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Distance Learning for Gap-Year Students
The Royal Academy of Engineering Best Maths Programme

Contents

Background	2
Distance learning materials and assessment regime	2
The work regime and some technical issues	3
Results	10
Conclusions	10
Acknowledgements	11

Distance Learning for Gap-Year Students

The Royal Academy of Engineering Best Maths Programme

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Abstract: This article describes the implementation of a distance learning course for 'gap-year' students. It has been developed to provide an opportunity for them to keep the mathematical knowledge they have acquired at A-level from waning during their year in industry. Assessment and record keeping is entirely web-based.

1. Background

The Best Maths Programme has been developed with funding from the Royal Academy of Engineering and the Year in Industry Scheme. This scheme provides opportunities for students to take a gap-year, after Year 13, before embarking upon university courses, usually in engineering. What is of concern to many university admissions tutors nationally is that, whilst the scheme undoubtedly offers students many advantages and excellent opportunities, the mathematical skills developed at school can begin to wane during the gap-year. This can become a handicap once students arrive at university to embark upon their undergraduate studies. The Best Maths Programme helps to alleviate this negative aspect of the gap-year.

2. Distance learning materials and assessment regime

The Programme consists of six compulsory sections of mathematics and two optional sections that students can choose from five available. Course material is provided in the form of workbooks. These are available in printed form and also as pdf files. The level is appropriate for students who have studied and obtained a mathematics qualification at A level. Some sections revise topics in A level mathematics and others introduce more advanced topics likely to be met in the first year of a university engineering course. The main aim is not the delivery of lots of new material; rather it is to keep students' mathematical skills 'ticking over' during their year away from academia. It is recognised that for the vast majority of these students mathematics will not be a high priority and they will be working hard in their new gap-year jobs and enjoying their year out.

The students are provided with a CD that runs on a PC and contains tests on each of the sections. Tests are provided for students to practise and for assessment purposes as described below. Marks are averaged and students achieving an average in excess of 50% are awarded a Pass. Those achieving an average in excess of 80% are awarded a Pass with Distinction. A Certificate of Achievement endorsed by Loughborough University and the Royal Academy of Engineering is presented upon successful completion. A transcript details all sections successfully completed and provides a record of performance in the tests.

3. The work regime and some technical issues

In October 2002 around 150 students employed at various locations around the UK were enrolled and embarked upon the programme. They had all been offered and accepted places at university for October 2003. As this is a distance learning package the team feel that it is important for students, on at least one occasion, to meet those responsible for delivering the Programme. Due to the large numbers involved and their spread around the country a number of induction days are arranged for the benefit of students. On these days, all matters related to the Best Maths Programme are outlined to groups of up to fifty students. There is usually a break for lunch when students can meet the team informally. The team feels students are more likely to engage in the learning process by getting to know them rather than simply having to relate to material delivered anonymously through the letterbox.

During Induction Days the complete package is overviewed. The first few workbooks are presented and examined in some detail. How best to use the workbooks is described and how they will become a valuable resource in future undergraduate programmes. The rationale behind having workbooks in their present form is explained; that 'learning at a distance' requires more than a traditional textbook. The team are aware that the majority of Best Maths students, though generally well able to cope with A-level mathematics, will still need considerable guidance and support when working on their own. The workbooks provide that guidance, the back-up team at Loughborough University provide that support. The workbooks are student friendly; each Section contains a what you should know statement and a what you will find out statement. They are liberally filled with worth knowing boxes, worked examples, try this exercises (with plenty of white space for working) and End of Section Exercises with Answers. At the end of a Section a complete list of all the worth knowing boxes from each part is provided. The following images (Figures 1-4) give a flavour of the workbook material.

try this Find $\int \frac{1}{x^5}\mathrm{d}x$

Your answer

Use the laws of indices to write the integrand as x^{-5} and then use the Table.

$-\frac{1}{4}x^{-4} + c = -\frac{1}{4x^4} + c.$

Figure 1: A typical workbook exercise for students to attempt.

Worked Example

Find $\int (x^3 + \sin x)\,\mathrm{d}x$

Solution

$$\int (x^3 + \sin x)\,\mathrm{d}x = \int x^3\mathrm{d}x + \int \sin x\,\mathrm{d}x = \frac{1}{4}x^4 - \cos x + c$$

Note that only a single constant of integration is needed.

Figure 2: A typical worked example from an integration workbook.

what you should know

Before starting this Part you should ...

- thoroughly understand the various techniques of differentiation

what you will find out

After completing this Part you should be able to ...

- find some simple integrals by reversing the process of differentiation
- use a table of integrals
- explain the need for a constant of integration when finding indefinite integrals
- use the rules for finding integrals of sums of functions and constant multiples of functions

Figure 3: Students are provided with information on prerequisites, and also on what they will learn by studying the material.

worth knowing

The Inverse of a 2×2 Matrix

If $ad - bc \neq 0$ then the 2×2 matrix $A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$ has a (unique) inverse given by

$$A^{-1} = \frac{1}{ad - bc}\begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$

Note that $ad - bc = |A|$, the determinant of the matrix A.
In words: to find the inverse of a 2×2 matrix A we effectively interchange the diagonal elements a and d, change the sign of the other two elements and then divide by the determinant of A.

Figure 4: Key results are highlighted throughout the workbooks.

The team also detail the working regime that they prefer students to adopt. Firstly it is advised that the written material should be covered thoroughly before attempting the corresponding practice tests on the CD. The practice tests can be attempted as often as a student likes. All our tests are constructed in the same way; there is a Practice Test and Final Test for each workbook. A screen shot of the test menu from the CD is shown in Figure 5.

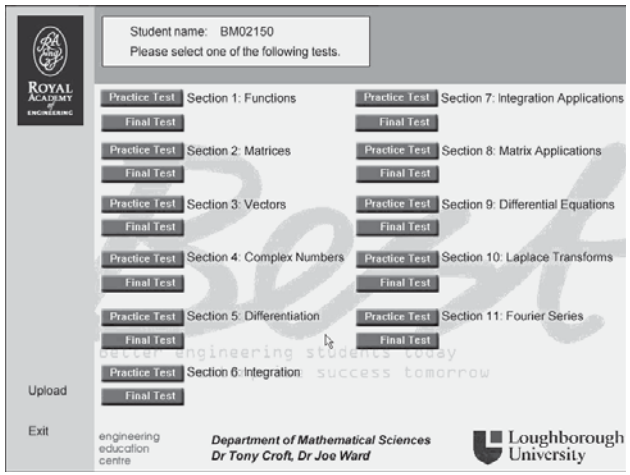

Figure 5: A menu from the CD showing the Practice and Final Tests in each Section.

Each test contains a fixed number of questions and each question corresponds to a sub-topic of the workbook. For example 'vectors' would have a question for each of the sub-topics: modulus, angle between vectors, dot product, cross product, shortest distance problems etc. There is in fact a library of questions for each sub-topic which are, as far as possible, written at a similar level of difficulty. When a student takes a test each question is picked at random from the corresponding library. Each library bank of questions is also divided into two, one half of the library being used solely for practice tests and the remaining half being used for assessment, or final, tests. A typical multiple-choice test question is shown in Figure 6; other question types used include numeric input and hot-spot questions, but no attempt has been made to develop algebraic input questions. A student failing to answer a question correctly in a practice test is presented with a page of feedback detailing the solution either in specific or generic form. Typical feedback is shown in Figure 7.

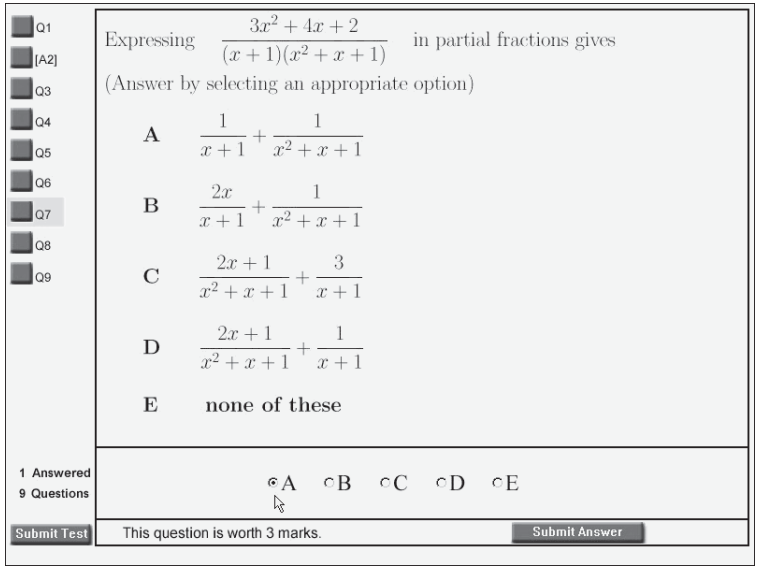

Figure 6: A typical multiple-choice practice test question.

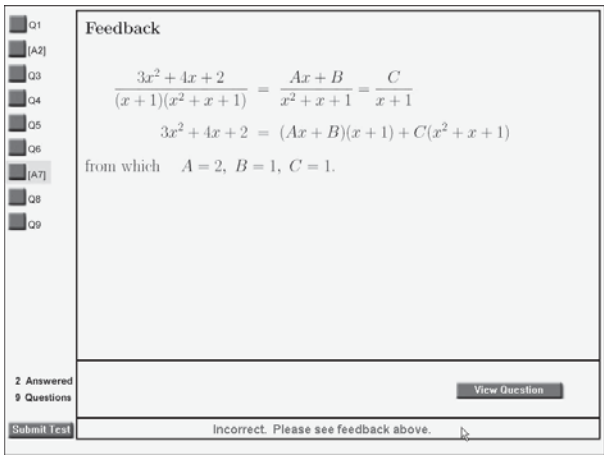

Figure 7: A typical page of feedback indicating how to obtain a correct solution.

At the end of a practice test information is presented to the student detailing which questions were answered correctly. Only a single attempt at an assessed, or final, test is allowed (once the test is taken it is hidden from the student) which students then upload onto the website for recording as described below. Note that questions in an assessed test will have been previously unseen by the student though in form and in level they will be very similar to the practice tests.

The CD has been developed so students can undertake tests during breaks or quiet periods in the workplace. The software was designed to run directly from the CD as a number of companies, particularly those in sensitive fields e.g. defence, have restrictions to prevent the installation of software, particularly executables, onto their computers. There are often internet firewalls or there can be limited internet access in the workplace; consequently the CD was developed so that all tests are completed offline.

Final tests are encrypted and are not marked until they are uploaded to the web site. The encrypted test files are all small enough to fit easily onto a floppy disc, so that they can be transferred to a different computer, if necessary, to upload the file to the Best Maths web site. The upload process only takes a couple of minutes and as a result only a small amount of time is spent online. The file is automatically decrypted when it is uploaded and the student is then provided almost immediately with the mark for their final test and a breakdown of the marks for each question as shown in Figure 8.

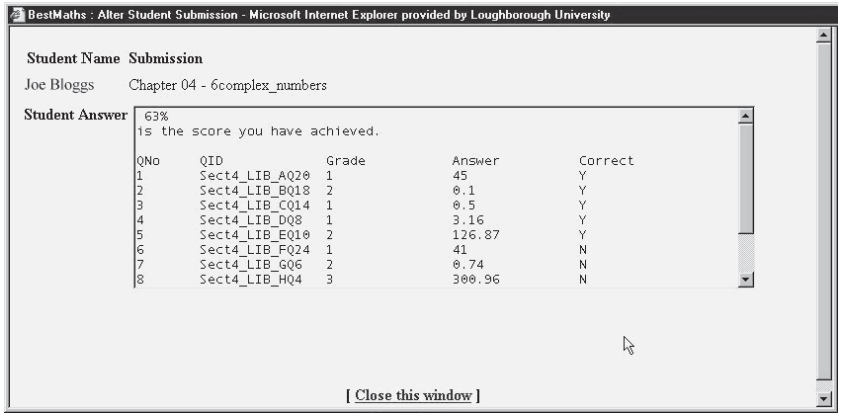

Figure 8: Summary of a student's test result as it appears on the web site.

The student can also access marks for any of their previous tests and a summary page indicates which tests they submitted, when they submitted the tests and the corresponding marks. See Figure 9.

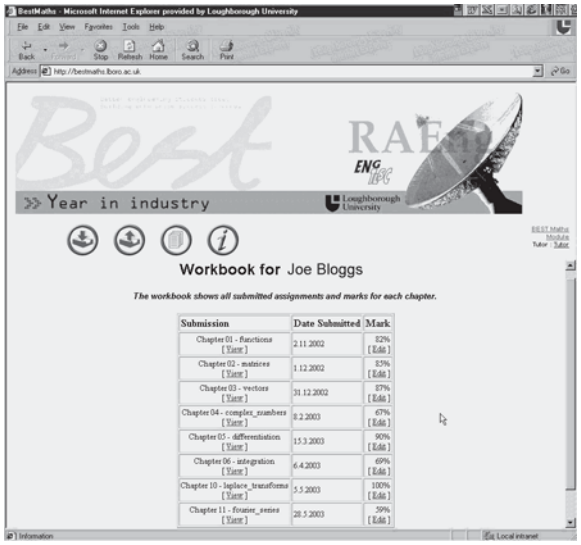

Figure 9: Each student has access to their own personalised summary page on the website.

The tutors have access to all of these student marks pages, which are stored in a database on the server, and also have access to a summary page that lists all of the students together with the number of tests they have submitted as shown in Figure 10. The use of the online data provides an excellent monitoring system for both students and tutors and is used to generate the final transcripts. Students requiring help with the mathematical material can and do contact the two mathematicians on the team by email. Uptake of this service is very variable - some students make quite frequent contact, others never at all. With 150 students this email support service has worked well and not put undue burden on staff. This is an area which will be monitored carefully in future years. Where appropriate an email response is sent; where more detailed explanation is required it is the practice of the team to produce this in latex, and email a pdf file to the student concerned.

A part-time Project Administrator has been employed to deal with students' general queries. She maintains a watching brief on student progress regularly emailing students with words of encouragement.

In the coming year, 2003/4, a CD, containing video clips of the Programme team and detailed information on how the instructional CD is to be used, will be given to all participants in the scheme. This will be valuable for those unable to attend an Induction Day, and also as an aide memoir.

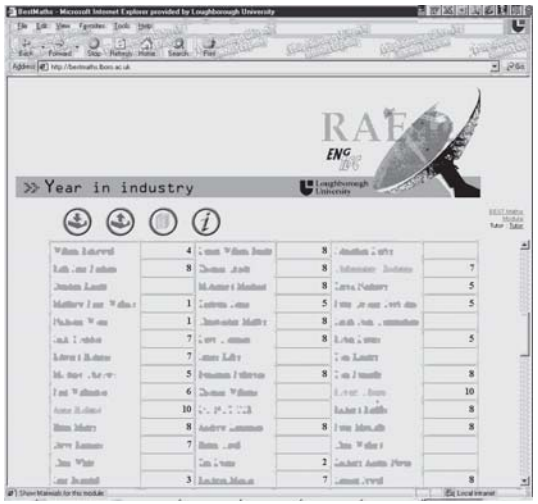

Figure 10: The tutor record screen through which overall student progress can be tracked.

4. Results

The programme was piloted with just 12 students in 2001/2. Comments received from emailed questionnaires were used to inform improvements to the workbooks, CD and website.

In the academic year 2002/3 approximately 150 students from around the country enrolled for the programme. For most of these students this is their first extended period away from home, and they are coming to terms with their first full-time job. All of these students have already successfully completed their A levels and have accepted offers of places at university; consequently the Programme has little 'currency' in terms of immediate study or career prospects. So, whilst the programme is designed to be as flexible as possible it is expected that not all students would have the necessary drive and motivation to stick at the course. In the event, 66 students achieved a Pass with Distinction, 28 achieved a Pass, and a further 29 made a reasonable attempt but failed to reach the standard required to Pass. About one fifth of the students originally enrolled failed to make a serious attempt at the assessment process, although some of these may well have started learning material in the workbooks. In the year 2003/4 200 students are expected to enrol on this programme.

5. Conclusions

The Best Maths Programme provides an opportunity for many students in their gap-year and on the Year in Industry scheme to continue practicing and developing their mathematical skills. The project team have taken account of the particular nature of these students, that they are not 'mature' distance learners, and that they have already secured their university places and so the course does not carry the usual 'currency' associated with a mathematics qualification. The team also recognise that mathematics is not likely to be a high priority for most of these students, and so effort has been put into initial induction, and regular encouragement is provided through email. The team have tried to develop mathematical content which will have sufficient revision to be useful, and have sufficient new material to stretch those who are sufficiently keen to want to learn more. The technical regime is sufficiently flexible for those who, for various reasons, have difficulties obtaining web-access and/or using computing facilities at work. The web-based testing and monitoring regime has worked particularly well in 2002/3 and all concerned have found it a useful and very efficient way of working.

Acknowledgements

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