Tertiary Teaching Excellence Awards 2004

Nomination for:

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Department of Physics
The University of Auckland

Category One: Sustained Excellence

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND

CONTENTS

1 MY APPROACH TO TEACHING: A PERSONAL STATEMENT

I've been a university teacher for 43 years. In that time I've met many good teachers, and a very few great ones. I've tried to distil the essence of what each of them excelled at, and adapt it to my own style and personality. Thus, many aspects of what I do and shall describe I owe to others, and I acknowledge that at the outset.

One thing I hold as a central principle: any teacher who aspires to excellence must approach this high calling with **friendliness, humility** and **absolute honesty** in interactions with students**.** More, much more is required, but students will also *forgive* much in those in which they sense at least these attributes, and they will sense them very fast.

To be perceived as friendly is vital. I have the picture to the right on my office door. If I'm not in, I want students to sense that they'll be welcome when they find me.

Formal lecturing is a central part of most tertiary teaching. As a young lecturer, I soon became aware that a key factor in successful lecturing was an ability to communicate verbally. I therefore made it my business to attend lunchtime talks by renowned masters of the English language such as John Reid, Sydney Musgrove and Ernest Blaiklock of the Arts faculty. The fluency and vocabulary of these superb scholars were things I knew that I could never equal, but I extracted valuable information about pace, voice production, and in particular the importance of 'presence' and a sense of the dramatic. I had found these qualities largely lacking in lectures I had sat through in the science faculty, and I attempted to incorporate them in my own teaching.

Allied to this, I remembered too well that the overwhelming impression most graduates take away from their experience of 'being lectured to' was (and still is) many hours of **boredom.** I resolved that to the best of my ability, I would structure my lectures so that they would, at least, **not** be boring. Again, much more than this is required, but it's a great start.

The best lecturers vary greatly in what they do, and how they do it. There is also a subtle interaction chemistry between lecturer and class which is often mysterious. All lecturers have experienced classes where everything fires, the jokes are appreciated, the anecdotes work, the students are caught up in the subject matter and everyone leaves with a feeling of satisfaction. The lecturer feels that something valuable has been shared, and the students feel that their understanding has been enhanced. On other occasions, despite having undertaken equally thoughtful preparation, everything falls flat, the anecdotes are met with incomprehension, and both students and lecturer leave disappointed. Nevertheless, I hold that success in lecture delivery must be based on, (but will not be *assured* by), attention to five broad areas: The lecturer must have:

- Absolute mastery of the **technical material** to be presented in the lecture.
- Total confidence in **presentation technique**: Facility with voice projection, hand-writing, body language skills, AV aid operation must be so automatic that total concentration can be given to delivering the material without conscious thought given to the delivery process.
- **Sensitivity** to the mood, attention and comprehension level of the class.
- Ability to **adapt** pace and delivery style to respond to this feedback.
- **Humility** to accept and act upon informed criticism from students and colleagues.

I assume that any tertiary level teacher would certainly have attained the first requirement (mastery). However, not so many are fully aware of the importance of the second (presentation technique). Hesitation, inaudibility, insecure body language, and nervousness can be, and often are interpreted incorrectly by students as unfamiliarity with the subject, so these aspects are strongly linked. My experience tells me that students are very irritated by *simple* faults in delivery, which are often easy to fix. These include 'speaking to the white/blackboard', verbalizing 'filler-phrase-intensive' explanations (too many umms, ahs, coughs), PowerPoint and OHP slides which contain too much information written too small, or flashed through too quickly.

Periodically I retire to the back of the lecture theatre after the class has left and critically examine the visibility of my slides and blackboard writing. Every five years or so I ask one of the technical staff to video 20 minutes of a typical lecture (although it is very difficult to *give* a 'typical' lecture when being videoed) and watch it critically afterwards. Faults in delivery stand out, and I have been able to eradicate annoying hand-gestures and repetitive phrases.

The third area (sensitivity) requires time and conscious effort to master (although most lecturers feel that they do it quite well). In science teaching one can spend considerable time turned away from the class, explaining transparencies, or working derivations and examples on black/whiteboards. It is easy to lose track of how the class is reacting, and the necessity of delivery modification (adapting, the fourth point) when boredom, incomprehension or the low body-sugar syndrome (often observed in the dreadful noon to 1 pm lecture slot) kicks in.

The fifth area (humility) I think is the most difficult of all to seek and accept. It *is* humbling to have faults criticized, often unkindly, by students and tempting to think 'they don't know what they're talking about'. But those who have turned out to be the *best* teachers in my department have, before commencing, been humble enough to seek permission (which is always given) to sit in on, and observe the lecturing of those deemed by common consent to be the department's best teachers.

2 TEACHING EXPERIENCE

I started teaching in 1960 as an MSc thesis student, when a senior staff member of the department died suddenly and tragically of a brain tumour. With two weeks notice, I was offered the chance to teach a first year course, and accepted it.

Since then, from 1960 to 2003, I have taught all courses in the University of Auckland Department of Physics at stage one and two, all courses in geophysics, signal processing, network theory at stage three and Honours. I also taught parts of courses in computer science, engineering, environmental physics. I have taught classes ranging in size from 1 to about 300 students. On research and study leave, I have taught advanced courses at the University of Michigan, Ann Arbor.

Here is a summary of **courses taught**:

- **First year:** Mechanics, thermodynamics, waves, electricity and magnetism, modern (quantum) physics. Laboratory courses in all areas.
- **Second year:** Network theory, analogue and digital electronics, electricity and magnetism, computer systems. Laboratory courses in all areas.
- **Third year:** Network theory, numerical modelling, electronics, instrumentation, digital, electrical and optical signal processing, solid-state physics, underwater acoustics, oceanography, analogue communications theory. Laboratory courses in all specialist areas.
- **Graduate:** Transform theory, signal processing, practical instrumentation. I have supervised many thesis students.

I have developed many **teaching experiments** for the advanced teaching laboratory, in areas of electronics, signal processing, and optical communications. In 2000 I revised and re-wrote most of the second-year electronics instruction pamphlets.

Experiments that I have devised or extensively revised are:

- **Second year:** Electrical measurements, potentiometer principles, resonance, AC bridge measurements, diode and transistor studies, DC power supplies, small signal amplifiers.
- **Third year:** Operational amplifiers, feedback and oscillation, optical fibre communications.

I designed and supervise the laboratory course in ‘Instrumentation Techniques’, which the Physics Department runs for all first-year Engineering students. Typically 570 students perform three experiments, involving work on strain gauge measurements, signal processing with operational amplifiers.

I designed the present curriculum for all second and third level physics courses in network theory, digital signal processing, electronics and instrumentation. I continually modify the upper-level courses to take account of employer expectations, advances in scientific understanding, and the evolution of teaching technology. Examples of this are:

- the third-year module in Digital Signal Processing I introduced two years ago as a result of former student feedback from the workplace and discussions with employers. This is the first time such a module has been incorporated into any tertiary *physics* curriculum in New Zealand.
- My continued development of computer-aided learning methods at second and third-year levels, where they are most appropriate.

Both of these topics are discussed further below under ‘Teaching Materials’.

Teaching Related Departmental Responsibilities

- Member, Physics Department Advisory Committee, 1985 – 1999
- Member, Physics Department Curriculum Committee 1985 – present
  Member, Physics Staff-Student Liaison Committee, 1975 – present
- Stage two Physics course co-ordinator, 1985 – present
- Physics Department Advanced Laboratory Electronics Experiment co-ordinator, 1995 – present
- Physics Department course assessment co-ordinator and processor, 1985 – present

3 DESIGN FOR LEARNING

a Overview

Tertiary physics teaching poses some unusual demands, in that parallel ability in other areas is also demanded of students. To obtain a BSc with a physics major, mathematics at least to Stage two level is required, stage three mathematics is necessary to advance to graduate work in most areas, and familiarity with scientific computer programming has to be developed.

The core material taught at any level is much the same in any Physics Department anywhere in the world, and from the results of the recent review of the University of Auckland Physics Department we know that our courses meet and in some cases exceed the requirements generally agreed to be necessary. Where courses differ is in the research-based and work-place related material progressively introduced at higher levels. This is a function of the particular research areas in which departments specialize. At the University of Auckland we have major experimental research programs in modern optics and geophysics, both of which are electronics-instrumentation intensive. Thus, most of my own course development effort has been in finding more efficient ways of making the acquisition of this very practical, research-related knowledge interesting and fast. There are two separate but complementary aspects to this:

- The acquisition of instrumentation-related practical *skills*, such as the ability to design and construct electronics equipment and signal acquisition and processing hardware and software to make *measurements* of physical parameters; and
- The acquisition of *theoretical knowledge* in system and network theory, which will enable graduates to devise measurement and control system for *new* physics research areas under development. Examples of such areas in our department are in our evolving commitments in atom trapping, high-speed and non-linear laser optics and communications, and geophysical instrumentation.

The first requirement (skills) is met mainly by laboratory work, and later, graduate thesis projects. The second (theory) is taught in formal lectures. Employers also value students having a background in these areas.

b Teaching methods

Here I discuss only methods used in the second and third-year courses I teach. Over 40 years I have experimented with a variety of formal teaching methods involving small-group discussions, class-conducted tutorial sessions, formal and informal tests, quizzes, take-home assignments, class-time assignments and projects. At second and third-year level I have found the most effective method, based on examination pass-rates and student preference expressed in course evaluation, is to have three components.

I give five to eight classroom sessions on a topic, which comprise:

- Four to six formal 50-minute **lectures**;

- One **tutorial** based on the material covered; and
- One 50-minute in-class, **open-book assignment**.

Lectures

Before commencing a course, I explain my philosophy of lecturing to the class. I make it clear that all the material I will teach is contained in the class texts that I have authored or co-authored, and which they all must (and do) purchase (see the next section). A pass in the course could, in principle, be gained by merely assimilating this material and being able to solve the problems based on it. My role as a teacher is that of a *prophet*, interpreting the material that they are required to master. However, I also tell them that those in the past who have skipped lectures and tried to learn *only* from the text have invariably failed. There *is* additional insight that comes from seeing, and hearing the material expounded.

I also make it clear that I value and expect continued interaction from the class. No question or comment will be considered foolish, and nobody need fear ridicule for saying something 'dumb'. On the contrary, a 'dumb' question probably means that I haven't explained something properly.

I *write* and *speak* mathematically complete, but explanation-condensed notes on the blackboard or whiteboard, with references to pages in the text. I tell students that they are free to either:

- write down everything that *I* write, in which case they will have an excellent, condensed version of the material suitable for end-of-course revision; or
- merely *follow* what I do in the text, making marginal notes as appropriate.

The very able students sometimes make no notes, but most do, since I also tell them that the action of copying the material as it is presented means that it has passed once through their own brain, and the learning process has already started.

I *write* most material on the board, rather than *showing and explaining* it from OHP or PowerPoint slides for two reasons:

- the act of writing paces my own delivery. I am not in danger of going too fast, and the class can keep up.
- many ideas, circuits, plots and diagrams are best presented *progressively.* It's important for students to see where to *start* a construction, and the order in which later elements are added. Completed, text-book diagrams showing only the final result give no information about this, and frequently mystify students.

I am very aware that boredom is the enemy of learning. So I never do the same thing for more than a few minutes. I frequently break for an aside illustrating some application of what I'm doing, walk around reviewing what I've just done while their thought-processes catch up, show a transparency, talk about the historical evolution of this idea, or quote an appropriate passage from Shakespeare.

I continually throw out questions about the material we're covering, and after a few sessions the class has learned to respond. In fact, some of the more able students respond so readily that I have to limit their contributions to give others a chance, and make it clear that I don't wish to have dialogue with only the very fast-thinkers – which can be very disheartening for earnest souls who find the resulting discussion over their heads.

I try to pace my delivery on the ability of the class. I continually visually monitor 'indicator' students, identified by perusing records and by observation in the first few lectures. There are always some whose faces reflect their state of awareness, comprehension level, and degree of boredom. I try to pace my delivery so that the brighter students are nodding their understanding, the earnest but less-able majority are following pretty well, and the tail-enders have not given up completely. For this reason, my individual lectures do not follow the same timing pattern from year to year.

I keep the class on their toes by running a competitive error-spotting competition in every lecture. If a class member correctly identifies a mistake in what I've said or written, the class gets a point. If it's *not* an error, but the class has misunderstood, I get a point. I keep a written table on a side black board. If the class gets to 5, the lecture stops, because the lecturer, today, has been incompetent. If I get to 5, everybody gets one mark taken off their next assignment result. It is remarkable how animated and attentive a class gets when their count gets to 4 – as I cunningly contrive from time to time.

Tutorials

I conduct these in a standard class period, and all students are expected to attend. These are 'problem-working' sessions, based on the preceding lecture material. Because of modern educational practice in schools, student problem-solving ability is now initially very poor. I hand out sample problems and past examination questions, and work them, interactively, with the class on the board. After stating the problem, I elicit from the class what steps are necessary to solve it, and then give them time (30 – 50 seconds) to attempt each step in order. A class member is then invited to guide me on the board in writing it down. We discuss pitfalls and common errors as we go. This procedure is immensely valuable in alerting students to gaps in understanding that they didn't know that they had, and I emphasize that I'll be happy to talk with those who still don't understand the material, if they seek me out afterwards. Written solutions to *all* problems set during the course are provided.

Student assessments tell me that this procedure is very effective, and most feel that they have been 'involved' with the solution, and feel empowered by it.

Assessment

All assessments are open-book, problem solving assignments, conducted in a standard 50 minute class period. As preparation, I hand out a sample set of problems 'similar to those you'll be tested on' a week beforehand. Two days before the formal assignment, I hand out full solutions, and also run over these quickly on transparencies at the beginning of a lecture. These problems cover *every aspect* of the work in the module, and give students an understanding of the level of work expected.

Typically, the most able students complete the assignment and leave after 25 minutes. Most stay for the full 50 minutes, though it is rare for any to be still working at that stage, as they have done all that they can do.

If the class numbers less than about 60, I can mark the assignments, have the results entered and placed on the class noticeboard and on Cecil (the University of Auckland course-management system which is student-accessible), and have the marked scripts placed in distribution boxes, the same day. This immediate feedback is immensely appreciated.

I invite anybody to come to haggle about their mark, and some do. I often find things I have missed, or can explain to them exactly where they went wrong.

Student evaluation of this assessment method is, overall, extremely positive. Favourable points made about it are:

- The assessment is over in 50 minutes. It's fast and relatively painless.
- Students are forced to revise *all* of the material covered in the module, unlike a 'written, take-home' assignment, which, in their experience, will typically ask more in-depth questions about specific areas. Thus, they see this as better preparation for the final examination.
- The assessment uncovers errors in their understanding, which they can correct immediately.
- More able students are relieved that they are not pressured by less able friends to 'help them with their assignments'.

The average mark for the first assignment in a course is typically 12/20. This increases monotonically to 15 or so for the last assignment, as class understanding and problem-solving ability grows. Students find this sign of improvement very heartening.

Course Revision

All modern students are largely driven in their end-of-course revision by what has appeared in past examination papers, regardless of what is actually in the course notes and syllabus. If a topic has never been examined, they simply won't revise it. Thus, rather than 'course revision notes', I hand out a set of 'sample examination questions' at the end of every course. This name gives a completely different flavour. I compose these questions by using my lecture notes to set one or more sample questions, at the required level, on *every* topic I have covered. This typically comes to 10 -15 questions, and the class is told that to completely prepare for the final examination, they should work through *all* of these, as they cover all of the material that I can possibly examine. This is much appreciated, and almost everyone does it.

c Teaching Materials

As described above, experimental research in the Auckland department relies extensively on electronic and computerized methods of signal acquisition and data processing. A major problem in the early days was the selection of suitable texts for courses supporting these requirements. Existing undergraduate texts were almost exclusively written to support electrical engineering courses. They were also very expensive, and many students did not buy them. Neither did these texts develop theoretical treatments in the more general way required by physicists.

In 1987 a deputation of second year students approached me and asked me to expand my second-year network theory and electronics lecture notes into a locally produced text, which they could buy cheaply. I did so (indeed, this is how many texts start out) and the first edition of the first text mentioned below, written in collaboration with the then head of the electronics group in the department was the result.

This text was received so favourably that the year after I produced the second in the list to supplement it, also a second-year level text, and the following year the third, with colleague and former student Associate Professor Sze Tan, for the corresponding third-year course.

Since then, I have produced four others, which I regularly update to reflect curriculum changes and advances. The list of texts is:

- BOLD, G.E.J., EARNSHAW, J.B.E., 'Linear Steady-state Network Theory', 6th edition, 7th printing, University of Auckland Physics Department, 157 pages, 1997
- BOLD, G.E.J., 'Transistor Electronics', 7th edition, University of Auckland Physics Department, 180 pages, 2003
- BOLD, G.E.J., TAN, S.M. 'Theoretical and Computer Analysis of Systems and Networks' 6th edition, University of Auckland Physics Department, 1997
- BOLD, G.E.J., TAN, S.M. 'Circuit Modelling with PPRE and WINSPICE', University of Auckland Physics Department, 53 pages, 2003
- BOLD, G.E.J., 'Electromagnetism', 4th edition, University of Auckland Physics Department, 133 pages, 2003
- BOLD, G.E.J., 'Digital Signal Processing', 3rd edition, University of Auckland Physics Department, 150 pages, 2003
- BOLD, G.E.J., TAN, S.M., 'An Introduction to SPICE, PPRE and PROBE', University of Auckland Physics Department, 40 pages, 1996

These are texts and not coursebooks because they are *purposely not* structured as lecture by lecture programmed learning guides, but written in true 'text' or scientific paper format which students will have to become familiar with in their research or the outside world. Presenting them with programmed course guides does them, in the long run, a disservice.

Several of these texts are, or have been, used at other New Zealand universities. I have often been asked why I do not submit them for formal publication. However, for a modern Physics text to stand a real chance of publication, publishers' representatives admit that it has to be designed for a mass market, usually at first-year level, and contain such a broad variety of material that it can be adapted to almost any course taught anywhere. This, of course, is why first year physics texts are now so immense, often in excess of 1000 pages, and so expensive, and contain so much material that it is impossible to cover all of it in standard first year courses, nor is this expected.

I provide free codes (usually MATLAB scripts) and also freeware versions of commercial software packages for students to download from CECIL or my web-page. Students are recommended to use these on their home computers to practice practical problem solving, and give experience in working with software that they will probably encounter during research, or in the workplace. One of the most popular is the freeware version of a SPICE network simulation package. I have co-authored a text (the last on the list above) that instructs students in its use, and also in the use of an accompanying circuit-entry package (PPRE, written by myself and Associate Professor Sze Tan).

d Engaging Learners

I believe that Tertiary students *want* to be engaged in their courses, and a better question to ponder is 'what makes students become *disengaged?'* This observation results from advising several generations of students about their course choice, and listening to their hopes and aspirations. Almost without exception, students arrive at the start of a semester fresh with the optimism of the young. They have high hopes and a desire to do well, even if they have previously done poorly. Some of them, however, feel insecure and are worried by earlier failures, and need encouragement and positive reinforcement. I cope with these by:

- Ensuring that their course choice is suitable, and within their capabilities.
- Introducing them to the lecturers who will be teaching them, who can assure them that help will be available whenever they need it.
- Introducing them to other students who I know to be confident and outgoing, and who can befriend them (very few highly-achieving students turn down the chance to be a helping hand to someone less able).
- Always greeting them personally in the corridors, inquiring concerning their progress, and giving encouragement as needed.

These simple steps frequently have a startling effect. When students feel that their lecturers know and care about them, they have friends in the class, and they are known and valued, their performance can improve dramatically.

Occasionally it becomes obvious that the test, assignment or laboratory grades of a particular student have declined, often quite suddenly – a definite symptom of 'disengagement'. A confidential talk with the student concerned usually elicits the reason, which is often completely unrelated to academic problems. These problems can sometimes be of quite a serious personal nature. Often, I can help by directing the student to the appropriate University service, and by reassuring him or her that the Physics Department will do all that it can to offer academic and pastoral support.

e Research-Based Teaching

It is vital both for continuity of the discipline, and for obtaining a sense of perspective, that undergraduate students are continually exposed to research activities of the Department. I attempt to achieve this in several ways.

I start every fifth lecture or so at all undergraduate levels with a brief talk about my current research, or a student thesis project in the Department, related to what I am teaching. Often, I can induce the more confident graduate students to present their work themselves, which usually makes a bigger impact. Student reaction to this is overwhelmingly positive. They see what they may themselves be doing in a few years, see that the lecture material is actually useful, and see what research their laboratory demonstrators are involved in.

I also read emails and letters from ex-students working in laboratories overseas, or in research or industry, commenting on ‘how useful this course was in the real world’.

I do *not* publish formal ‘office hours’, for two reasons. Firstly, it’s impossible with the multiplicity of individual timetables students now have to find times when everybody can potentially come. Secondly, I remember the frustration I felt myself (and which students still experience) when the lecturer is not there, because of some other imperative and unforeseen commitment.

Instead, I invite students to come for help, at any time, to my office adjacent to my research laboratory. I have plastered the corridor outside my office with blackboards. Unless discussion of some personal problem precludes it, I never retire to my office to help students, but always explain and expound in the corridor with chalk on these blackboards. Frequently other students stop, observe, and are encouraged to ask questions too – since many typically have the same problems. I leave what I’ve written on the blackboards as long as possible. Other students hear about it on the grapevine and come to look at them too. I’m a few feet away in my office, and can emerge to help them if I hear signs of confusion.

If I’m not there, I encourage students to ask questions of the graduate students in my research laboratory, next door, instead. Unless exceptionally busy, these marvellous young people are always keen to help, and in fact get a great kick out of it. Often they invite interested enquirers inside to see their research.

I leave copies of my (less complex) professional journals, once read, on table in the corridor opposite my office door, which I encourage students to read and borrow.

Research Laboratory Visits

I consider the second year to be a key one for graduate student recruitment.

For the last 30 years I have organized tours of the departmental research laboratories in the second semester for stage two students. These are held at some mutually agreed time, usually in an hour around lunchtime. Students are split into groups of 10 – 12, conducted around 5 – 6 laboratories by graduate student guides. Handouts, 1 – 2 pages per lab, are prepared and distributed.

We now have an established system where, in fact, the graduate students organize the whole thing themselves, and do much of the talking and demonstrating. These visits have a dramatic effect on the students, often completely change the way they look at the Department, and cause them to seriously contemplate graduate research. Staff also realize that this tour is a most effective graduate student recruitment exercise, and go to extensive lengths to set up demonstrations, and explain them in terms that stage two students will understand. There are *always* more offers of labs to view than we can accommodate, so research groups compete for places. Interested students are always encouraged to return for more in-depth discussion, and many do.

Advanced Experimental Work for Undergraduates

Exceptionally able students often find the formal teaching laboratory experiments straightforward, and not very interesting. Frequently, near the end of their required laboratory course they will have completed all the relevant ones anyway. Instead of asking them to undertake further 'standard' experiments, I take the more confident ones to a research group in their course area and request the group leader to set up a simple project which the student can do as an 'experiment', write up, and present as part of the laboratory course. Being much more open-ended, students find this challenging and interesting. We often get marvellous write-ups.

Like many Departments, we offer summer scholarships over the Christmas vacation period. Top stage two and three students are absorbed for a month into research groups, undertake a simple project, and write a report. Sometimes these can be expanded into a conference paper, as discussed in the next section.

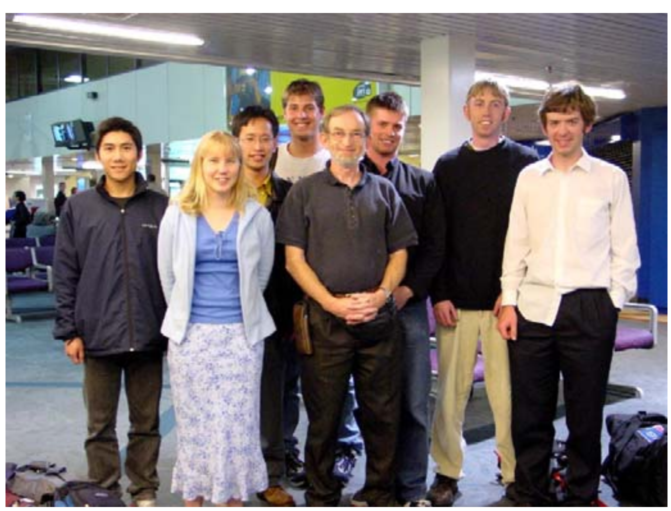
Student Conference Attendance

A major factor in science graduate employability is an ability to stand up before groups and talk with confidence about technical topics. For the last 10 years or so I have taken groups of graduate and senior undergraduate students to a national conference called 'ENZCon'. This was originally an 'electronics' conference, but at my suggestion some years back was widened in scope to include *all* experimental research undertaken at universities, technical colleges, and commercial and government laboratories. In particular, it provides a venue for students to talk about *thesis work in progress* in a friendly environment and (usually) receive helpful information from others.

This conference is typically held around August, when graduate students' research is well advanced. Preparing a written conference paper and a verbal presentation at this stage enables them to reflect on what they have done and take stock of their progress.

As preparation for this, other senior staff and I help with paper writing and school the students in oral presentation technique. This involves several 'simulated conference' situations where students are required to present their transparencies or PowerPoint slides and talk to them in the allocated conference time-frame. This conference experience not only gives students confidence in themselves and their work, but also renews their enthusiasm and determination to complete, at a time when many of them are losing heart at 'how much is still to be done'.

At right is the group I took to the ENZCon02 conference in Dunedin. Stephanie has just won the prize for the best 'first presenter'.



I actively solicit contributions related to physics teaching, and try to run a teaching-related session at ENZCon.

I am active in graduate student thesis supervision. My last three students and their topics were:

1. Kelsey Grant, *An Underwater Acoustic Rangefinder'*, 2004
2. Bevan Diprose, *A New Microphone Principle Using Ultrasonics',* 2003
3. Greg Ewing, *'Design and Simulation of Range-Finding for Divers',* 2002

I have directly supervised or co-supervised between 20 and 30 other MSc thesis projects (before about 1980 co-supervision duties were often distributed rather informally). I have acted as an informal advisor on instrumentation, software, and data processing for almost every Bachelor of Technology (Optoelectronics) project since this degree was set up.

4 EVALUATING TEACHING AND LEARNING

a Course and Lecturer Evaluation in the Department of Physics

Many of us in the Department of Physics have used an evaluation system developed within the Department to help improve our courses and their delivery. The evaluation of teaching in science is a difficult problem, and while this system does not solve the problem, it is capable of giving valuable *diagnostic* information about the way we teach, therefore helping us to identify how best to facilitate learning.

In the Department of Physics this system is used alongside the University's formal evaluation system, administered by the Centre for Professional Development (CPD).

Introduction

I started evaluating my own courses in 1963, and others began to evaluate spasmodically at about the same time. Initially, we experimented with a variety of forms we devised ourselves. In 1987 we set up a committee to examine assessment methods. I chaired this committee, which was a sub-committee of the staff-student liaison committee, having an equal representation of staff and students. Over a period of about 6 months we examined all the assessment material we could get our hands on from around the world. The vast majority of it came from North America. A major objective of the committee was to select questions which examined aspects that the *students* felt important (things they wanted to tell *us)* and what *staff* felt important (things we wanted to know about us and our courses).

A set of fifteen questions was mutually agreed upon, which have subsequently been fine-tuned. The Committee felt, and the Department still feels, that the use of an assessment procedure agreed upon by *both* staff *and* students is a very positive and fundamental strength.

Following this, a standardized system of computerised data processing was introduced which gave numerical 'figures of merit' for overall course, lecturer, and material quality. Because of my interest in teaching, and because I wrote all the software, I became the Departmental 'Course Evaluation Officer'.

The Assessment Process

This occurs *during* a lecture. Three to five minutes are required to set it up and explain what to do. The form is handed out at the start of a lecture in the last week of a course. While it's being distributed, the lecturer makes these points:

- For questions 1 to 11, 1 means 'awful', 5 means 'excellent!', 3 means 'no strong feelings' or 'OK'.
- Questions 12 to 15 have *three* as the 'optimum' answer.
- You're encouraged to write verbal answers to the 3 more open-ended questions at the bottom. Continue over page if necessary.

- No attempt will be made to identify anyone.
- This is important. We take it seriously. Your feedback will be used to improve the course for the next time it's given.

The hand-in rate at the end of the lecture is usually 100%.

The next page **(Figure 1)** shows the form currently used. Each form is identified with lecturer's name and course.

FIGURE 1: Evaluation Form

Course and Lecturer Evaluation

Physics 340SC, 2003
Dr Bold, Circuits and Systems

Please answer this questionnaire during the lecture, and hand it in as you leave. All answers are confidential. Your feedback will be used to improve the course in future years.

Please put a cross in one of the boxes below for each question, showing how well you agree or disagree with the statement made.

1 means 'disgree stongly' (very poor rating)
2 means 'disagree'
3 means 'don't feel strongly' (average rating)
4 means 'agree'
5 means 'agree strongly (very good rating)

		Very poor				Very good
1	The lecturer was enthusiastic	1	2	3	4	5
2	The lecturer's exlanations were clear and understandable	1	2	3	4	5
3	The lecturer's material was interesting	1	2	3	4	5
4	The lecturer used demonstrations and audio-visual aids well	1	2	3	4	5
5	The lecturer's use of problems and examples was good	1	2	3	4	5
6	The lecturer's blackboard/transparency writing was easy to read	1	2	3	4	5
7	The lecturer spoke loudly enough to be easily heard	1	2	3	4	5
8	The lecturer's handout were useful	1	2	3	4	5
9	The lecturer was friendly and approachable	1	2	3	4	5
10	The course was well organised	1	2	3	4	5
11	The course text/supporting material was useful	1	2	3	4	5

The questions below have '3' as the optimum answer.

12	Speed of presentation? (1 = too slow: 5 = too fast)	1	2	3	4	5
13	Difficulty of course material? (1 = too easy: 5 = too hard)	1	2	3	4	5
14	Amount of material presented? (1 = too little: 5 = too much)	1	2	3	4	5
15	Difficulty of assignments? (1 = too easy: 5 = too hard)	1	2	3	4	5

What did you LIKE most about the course?
What did you DISLIKE most about the course?

Please write any other comments below. Continue on the back if necessary.

Data Processing

Once the evaluation forms have been processed, the lecturer concerned receives a letter explaining how the results have been analysed. The numerical analysis involves converting the responses on a 1-5 scale to a number on a 1-100 scale. A different procedure is used for the questions for which '5' is high, versus those for which '3' is the optimum answer. Three overall 'figures of merit' are then computed:

- 'Average overall rating' is the average of *all 15* ratings above,
- 'Lecturer rating' is the average of questions 1 - 9 (questions relating predominantly to the perceived merit of the lecturer)
- 'Course rating' is the average of questions 10 - 15 (questions relating predominantly to the perceived merit of the course)

Finally, the rating percentages are plotted as a histogram. Because of the mapping, 'high' numbers indicate 'good' in each case. From this, it's easy to see how different aspects of our lecture delivery and course are differentially rated by the class.

- An average rating of over 90 in any of the 3 categories indicates 'truly outstanding'. (In 20 years, this has only been achieved three times).
- A rating in the 80s implies 'excellent'.
- A rating in the 70s implies 'very good'
- A rating in the 60s implies 'acceptable'
- A rating below this implies 'poor'.

Evaluation Analysis

A sample of the statistical course analysis distributed to lecturers is shown in **Figure 2**.

This shows:

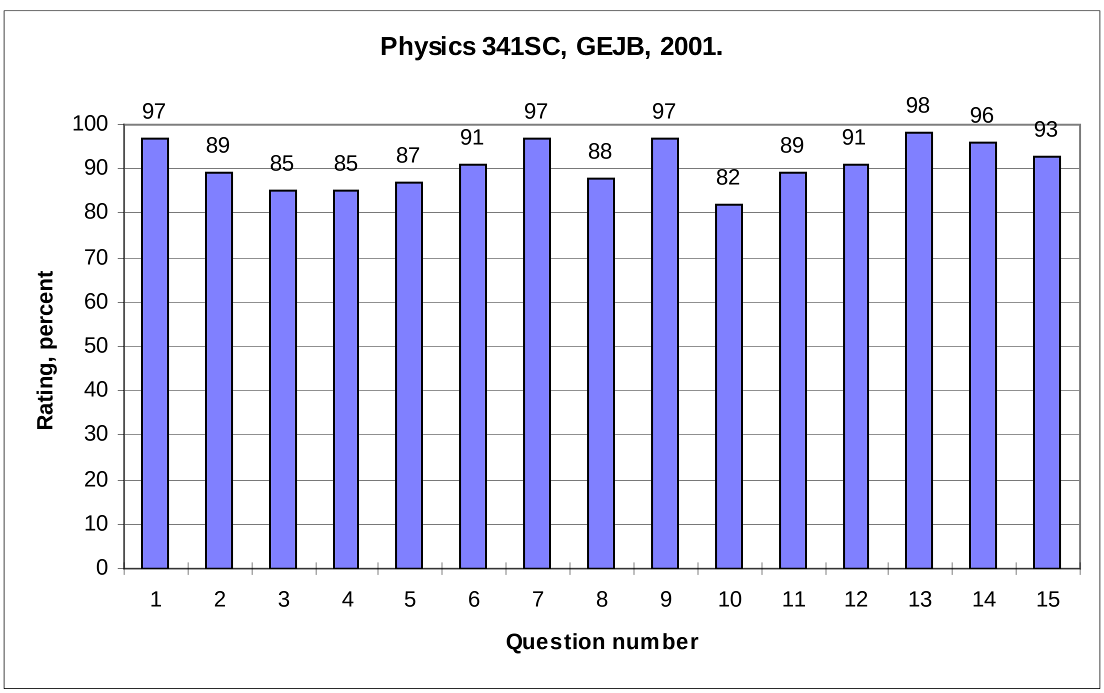
- The rating computed for the individual questions, as a percentage of the maximum (100), tabulated at the top.
- Then, the three ratings combining individual questions,
- At the bottom, a histogram of the individual question results.

The 'course profile', the overall envelope of the histogram, is an indication of how various aspects of the course and its delivery are perceived. This is quite characteristic of the lecturer. In the long term, we aim for a profile which is as *even as possible.*

FIGURE 2: Sample Statistical Course Analysis sent to Lecturers

Question:	Rating:	Description:
1	97	Enthusiasm
2	89	Explanations clear, understandable
3	85	Interesting material
4	85	Demonstrations and A/V aids
5	87	Problems and examples
6	91	Blackboard writing
7	97	Easily heard
8	88	High quality notes
9	97	Friendly and approachable
10	82	Well organised course
11	89	Course textbook
12	91	Speed of presentation
13	98	Difficulty of material
14	96	Amount of material
15	93	Difficulty of assignments

Average overall rating: 91
Lecturer rating: 91
Course rating: 91



Evaluation Follow-up

There is no point in conducting an evaluation unless *something happens* as a result.

A simple form of feedback suggested to the lecturer is that he or she ‘do something to increase the height of the *lowest* histogram element.’

Of course, the lecturer may choose to work on *more* than one aspect of his or her teaching, but it is helpful to be aware of the *one* component which is perceived as *most* in need of improvement.

5 BRINGING SCIENCE TO THE COMMUNITY

I strongly believe that all academics should be active in raising the public profile of their discipline and their university in the outside community. I am fortunate that one of my hobbies, Amateur Radio, has given me many opportunities for this.

Amateur Radio clubs and members (Hams) have historically provided a valuable resource of keen, unpaid volunteers to help set up and maintain field experiments in geophysics. The University of Auckland Department of Physics and Radio Research Centre utilized the services of keen volunteers in Invercargill, Cambridge, Auckland, Whitianga and Whangarei in a variety of experiments for over 30 years. In return, those of us at the University were frequently invited to speak at their meetings. I commenced such speaking around 1965, and since then have delivered several invited talks every year at Ham meetings all over the country. I sometimes talk about radio topics, but often they are more interested in hearing about the function of a university, what its members do, what their children can expect if they attend one. They are always *delighted* to have a captive ‘real’ scientist amongst them, and are *very* attentive when I discuss ‘real’ research.

As is the case with most people in the community, it is apparent that their only knowledge of what universities *do* comes from the media, and this is often very flawed. I have also arranged for colleagues to speak to such groups from time to time, and they get an equally attentive reception.

My major Ham activity is operating using Morse code. I write a regular column in the New Zealand Association of Radio Transmitters (NZART) journal *Break-In* on technical and scientific matters. As a result of my status as a university member with teaching and examining experience, I was asked in 1999 to devise a new syllabus for the New Zealand Radio Amateur examinations. I did this, and then wrote freeware software for examiners to download from the NZART website to construct and print examination papers. I have also written free computer programs for teaching Morse code, and for examining proficiency in it. These programs are now used all over the world.

For these contributions I was elected a life member of the NZART in 2002. The end result of all this is that I am known by Radio Hams all over the country, as a member of a university who is active in their affairs. I know that this has raised the profile of universities considerably in the awareness of this admittedly small segment of the population. It is a pity that more of us do not seize opportunities to speak about what we do in the many other organizations and clubs in which we are active outside the University.

In 1975, Professor Alick Kibblewhite, then HOD of Geophysics at the University of Auckland, was invited to deliver the keynote address at the first National Energy Conference. Unfortunately, the night before the talk he fell ill and was forbidden, on medical advice, to give it. He called upon me to deliver the paper on his behalf, and I did so.

Alick's paper was so riveting (at that time few people knew about non-renewable energy sources and their eventual decline) that we both became (in my case by accident) 'energy experts' overnight. As a result, for the next decade I received invitations to speak at Rotary, Lions and other service clubs all over the Auckland province, which again provided excellent opportunities for raising the profile of universities.

6 REFLECTION

Nearing the end of my research and teaching career, I can't believe how lucky I have been to have had the delight of interacting with so many talented, wonderful young people. They have kept me young at heart myself.

I have constantly been challenged to adapt my techniques of teaching, and it fascinates me to find every year that I'm still changing things, trying to do better. But I feel that I'm getting there. I remarked to my wife the other night:

'After 43 years grappling with university teaching, I finally feel that I'm getting the hang of it.'

What are the things that I've learned, that I'd like to recommend to others? I commenced this document by recommending three paramount qualities. I commend them again.

- Seek for **friendliness, humility** and **honesty** with students and colleagues. Any teacher who keeps these qualities central in his or her thinking cannot go far wrong.
- Seek for excellence in *all* areas of tertiary teaching at *all* levels.
- Seek constant feedback from students and colleagues. Weigh it. Use it.
- Never stop trying to do better.

I hope I've made a difference. My best wishes to all teachers. Good luck.

APPENDIX ONE: RECOGNITION OF EXCELLENCE

- In 1985 I became the University of Auckland Department of Physics' course assessment and evaluation processor.

- I presented a keynote paper on assessment and evaluation at the third Vice-Chancellor's Symposium on Enhanced Learning, University of Auckland, 16 July 1997.

- In 1999 The University of Auckland gave me a 'Distinguished Teaching Award', which included a citation and medallion.

- Judge for 'best paper' award at many conferences.

Membership of Professional and Other Societies and Committees

- Assistant Dean, University of Auckland Faculty of Science, 1995-1998
- Member, University of Auckland Board of Studies in Education, 1995 – present
- Member, Vice Chancellor's ad-hoc committee on teaching, learning and assessment, 1995-1997
- Member, Faculty of Science Committee for selection of Distinguished teachers, 1998 – 2000
- Committee member, design team for current University of Auckland CSPD course evaluations. I was a mentor in this scheme, acting as an advisor to new staff members.
- Life Member, Institute of Electrical and Electronic Engineers
- Member, New Zealand Institute of Physics
- Member, Acoustical Society of America
- Member, New Zealand Institute of Physics, Auckland Branch, at different times Chairman, Secretary, Committee member, 1975 – 1995
- Member, New Zealand Ministry of Education Committees on `Achievement initiative in Science', 'Science Mapping' around 1995
- Life member, New Zealand Association of Radio Transmitters, for contributions to electronics education in the community.
- Life member, University of Auckland Tramping club.
- Judge, Auckland Secondary Schools Science Exhibition, for 20 years.
- Organizing Committee member, all NELCON conferences 1985 – 1993
- Organizing Committee member, all ENZCon conferences 1994 – present. Teaching sessions convenor.
- Chairman, NELCON90 Conference

APPENDIX TWO: PUBLICATIONS, REPORTS AND CONFERENCE PAPERS

REFEREED JOURNAL ARTICLES

DUDLEY, J.M.[1], G.E.J. Bold, 'Top-down teaching in non-calculus based introductory physics classes', *American Journal of Physics,* 418-421, April 1996

BOLD, G.E.J., 'Simple Computer Network Analysis', *IEEE Transactions on Education, E-3(2),* 99-102, 1987

BOLD, G.E.J. 'Simulation of Non-Linear Acoustic Systems using Bilinear Transform and Higher-Order Simulators', *Journal of the Acoustical Society of America, 78(5),* 1902-1904, 1985

BOLD, G.E.J., TAN, S.M., `Teaching Simulation with a Digital Analog Computer', *American Journal of Physics, 53(5), 437-442, 1985*

MONOGRAPHS, PUBLISHED BY THE DEPARTMENT

BOLD, G.E.J., `Signal Processing for Underwater Acoustics', Department of Physics, University of Auckland, 122 pages, 1991

BOLD, G.E.J., `Using SOLVN for Network Problems', Department of Physics, University of Auckland, 44 pages, 1991

TECHNICAL REPORTS

BOLD, G.E.J., `Computer Teaching in Physics', Auckland, HERO *(Higher Education Research Office Technical Report)* 45 pages, 1986

BOLD, G.E.J., `SOLVN.BAS: a BASIC Skeleton for Numerically Solving Linear Networks', Auckland, *AUPDAG Report, 87-3,* 15 pages, 1983

BOLD, G.E.J., `Evaluating Time-Domain Network Functions on Small Computers', *AUPDAG Technical Report, 87-2*, Auckland, 18 pages, 1982

BOLD, G.E.J., `Spectral Analysis and the Fast Fourier Transform', *AUPDAG Technical Report. 87-1,* 20 pages, Auckland 1982

PAPERS IN REFEREED CONFERENCE PROCEEDINGS

CONWAY, M., BOLD, G.E.J., `Energising Physics Teaching With Demonstrations', *Proceedings of ENZCon03,* Hamilton*,* New Zealand*,* pp 169-172, 2003

BOLD, G.E.J., `Software-Aided Electronics Teaching', *Proceedings of ENZCon 02, Dunedin, NZ*, pp 84-89, 2002

BOLD, G.E.J., `New Sound-Card Communication Modes', *Proceedings of ENZCon00,* Dunedin, New Zealand*,* pp 10– 5, 2000

BOLD, G.E.J., `Signal Processing Shareware in Electronics Teaching', *Proceedings of ENZCon97,* Massey University, Albany, New Zealand*,* pp103–107, 1997

BOLD, G.E.J., `Teaching signal processing and electronics with MATLAB', *Proceedings of 28th NELCON conference,* Massey University, Palmerston North*,* New Zealand, pp 87–92, 1991

CREATIVE WORKS: SOFTWARE: DISTRIBUTED INFORMALLY AND BY DEPARTMENT

BOLD, G.E.J., TAN, S.M., `SHARC.EXE' 'A Public Domain C Code for Underwater Acoustic Ray-Tracing, used in ATOC Path Prediction Analysis', 1986

BOLD, G.E.J., TITHERIDGE, J.E.[1], '"FFT0", A Public Domain FFT Algorithm Using No Transcendental Functions', 1986

BOLD, G.E.J., TAN, S.M., '"RKN.BAS"; Functions for System Simulation by Simulating Digital Analogue Computer', 1985

BOLD, G.E.J., '"SOLVN.BAS BASIC": A Public domain Subroutine Package for Linear Network Analysis', 1985

SOFTWARE PRODUCED AS COMMITMENT TO PUBLIC SERVICE: (ELECTRONICS AWARENESS IN THE COMMUNITY)

BOLD, G.E.J., '"TEACH": Interactive Morse Code Teaching Package', now used internationally, various versions, 1987–present.

BOLD, G.E.J. 'NZARTXD', Official New Zealand Amateur Radio examination paper generator, 1998

BOLD, G.E.J., 'MORSETEST', Official New Zealand Amateur Radio Morse code tester, 1999.

These three codes can be downloaded from the web-page at
http://www.phy.auckland.ac.nz/Staff/geb/loads.htm

RADIO TALKS

`The wireless messages of the Titanic', talk on New Zealand overseas short-wave service, 1999

`The origins of Morse code', talk on New Zealand overseas short-wave service, 2000

APPENDIX THREE: SAMPLE TEACHING MATERIALS

Typical in-class assignment preparation exercise

Physics 340
Assignment 3 Preparation, 2003

The third 50 minute, in-class assignment will examine material covered in chapter 9, 12 of the text, and (simple) material on Laplace transforms.

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1. Draw a block diagram of an amplifier having open-loop voltage gain A and feedback around it with feedback fraction β, and derive the expression for the closed-loop gain.
2. An amplifier has a voltage gain of 100 dB, and lower and upper half-power frequencies of 100 Hz and 10 kHz respectively. Negative feedback, with $\beta = -.001$ is applied to the amplifier.
   (a) Find the new upper and lower 3 dB frequencies.
   (b) Plot the frequency response of the amplifier before and after feedback is applied.
3. Fig. 1(a) shows an oscillator constructed with 3 identical ideal amplifiers. Find the oscillation conditions.

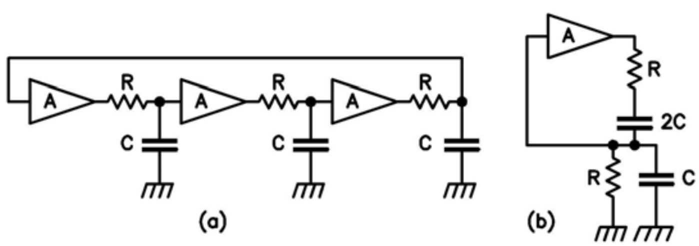


Figure 1: Circuits for question 1.

4. Figure 1(b) shows another RC oscillator, where the two capacitors have *different* values. Find the oscillation conditions.
5. A non-linear amplifier has a voltage transfer function given by

$$A_v = \frac{V_2}{V_1} = 10 + V_1$$

   An input signal consisting of two sinewaves, each of amplitude 1 volt, and frequencies of 2 kHz and 3 kHz, is applied to the input.
   (a) Find amplitudes and frequencies of all components present in the output voltage, V_2.
   (b) Sketch a frequency domain plot showing the amplitudes and frequencies of these components. Identify the type of each component.
   (c) Negative feedback, with $\beta = 0.1$, is applied around the amplifier. But what approximate factor will the total distortion be reduced?

6. A carrier wave having a frequency of 1 MHz and amplitude 10V is 50% amplitude modulated with a 2 kHz sine wave.

   (a) Draw time and frequency domain pictures of the resulting modulated waveform.
   (b) The power in the unmodulated carrier was 100 Watt. What power is in each of the sidebands? What is the total power in the modulated output signal?

7. A signal V_1 is applied to the input of a non-linear amplifier which gives an output V_2, where

$$\begin{aligned} V_2 &= \alpha V_1 + \beta V_1^2 \\ \text{and } V_1 &= \cos\omega_c t + A\cos\omega_m t \\ \text{where } \omega_c &>> \omega_m \end{aligned}$$

   Show that V_2 contains a high-frequency component which consists of the high-frequency input waveform component amplitude modulated with the low-frequency one, and find the modulation percentage. What other frequency components are present?

8. An fm waveform has an instantaneous frequency given by

$$\begin{aligned} \omega_i(t) &= \omega_c + km(t) \\ \text{where } k &= 10^4 = \text{the VCO gain constant} \\ \text{and } m(t) &= A\cos\omega_m t \\ \text{where } A &= 1 \text{ volt} \end{aligned}$$

   (a) Find the value of β, the modulation index, for modulation angular frequencies of 200 radian/second, 2000 radian/second and 20,000 radian/second.
   (b) Find the significant bandwidth, B, for each of these modulating angular frequencies.
   (c) Estimate the number of significant sidebands each side of the carrier frequency for each of these modulating angular frequencies.

9. The "pulse shaper" network (from the *Passive pulse* laboratory experiment) shown in figure 2 is energised by a unit step function, $u(t)$.

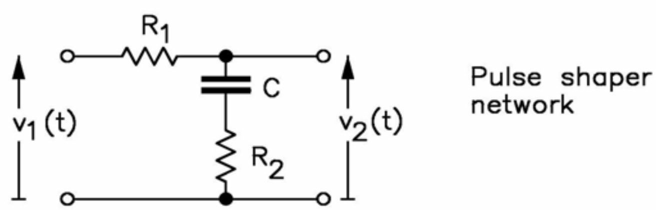


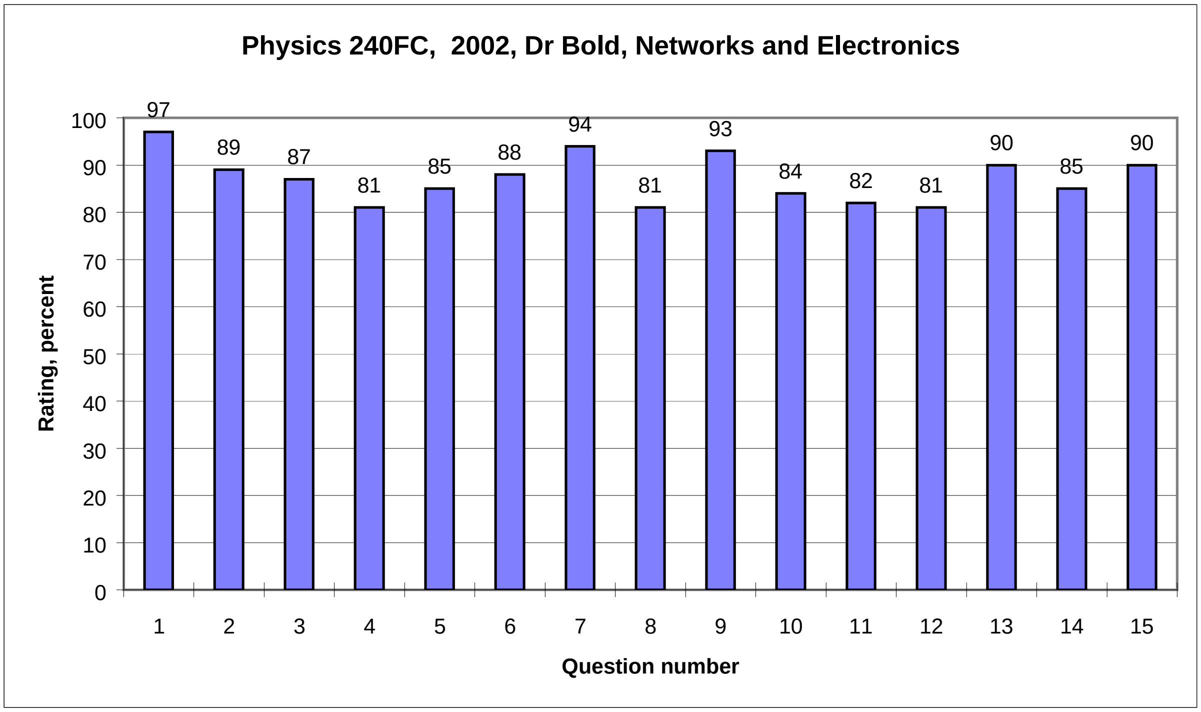
Figure 2: Pulse shaper network

   (a) Find the Laplace transform of the network's voltage transfer function, $V_2(s)/V_1(s)$, and that of the unit step function.
   (b) Find the Laplace transform of $V_2(s)$, the output voltage.
   (c) Find an analytical expression for $v_2(t)$, the output waveform in the time domain.

APPENDIX FOUR: EVALUATIONS

Sample Department of Physics Evaluation, 2002

***** Please refer to explanation of evaluation histogram, p.19



APPENDIX FIVE: EXCERPT FROM PUBLISHED WORK ON PHYSICS TEACHING

J.M Dudley and G.E.J Bold

'"Top-Down Teaching" in Non-Calculus-Based Introductory Physics Classes'

***American Journal of Physics*, 64, (4), April 1996, pp. 418-421**

Most universities offer non-calculus-based introductory courses in physics. Some of these are aimed at students who need to satisfy some basic, but well-defined physics requirements as part of a preparatory year before further studies in, for examples, medicine or the life sciences. Others are aimed at liberal arts students, with the aims of cultivating some scientific literacy, and of giving them an appreciation of the important role that the scientific process, as exemplified by the methodology of physics, plays in their everyday lives.

At Auckland University, we teach a non-calculus-based course with aims similar to those of the general liberal arts 'science-literacy' course. However, the course is also taken by a large number of science students with majors in disciplines other than physics. These students have some familiarity with physics from high school, but fear that they lack the background to cope with the rigor of university-level courses presented to physics and engineering majors.

…Perhaps the most serious problem in teaching general non-calculus-based physics courses, is that while students attending the courses may indeed be intelligent and well motivated, and some are even studying other sciences at high levels, they approach the study of physics with considerable apprehension. Most have perceived physics in high school as a subject full of mystery…

…The traditional methods used for teaching physics to science or engineering majors are inappropriate here. A large component of traditional university physics teaching is based on the review, followed by the extension, of material already covered in high school. For physics majors the 'review' process is thought to be necessary to identify, and hopefully correct, any conceptual misconceptions which they have acquired. …Hence, at university we start again with the simple but rather abstract ideas concerning force, energy, charge, etc., and in an orderly but usually rapid manner, build upon these foundations progressively more complex ideas and systems. For simplicity, we characterize this in this paper as a 'bottom-up' approach.

…In 1994 and 1995 we completely changed our approach to a ‘top-down’ one. Now, instead of starting with basic concepts and working up to more complex ideas, we begin with experimentally observed, common, complex phenomena and go backwards, working ‘from the top-down’ from the ‘complex’ to the ‘simple.’ We aim to thus illustrate to students how scientific understanding evolves by breaking complex phenomena down into a series of simpler ones, and we try to show how the essential features of complex physical phenomena can be described using the simple laws of physics which we subsequently introduce.

…We concentrate mainly on conceptual understanding and we always try to relate the problems to everyday phenomena with which students are familiar.

…Having commenced with some complex phenomenon, progressively simpler demonstration experiments which illustrate the key concepts involved are then carried out – if at all possible, with student involvement.

…Our reversal of the traditional sequence of instruction retains student interest, and familiar, everyday examples are used to motivate simple experiments that experimentally justify the development of new physical concepts and ideas. The combination of a high degree of student interest and simple illustrative experiments mean that students often have a better understanding of the basic concepts than students in more standard physics courses, as well as still receiving a positive experience in their physics education.

The ‘top-down’ approach provides an alternative strategy to teaching introductory science literacy physics courses. The philosophy of reversing the traditional sequence of instruction, and working backwards from the complex to the simple seems to provide a framework for effective teaching of fundamental physical concepts, whilst still remaining interesting for students. Physics is above all, a subject based on observation, and our main point is to make the observations of our students provide the starting point of the lectures.