

Math Requirements for Engineering Technology at the University of Dayton

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Abstract

Deficiencies in the mathematical preparation of engineering technology students have been noted in some mid- and upper-level courses at the University of Dayton. As a result, an ad hoc committee was formed to review the topics covered in the existing mathematics sequence and recommend changes. This paper will review the findings of that committee. Specifically, it will address the areas where students were found deficient, the committee's curriculum recommendations, the creation of a capstone course for the mathematics sequence, and the current state of implementation.

Introduction

An ad hoc committee of engineering technology and mathematics faculty was formed during the fall of 2001 to review the mathematics curriculum for the engineering technology programs at the University of Dayton. These programs include computer, electrical, industrial, manufacturing, and mechanical engineering technology. The formation of this committee was motivated by faculty observing that students were lacking instruction in some mathematical topics pertinent to engineering technology coursework. This situation was most apparent in a number of required mid- and upper-level courses. Subsequent to the committee's recommendations in the winter of 2002, curriculum changes were implemented beginning with the incoming class of the 2002-2003 academic year. Most notable was the creation of a capstone mathematics course taken by computer, electrical, and mechanical engineering technology students.

Listed below are the mathematics courses included in the curriculum that existed prior to implementation of the committee's recommendations. The courses are presented in the order the students were required to take them and the descriptions are taken from the University of Dayton course bulletin [1].

1. MTH 106 Introductory Mathematics for Engineering Technology (3 semester hours): Introduction to topics in plane geometry, triangle trigonometry, matrix algebra, and Boolean algebra with an emphasis on applications to real world technical problems. Intended for students in the engineering technology programs. Prerequisite: Two years of high school algebra.
2. MTH 137 Calculus I with Review (4 semester hours): Introduction to the differential and integral calculus with an extensive review of algebra and trigonometry; differentiation and integration of algebraic and transcendental functions with applications. Prerequisite: Two years of high school algebra.

3. MTH 138 Calculus I with Review (4 semester hours): Continuation of topics listed with MTH 137. Prerequisite: MTH 137
4. MTH 149 Introductory Calculus II (3 semester hours): Techniques of integration and differential equations with applications to the life and social sciences, indeterminate forms, infinite sequences and series. Prerequisite: MTH 138 or 148.
5. MTH 207 Introduction to Statistics (3 semester hours): Introduction to the concepts of statistical thinking for students whose majors do not require calculus. Methods of presenting data, including graphical methods. Using data to make decisions and draw conclusions. Basic ideas of drawing a sample and interpreting the information that it contains. Prerequisite: Two years of high school algebra.

Please note that the industrial and manufacturing engineering technology programs did not require completion of MTH 149.

Analysis of the Curriculum

By surveying the engineering technology faculty, the committee was able to identify a number of areas the mathematics curriculum was deficient and could be improved. Most notable was the omission of any coverage in differential equations beyond separable first order equations, which is covered in MTH 149. Consider for instance subjects included in the mechanical engineering technology curriculum where differential equations arise.

- Fluid mechanics (e.g. flow due to falling head).
- Electric circuits (e.g. RL, RC, and RLC circuits).
- Mechanical vibrations (e.g. damped and undamped free and forced vibration).
- Heat transfer (e.g. walls with internal heat sources, fins, transient behavior of lumped-heat-capacity systems).
- Measurement (e.g. first- and second-order devices).

A second topic completely omitted from the curriculum was multivariable calculus. Once again, subjects founded upon the tools of multivariable calculus and arising in the mechanical engineering technology curriculum are listed below.

- Statics and dynamics (e.g. center of mass, mass moment of inertia).
- Strength of materials (e.g. first / statical moment and second moment of an area).
- Thermodynamics (e.g. P-v-T diagrams, specific heats)
- Measurement (e.g. linear regression).

An added problem was that the first course in the math sequence (i.e. MTH106 Introductory Mathematics for Engineering Technology) was largely a review for most entering engineering technology students although it did include content new to most including Boolean algebra, matrix algebra, and manipulation of complex numbers (which is not specifically noted in the bulletin description of the course). Frankly, many students felt some of the content set a low academic standard. Compounding the problem was that MTH 137 Calculus I with Review began with a concise review of algebra and trigonometry. As such, the students would spend approximately half of their first two collegiate mathematics courses reviewing topics they had covered in high school.

A final issue was noted with regard to the content of MTH 149 Introductory Calculus II. Along with MTH 148 Introductory Calculus I, these courses form a calculus sequence designed for

students in the life and social sciences. As such, the text, applications, and topics covered were not geared for engineering technology. Notable was a significant portion of the course being devoted to infinite sequences and series, which are not utilized to any great extent in engineering technology courses. As a final comment regarding MTH 149, it does include integration by parts and the logarithm as an integral, which is considered desirable content.

Curriculum Constraints

In recommending modifications to the mathematics curriculum, the committee was faced with a number of constraints. First of all, it was desired to maintain the same number of credits in each technology program for mathematics coursework - for computer, electrical, and mechanical engineering technology programs 17-semester hours, and for industrial and computer engineering 14-semester hours.

Secondly, the new curriculum would ideally contain no more than the current three semester hours of coursework unique to engineering technology. Such courses typically suffer from small student populations resulting in less flexibility in scheduling and adverse economies of scale. Moreover, from a student perspective, these courses are often difficult to obtain credit for if transferring.

Finally, the committee worked under the constraint that any content modifications to existing courses be minimal. Also, the statistics course (i.e. MTH 207 Introduction to Statistics) was found highly satisfactory and would be left intact.

Recommendations

Ultimately, it was apparent that MTH 106 Introductory Mathematics for Engineering Technology was less than optimal in its current form. On the other end of the spectrum, only about half of the terminal calculus course (i.e. MTH 149 Introductory Calculus II) content was utilized. It was also obvious that hours would have to be added to the programs to prepare the students for the traditional full-blown multivariable calculus and differential equations courses currently offered. Meanwhile, these courses would provide depth and content extraneous to a student succeeding in engineering technology.

The remedy to the situation was to eliminate MTH 106 Introductory Mathematics for Engineering Technology and create a unique terminal calculus course, which would include selected topics from MTH 106, integration techniques content from MTH 149, introductory concepts from multivariable calculus, and introductory topics in differential equations. The newly created course would be titled Advanced Technical Mathematics and numbered as MTH 250. The revised math sequence with MTH 250 serving as a capstone of sorts is given below along with the bulletin description of MTH 250.

1. MTH 137 Calculus I with Review (4 semester hours).
2. MTH 138 Calculus I with Review (4 semester hours).
3. MTH 250 Advanced Technical Mathematics (3 semester hours): Topics essential for engineering technology majors. These include the calculus of functions of two variables, complex numbers, systems of linear equations, matrices and determinants, separable differential equations, first and second order linear differential equations, and Euler's method. Applications will be chosen from areas pertinent to engineering technology. Prerequisites: MTH 138 or MTH 168.

4. MTH 207 Introduction to Statistics (3 semester hours).

Notice that the number of credit hours has actually been reduced by three hours for all programs, and that for the industrial and manufacturing engineering technology programs, MTH 250 is not required, but can be taken as an elective.

Specific topics included in MTH 250 and the approximate amount of class time for each topic is listed below.

Calculus / Multivariable Calculus (7 weeks)

- Integration by parts
- Functions of two variables
- Partial derivatives
- Double integrals
- Polar Coordinates

Complex Numbers (1.5 weeks)

- Algebraic properties of complex numbers
- Graphing complex numbers
- Polar form of complex numbers
- Exponential form of complex numbers
- Operations on polar forms of complex numbers

Matrix Methods (2.5 weeks)

- Matrices and systems of linear equations
- Matrix algebra

Differential Equations (4 weeks)

- Properties of differential equations
- Separation of variables
- Exact differential equations and integrating factors
- First order linear differential equations
- Higher order differential equations with constant coefficients
- Euler's method

The text used is *Technical Mathematics with Calculus* by John C. Peterson [2].

Implementation Status

The revised curriculum was implemented with the incoming class of the 2002-2003 academic-year. MTH 250 was first offered in the fall of 2003 to these students and has since been offered each fall and winter term.

Conclusions

To date the student passing rate the newly developed MTH 250 is approximately 80%. However, having offered the course only twice this statistic could be misleading. One opinion that has been voiced by a number of students who took the course is that the sheer volume of material poses the greatest difficulty, rather than the complexity of the topics. Ultimately, how

the students are able to perform in engineering technology situations where this math content is used will be the true test. Students who have taken MTH 250 have begun to trickle into mid-level engineering technology courses that are currently being taught. It should be easier for these students to grasp concepts like mass properties, for instance, when they have a conceptual understanding of integrating over a volume. Further monitoring over the next four years will be necessary to fully assess the impact of these changes.

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References

1. University of Dayton, *University of Dayton Bulletin 2002-03*, August 2002.
2. J. C. Peterson, *Technical Mathematics with Calculus*, 2nd ed., Delmar Publishers, Albany, New York, 1997.

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