

Online Testing of Mathematics for Engineers

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It is well documented that there is currently an unsatisfied need in industry for more qualified engineers, and a disturbing decline in college students opting for technical degrees. Part of the problem is the high attrition rate among engineering majors, which can be attributed in part to problems with mathematics. We are currently developing a strategy using web-based mathematics examinations, tutoring and advising to help improve retention of engineering students and to address ABET's outcomes-based assessment.

Currently, about 50% of engineering students at the University of Nevada drop out or change majors in the first two years of study, some without actually taking a single engineering class. This high dropout rate can be attributed in part to a misunderstanding of what a career in engineering involves and a realization that such a career does not meet the expectations of the student. Nevertheless, many of these students drop out because of problems with mathematics. In addition, the current educational environment does not allow them to remedy their deficiencies in mathematics at their own pace. Another problem is that some students who do decide to stay with engineering programs achieve only minimal proficiency in mathematics. This is later a serious handicap to their education and is the cause of problems for them and for their instructors.

The University of Nevada and the South Dakota School of Mines and Technology have received NSF funding to develop a strategy using web-based mathematics examinations and tutoring to help students achieve the desired competency in mathematics and to encourage students to continue in their programs. This includes monitoring and verifying their progress. We will then assess the use of these web-based examinations to complement the existing math curriculum for engineers to achieve these goals.

One of the goals of the program is to include mathematics problems in the context of engineering applications. Colleagues in the College of Engineering have observed that students who have otherwise successfully completed a mathematics course have difficulty applying it in engineering classes. It is believed that this is partly because the students are seeing the mathematics in an unfamiliar setting with different notation. The web-based tests are designed to couch mathematics in engineering terminology. Here are two simple examples:

Capacitance is a circuit property used to model the storage of energy in an electrostatic field by a device called a capacitor which has two conductor plates separated by an insulator. Capacitance is measured in units of Farads (F) although practical values are less than one microFarad (10^{-6} F). Capacitance is

associated with two conductor plates separated by an insulator. The capacitance is given by $C = \frac{\epsilon A}{d}$

where ϵ is the permittivity of the insulator, A is the area of the plates, and d is the separation between them. The permittivity of mica is 5×10^{-11} F/m. If a capacitor with a mica insulator has a capacitance of one microFarad and the area of the plates is 15 square centimeters, what is the distance between the plates?

Capacitance is a circuit property used to model the storage of energy in an electrostatic field by a device called a capacitor which has two conductor plates separated by an insulator. The capacitance is directly proportional to the area of the plates and inversely proportional to the distance between the plates. What happens to the capacitance if the area of the plates is doubled and distance between the plates is cut in half?

(a) it is quadrupled (b) it is doubled (c) it stays the same (d) it is half as much (e) it is 1/4 as much.

Drs. Jeff McGough of the South Dakota School of Mines and Technology and Jeff Mortensen of UNR have written a prototype program that selects questions at random to build an exam, which is then delivered to the student through a browser. The student answers the questions and submits the responses. The system will grade and record the results. It does not require any special software for the student; all of the processing is done on the server.

There are three aspects to the system: (1) *The front end* has the authentication code and the code to connect to a student registration system to allow automatic registration into the exam system. (2) *Test administration* is the core of the system. It will give the exams and "interpret" them. (3) *Record-keeping* maintains student data and exam results.

During October, 2000 an exam consisting of eight questions was administered to 43 electrical engineering majors in an orientation class, Electrical Engineering 101. For a complete sample test please see devnull.math.unr.edu/webtest/

The scores were as follows: 3 scores of 1, 9 scores of 2, 9 scores of 3, 4 scores of 4, 7 scores of five, 8 scores of 6, no scores of 7, and three scores of 8. Both the average and median scores were 4.

This was a trial run, but it illustrates the fact that the students are not exceptionally well prepared (or else that they were not trying very hard). We have a lot of follow-up work to do.