Proposal to Amend the Requirements for BS Degree
Submitted by Kathy Hoke on behalf of the School of Arts & Sciences

The Mathematics Program will begin offering in the fall of 2005 a new calculus sequence, Scientific Calculus I and II (Math 231-232), in addition to its traditional calculus sequence, Calculus I and II (Math 211-212). The rationale for this decision is given below. The new courses have been approved by the A&S faculty (1/11/05).

Math 212 is currently required for the Bachelor of Science (BS) degree. We would like to amend this requirement to include the second half of either track: Math 212 or Math 232. This change requires University Senate approval.

I would like to emphasize that entering students will have a choice of calculus sequences: either Math 211-212 or Math 231-232. We would like for both choices to lead to fulfilling the requirements for the BS degree. The current requirements include only the first option.

Rationale for the Scientific Calculus Sequence

First semester calculus has become a high school course for many of our students. Our observations at UR in the last 10 years have been that very few (under 30) of the students enrolled in Calculus I in the fall did not have a calculus course in high school.

Students who score a 4 or 5 on the AB version of the Advanced Placement (AP) Calculus exam get credit for Calculus I (Math 211). Those who plan to be science majors then begin in Calculus II (Math 212). Further, we encourage students who scored a 3 on the exam to begin in Calculus II as well. Yet, many students who begin in Calculus II feel overwhelmed in the first few weeks. Many feel they need a review of the Calculus I material before jumping into Calculus II.

Moreover, study in the sciences has become increasingly quantitative. There are vast quantities of data available (from the genome project for example) and an increasing need to use more sophisticated quantitative approaches. To understand these approaches, scientists need more quantitative tools, including tools from multivariable analysis and probability.

The proposed Math 231-232 is designed to address the needs of the strong science student who has had a year of calculus in high school, but is either not quite ready to begin in Math 212 or wants to see some multivariable techniques and some probability.

A brief description of the topics covered in Math 232 is given below. A description of Math 231 is also given so that one can have a clear idea of how the new sequence Math 231-232 compares to Math 211-212.
Math 232 Scientific Calculus II

Prerequisite: Math 231
(4 or 5 on the AP BC calculus exam)

As in Math 231, an emphasis will be placed on applications and examples from the sciences. Also, examples from probability theory will be incorporated when appropriate. Dimensional analysis and error analysis will be used throughout.

The course will include the following topics that are currently covered in Math 212 (not necessarily in the order listed):

- Solving linear DE’s (singles)
- Geometric series
- Taylor series (e^x, sin(x), cos(x), (1+x)^p
- Estimation using Taylor polynomials
- Alternating and integral test for convergence at endpoints

The rest of the course will be devoted to selections from the following multivariable topics:

- Equations of lines and planes
- Functions of 2 or more variables
- Level curves
- Partial derivatives
- Local linearity (and the differential); tangent plane
- Chain Rule for functions of 2 or more variables
- Applications from optimization, such as
  - Least squares
  - Optimal strategies for things like population harvesting or vaccination programs.
  - Applications in genetics, like the Hardy-Weinberg Law.
- Directional derivatives; gradients
- Double integrals (over rectangles)
- Partial integration
- Systems of linear equations; writing a linear system as a matrix equation
- Vector-matrix arithmetic
- Eigenvalues/vectors
- Applications such as difference equations, 1st order linear systems of differential equations, discrete dynamical systems
Math 231 Scientific Calculus I--Outline

The course will be taught from the viewpoint of mathematical modeling. Applications and examples will be taken from the sciences. An attempt will be made to use specific examples from our Biology and Chemistry courses. The language of probability will be introduced early (expected value, variance, distribution). Probabilistic thinking and examples will be incorporated throughout, including continuous and discrete distributions. For example, one can do a probabilistic interpretation of the logistic equation.

Some other threads to include are genetics applications (e.g. Hardy Weinberg), population dynamics, and chemical reactions. Also included throughout will be dimensional analysis and error analysis.

Approximately half of the course will be topics that are currently taught in Math 211:
- Basic functions: algebraic, graphic, and numerical
- Exponential growth vs. linear growth
- Limits (but not too deeply); convergence
- Definition of derivative
- Derivative as rate of change
- Derivatives graphically and numerically
- Linear approximation and differentials
- Derivatives and graphs
- Optimization
- Implicit differentiation
- Newtons method
- Definition of definite integral
- FTC; antiderivatives
- Areas and distances
- Cumulative change

The remaining portion of the course will cover the following topics that are currently covered in Math 212:
- Techniques of integration
  - Substitution
  - Parts
- Numerical/approximate integration; error analysis
- Applications of integration (including probability)
- Improper integrals
- Basic DE Lingo
- Slopefields
- Eulers method
- Separation of variables