and portable, with a docking station to interface directly with a PC, a TV or a VCR. Editing software for the PC is also included.

Minimum PC requirements are :

120 MHz processor running Windows 3.1 with more than 8MB RAM. The software is not designed for the Macintosh.

Editing can be done either on the camera itself, or on the PC. Images are saved in *MPEG*, *JPEG*, or bitmap formats.

Analysis of the video is again done using *VideoPoint*. For compatibility, files should be in either *MPEG* or *JPEG* formats.

The main positive aspects are:

• Very good frame rate and image quality is obtained.

• Editing is possible.

• Easy to use.

• Requires no extra image grabber.

• Non-exclusive in its use.

• The JVC Digital Camcorder would find use in many other applications.

The main negative aspect is that it is relatively expensive.

Digital photography summary

While researching this subject, many systems were considered which we have not described here. We had to limit what to look at to prevent the research getting out of hand.

Although only three systems were covered, this should still provide an overview of significant sections of the technology and indicate how they might be applied in laboratories. We would like to hear from anyone who can offer other direct experience.

The choice of system really depends on your budget. Spending more on a system ensures better quality images and faster frame rates.

The *QuickCam* does the job adequately, but a lot of quality is sacrificed for speed. For those who already have access to a camcorder, a video capture card such as the *ELViS III* is worth considering. But for state-of-the-art quality, the JVC *Digital Camcorder* system is the best of the three examined. It may seem expensive, but could be used in many other applications.

Reference

1 *Video equipment in science teaching* Bulletin 154 SSERC 1986.

EQUIPMENT NOTES
VideoPoint

Having captured a movie sequence with a camera, the video images can be analysed with the software package *VideoPoint*, which provides quantitative data on distance and time.

VideoPoint is a video analysis software package that allows the user to analyse the motion of specific objects in digital video movies. The movies are stored in a format called *QuickTime*. The user collects data from successive frames of *QuickTime* movies by clicking on objects of interest to produce a sequence of *video points*. By analysing the video points, users can get information on position and time in tabular and graphical formats (Fig. 1). This information can be displayed in distances of pixels, or can be scaled by clicking on a reference marker in the movie, such as a metre stick. Further information can be provided on derived quantities such as velocity or acceleration.

A large selection of movies is supplied with the software, and there is a browser to help you find your way about. Some examples are given in the textbox below. Thus *VideoPoint* is self sufficient, which is to say that because the library of movies is quite extensive, the user need not make his of her own movies, but can make do with the ones provided.

But hey! Physics is supposed to be fun, is it not? *VideoPoint* is not restricted to just these movies in the *VideoPoint* ready made collection. Why not make your own, as we described in the previous article. Provided that you transform your own video data into the *QuickTime* format, you may then proceed to analyse it with *VideoPoint*.

VideoPoint movie collection
(part of, for illustration of scope)

Sports and human interest :
- Juggling 3 balls in standard cascade formation
- Grand jeté and floating illusion in ballet
- Rollerblade jump over obstacle
- Volleyball with topspin

Fairground movies :
- Roller coaster
- Ferris wheel

NASA movies :
- Space shuttle launch
- Appollo Lunar Module launch

Laboratory based movies :
- Cart collisions (elastic and inelastic)
- Projectile launches :
    - 30°, 45°, or 60° from horizontal
    - hard plastic ball, or styrofoam ball
- Ballistic Cart ball launch :
    - ball launched from, and caught by, a moving cart
- Transverse wave moving along a stretched spring

A *video point* is the location in space and time of a specific part of a *QuickTime* movie frame selected by the user. Information on each video point is stored as a set of values of x, y and t, where x is the distance in pixels from the left hand side of the frame and y is the distance from the bottom of the frame.

For instance if you are studying projectile motion and made a movie of a ball lobbed through space you would get one image of the ball per frame. You may then create one video point per frame by clicking on the image of the ball in each frame in the movie.

In this example you would normally reference the data set to a Cartesian coordinate system. By clicking on points on a reference marker, such as a ruler or metre stick, the dimensions are transformed from screen units in pixels into metres or centimetres.

The origin of a video point series is chosen automatically by the software. However this default value can be overridden. Any position in a frame can be selected as the origin.

The best way of further describing this software is probably to give examples of its features:

- The movie can be scaled to collect data in SI units.
- If the first origin moves off screen, a further one can be transformed to another point.
- Co-ordinate systems can be rotated (e.g. if the main axis of the images is on an incline).
- There is a choice of Cartesian or polar co-ordinates.
- Relative motions can be studied.
- Centre of mass motion can be studied (by entering the masses of selected objects, the computer automatically calculates the centre of mass motion of the system).
- Data can be exported to a spreadsheet or a text file.
- A mathematical model of the data can be constructed.
- A curve can be fitted to data points on a graph.
- Derived values such as velocity, acceleration, momentum and energy can be plotted.
- It is compatible with PASCO's *Workshop Physics* program.
- It is applicable to mechanics, sports science and the study of human movement.

Having collected a series of video points, the data can be graphed in a variety of ways, such as (y, t) or (r, θ) graphs. A mathematical model can be constructed and
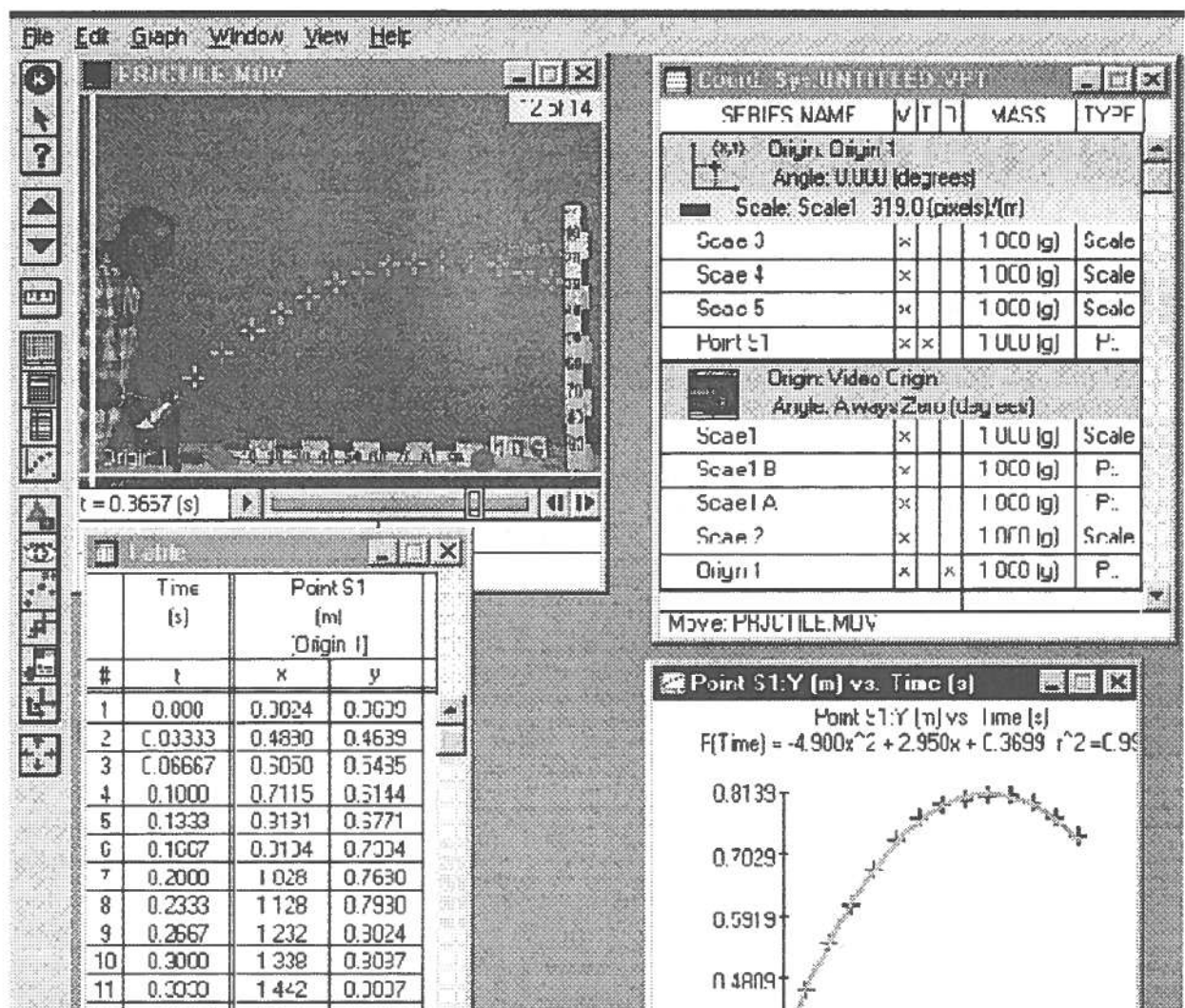
Figure 1 *VideoPoint* screen display showing four windows : the Movie Window with a series of markers, the Coordinate System Window, a Table Window and a Graph Window with a line superposed through a graphed data set.

superposed on the data plot. The model types that can be chosen are : linear, quadratic, cubic, sine, cosine, logarithmic, exponential and power. The user must first select which type of graph is appropriate and then input the values of the constants. The line is superposed on the plot of the points and, assuming the constants have been chosen correctly, should give a reasonable fit to the plot. Care must be taken when choosing the end point of the axes. Because the axes are scaled automatically, they may be subdivided inappropriately.

The latest version of *VideoPoint* has a curve fitting option, but for older versions a computer generated best fit is possible by exporting the data to MS *Excel*, and using the *Workshop Physics* Tools facility that comes on the CD. Updated versions of this facility (e.g. for *Excel 97* version) as well as older Excel versions are available from the web site :

http://www.lsw.com/videopoint.

Follow the path : Workshop Physics > Computer Software > WPTools > Download. This add-in has been found to be very useful for analysis of data from a range of sources. So, it is well worth downloading, even for use other than with *VideoPoint*.

Finally, because *VideoPoint* is a little complex to learn to use, the provision of training is recommended.

VideoPoint is available in two kits. The Teacher's Kit (SE-7473) comprises a CD-ROM disk with *VideoPoint* software for both Macintosh and PC Windows' computers, example analysis files, a movie collection with 260 movie clips and browser, *WPTools* (*Workshop Physics* Tools) add-in for *Excel* and an electronic version of the manual for local editing. It also includes the user manual as hard copy. The Student Kit (SE-7472) consists of the CD-ROM disk only. The kits are supplied by PASCO Scientific through their UK agent, Instruments Direct Limited, at £167 and £53 respectively. The suppliers point out that at least one Teacher's Kit must be purchased with as many Student Kits as you need. The minimum computer requirements are specified below. Each *QuickTime* Movie requires (on average) 350K HD storage :

Macintosh : LC with system 7.0, 1.5MB of free RAM, 1MB free on hard drive, CD-ROM drive.

PC : 386 PC with Windows 3.1, 3MB of free RAM, 1MB free on hard drive, CD-ROM drive.

Summary

The software has been designed specifically for video analysis in physics education. As such, it performs well and should meet, if not exceed, the expectations of most people.

VideoPoint is also reasonably straightforward to use, with a variety of useful features. One needs a bit of practice to get the required results for anything other than the basic applications.

Measuring iron in water and soil

A simple colorimetric procedure using 1,10-phenanthroline is described. Measurements in the field may be practicable.

This procedure is both simpler and faster than those classical methods in which dilution and reaction are carried out in volumetric flasks. Here, reactions are carried out in test tubes which can then be placed directly into certain makes of colorimeter. Transfer to a cuvette is then unnecessary.

The addition of reagents and sample can be further simplified by marking volumes on the test tubes or by using the now ubiquitous small, calibrated, plastic transfer pipettes which are roughly calibrated to a quarter of a cubic centimetre or so. The other suggested change to the methodology is to substitute the reducing agent, hydroxylamine hydrochloride, by the less harmful ascorbic acid. An added bonus is that this small scale method is about four times more sensitive than the more traditional 'dilution in a volumetric flask' procedures.

If a portable battery operated colorimeter is available then measurements can be made in the field.

Occurrence in waters

Iron may be present as iron(II) in concentrations of up to several parts per million (ppm) in ground waters or in anaerobic conditions. In surface waters however, the higher oxygen concentrations present will readily bring about oxidation to the iron(III) state :

$$4Fe^{2+} + O_2 + 4H^+ = 4Fe^{3+} + 2H_2O$$
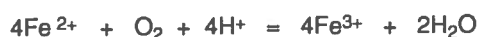
Initially there will be an orange suspension of iron(III) hydroxide. This soon deposits, for example on stones or mud etc on the river bottom, as a brown form of the hydroxide.

Water draining through ore-bearing deposits, spoil or tailings from mines, can leach out iron salts. Effluents from flooded mines, especially if acidic, or from industrial pickling processes, also may enter watercourses. Sometimes on a river survey sudden 'spikes' of high iron concentration in solution may be found which rapidly drop away on moving downstream. These are generally indicative of one of the above sources close by. Such effluents clearly are potentially detrimental to the flora and fauna of streams and rivers.

In drinking water supplies the total iron (combined Fe^{2+} and Fe^{3+}) is usually less than 0.1 ppm and in concentrations exceeding 0.2 ppm it is an undesirable contaminant. Above that concentration, iron imparts an astringent taste (shades of the auld Im Bru?). Used for domestic washing, it can lead to precipitates and stains of iron(III) hydroxide on clothing.

Principle

Iron(II) reacts with an aqueous solution of 1,10-phenanthroline to form a pinkish/orange complex whose colour intensity is proportional to the concentration of iron(II). The colour is independent of pH in the range 2 to 9. An excess of the reagent is added to ensure complete conversion of all Fe^{2+} ions to the coloured complex (Figure 1).
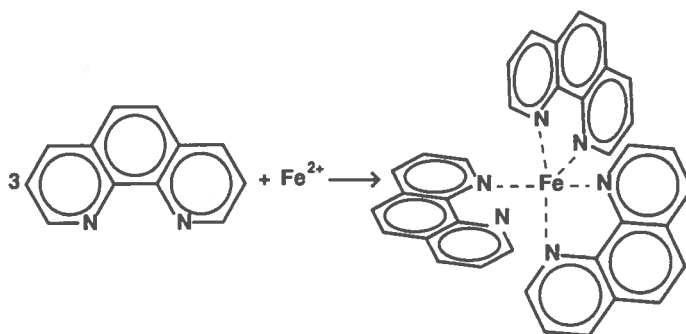

Figure 1 Reaction between phenanthroline and iron(II) to produce a coloured complex.

As shown in Figure 1, three molecules of phenanthroline combine with each Fe^{2+} ion to produce the pink/orange complex; the colour of which is stable for about two weeks. This coloured complex absorbs strongly at about 515 nm and 420 nm (we used our nearest filters - 520 nm and 440 nm).

Adding a reducing agent means that any iron(III) [Fe^{3+}] is reduced to iron(II) [Fe^{3+}] and thus total iron is determined. Conversely omission of the reducing agent allows iron(II) alone to be determined.

Note that any copper, nickel, cobalt, bismuth, silver or cyanide present will interfere seriously with these determinations.

Method

For a calibration graph : Prepare standard solutions of concentrations 1, 2, 4, 6, 8 and 10 ppm by dilution of the stock iron solution of 100 ppm iron (see Appendix). To 5 cm^3 of each such solution in a test tube add in turn :

- 0.5 cm^3 of 10% ascorbic acid solution;

- 0.5 of cm^3 1M sodium ethanoate and

- 1.5 cm^3 of phenanthroline reagent.

Mix the contents between each addition. Wait five minutes and then measure the absorbance at or about 420 or 515 nm using a colorimeter (or spectrophotometer if you have such a luxury). For the blank, use 5 cm³ of deionised water, adding the reagents as for the standards. Treat the unknown sample in the same way.

Results

The method was used with several different models of colorimeters. The results shown, in Figures 2 and 3, were obtained with a WPA CO 75 model. There is little difference in the slope of the calibration graphs prepared at the two wavelengths (A and B). Both of these used the "test-tube" method described above. This small scale would seem more sensitive than the method often given in texts (see graph C). The more 'classical' laboratory procedure requires the use of 50 cm³ volumetric flasks, burettes and larger quantities of reagents. It is thus unsuitable for the field. There may be merit however in teaching the classical method for its own sake.

Graph D in Figure 3 shows the linearity of test tube scale determinations at low concentrations, with 0.5 ppm about the lowest concentration easily measured by this method.

Note that both Fe^{2+} and Fe^{3+} can be determined in the same mixture. This means making two measurements. When ascorbic acid is added, total iron is measured. If it is omitted, but replaced by an equivalent volume of deionised or distilled water, only the Fe^{2+} is determined.

It has been generally considered poor technique to make measurements on more concentrated solutions which have absorbances greater than about 0.7 or 0.8. This is because non-linear graphs usually result. Modern colorimeters and spectrophotometers seem better able to cope with this difficulty. Note also that light detectors in different models of colorimeters may well have different sensitivities. Hence the need always to start with a calibration graph. Do not expect identical readings for the same concentrations on different instruments.

Figure 2 Calibration graphs using the test tube procedure described in the text.

5 cm³ of iron (Fe^{2+} or Fe^{3+}) solution; 0.5 cm³ of 10% w:v ascorbic acid; plus 0.5 cm³ of $^M/_1$ sodium ethanoate and 1.5 cm³ phenanthroline.

A - with filter to measure at 520 nm

B - filter to measure at 440 nm

C shows the results (520 nm) with the larger scale 'classical' laboratory method :

10 cm³ of iron (Fe^{2+} or Fe^{3+}) solution in a 50 cm³ volumetric flask, water added to half fill; add 1 cm³ of $^M/_1$ sodium ethanoate and 3 cm³ phenanthroline. Make up to 50 cm³ with water.
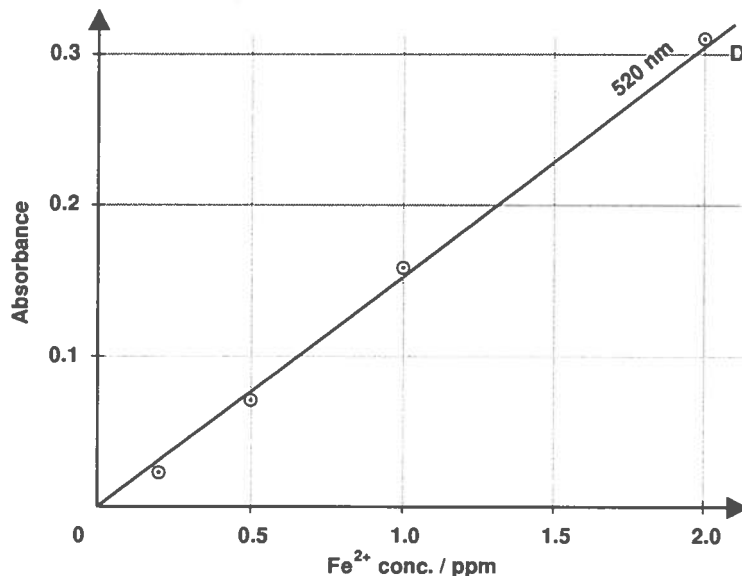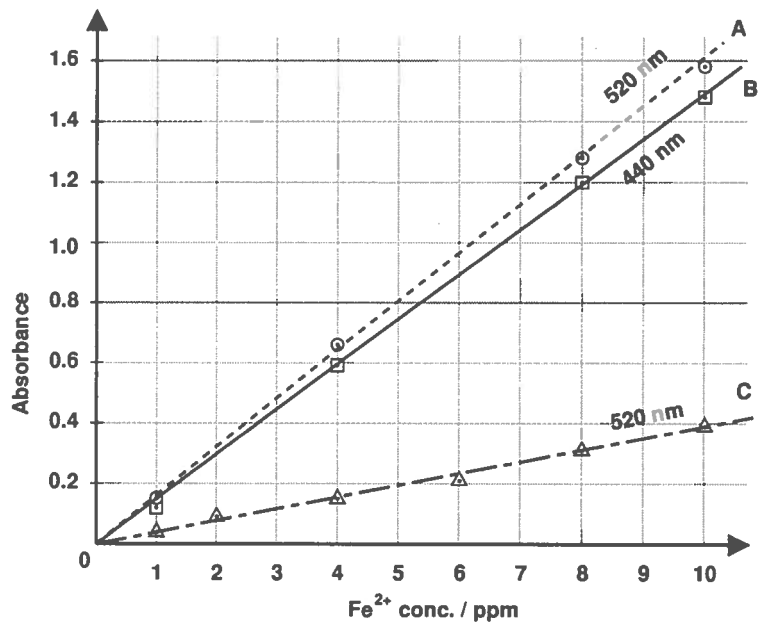
Figure 3 'Extended' calibration at low end of the range (Graph D - again using the test tube scale procedure).

Extraction from soils

Iron is widely found in soils, though in very different forms. Most determinations are made for total iron or for exchangeable iron. Some methods use hydrofluoric acid and obviously this should be avoided in schools. Sodium carbonate fusions may be used for total iron.

According to the literature, iron available for plants is extracted with DTPA (diethylenetriamine-pentaacetic acid) at neutral or slightly alkaline pH values in spite of the fact that the extraction of iron is more efficient at lower pH. This is because in acid conditions more calcium carbonate will dissolve which in turn would release iron which is not normally available to plants.

Much iron is found as free iron oxides which may exist as discrete particles. This can be as coatings on soil minerals or as a matrix or cement between the grains. One recommended extractant, for such forms of iron, is sodium dithionite combined with sodium citrate buffer.

Exchangeable iron is usually extracted with 1M ammonium ethanoate, but the fraction of the iron extracted depends greatly on the soil conditions. In highly acid or water logged soils large amounts are extracted, but in well-aerated soils which are alkaline or neutral very little iron is extracted. This is because in those conditions most of the exchangeable iron is converted into iron(III) hydroxide.

Appendix : Technical and safety notes
Reagents

Complexing reagent : 1,10-phenanthroline, 0.3 g dissolved in 100 cm^3 of water[1].

Reducing agent : 10% w/v ascorbic acid in water (or hydroxylamine hydrochloride [$NH_2OH.HCl$] of the same concentration has also been used.)

Buffer : sodium ethanoate-3-water [$CH_3COONa, 3H_2O$], a 1 molar solution.

Standard solutions for calibration : ammonium iron(II) sulphate-6-water, 100 ppm Fe^{2+} solution made by dissolving 0.7003 g in a little water, adding 20 cm^3 of 1M sulphuric acid and making up to 1 litre with water. The equivalent quantity of iron(III) ammonium sulphate could be used instead since the ascorbic acid will reduce the iron(III) to iron(II).

Tubes

Transfer to cuvettes may not be necessary - ordinary test tubes will do for some colorimeters (eg use 16 mm diameter in the CO75 model). It is wise though to check that they are reasonably close optically. Do this by filling them with water and placing them in the colorimeter. You may also note slightly different absorbances with the tube rotated. We have found most tubes in the same batch to be fairly good, with just a few rogues. You might like to reserve a set of reasonably matched tubes for colorimetry. If so, mark them with a dab of paint (above the optical path!) to indicate the direction in which the tube should be placed in the colorimeter.

Health and safety information

Iron salts : are harmful by ingestion of large quantities. Risks are controlled because the quantities used are small.

1,10-phenanthroline hydrate : toxic if swallowed, but only small quantities of a dilute solution are used by pupils. Good technique and hygiene will ensure insignificant risk to health. Those preparing the solution should wear gloves.

Hydroxylamine hydrochloride (hydroxylamine) : is harmful if ingested, irritates eyes and lungs and may cause skin sensitisation by skin contact. Substitute with ascorbic acid.

Sodium ethanoate : may irritate the eyes - wear eye protection.

Alternative methods

The phenanthroline colorimetric method has a sensitivity suitable for the concentrations of iron typically found in environmental work. For higher concentrations the samples can be diluted a known number of times before measuring. Alternatively the sulphosalicylic acid / EDTA titration can be used. Another, similar, approach is to reduce the sample with a zinc column (a Jones reductor) and determine Fe^{2+} by titration with standard potassium manganate(VII).

Two other colorimetric reagents, suitable for lower concentrations are *ferrozine*, [3-(2 - pyridyl)-5,6-diphenyl-1,2,4-triazine-4,4'- disulphonic acid, disodium salt, monohydrate] and *TPTZ* [2,4,6-triphenyl-s-triazine].

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[1] For "water" read glass-distilled or deionised water.

EQUIPMENT NOTES
Teaching Chip boards

JJM Electronics have designed a set of printed circuit boards with 4 mm socket outlets for use with the Edinburgh University Teaching Chip set.

The Edinburgh University Teaching Chip Set was designed to be used on prototype board. However this platform has proved to be unpopular with schools because it is fairly complex to work with. In recognition of this problem, JJM Electronics has designed a set of boards which should make the Chips much easier to use. The boards are :

Project Board	- as illustrated (Figure 1)
	- may be used with any of the four chips
	- circuit shown on overlays as illustrated (Figs. 2 and 3)
Resistor Length Board	- Chip 1 resistors R1, R2 & R3
	- to investigate dependence of resistance on resistor length
Resistor Width Board	- Chip 1 resistors R3, R5, R6 & R7
	- to investigate dependence of resistance on resistor width
Oscillator Board	- Chip 4 ring oscillator

JJM supply the boards without the chips, which are available separately from SSERC (see "Equipment Offers").

With the appropriate overlay fitted to the Project Board, a student should be able to experiment with either a single component, or small group of components, see Figures 2 and 3 respectively. This should facilitate bench work with resistors (Chip 1), MOSFETs (Chip 2), diodes and photodiodes (Chip 3) and oscillators (Chip 4).
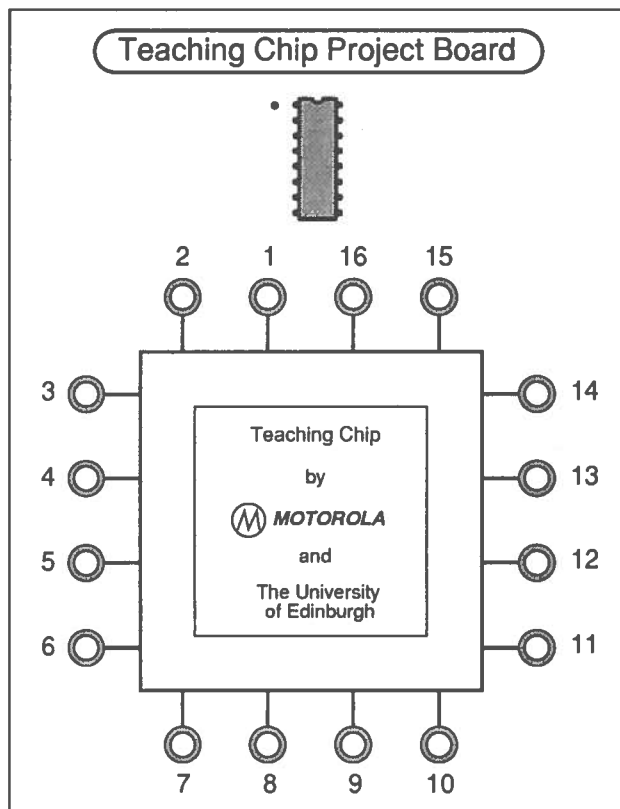

Figure 1   Plan of JJM Project board with sixteen 4 mm socket outlets connecting to the pins on the integrated circuit. Printed card overlays fit within square to show the circuit diagram. Scale 80% of actual size.
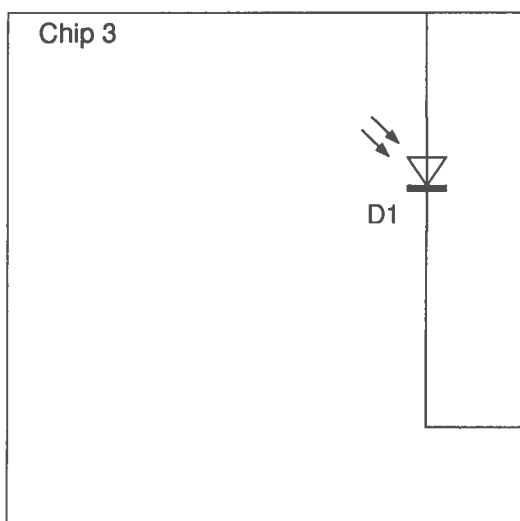

Figure 2   Example of an overlay. Circuit diagram for p-type diode D1 on Chip 3. Drawn to actual size.
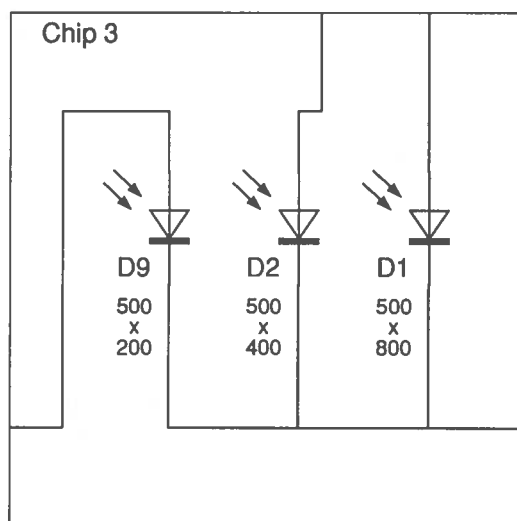

Figure 3   Example of an overlay. Circuit diagram for p-type diodes D1, D2 and D9 on Chip 3. Drawn to actual size.

TECHNICAL NOTES
Light intensity experiments

The Edinburgh University Teaching Chips have a set of photodiodes. These are suitable for showing the inverse square law of intensity against distance and lead into other investigations on the effects of diode area.

It is well known that the reverse leakage current in a photodiode is directly proportional to light intensity. This may be confirmed by the two lamp test, which would be appropriate before trying to show the inverse square law dependence of light intensity on distance.

There are thirteen p-n junctions on Chip 3 of the Edinburgh University (EU) Chip Set, ten of which are light sensitive (Table 1) (Fig. 1). Any of these ten photodiodes may be used as the sensor in light intensity experiments. The other diodes, insensitive to light, are known as *black diodes*[1].

All of the semiconductor structures sit on a substrate of n-type silicon. Eleven diodes have a surface layer of p-type silicon. These are called *p-type diodes*[1]. The other two diodes, known as *n-type*, have a surface layer of n-type silicon implanted into a well of p-type material. This p-well has itself been implanted into the n-type substrate.

A thin section of silicon is fairly transparent to visible radiation. In the photodiodes, light penetrates to the junction between the surface layer and the underlying layer (Fig. 2). This boundary is the actual p-n junction where the action of light produces electron-hole pairs to generate the leakage currents which we are using in these experiments.
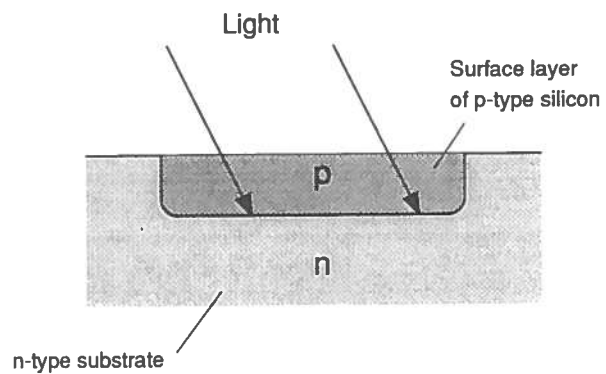

Figure 2   Section through a p-type photodiode.

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1   The terms *black diodes*, *p-type diodes* and *n-type diodes* are used specifically to distinguish the structures on Chip 3. So far as we understand, they do not have any wider currency.

Figure 1   Plan of Chip 3 showing aspect ratios of diodes. Dimensions are in microns (μm).
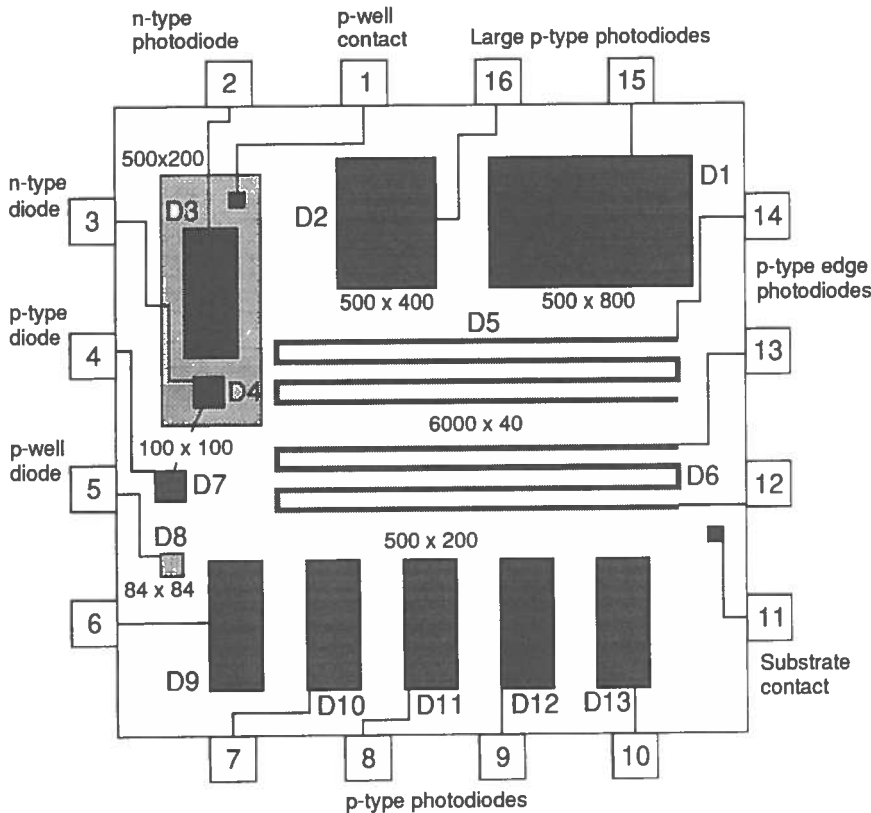
Diode	Photo or black	Type	Length (μm)	Width (μm)
D1	P	p+ n	800	500
D2	P	p+ n	500	400
D3	P	n+ p	500	200
D4	B	n+ p	100	100
D5	P	p+ n	6000	40
D6	P	p+ n	6000	40
D7	B	p+ n	100	100
D8	B	p- n	84	84
D9	P	p+ n	500	200
D10	P	p+ n	500	200
D11	P	p+ n	500	200
D12	P	p+ n	500	200
D13	P	p+ n	500	200

Table 1   Chip 3 diode specifications. The negative and positive signs denote light and heavy doping levels.

Leakage current measurement

Diode D1 was used in the test of linearity. Initial measurements indicated that leakage current magnitudes lay between 1 nA and 1000 nA. By connecting a 1 MΩ resistor to the diode and placing a high impedance voltmeter across the resistor, a 1 nA current is represented by an output signal of 1 mV (Fig. 3). For most purposes, any d.d.m. would do for the instrument. It is generally convenient to regard the voltage reading on the d.d.m. as being an expression of light intensity, there being no need to calculate current.

The biasing voltage should be from a battery of between 1.5 V and 9 V. Because D1 is a p-type diode, the top surface layer, being p-type, is the anode and the substrate, being n-type, is the cathode.

Another way of measuring leakage current is a current to voltage converter with an op-amp (Fig. 4). Because this circuit's input impedance is extremely high, this has the advantage that it does not load the photodiode.

Suitable op-amp types include TL271, TL071 and LF355. Unlike many other op-amps, a TL271 may be powered by a single rail, voltage regulated supply, between 3 V and 16 V. Note that the pin numbers for diode D1 are indicated (Fig. 4).

The op-amp circuit is to be preferred when determining the *I-V* characteristics of diodes and photodiodes. The simpler circuit with the voltmeter across a resistor is generally satisfactory for experiments on light intensity.
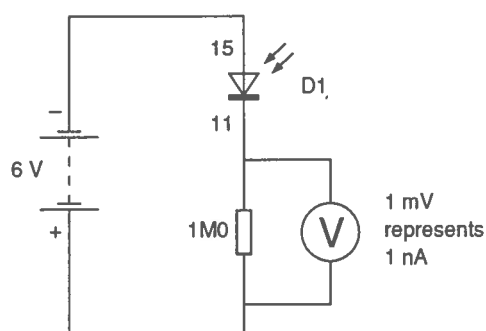
Linearity test

Two experimental arrangements were tried and found to be satisfactory. The first of those requires the whole laboratory to be blacked out. The circuit with Chip 3 was fastened to the lens carrier of an optical bench. A pair of 6.5 V, 0.3 A MES lamps in battenholders were set up in another lens holder. The lamps were independently controlled by finely adjusting rheostats.

The separation between the diode and lamps was 75 cm. Both the benchtop and optical bench were covered with matt black paper to prevent reflected radiation from reaching the diode.

The second arrangement uses localized blackout. The circuit with Chip 3 was placed on the bottom inside surface of a cardboard box that had held A4 copier paper. Lamps (6 V, 60 mA) were mounted on the inner surface of the lid (Fig. 5), about 20 cm from the photodiode.

It can be seen from the readings in Table 2 that

$$A + B = (A \text{ and } B)$$

where A and B are the outputs when the diode is illuminated by Lamps A and B respectively and (A and B) is the output when the diode is lit by Lamps A and B jointly. Because the relationship holds for many sets of readings, it can be concluded that the reverse leakage current is indeed directly proportional to light intensity for the values investigated.

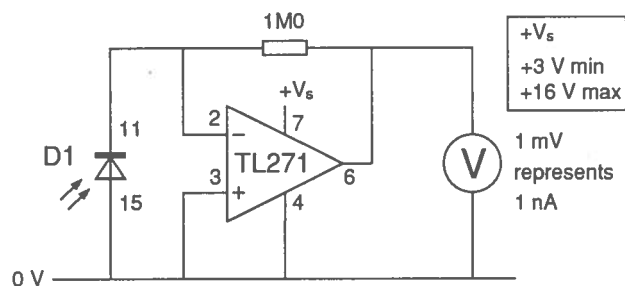**Figure 3** Simple method for measuring reverse leakage current through D1.

Figure 4 Current to voltage converter circuit diagram. Circuit converts the reverse leakage current produced in the photodiode into a voltage. (TL271 : RS 638-914).

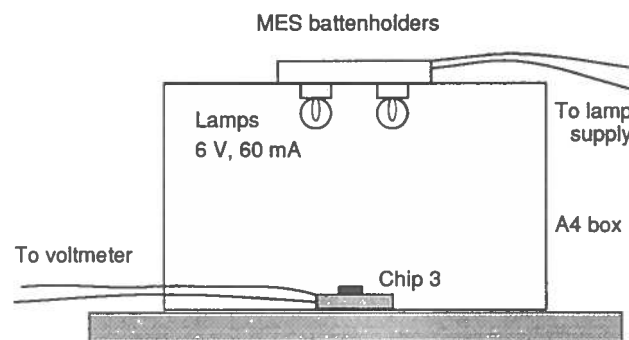**Figure 5** Apparatus for controlling level of illumination on photodiodes. May be used in two lamp test of linearity.

A (mV)	B (mV)	(A and B) (mV)
10	10	20
20	20	40
30	30	61
40	40	80
59	59	118
120	121	241
160	160	321
200	200	201
242	240	483

Table 2 Two lamp test readings.

Inverse square relationship

In the experimental arrangement used by us, Chip 3 and a MES lamp were mounted in lens holders on an optical bench as before. The distance separating them could be ascertained to ±1 mm. Sensitivity was increased twentyfold by replacing the 1.0 MΩ resistor (Fig. 4) with a 22 MΩ resistor in the current to voltage converter. The laboratory was blacked out.

Measurements (Table 3) were made with three p-type diodes (D1, D2 and D13) and one n-type diode (D3). The surface areas of D1, D2 and D13 vary as 4 : 2 : 1. D3 and D13 are equal in area.

When plotted on log-log graph paper (Fig. 6), sets of parallel, straight line relationships are seen. The gradients are exactly -2.0. The lines for diodes D1, D2 and D13 are almost exactly equidistant because the reverse leakage currents depend on area. The lines for D3 and D13 do not overlap, indicating that where there is a difference in composition of materials the sensitivities differ.

Equally satisfactory results are obtained with the simpler circuit (Fig. 3) across a range from 5 cm to 100 cm.

The dependence of intensity on distance was also investigated using localized blackout. A cardboard tube was mounted vertically over Chip 3 and a MES lamp was suspended on a metre stick within the tube. Several trials were made with two tubes of different diameters, 50 mm and 140 mm. In one of the trials, the inner tube surface was covered with matt black paper. In no instance did we find an inverse square relationship. The actual relationship had a discontinuity which depended on the experimental conditions. We concluded that localizing the blackout significantly disturbs the radiation flux from the point source because of reflections off the walls of the experimental chamber. It was noticed that there is a considerable amount of specular reflection at a large angle of incidence off a matt black surface.
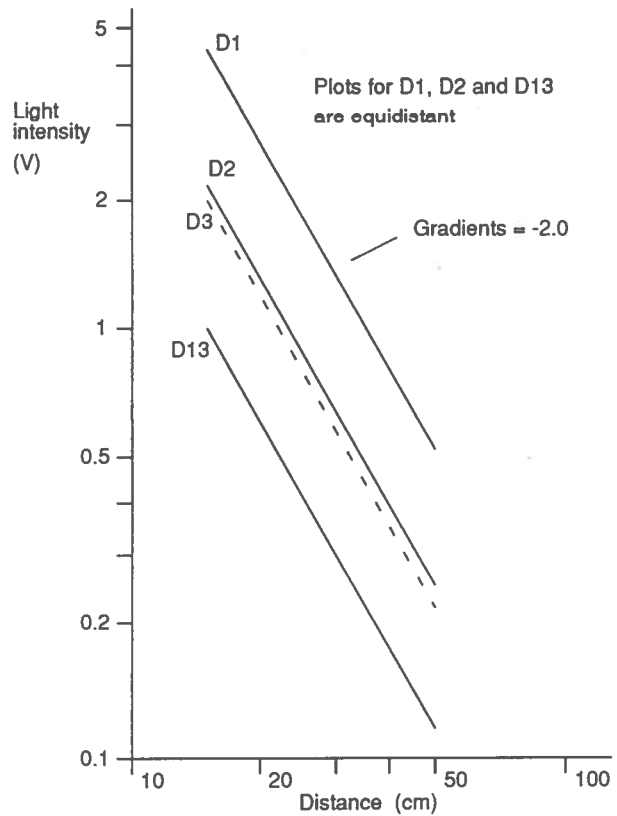

Figure 6 Log log relationships of light intensity versus distance for p-type photodiodes (D1, D2 and D13) and n-type photodiode D3.

A tube is possibly the worst shape of chamber to deploy for trying to demonstrate an inverse square relationship between radiation flux and distance from a point source. Any reflected radiation is bound to concentrate on the detector because of cylindrical symmetry. Some trials were therefore done using a large rectangular box as the localized, blacked out chamber.

This was prepared by removing the lid from a large, cardboard, packing case, which was upturned over a workbench. The circuit with EU Chip 3 was placed within the chamber (Fig. 7). A 6 V, 60 mA, MES lamp was taped to the end of a metre stick, which was inserted through a slot in the roof.

A log log plot of the first run of readings gave a linear relationship with a gradient of -1.8 for distances under 30 cm. This indicates that the radiation flux was still not right, pointing to the need to black out all internal surfaces. After covering the roof and sides of the chamber and worktop with matt black paper, we did a second run. This gave the desired set of readings - a log log plot with a gradient of -2.0 for distances from 5 cm to 60 cm, the limit of our size of chamber.

There were two further experimental conditions that we found must be controlled.

Firstly, it was noticed that a change in lamp voltage of just 0.1 V causes the light intensity to alter by about 5%. Thus lamp voltage should be monitored with a voltmeter and maintained at a constant level, preferably by using a voltage regulated supply.

Distance	Light intensity			
	D1	D2	D13	D3
(cm)	(V)	(V)	(V)	(V)
15	4.40	2.16	0.99	1.95
17.5	3.33	1.645	0.761	1.48
20	2.57	1.27	0.586	1.15
22.5	2.07	1.017	0.464	0.92
25	1.696	0.830	0.383	0.749
27.5	1.430	0.700	0.323	0.631
30	1.231	0.603	0.279	0.540
35	0.940	0.460	0.213	0.413
40	0.748	0.366	0.170	0.322
45	0.616	0.299	0.140	0.266
50	0.527	0.257	0.119	0.231

Table 3 Readings of light intensity versus distance for four photodiodes.
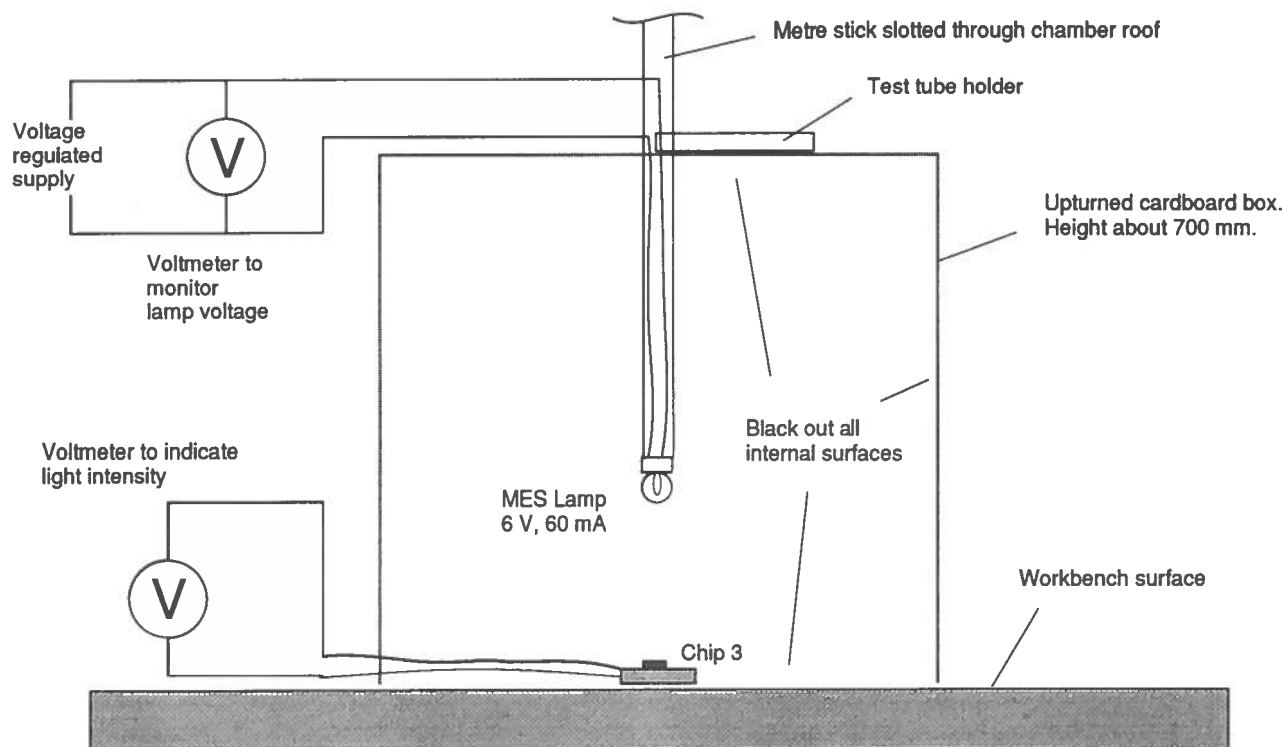
Figure 7 Localized blackout chamber for inverse square law demonstration.

Secondly, the radiation flux from a MES lamp is spatially non-uniform. You can see this by viewing the light cast on a sheet of paper 10 cm from a lamp in a dark room. The patch of light is slightly dappled. If the photodiode sensor is moved transversely through the light flux, the output varies by ±10% for small translations. We could overcome this problem by using a large area sensor which is about 1 cm square. However the diodes on Chip 3 are less than 1 mm overall, therefore the lamp should be moved slightly until a maximum output is found. This value should be taken as the reading.

Diode size

There is a linear relationship between photodiode area and leakage current (see for instance the readings in Table 4 and the equidistant log log graphs in Figure 6).

Diode	Relative area	Current (µA)
D1	4	1.31
D2	2	0.64
D11	1	0.30
D10 D11	2	0.64
D9 D10 D11	3	0.90
D9 D10 D11 D12	4	1.19
D9 D10 D11 D12 D13	5	1.49
D9 D10 D11 D12 D13 D2	7	2.33
D9 D10 D11 D12 D13 D2 D1	11	3.57

Table 4 Values of reverse leakage current from single photo-diodes and parallel combinations. Shows effect of area on current.

It is possible to connect diodes in parallel to find out how current depends on area. D9 to D13 comprise of a set of five identical diodes. By connecting them sequentially in parallel, the student can readily get five, equally spaced values of area.

Summary

These results indicate that the photodiodes on EU Chip 3 have a linear response and may be used to demonstrate the inverse square relationship between intensity and distance from a point source.

Conditions for showing the inverse square relationship include (1) blackout - either whole room, or local, (2) absence of reflecting surfaces which would disturb the radiation flux, (3) constant voltage lamp supply, and (4) finding the localized maximum intensity because of spatial variations in the radiation flux.

Intercomparisons of leakage currents in diodes of similar composition show linear relationships between diode size and current. These relationships may be investigated at different levels of the Physics curriculum, particularly Standard Grade investigations, or CSYS projects.

EQUIPMENT NOTES
PicoScope

With *PicoScope* you can turn your PC into a virtual instrument for capturing and analysing experimental data.

Pico Technology manufacture a range of A to D converters and associated software drivers and operating programmes which constitute the Pico range of virtual Instruments. This review considers the virtual instruments based on the *ADC-42* interface. The *ADC-42* lies midway in the Pico range regarding price and specification. The products reviewed here (*ADC-42 PicoScope* and *PicoLog*) together cost about £100. We chose to review this product as a trade-off between trying not to exceed £100 in expenditure but maximizing on technical specification and facilities.

The Pico *ADC-42* is a 12-bit analogue to digital converter. It is bipolar and provides a single channel. The *ADC-42* connects directly into the parallel printer port of a PC and requires no external power source. It is about the size of a match box.

The virtual instruments which may be run are :

- real-time oscilloscope
- digital storage oscilloscope
- digital voltmeter
- spectrum analyser
- data logger and analyser

The software consists of five programs : *PicoScope* for DOS, *PicoScope* for Windows, *PicoLog*, *Clipboard* and *adc42.exe*. *PicoScope* is a virtual instrument program running as an oscilloscope, voltmeter and spectrum analyser. There are versions for DOS and Windows. *PicoLog* is a DOS data logging and analysis program. *Clipboard* is a Windows data collection program; it is designed so that data can be analysed with a spreadsheet (not supplied). The *adc42.exe* is a DOS program to read in large amounts of data and write to a text file. This review considers both DOS and Windows versions of *PicoScope*. It also looks at *PicoLog*, which is DOS only.

Specification with ADC-42

Resolution :	12 bits
Number of input channels :	1
Input voltage range :	-5 V to +5 V (bipolar)
Maximum sampling rate :	15k / 12k samples per second on 486/386
Repeatability :	±4 l.s.b. at 25°C
Absolute accuracy :	±1% typical at 25°C
Overvoltage protection :	±30 V
Input impedance :	1 MΩ

Trigger mode

Mode :	None, Auto, Repeat, Single
Direction :	Rising, Falling
Threshold :	user defined between 0 and 5000 mV
Delay :	user defined between -100% and 1000%

Operation

For someone who is familiar with the operation of oscilloscopes, *PicoScope* software is easy to use, although problems were encountered when we ran it with *Windows 95* (see below). Any other difficulties found with the operation can readily be resolved via the help files.

When running on *PicoScope* graphical displays are shown in real time, just as you get with a real oscilloscope display (Fig. 1). The type of display is controlled by the Trigger Mode (see above). The usual mode is Auto, which would be used for displaying a continually repeating signal. Another useful mode is Single, for displaying a fast transient event, or a very slow occurring event. The instrument operates as a storage oscilloscope when the Trigger Mode is Single.

Windows 95

PicoScope for Windows was found to operate satisfactorily on *Windows for Workgroups* (version 3.11), but did not operate on one machine running on *Windows 95*. The problem was that the program did not register that the *ADC* was connected to the computer. However the other programs, *PicoScope for DOS*, *PicoLog* and *ADC-42 Clipboard*, all worked fine on the PC running on *Windows 95*.

The cause was found to be that during installation the "system.ini" file had not been amended to handle the ADC driver when running *Picoscope for Windows*. This was resolved by adding the command "driver = pico.386" to the [386 Enhanced] section of the file.

Performance

The hardware specification has been tested and found to be correct.

At ±1%, the voltage accuracy is better than you get on the typical school oscilloscope. The same comment can be made about the time base accuracy. The bandwidth is about 5 kHz, which is sufficiently fast to capture mid audio frequency signals. Signals up to 8 kHz can be handled by the spectrum analyser (Fig. 2).
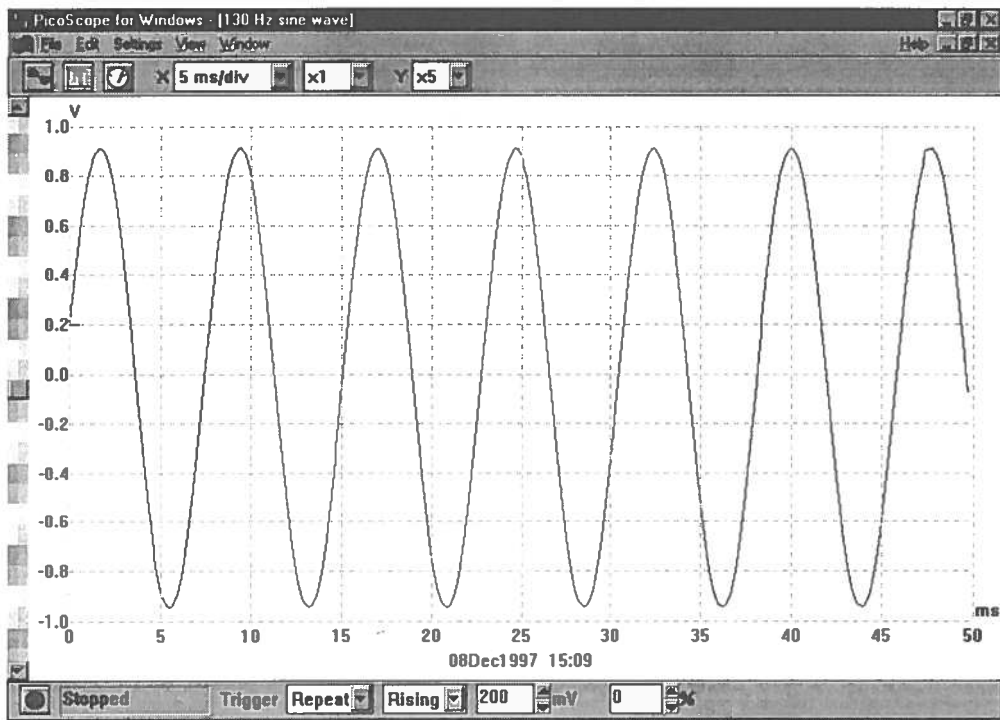
Figure 1   Screen display of a sinusoidal waveform.

Summary on *PicoScope* with ADC-42

GOOD POINTS

1. The *ADC-42* package is compact and reasonably cost effective for the facilities which may be run with it, viz. oscilloscope (real-time and storage), spectrum analyser, datalogger, digital meter. Because it has a DOS program, it can be used as easily on an old 286 as it would on a new Pentium 486, although the sampling rates are slower on a 286.

2. It is easy to use and performs well.

3. It is good for demonstrations. The display is much bigger than those on oscilloscopes or digital meters.

4. The data gathered is available for digital processing. It can be saved for reference at a later date, processed in a spectrum analyser (supplied), or spreadsheet (not supplied) or graphics package (not supplied), or printed out.

5. The scope function has two mouse controlled rulers that can be positioned either horizontally or vertically. Exact ruler positions are shown on the screen and, if they are parallel, the difference between the rulers is shown too. This is a simple and effective way of getting values with small uncertainties from experiments.

5. The technical performance complies with specification.

6. The FFT spectrum analyser is a useful feature.

7. With *ADC-42*, the *PicoScope* is limited in its use as a traditional oscilloscope, but will perform satisfactorily within the bounds of its specification. The restrictions are ones of the *ADC-42* hardware, and are not generated by software deficiencies. The software is easy to use and performs well.

BAD POINTS

1. Single voltage range : -5 V to +5 V with a 12 bit, or 2.5 mV, resolution. Whereas the resolution is suitably fine and is just right, we are concerned that there is only one voltage range. The user of an oscilloscope expects to be provided with several ranges. Minimally there should be three decade ranges. Preferably there should be multiple ranges spanning three decades with 1 - 2 - 5 - 10 switching.

2. Bandwidth : The 5 kHz bandwidth is limiting, but not immoderately so. At such a low value the *ADC-42* with *PicoScope* would neither be able to resolve high frequency audio signals, nor, of course, ultrasound. By comparison the bandwidth of a typical bottom-of-the-market oscilloscope is 20 MHz, which is three orders of magnitude greater.

3. *Windows 95* : A difficulty was encountered using *PicoScope for Windows* with Windows 95. The problem was resolved fairly easily after contacting Pico direct.

PicoLog with the ADC-42

PicoLog is the additional data-logging program that complements the *PicoScope* program. It may be used on many of the ADCs supplied by Pico Technology. *PicoLog* is assessed here using the ADC-42.

The program collects a sequence of data samples and stores them to disk. These samples can be scaled in various ways and then output as either numerical data or graphical displays. The scaling operations are *Linear*, *Table lookup*, or *Equation*. *Linear* scaling is for use with sensors which have a linear response. *Table lookup* or *Equation* is for sensors with a non-linear response. Graphical data can be operated on to show the measured data plotted against either time or some other parameter.

The sampling rate can be set at a slowest value of once every 11 days and at a fastest rate of once every millisecond. The maximum number of samples is 65 000, giving the shortest period for a full set of samples to be 65 seconds and the longest period to be 55 centuries!

Real time graphing is not available for sample rates faster than 1 per second.

The ADC-42 does not operate as a free-standing datalogger, but only while connected to a PC.

Graph mode

The Graph Mode can be set up to plot a measured data set against either time or another data set. Up to 10 data sets can be plotted in superposition on the Y-axis against time and up to 4 data sets can be plotted against each other on an X-Y plot. The X and Y axes can be manually or automatically scaled and there is a zoom function for each of the axes. However care is called for when choosing the scaling factor. A grid gap of 10 mm, 20 mm, or 50 mm is convenient to subdivide on a paper copy, whereas almost any other value is not.

Learning to use

It took a while to learn how to use *PicoLog*. The main difficulty was understanding how to use the various options given to obtain the required measurements and analysis methods. The manual was generally helpful in clearing things up. However we are of the opinion that most users (that is, in our context, school teachers) would need to be shown how to use *PicoLog* in a training course rather than being left to learn by themselves.

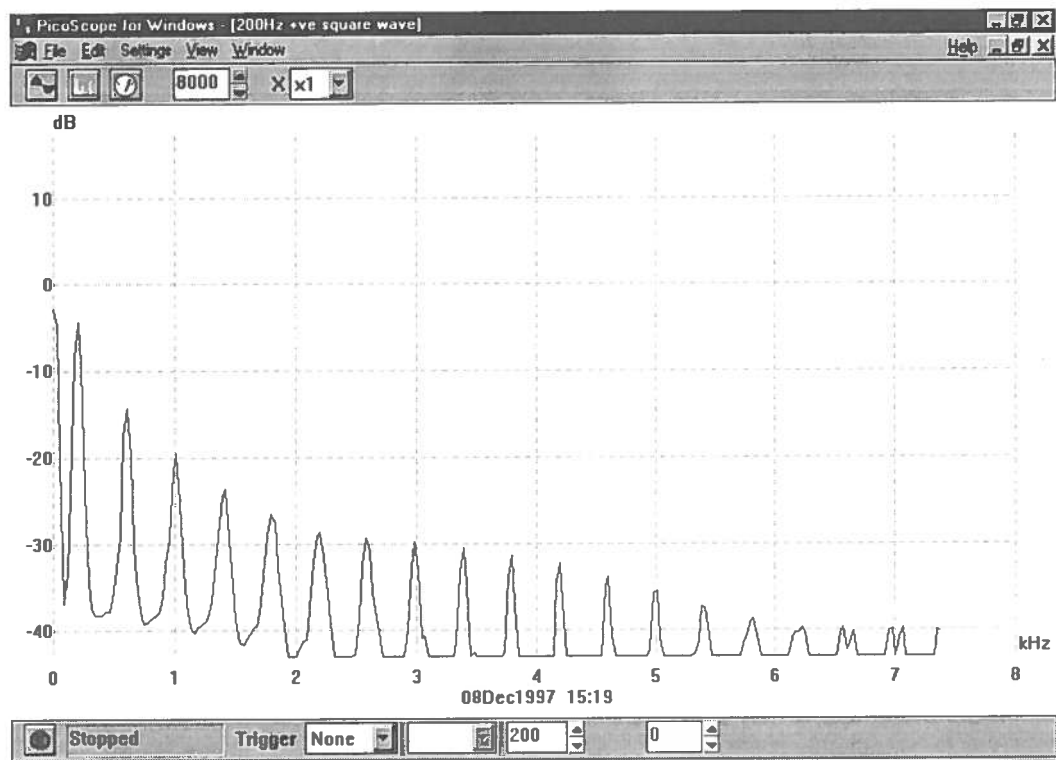Once the basic functions are understood, the program can be operated relatively easily.

Figure 2   Frequency spectrum of a 200 Hz square wave signal.

Summary of PicoLog on ADC-42

GOOD POINTS

1. It is a reliable program that can be used efficiently once learned.

2. It is useful that several data sets can be superposed, or plotted one against the other.

3. The facility to scale data may be of use.

BAD POINTS

1. The fact that the Picologger cannot be used disconnected from a computer is a restriction.

2. The program itself is difficult to learn how to operate and can be confusing. Care must be taken when inputting data as it doesn't always handle non-integer numbers very well. This can cause the program to crash, losing all unsaved information.

Assessment

The assessment category for the *ADC-42* with *PicoScope* and *PicoLog* is an *A* (Most suitable for use in Scottish schools and non-advanced FE).

Acknowledgement

SAFETY NOTES
GS23 electrical safety guidance withdrawn

The Health and Safety Executive (HSE) withdrew Guidance Note GS23 *Electrical safety in schools* at the end of last year. We understand that they do not plan to replace it.

It would seem that sector specific guidance such as GS23 is not considered necessary if generic guidance will suffice.

There is for instance generic guidance from the HSE on complying with the Electricity at Work Regulations [1], maintaining equipment [2] and safe working practices [3]. One of the high risk areas in schools is the assembly hall or theatre. Specific guidance on electrical safety in places of entertainment has recently been revised and reissued by HSE [4].

Moreover there is guidance on electrical safety from other agencies, including SSERC. Leaving ourselves to the end, recommendations for periodic safety checks on business equipment has been produced by the Federation of the Electronics Industry [5]. A code of practice for in-service inspection and testing of electrical equipment has been issued by the IEE [6]. Advice on the maintenance of electrical services in schools has been published by the Architects and Building Division of the DfEE [7]. There is also a code of practice, but now rather dated, from the BSI on health and safety in school workshops [8]. Its scope includes electrical installations, machines and working practices.

Turning from maintenance to practical work in laboratories or workshops, there is a chapter on electricity in the latest edition of *Safeguards in the school laboratory* by the ASE [9]. This refers out to other publications including the SSERC Bulletin for advice on specific hazards such as HT transmission lines. Information on safe upper limits for voltage, current, energy and charge can be found in our article on preventing electric shock [10].

On routine maintenance tests and inspections, we have published information on portable appliance tests [11] [12], the latter document being advice prepared jointly by our sister organisation CLEAPSS and ourselves. The Bulletin article on inspecting [13] adopts a risk assessment approach and therefore supersedes GS23, which had been published before this approach became mandatory.

Seeing how extensive this reference list is, sector specific advice in a single document seems no bad thing. Have the HSE got it wrong? Perhaps someone should reinvent it!

References

1 *Memorandum of guidance on the Electricity at Work Regulations* 1989 HSE HS(R)25 1989 ISBN 0 11 883963 2.

2 *Maintaining portable and transportable electrical equipment* HS(G)107 HSE 1994 ISBN 0 7176 0715 1

3 *Electricity at Work Safe working practices* HS(G)85 HSE 1993 ISBN 0 7176 0442 X

4 *Electrical safety in places of entertainment* GS50 HSE 1997 ISBN 0 7176 1387 9

5 *FEI recommendations for periodic safety checks for business equipment* Issue 2 Federation of the Electronics Industry 1994

6 *Code of practice for in-service inspection and testing of electrical equipment* IEE 1994 ISBN 0 85296 844 2.

7 *Maintenance of electrical services* Building Bulletin 76 Architects and Building Division Department for Education 1992 HMSO ISBN 0 11 270799 8

8 BS 4163 : 1984 *Health and safety in workshops of schools and similar establishments* BSI

9 *Safeguards in the school laboratory* (10th edition) ASE 1996 ISBN 0 86357 250 2

10 *Preventing electric shock* Bulletin 173 SSERC 1992

11 *Portable appliance testers* Bulletin 170 SSERC 1991

12 *Electrical safety testing* CLEAPSS/SSERC 1991

13 *Portable appliance inspecting* Bulletin 184 SSERC 1995

Reaction timer with the BASIC Stamp

BASIC Stamps are programmed in a simple version of the BASIC language, called *PBASIC*. A short program is described to illustrate features of PBASIC.

This is the second in a series of articles on programmable controllers. We intend setting out in the next issue some criteria for the educational use of such devices. Also planned are reports on our evaluation of TEP's equipment and teaching materials for using the Stamp in Scottish courses.

The BASIC Stamp can be used as a simple reaction timer, using only a switch and a few LEDs. The end result is a timer that is accurate to about a couple of milliseconds, and needs little or no technical knowledge.

The idea behind the timer is simple. The BASIC Stamp will wait for the person to press a button to start the test. The BASIC Stamp will then wait a short while before signalling the user to press the button again. While it waits for the button to be pressed, it performs a simple loop that adds one to a counter, then checks whether the button has been pressed. Once the button has been pressed, it sends the value of the counter to the computer, and returns to the start of the program.

The program below does exactly this, but has a few other little extras to allow us to follow what is going on. While the BASIC Stamp waits for the user to start the test, it lights the red LED. When the button is pressed, the red LED is turned off, and the yellow LED turned on. After a short wait the yellow LED is turned off, and the green LED turned on, signalling the start of the timing. Once the button is repressed, the green LED goes out. If the counter holds a value greater than one, it is displayed on the screen. If the value of the counter is equal to one, the person has either (accidentally?) cheated, or has the best reactions in the world!

Program explanation

The first line of the program starts with the word "REM". This is short for *reminder* and does nothing to the program - it only allows us to add comments to the program to remind us how it all works. The apostrophe is used in exactly the same way. Adding comments to your programs is always a good idea, since it allows other people to understand what you have written, and makes it easier to remember what different bits of the program do.

The *dirs* variable defines which of the eight input / output pins are used as inputs and which are used as outputs. The pins are numbered 0 to 7, with 7 being the leftmost, or most significant, bit. The percentage symbol is used to indicate that the number that follows it is in binary. A one indicates that the pin is an output, and a zero indicates that it is an input. So "dirs=%11111110" resets pin 0 to be an input, and sets all of the other pins to be outputs.

The symbol command allows us to use names to refer to variables and constants. The line "symbol push_button = pin0" tells the computer that when we write push_button what we mean is the value of pin 0. This allows us to refer to the specific input/output pins by names that reflect their actual use. The context in which the symbolic name is used also makes a difference. Because it is not clear from the rest of the program whether push_button is referring to just a number, or an input pin, we have to refer to it as "*pin0*", whereas the rest of symbols are used in commands that only refer to output pins. Symbol is also used in this program to refer to a specific area in the chip's memory. The lines "symbol delay = w0" and "symbol timer = w1" instruct the computer to use the first two words of the BASIC Stamp's memory whenever we refer to *delay* or *timer*, both of which are variables. A word is the maximum amount to memory that the computer can use in one instruction. The BASIC Stamp can access sixteen bits of the memory in one go - so a word is sixteen bits. This means that the *delay* and *timer* values can be any value from 0 through to 65535. If we didn't need these variables to have as large a range, then we could assign the symbolic names to bytes, nibbles or individual bits of the memory. In fact "*pin0*" refers to a single memory location - the single bit that contains the logic state of pin 0. (See page 11 of the Parallax programming manual for further discussion of the memory names and allocation).

The next line "Start:" is an address label. The semi-colon used after the name tells the computer that this word is to be used as a place marker. We refer back to this place by using the name. (Note that we do not include the semicolon when we refer to the labels).

We set the value of the timer to be zero, then turn the red LED on. Because all of the LEDs are connected through a 1.0 kilohm resistor to ground, setting a BASIC Stamp's pin to logic high turns one of them on. The high command sets the pin whose symbolic name is red (pin 4) to logic high. Because the high command can only be used with output pins, the BASIC Stamp will make the pin an output pin if it is not already assigned as an output.

The next three lines of the program generate a truly random variable. The random command generates a pseudo-random number. The number is pseudo-random because computers cannot generate truly random numbers. The BASIC Stamp has 65535 essentially random numbers that it can choose from. Which number is chosen depends on the contents of the memory that it is given to work with. This leaves us with the problem that the sequence of numbers is entirely predictable. More

importantly, each time the BASIC Stamp is switched off the memory is reset - causing the first call to random result in the same number every time. To avoid this, and to generate truly random variables, random is called continuously until the user presses the button. Because pressing the button connects the input pin to logic high, we loop while push_button is connected to logic low. The line of code in between these two simply filters out any value that is less than 2000 or greater then 10000, causing the delay to be between 2 and 10 seconds.

The low command sets an output pin to zero volts.

The pause command causes the BASIC Stamp to wait the specified number of milliseconds before processing the next instruction. This makes the user wait between 2 and 10 seconds before starting the test.

The next loop does the actual reaction timing. The timing loop does not contain any pause commands because we want it to run as fast as possible. Initially the button command was used in this loop, but it was found to take longer to execute, and is too complex for our needs here. The *timer* variable is increased by one every time the loop is executed. Since the time to execute the loop does not change, the timer value will increase linearly with time. (Due to the number of options available with the button command, it does not always take the same length of time to execute.) The timer value is therefore accurate, but uncalibrated.

The value of the reaction time is tested. If the time is equal to 1, then the result indicates that the user cheated by holding the button down, or he has a reaction time of approximately 1 millisecond! Since this is highly unlikely, only values greater than one are displayed using the debug command. The debug command has several options, but as it is used here it displays the text "timer =" and then the value of *timer* in decimal.

The last command causes the program to repeat until the BASIC Stamp is turned off. The goto command instructs the BASIC Stamp to return to the label "start".

Calibration

The program used above outputs a value that varies linearly with time to the computer display screen. But as stated, it is an uncalibrated value. Calibration is a simple exercise. It simply involves running the program a few times with a timer connected to pins 6 and 0 (the green LED and the switch). The timer should start when the LED is lit, and stop when the switch is pressed. The Unilab Motion QED was used for this. For maximum accuracy, the experiment should be carried out ten or twenty times, noting the value displayed on the screen and the actual time. These should then be graphed and a line of best fit drawn. Since the relationship is linear, and nearly goes through the origin (there is a slight offset due to the time taken to load instructions), then three timings will probably suffice. To obtain the actual reaction times from the value on screen is then simple maths. The relationship was found to be

actual time in milliseconds = value from BASIC Stamp x 1.1196.

Program listing

REM Program written 2nd September 1997 by D Weir
'Uses the stamp as a reaction timer.

'Red LED lights telling the user to press the button.
'Red LED goes out when button is pressed.
'Yellow LED lights, indicating that the test will start shortly.
'Yellow LED goes out and green LED lights.
'When user presses button, the time from green LED lighting to button press is displayed on screen.
'If the user cheats (time of 1) then the time is not displayed

```
dirs = %11111110                'set pin 0 as input

symbol push_button = pin0       'push_button connected to
                                 pin0
symbol red = 4                  'red led connected to pin4
symbol amber = 7                'yellow led connected to pin7
symbol green = 6                'green led connected to pin6
symbol delay = w0               'delay variable uses word 0
symbol timer = w1               'timer variable uses word 1

Start:    timer = 0
          high red              'red led on

Repeat:   random delay          'generates a truly random
                                 variable while waiting
          if delay < 2000 or delay > 10000 then repeat
          if push_button = 0 then repeat
          low red
          high amber            'indicate that the test will start
                                 soon
          pause delay           'wait between 2 s and 10 s
          low amber
          high green            'start the test

Timing:   timer = timer + 1
          if push_button = 0 then timing
          low green             'indicate that button has been
                                 pressed
          pause 2000
          if timer = 1 then start  'do not display result if user
                                    has cheated
          debug timer           'send variable to PC for
                                 viewing

          goto start
```
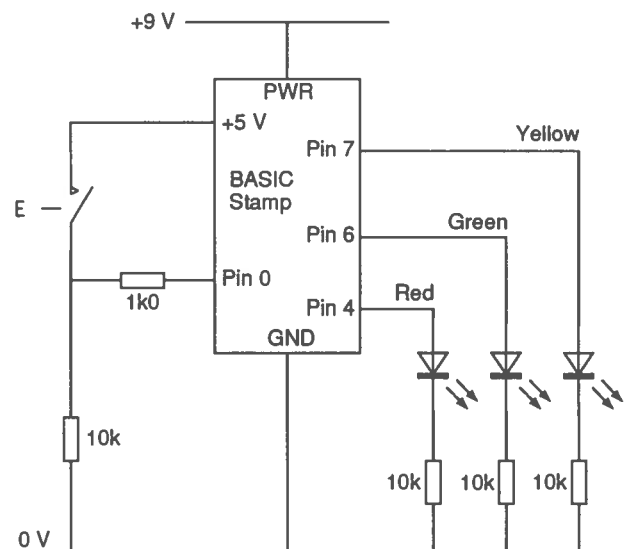
Figure 1 Reaction timer circuit diagram. A connection between the BASIC Stamp and PC must be maintained during this application.

SAFETY NOTES

Young Persons Regulations

New regulations came into force last year to protect young persons at work.

The Health and Safety (Young Persons) Regulations 1997 (YPR) implement an EU Directive and came into force on 3 March 1997. Their purpose is to protect young people at work.

The YPR amend the *Management of Health and Safety at Work Regulations 1992*. Such amendment serves mainly to clarify the additional duty of care which an employer holds when employing young persons. This is because experience tends to match maturity.

A distinction is made between a *child* and a *young person*. The former means a person who is not over the minimum school leaving age. The latter means any person who has not attained the age of eighteen.

Children at work are treated as employees by the YPR. They are prohibited by other legislation from working in industrial undertakings such as factories or construction sites unless on a work experience scheme approved by the education authority. Furthermore there are age restrictions with particular machinery, such as operating certain woodworking machines, or undertaking particular tasks, such as some processes in pottery making.

Children under the age of 13 are generally prohibited from any form of employment.

The YPR require an employer to carry out a risk assessment *before* a young person goes into the workplace. The risk assessment should take account of :

* the inexperience, lack of awareness of risks and immaturity of young people;
* the physical state and condition of the workplace and workstation;
* the form, range and use of work equipment and the way in which it is handled;
* the organisation of processes and activities;
* the extent of the health and safety training provided or to be provided to young persons; and
* the nature, degree and duration of exposure to physical, chemical and biological agents.

The parents and anyone with parental responsibility for a child must be informed by the employer about the potential risks to the child and the steps that have been taken to control these risks. This information need not be given to the parents in writing. It may be given orally, such as by telephone.

Referring to specific restrictions, the YPR state that no employer shall employ a young person for work :

(a) which is beyond their physical or psychological capacity;

(b) involving harmful exposure to agents which are toxic or carcinogenic, cause heritable genetic damage or harm to the unborn child or which in any other way chronically affect human health;

(c) involving harmful exposure to radiation;

(d) involving the risk of accidents which it may reasonably be assumed cannot be recognised or avoided by young persons due to their insufficient attention to safety or lack of experience or training;

(e) in which there is a risk to health from extreme cold or heat, noise, or vibration.

However nothing in the above list shall prevent a young person who is no longer a child being employed for work where it is necessary for his training, where there will be supervision by a competent person and where any risk will be reduced to the lowest level that is reasonably practicable.

Work experience

In so far as schools may be affected by the YPR, the main effect will be on work experience. Ostensibly the YPR should have little effect on schools because it is the employers who have the duty of making risk assessments and informing parents of the results. However the school (or work placement provider) has a duty of care towards the child and should therefore ascertain that the work placement is reasonably safe. It would be sensible also for the school, on behalf of the employer, to inform parents of the results from the risk assessment, and of any special preventive and protective measures which might be needed. This is because the school would in any case be providing information on other matters related to the work experience.

A consultation document on work experience has been prepared jointly by the Scottish CCC in consultation with the Health and Safety Executive [1]. The document was issued this January to interested parties. Its scope is much broader than the YPR Regulations.

Another consultation document, which is specifically about YPR, is being prepared by the HSE in London for circulation throughout the UK later this Spring. The HSE Guidance for employers has already been published [2].

References

1. *Work experience*, Consultation paper, Scottish CCC, Jan 1998.
2. *Young people at work*, A guide for employers, HS(G)165, HSE 1997, ISBN 0 7176 1285 6.

Trade News

Atmospheric Pressure Demonstrator

The PASCO ME-8966 Atmospheric Pressure Demonstrator was devised to illustrate this phenomenon with dramatic effect. It consists of a flat piece of rubber matting, 200 mm square, to which is attached a knob for lifting (Fig. 1). When the mat is placed on a smooth, flat surface and pulled straight upwards by the handle, a partial vacuum is created under the mat preventing it being lifted off the surface. In fact if the surface is the top of a freestanding laboratory bench, you may succeed in lifting the bench off the floor. It is quite amazing!

How much can be lifted? Given that its area is 0.04 m^2, then the most you could lift might be 400 kg - at the risk of a hernia, or ruptured muscles, or back injury. Or the handle might tear itself from the mat. Sensibly the smallness of the handle limits the grip to three fingers, which prevents too much force being exerted. Anyone using the apparatus should be warned not to exert immoderate force.
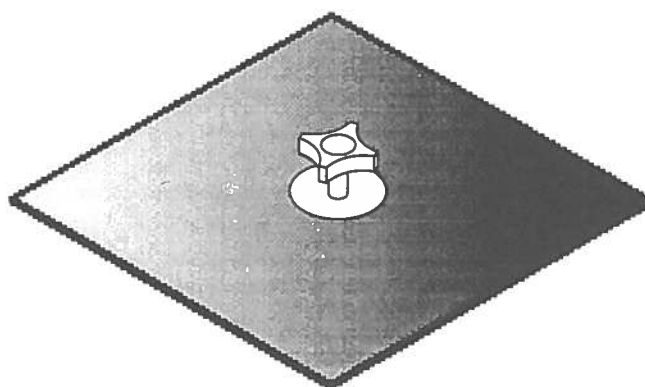

Figure 1   The PASCO Atmospheric Pressure Demonstrator.

Extra flexible test leads

Several schools have asked us for a source of extra flexible test leads (55/0.1 mm PVC insulated copper) now that RS Components have ceased to stock this product. We know of three other sources of supply :

Farnell	710-532 etc.
Maplin	PA97F etc.
Rapid	01-0600 etc.

We have looked at samples of test leads from Maplin and Rapid, but not Farnell. The Maplin test leads would appear to be identical to the ones which RS used to sell.

As always, you get what you pay for. The leads from Rapid are cheaper than the others but, being significantly less flexible and capable of kinking, would not be an ideal substitute for the old RS types.

Further to this information on extra-flexible wire, there is a new type of test lead wire called Flexivolt which has a superior specification to 55/0.1 mm PVC insulated copper. Flexivolt costs about £1.20 a metre compared with about 12p a metre for the traditional stuff.

Please see the table below for its specification.

Supplier	Order code	Specification		Colour								Reel length	Cost
Extra flexible test lead wire :													
Farnell	710-532 etc.	55/0.1 mm	PVC insulation	BLK		R	Y	GN	BLU			100 m	£11.85
Maplin	PA97F etc.	55/0.1 mm	PVC insulation	BLK		R		GN	BLU			25 m	£3.27
Rapid	01-0600 etc.	55/0.1 mm	PVC insulation	BLK	BR	R	Y	GN	BLU	W		25 m	£1.98
Flexivolt test lead wire :													
Farnell	611-372 etc.	258/0.07 mm	PVC insulation	BLK		R	Y	GN	BLU	W		5 m	£6.20
RS	285-7820	129/0.07 mm	PVC insulation	BLK		R	Y	GN	BLU			25 m	£32.40

Trade News

Brass lampholders

Brass lampholders can be bought directly, in boxes of 10 or 20 depending on type, from S Lilley and Son Limited, the manufacturer. The product range includes many types of B15 small bayonet cap and B22 bayonet cap lampholders, as well as E27 Edison screw lampholders. There are suitable fitments for rayboxes, bench lamps and combined bench/microscope lamps.

Lilley have developed a new, switched, B22 bayonet cap lampholder designed to reduce the risk of electric shock from accidentally touching the exposed pins. A third plastic pin activates a switch to energize the lamp contacts only when this pin is depressed. If the supply to the lampholder is switched on, the contacts are energized when a lamp is inserted into the lampholder. The product is called the *Safer-switch lampholder*.

We have examined a sample coded 3413E, which has a cord grip. This product may be fitted with shade rings to bench lamps, or suspended as a pendant.

Spillage trays

We have recently received samples from Clark Scientific Limited of inexpensive *Spill-Trays*. The trays are made from high impact polystyrene and could be useful for containing a variety of small spillages. It is often the case that the step with the highest risk is the weighing out of a powder and the preparation of a solution. If the substance is a suspected carcinogen, or has other irreversible or long term effects, it is doubly important to ensure no trace of an accidental spillage is left on a bench.

Certain stages of projects could usefully be carried out and contained within such trays. The Clark Scientific trays are available in two sizes :

AT1   475 mm x 360 mm at £14.50 (pack of 20) and £48.50 (pack of 100)

AT2   700 mm x 450 mm at £28.00 (pack of 20) and £95.00 (pack of 100)

The material is not rigid enough for use in a tray for carrying materials, but is sufficiently sturdy to be used repeatedly to contain spills. It withstood concentrated acids and moistened sodium hydroxide pellets - as well as propanone - each for an hour. The only noticeable effect was browning in the area which had been covered by the concentrated sulphuric acid. A variety of biological stains were also tried, with only a few being adsorbed on the surface.

In tests for static electricity, using a coulombmeter the tray material built up a similar charge to that produced on standard plastic laboratory bins, though less than that generated on a number of other plastic surfaces.

Being plastic the trays will naturally be affected by heat. When heating a beaker of water within a tray - on a tripod and gauze, but with no heat resisting mat - there is very slight distortion of the tray base, but it recovers afterwards. When 10 cm^3 of propanone were poured on the tray and ignited, the solvent burned off but the tray did not catch fire. Obviously the tray would melt in a direct Bunsen flame.

Both trays have a small lip of 15 mm and will contain many spillages. As a mercury tray either would be satisfactory for handling the metal, but only at low heights above the surface. However even those trays sold as mercury trays with lips of ca. 25 mm will fail to contain the bouncing drops which are likely when the liquid falls from any significant height.

Suppliers merge

Scientific and Chemical Supplies Limited at Bilston, West Midlands, and Hogg Laboratory Supplies Limited in Birmingham merged last December. The companies have combined their businesses at the new, larger premises of Scientific and Chemical Supplies at Bilston (see address list).

Heat experiments

Nicholl Education have developed new apparatus for some of the traditional experiments on heat. Having ourselves tested the apparatus, we intend reporting on it more fully in a later issue.

The *Conductivity Bars* comprise of a set of four different metal bars attached to an acrylic frame. If the bottom of the apparatus is immersed in hot water, the conduction of heat is shown by the movement of coloured bands along strips of thermochromic film attached to the bars. This clean substitute for the traditional greasy method costs £26 for one, or £120 for a set of five.

To replace the traditional mains radiant heat source with open coil elements, Nicholl have devised the *Radiant Heat Source* with mains heating elements safely secured within quartz glass insulated rods. The power output is 300 W and the price, £125.

An associated product is the *Radiation Absorption Discs* to show infrared absorption. These four discs each have a different anodised surface - matt black, polished black, matt silver and polished silver. A liquid crystal temperature indicator on the reverse shows the temperature. The set of discs and holder costs £36.

Waugh Oscilloscope

The Mendascope division of Waugh Instruments is well known for their service in repairing and recalibrating oscilloscopes. The company have now put their expertise into designing a user friendly oscilloscope for education. Priced £318 and known as the DB20, it is dual trace, has a 20 MHz bandwidth and 1-2-5-10 settings on the Y amplifiers and timebase. It also features :

- help button, which returns the display to the screen whatever the button settings;

- one control for trigger slope and level;

- automatic warning if user tries to trigger on the wrong channel;

- one button for X/Y operation;

- choice of BNC, or 4 mm sockets, or both of these;

- coloured controls for ease of referral ("turn the blue knob" rather than "turn the Channel A voltage selector";

- operates off a mains supply, or 12 V battery.

Micromouse kit

The annual IEE Schools' Micromouse Competition attracts a relatively small number of entrants. Whether or not you enter, the construction and subsequent operation of a little line-following mouse can be a lot of fun - as well as providing the participants with much to learn from.

Swallow Systems supply parts and instructions for building micromice. *Dash Free* is a kit of electronic and mechanical parts to make a line follower. The motors and drive train are assembled ready for use. The chassis, which is left to the builder to design, can be made from stripboard. Intentionally, the kit is incomplete. The user has to add stripboard, wire, batteries and some mechanical parts.

Dash Free has a DC drive motor on each side. A pair of downward pointing reflected light sensors detect the white line. They are on or off depending on whether they are above the line or not.

The control circuit contains several transistors and diodes per motor. Each motor is alternately driven fast or slow, one in counterpoint with the other. There is a lot of skill in tuning the speed controls, two per motor, for optimum response. This means training the mouse to run fast along the straight sections, but to turn sharply, without overshooting, on the corners.

To avoid erroneous signals from sunlight or room lights, there are photo i.cs. which drive downward pointing LEDs with pulsed light and look for reflected light phase locked to these pulses.

Dash Free costs £58.69, with post and packing being £10.28 extra, both prices including VAT. Other kits, parts and plans are available.

Resources

Education and industry

With the fairly recent publication of the SOEID paper on the quality of school industry links, two new Directories may be of interest to readers. Both have been produced by *Resources Plus*. One, sponsored by DfEE, Esso, Glaxo-Wellcome and British Aerospace, is entitled :

"1998 Directory of Education-Industry Links"

The second covers a large number of resources across the whole curriculum and is arranged largely as sets of tables. Resources are classified according to age range, context and subject. This publication is entitled :

"1998 Resource Guide : Resources for Education Produced by Industry"

Each of these titles costs £6.00 (including post and packing) and they are available directly from Resources Plus (see inside rear cover of this bulletin issue).

Science options file

A must-have for any science teacher trying to add variety and Science-spice to life. A measure of quality in teaching is the breadth and variety of approaches to learning on offer to the pupils (i.e. the 'richness' of their overall experience - if that doesn't embarrass you). It is also one of many aspects of the dreaded differentiation. The *Science Options File* has been compiled by a highly respected and experienced practitioner - Dr Johanna Carrie - who teaches science still, full time, at Portobello High School. The Options File was put together with the encouragement and co-operation of several individuals and organisations. Walter Whitelaw, Adviser in Science and Technology for City of Edinburgh took over some of Johanna's timetable to provide more time for the work.

The file is organised in *Blocks*, each covering a broad category of learning approach such as Practical Activity. Each in turn is further divided into teacher or pupil based activities and includes the varied approaches needed to achieve a range of different purposes. A similar classification is provided, with lots of illustrative examples, for pupil activities which are not practicals. For each such approach particular strengths are indicated and limitations listed. Lots of other useful suggestions, hints and tips etc are provided in blocks for : specific teacher interventions; group work; positive attitudes; 5-14 strands; common misconceptions and homework. There is a Variety Planner near the end to aid selection of suitable activities for particular types of topic. Case Studies illustrate its use. One let-down is that Johanna's original ideas for easy reference - coloured separators and tabs between blocks etc - were dropped on cost grounds.

Dr Carrie's claims for this publication in our view are, typically, far too modest. If you have the £25, buy it - see Address List under City of Edinburgh Council. (Discounts are available for institutional or Local Authority copy masters).

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

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

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. 35p
(Replaces Item 791 at lower cost).

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 <u>back in stock</u>	55p
846	<u>Sound module</u>, 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	<u>Rocker switches</u>, 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	<u>Battery holder</u>, 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
833	5¼" double density floppy disks, box of 10	60p
834	5¼" high density floppy disks, box of 10	60p

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: 180 pF, 220 pF, 330 pF, 560 pF, 1000 pF, 2400 pF, 3000 pF, 3300 pF, 3900 pF & 4700 pF	4p
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 member EAs, subscriber schools	£4.00
	FE colleges in membership of SSERC	£15.00
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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
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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
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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 :

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852	replacement tips for 1 cm^3 micropipettor, pack.	£1.50
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Glassware, chemicals etc.

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*   *   *

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