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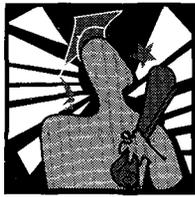
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## Engineering project oriented mathematics supported by algebraic software

### Abstract

In recent years there has been a revolution in engineering practice with the development of software that will perform basic symbolic mathematical operations. These software packages also have graphics facilities and can be used on desktop computers, including Macintoshes. Desktop computers can now carry out not only numerical calculations to produce numbers but also symbolic calculations to produce algebraic solutions. Provided that engineers understand the input and output parameters of symbolic mathematical calculations, many of the complex but time consuming intermediate steps can be handed over to a desktop computer.



## CAUT *project 2*

### Engineering Project Oriented Mathematics Supported by Algebraic Software

Philip Broadbridge

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#### **Aim of the project**

The aim of this project is to develop a course in engineering mathematics which educates engineers to carry out mathematical tasks in an environment which is much closer to that which they will encounter in their professional practice. One objective is to improve the students' real-world problem-solving skills, including the ability to idealise a real system so that it can be represented in mathematical form. Another objective is to develop their ability to work cooperatively in small groups, as they will often be required to do this in their professional practice. Compared to traditional courses in engineering mathematics, this new course will better prepare students to analyse real-world problems, emphasising the integration of learnt mathematical skills through group project work, rather than concentrating on distinct tedious calculations. Further, engineering students should see the usefulness of mathematics in their engineering career and should be motivated to learn mathematics as it will be used in the workplace. These innovations in teaching engineering mathematics will be made possible by using one of the currently available symbolic manipulation and graphics packages on a student network.

#### **Implementation**

To modernise the second year engineering courses, it is proposed to develop a tailor-made engineering mathematics course based on comprehensive mathematical software packages. The new course will enable second year engineering students to:

- a) integrate a number of skills and techniques in algebra and calculus that they have learnt
- b) practise programming with a comprehensive mathematics software package
- c) develop algorithms to solve practical engineering problems
- d) learn to work on mathematical projects in small teams.

In the first stage of the project, representatives of each of the Engineering departments will be co-opted to identify appropriate

engineering problems whose solutions depend on mathematical skills, primarily in algebra and calculus, which have been taught in first year mathematics and engineering subjects. This will lead to the production of a series of guided computer laboratory class exercises. These will be of two types:

- a) gaining competency in using the appropriate software for solving basic mathematical problems, and
- b) solving practical engineering problems, where the students are required to identify the component mathematical tasks, and then incorporate these mathematical ideas into a solution by using the computer.

A set of students' lecture and laboratory notes will be produced, based on one of the software packages MATHEMATICA or MAPLE V.

In the second year of the project there will be a full scale trial of the new course over two sessions. Students will have two hours of computing laboratory per fortnight, as well as two hours per week of formal lectures, illustrated by computer displays. During laboratory sessions, students will work at individual computers but will be encouraged to collaborate in groups of up to four. Some instruction will be given on how to assign and coordinate component tasks within a group project.

After successful implementation at second year level, computer algebra will be introduced at an elementary level in a first year mathematics subject. A number of computer algebra-oriented texts for elementary calculus are already being used at a number of teaching institutions eg *Guidebook to Calculus with Mathematica* by Philip Crooke and John Ratcliffe of Vanderbilt University. These texts will soon be supplemented by the first year Mathematica-based materials being produced by Fearnley-Sander and Abbott at the University of Tasmania. These materials, which are planned to cover algebra as well as calculus, will no doubt better reflect the needs of Australian rather than American first year students.

While we can make use of existing course material at first year level, we must design our

own material in a second year course which is engineering project-oriented and which assumes the knowledge of our first year mathematics subject. An important component of second year engineering mathematics involves partial differential equations. The texts by Abell and Braselton and by Vvedensky will be used as references for this component. These books provide some examples which may be used in the design of student laboratory projects. However, our final selection of projects will reflect the various needs of the three Departments within our own Faculty of Engineering. The student projects will be based on engineering problems which do not draw on one particular branch of mathematics, such as partial differential equations, but on several branches, including linear algebra and numerical analysis. This course will introduce practical problems requiring mathematical analysis, rather than mathematical methods requiring practical examples. For these reasons, most of our teaching materials must be home-grown. However, many engineering schools in this country are experiencing similar difficulties in motivating their students to study mathematics. Our proposed project is responding to a national need.

The applicants are very grateful for the advice of the University's internal selection committee and for the assistance of the Centre for Staff Development.

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*Project team members: Prof. Philip Broadbridge (Head, Department of Mathematics), Dr John Montagner (Sub Dean, Engineering), Dr Annette Worthy, Dr Frank Prokop and Dr Phil Laird (Department of Mathematics)*

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