MATH 1070 – Content Standards

Title: Elementary Statistics

Course Description: Prerequisite High School Algebra II.
Descriptive statistics, basic probability and distribution of random variables, estimation and hypothesis tests for means and proportions, regression and correlation, analysis of count data.

Goals. The goals of Elementary Statistics are for students to develop skills that will allow them to gather, organize, display and summarize data. They should be able to draw conclusions or make predictions from the data and assess the relative chances for certain events happening.

The following standards are offered as guidelines for assessing student progress, judging the effectiveness of instructional programs, and developing curricular units. The subject matter outlined in these standards represents the minimum knowledge in which a student should demonstrate proficiency at the successful completion of the course.

CS 1. Quantitative Reasoning

Students will use quantitative reasoning in problem solving including:
Geometric and symbolic representation and manipulation and pattern recognition.

CS 2. Graphical and numerical summaries, normal distribution

Students will be able to construct and interpret graphical displays of univariate data such as the stem plot, histogram, box plot, and time plot; calculate and interpret summary statistics such as the mean, median, standard deviation, and five number summary; describe and use density curves such as the uniform and normal density curves; use the normal density curve to calculate proportions.

CS 3. Graphical and numerical summaries for bivariate data

Students will be able to construct and interpret graphical displays of bivariate data: scatter plots, regression lines, residual plots, outliers, and influential points; discuss the meaning of the correlation coefficient and the least-squares regression line.

CS 4. Samples and experimental designs

Students will be able to select a simple random sample using a table of random digits; recognize biased sampling such as voluntary and convenience sampling; describe some experimental designs such as completely randomized and block designs.

CS 5. Sample distributions, probability and random variables

Students will demonstrate knowledge and be able to examine and understand and use basic probability concepts including the following: sample spaces of possible outcomes of random experiments, random variables and their probability distributions, the sampling distribution of the mean and the central limit theorem.

CS 6. Z-tests and confidence intervals for means

Students will demonstrate the ability to understand and use the vocabulary of statistical inference including: confidence intervals, confidence levels and margins of error in general, confidence level in general as the probability to give a correct estimate of the confidence intervals for the mean of a normal population of known variance, or the difference between means of two normal populations of know variances, null and alternative hypotheses, rejection region in terms of the population(s) standard deviation(s) and sample size(s), level of significance and p-values for one and two sided tests for means, when the variance(s) of the underlying normal population(s) is (are) known, or the sample is large.

CS 7. Z-tests and confidence intervals for proportions

Students will demonstrate the ability to make design and make correct inferential statements about: sampling distribution of a sample proportion, confidence intervals for a (difference between two) population proportion(s), and sample size for a required margin of error.

CS 8. T-tests and confidence intervals for means of normal populations

Students will demonstrate the ability to understand and apply inferential statements including: confidence level as the probability to give a correct estimate of the mean (difference of means) of a (two) normal population(s), when the standard deviation(s) is (are) unknown; level of significance and p-values for one and two sided tests for means, when the variance(s) of the underlying normal population(s) is (are) unknown.

CS 9. Chi-square tests for two-way tables

Students will be able to arrange general bivariate categorical data in several groups into a two-way table of counts in all the groups.

Students explain what null hypothesis the chi-square statistic tests in a specific two-way table; use percents, comparison of expected and observed counts, and the components of the chi-square statistic to see what deviations from the null hypothesis are important; make a quick assessment of the significance of the statistic by comparing the observed value to the degrees of freedom.

CS 10. Applications

When applying analytic, algebraic, geometric, and algorithmic techniques to solving applied statistical problems students will:

- Use appropriate technology

- Communicate how the problem is modeled by a mathematical/statistical formulation and how to interpret the results of the statistical analysis.

MATH 1101 – Content Standards

Title: Introduction to Mathematical Modeling

Course Description: Prerequisite: High School algebra II or equivalent. This course is NOT an appropriate prerequisite for precalculus or calculus courses.

Mathematical modeling using graphical, numerical, symbolic, and verbal techniques to describe and explore real-world data and phenomena. Emphasis is on the use of elementary functions to investigate and analyze applied problems and questions, on the use of appropriate supporting technology, and on the effective communication of quantitative concepts and results.

Click here for departmental outline.

1. Algebra. Students will demonstrate the ability to:
a. Graph points.
b. Graph linear, piecewise linear, exponential, logarithmic, and quadratic equations and functions. and identify horizontal asymptotes.
c. Determine the equation of a line given two points or one point and the slope.
d. Determine the absolute value of a quantity.
e. Solve and estimate solutions to linear, quadratic, exponential, and logarithmic equations, including use of the properties of exponents and common and natural logarithms.
f. Solve linear systems of two equations by substitution and elimination, including systems that have a unique solution, no solution, or many solutions.
g. Simplify expressions using the laws of exponents and logarithms.
h. Calculate average rate of change of any function.
i. Perform arithmetic calculations to answer questions regarding two-variable data presented in tabular, graphical, or equation form.
j. Express and compare very large and very small numbers using scientific notation and orders of magnitude.
k. Employ the relationship $y = bx \Leftrightarrow \log b\ y = x$ to solve exponential and logarithmic equations.
l. Factor quadratic expressions.
m. Complete the square of quadratic expressions.
n. Express the square root of negative numbers in terms of the imaginary unit, i.
o. Given conversion factors, convert units of measure.
p. Use the quadratic formula to solve quadratic equations.

2. Functions. Students will demonstrate:
a. An understanding of the definitions of function, domain, range, independent and dependent variables, and input and output.
b. The ability to determine if tables, graphs, and equations represent functions.
c. The ability to determine the domain and range of functions as mathematical abstractions or in a physical context.
d. The ability to compose functions.
e. The ability to determine from the graph of a function the values of the independent variable for which the function increases, decreases, or remains constant.

3. Linear Functions. Students will demonstrate the ability to:
a. Determine when two real-world variables are related by a linear or piecewise linear function.
b. Model the behavior of two real-world variables that are directly proportional or are related by a linear or piecewise linear function using tables, graphs, equations, or combinations thereof.
c. Use a linear function to approximate the value of a non-linear function.
d. Interpret the intersection of the graphs of linear functions as equilibrium points.
e. Evaluate linear and piecewise linear functions.
f. Define, calculate, and interpret average rate of change as slope.
g. Define the linear function and the general equation of the linear function.

4. Exponential Functions. Students will demonstrate the ability to:
a. Determine when two real-world variables are related by an exponential function.
b. Model the behavior of two real-world variables that are related by an exponential function using tables, graphs, equations, or combinations thereof including such applications as population growth and decay, radioactive decay, simple and compound interest, inflation, the Malthusian dilemma, musical pitch, and the Rule of 70.
c. Change the base of an exponential function to determine rate of growth/decay, growth/decay factor, and effective and nominal interest rate.
d. Express continuous growth/decay in terms of the number e.
e. Evaluate exponential functions.
f. Determine the exponential equation model from the table or graphical model.
g. Compare linear to exponential growth.

5. Logarithmic Functions. Students will demonstrate:
a. The ability to determine when two real-world variables are related by a logarithmic function.
b. The ability to model the behavior of two real-world variables that are related by a logarithmic function using tables, graphs, equations, or combinations thereof including such applications as pH and the decibel system.

c. Their understanding of the natural logarithm.
d. The ability to graph logarithmic functions.

6. Polynomial and Quadratic Functions. Students will demonstrate the ability to:
a. Predict the shape of graphs of polynomial functions degree n.
b. Estimate horizontal intercepts of polynomial functions from their graphs.
c. Determine the horizontal intercepts of polynomial functions in factored form.
d. Determine when two real-world variables are related by a quadratic function by calculating the average rate of change of the average rates of change.
e. Model the behavior of two real-world variables that are related by a quadratic function using tables, graphs, equations, or combinations thereof including such applications as maximum area for fixed perimeter, minimum perimeter for fixed area, free fall, maximum profit, and break-even analysis.
f. Determine the vertex, axis of symmetry, and horizontal and vertical intercepts of quadratic functions in either the a-b-c or a-h-k forms.
g. Convert quadratic functions from the a-b-c form to the a-h-k form and vice versa.

MATH 1111 – Content Standards

Title: College Algebra

1. Understand the general definition of a function and be able to:
   - Illustrate a function verbally, graphically, with charts/tables, and with set notation
   - Determine the domain and range of a function
   - Identify where a function is increasing, decreasing or constant.
2. Understand linear functions and be able to:
   - Identify, graph, and find equations of linear functions (including parallel and perpendicular lines).
   - Interpret the slope and y-intercept as an average rate of change and an initial amount, respectively.
   - Students will be able to interpret and apply these ideas in applied settings.

3. Identify, understand and apply graph transformations of $y = X^2$, $y = X^{1/2}$, and $y = |x|$ using:
   - Vertical and horizontal shifts
   - Vertical stretching and compressions
   - Reflections
4. Understand, identify, graph, interpret and apply the following in applied settings

   - Quadratic functions of the form $y = ax^2+bx+c$
     - Determine the vertex and intercepts.
   - Power functions and transformations of power functions
   - Polynomial functions where the polynomial is factorable.
     - Students will be able to describe the end behavior of polynomials and the relationship between end behavior and the degree of the polynomial.
     - Students will be able to determine intercepts of factorable polynomials exactly.
     - Students will be able to use appropriate technology to approximate x-intercepts and local extrema of polynomials.

   - Identify and graph transformations of $y = 1/x$ and $y = 1/ x^2$.
     - Students will be able to recognize and determine vertical and horizontal asymptotes, end behavior, and behavior near vertical asymptotes.
   - Piece-wise defined functions.
   - Compose two functions and determine the domain and range of the composite function.
   - Inverse functions
     - Get a rule for an inverse function
     - Graph a function and its inverse

   - Exponential functions of the form $y = a^x$ and their transformations.
   - Logarithmic functions
     - Define a logarithm

- Convert between logarithmic and exponential forms
- Understand the inverse relationship between logarithmic and exponential functions

5. Determine, both algebraically and graphically, solutions to the following types of equations and apply these solutions to concepts related to functions and other applications:
   - Linear
   - Quadratic
   - Factorable polynomial
   - Rational
   - Radical (involving more than one radical)

   - Equations of the form $x^n=k$
   - Simple exponential equations
   - Logarithmic equations using properties of logarithms.
6. Use graphical and algebraic techniques to find solutions to the following kinds of inequalities and apply these solutions to concepts related to functions and other applications:
   - Linear
   - Quadratic
   - Factorable Polynomial
   - Rational
   - Exponential
7. Solve linear systems of two equations in two unknowns using
   - Elimination
   - Substitution
   - Matrices

   as well as use linear systems to solve application problems.
8. Solve simple non-linear systems of equations algebraically and graphically.

MATH 1113 – Content Standards

Title: Precalculus

Catalog course description. Prerequisite: Math 1111, or departmental approval. Trigonometric functions, identities, inverses, and equations; vectors; polar coordinates, conic sections.

Goals. Prepare students for a course in calculus by consolidating their understanding of algebraic, trigonometric, exponential, and logarithmic functions, and the introduction of ideas leading to the concepts of limit and derivative.

Course Content Standards

The following standards are offered as guidelines for assessing student progress, judging the effectiveness of instructional programs, and developing curricular units. The subject matter outlined in these standards represents the minimum knowledge in which a student should demonstrate proficiency at the successful completion of the course.

CS1. Quantitative Reasoning

Students will use quantitative reasoning in problem solving situations including: geometric an symbolic representation and manipulation; pattern recognition; translating mathematics into words and words into mathematics; recognizing incorrect answers and arguments and knowing when an answer is reasonable; being able to write out a solution in a logical and clear form rather than presenting a collection of unidentified intermediate numbers that may end with the final numerical answer.

CS2. Algebraic Functions

Students will use functions and related concepts including: recognition of a function in either graphical, table, implicit, or explicit form; be able to find domains and ranges and determine if a function is one-to-one; perform operations of functions including composition, finding inverses, and finding difference quotients; graphically determine when a functions is increasing, decreasing, constant, one-to-one, continuous, and even or odd; apply basic

graph transformations including $af(x)$, $f(x) + d$, $f(x – c)$, $f(bx)$, , $f($ $)$ to the parent functions; graph a function defined as piecewise.

CS3. Defining the Trigonometric Functions

Students will use circular and trigonometric functions and related concepts including: find exact values of the functions by using the unit circle, wrapping function, and special triangles; know the relationship between radian measure and degree measure and be able to convert from one unit to the other; know the definition of the six (6) trigonometric functions as related to the right triangle; distinguish between right angled and oblique triangles and recognize the appropriate method needed to solve the triangle (Law of Sines, Law of Cosines, Pythagorean Theorem)

CS4 Use of Trigonometric Functions

Students will demonstrate knowledge of and be able to use trigonometry. Specifically: (1) given one of the trig values of an angle in a certain quadrant, be able to find the other five trigonometric functions through identities not limited to Pythagorean, identity, reciprocal identities, even/odd identities and quotient identities, (2) solve oblique triangles using the Law of Sines, and Law of Cosines, and work related applied problems, (3) graph the basic six trigonometric functions, including sine and cosine functions with applied graph transformations; identify the domain, range, period, amplitude and phase shifts of the functions. (4) find the exact values of the inverse trig functions, (5) solve linear and quadratic trigonometric equations and equations with compound angles.

CS5. Mathematical Proofs

Students will demonstrate an understanding of mathematical proofs and related concepts by specifically developing: sum, difference, and co-function identities, double angle and half angle formulas, and sum to product and product to sum identities.

CS6. Analytic Geometry

Students will be demonstrate knowledge of and be able to use analytic geometry concepts and related techniques, including polar coordinates and conic sections including: convert polar to rectangular coordinates and vice versa; sketch graphs of polar functions including cardioids, roses, circles, and spirals; identify equations of parabolas, hyperbolas, and ellipses and sketch their graphs.

CS7. Vectors

Students will demonstrate an understanding of algebraic and geometric vectors and be able to use them to model situations and solve problems.

CS8 Applications and Technology

When applying analytic, algebraic, geometric and algorithmic techniques to solving applied problems, students should be able to use technology when appropriate. Care should be taken to ensure that use of technology is not accompanied by a decrease in mathematical or fundamental understanding.

MATH 1220 – Content Standards

Title: Survey of Calculus

Course Description: Prerequisite MATH 1111.

Differential and integral calculus of selected real-valued functions of one and several real variables with applications.

The following standards are offered as guidelines for assessing student progress, judging the effectiveness of instructional programs, and developing curricular units. The subject matter outlined in these standards represents the minimum knowledge in which a student should demonstrate proficiency at the successful completion of the course.

1. Locate and describe discontinuities in functions.
2. Evaluate limits for polynomial and rational functions
3. Compute and interpret the derivative of a polynomial, rational, exponential, or logarithmic function.
4. Write the equations of lines tangent to the graphs of polynomial, rational, exponential, or logarithmic functions at given points.
5. Compute derivatives using the product, quotient and chain rules on polynomial, rational, exponential, and logarithmic functions.
6. Solve problems in marginal analysis in business and economics using the derivative.
7. Interpret and communicate the results of a marginal analysis.
8. Graph functions and solve optimization problems using the first and second derivatives and interpret the results.
9. Compute antiderivatives and indefinite integrals using term by term integration or substitution techniques.
10. Evaluate certain definite integrals.
11. Compute areas between curves using definite integrals.
12. Solve application problems for which definite and indefinite integrals are mathematical models.
13. Solve application problems involving the continuous compound interest formula.
14. Describe functions of several variables.
15. Compute partial derivatives.
16. Find local extrema of functions of two variables

MATH 2030 – Content Standards

Title: Principles of Mathematics

Course Content Standards
The following standards are offered as guidelines for assessing student progress, judging the effectiveness of instructional programs and developing curricular units. Theses standards describe what a student should be able to demonstrate at the completion of the course.

Problem solving

Students will be able to apply and adapt a variety of appropriate strategies to solve problems including:

- Solve problems that arise in mathematics and in other contexts.
- Apply and adapt a variety of appropriate strategies to solve problems
- Monitor and reflect on the process of mathematical problem solving
- Construct number meanings through real-world experiences and the use of physical materials.
- Relate the mathematical language and symbolism of operations to problem situations and informal language.
- Interpret the multiple uses of numbers encountered in the real world.
- Develop meaning for the basic operations by modeling and discussing a rich variety of problem situations.
- Relate the mathematical language and symbolism of operations to problem situations and informal language.
- Estimate and judge reasonableness of numerical results.
- Relate mathematical symbols to mathematical ideas.
- Relate subtraction to addition.
- Recognize, extend, and create patterns.
- Explore the use of variables and open sentences to express relations.
- Extend the number system to fractions and decimals.
- Relate algebraic ideas to geometric representations.
- Relate multiplication to addition, arrays, and Cartesian products.
- Relate division to subtraction and multiplication.
- Explore the use of variables and open sentences to express relations.
- Use models to represent mathematical ideas.
- Represent situations and number patterns with tables, graphs, and verbal rules.
- Use models to represent mathematical ideas.
- Represent situations and number patterns with tables, graphs and verbal rules.
- Understand the concepts of variable, expression, and equation.
- Formalize situations and number patterns with tables, graphs, verbal rule, and equations and explore the interrelationships of those representations.
- Analyze tables and graphs to identify properties and relationships.
- Solve linear equations using concrete, informal, and formal methods.
- Investigate inequalities and nonlinear equations informally.
- Apply algebraic methods to solve a variety of mathematical problems.

Sets, Functions, and Reasoning

Students will be able to develop an understanding of sets and should represent, analyze and generalize a variety of patterns and functions using words, tables and graphs including:

- Construct number meanings through real-world experiences and the use of physical materials.
- Relate the mathematical language and symbolism of operations to problem situations and informal language.
- Interpret the multiple uses of numbers encountered in the real world.
- Develop meaning for the basic operations by modeling and discussing a rich variety of problem situations.
- Relate the mathematical language and symbolism of operations to problem situations and informal language.
- Estimate and judge reasonableness of numerical results.

- Identify, describe, and draw lines, line segments, lines of symmetry, rays, angles, and parallel and perpendicular lines.
- Relate numbers to points on a line.
- Understand betweeness, closeness, rounding, and approximating.
- Understand closeness, rounding, and approximating.
- Recognize and describe mathematical relations and functions.
- Explore concepts of operational inverses.
- Expand the number system.
- Use relations and functions to solve problems.
- Recognize and describe relations and functions.
- Represent data in tables and graphs.
- Exhibit relationships graphically.
- Use Venn diagrams and truth tables in problem solving involving set theory and logic.
- Use inductive and deductive reasoning.
- Use counting principles.

Whole Numbers

Students will be able to develop a sense of whole numbers and represent and use them in a number of ways including:

- Construct number meanings through real-world experiences and the use of physical materials.
- Understand our numeration system by relating counting, grouping and place value concepts.
- Interpret the multiple uses of numbers.
- Develop meaning for the four basic operations.
- Relate the mathematical language and symbolism of operations to problem situations and informal language.
- Identify fractions using physical models, both as parts of a whole and parts of a set.
- Construct number meanings through real world experience and the use of physical materials.
- Understand our numeration system by relating counting, grouping and place value concepts.
- Interpret the multiple uses of numbers encountered in the real world.
- Develop meaning for the basic operations by modeling and discussing a rich variety of problem situations.
- Relate the mathematical language and symbolism of operations to problem situations and informal language.
- Develop, represent, and use order relations for whole numbers, fractions and decimals (rational numbers) and integers.
- Apply the basic operations to integers.
- Understand how the basic arithmetic operations are related to one another.
- Develop and use fractional exponents, negative exponents, and radicals.
- Estimate and judge reasonableness of numerical results.

Number Theory

Students will be able to develop number theory concepts including:

1. Construct number meanings through real world experience and the use of physical materials.
2. Develop and apply number theory concepts (e.g., primes, factors, and multiples) in real-world and mathematical problem situations.
3. Develop meaning for the basic operations by modeling and discussing a rich variety of problem situations.
4. Estimate, and judge reasonableness of numerical results.
5. Identify and Use Divisibility Tests
6. Identify and Use Greatest Common Factors
7. Identify and Use Least Common Multiples
8. Interpret the multiple uses of numbers encountered in the real world.
9. Investigate whether numbers are odd or even, prime or composite.
10. Recognize, extend, and create patterns.
11. Relate the mathematical language and symbolism of operations to problem situations and informal language.

12. Use models to represent mathematical ideas.

Integers and Fractions

Students will be able to develop a sense of integers and fractions and use them in a number of ways, including:

1. Apply operations for the real number systems to a variety of mathematical situations.
2. Apply the basic operations to integers.
3. Apply understanding of whole number operations to fractions.
4. Compare numbers to each other in terms of greater than, less than, or equal to and explore different representations of the same number.
5. Construct number meanings through real world experience and the use of physical materials.
6. Develop concepts of fractions and mixed numbers.
7. Develop meaning for the basic operations by modeling and discussing a rich variety of problem situations.
8. Develop, represent, and use order relations for whole numbers, fractions (rational numbers) and integers.
9. Estimate, and judge reasonableness of numerical results.
10. Expand the number system.
11. Explore concepts of operational inverses.
12. Identify fractions using physical models, both as parts of a whole and parts of a set.
13. Interpret the multiple uses of numbers encountered in the real world.
14. Investigate relationships among fractions, decimals, and percents.
15. Perform arithmetic operations with rational numbers.
16. Recognize, extend, and create patterns.
17. Relate division to subtraction and multiplication.
18. Relate mathematical symbols to mathematical ideas.
19. Relate numbers to points on a line.
20. Relate subtraction to addition.
21. Relate the mathematical language and symbolism of operations to problem situations and informal language.
22. Understand and apply ratios, proportions to a wide variety of situations.
23. Understand and appreciate the need for numbers beyond the whole numbers.
24. Understand betweeness, closeness, rounding, and approximating.
25. Use models to represent mathematical ideas.

Decimals, Rational and Irrational Numbers

Students will be able to develop a sense of decimals, rational numbers and irrational numbers and use them in a number of ways, including:

1. Apply fractions and decimals to problem situations, including money.
2. Apply operations for the real number systems to a variety of mathematical situations.
3. Apply understanding of whole number operations to fractions and decimals.
4. Compare numbers to each other in terms of greater than, less than, or equal to and explore different representations of the same number.
5. Construct number meanings through real world experience and the use of physical materials.
6. Develop and use fractional exponents, negative exponents, radicals.
7. Develop concepts of fractions and decimals with standard symbols.
8. Develop concepts of fractions, mixed numbers and decimals.
9. Develop meaning for the basic operations by modeling and discussing a rich variety of problem situations.
10. Develop the real number system.
11. Develop, represent, and use order relations for whole numbers, fractions and decimals (rational numbers) and integers.
12. Estimate, and judge reasonableness of numerical results.
13. Explore concepts of operational inverses.
14. Explore the properties of rational numbers
15. Extend the number system to fractions and decimals.
16. Interpret the multiple uses of numbers encountered in the real world.
17. Investigate relationships among fractions, decimals, and percents.
18. Perform arithmetic operations with real numbers.
19. Recognize, extend, and create patterns.

20. Relate numbers to points on a line
21. Relate the mathematical language and symbolism of operations to problem situations and informal language.
22. Understand the Pythagorean Theorem by relating it to rational and irrational numbers.
23. Understand and apply ratios, proportions, and percents to a wide variety of situations.
24. Understand and appreciate the need for numbers beyond the whole numbers.
25. Understand betweeness, closeness, rounding, and approximating.
26. Understand our numeration system by relating counting, grouping and place value concepts.
27. Understand, represent, and use numbers in a variety of equivalent forms (integer, fraction, decimal, percent, exponential and scientific notation) in real-world and mathematical problem situations.
28. Understand our decimal system by relating grouping and place value concepts.
29. Use percentages, orders of magnitude, ratios, and proportions to express relationships between quantities.

Statistics

Students will be able to develop an understanding of statistics and should be able to analyze data and make inferences about the real world including:

1. Apply measures of central tendency.
2. Apply measures of variability.
3. Apply measures of relative standing.
4. Collect, organize, and describe data.
5. Construct and draw inferences from charts, tables, and graphs.
6. Construct, read, and interpret displays of data, including picture, bar, circle, and line graphs.
7. Construct, read, and interpret tables, charts, and graphs.
8. Explore concepts of sampling.
9. Formulate and solve problems that involve collecting, organizing, and analyzing data.
10. Make inferences and convincing arguments and evaluate arguments that are based on data analysis.
11. Recognize statistical methods and probability models as powerful decision-making tools.
12. Understand and apply measures of central tendency, variability, and correlations.
13. Use line fitting to predict from data.
14. Use descriptive and inferential statistics.

MATH 2211 – Content Standards

Title: Calculus of one Variable I

Course Description: Prerequisite: Math 1113, or the equivalent
Limits and Continuity, Differentiation, Mean Value Theorem for Derivatives; applications of differentiation; definition of the integral; Fundamental Theorem of Calculus; applications of integration to area.

Goals.

Course Content Standards. The following content standards are offered as guidelines for assessing student progress, judging the effectiveness of instructional programs, and developing curricular units. These standards describe what a student should be able to demonstrate at the completion of the course.

The content standards are labeled CS1 through CS9 and carry a further designation such as CS1A, CS4B, or both. The “A” designation indicates topics that are used explicitly in the course, but introduced in earlier courses. Although these topics are reinforced in Math 2211, they may be considered prerequisite material. The “B” designation indicates that topics are introduced in Math 2211.

CS 1A. Quantitative Reasoning

Students will use quantitative reasoning in problem solving situations including:

- Geometric, symbolic, algebraic, and analytic representation and manipulation of quantitative information;
- Pattern recognition.

CS 2A. The Real Number System

- Students will use algebraic and order properties of the real number system and subsystems of the set of real numbers.

CS 3A. Functions.

Students will use and investigate functions and related concepts including:

- Representations of functions using formulas, graphs, and parameters;
- Operations on functions defined by arithmetic operations, composition, and inversion;
- Types of elementary functions such as polynomial, rational, radical, absolute value, trigonometric, and piecewise-defined functions.

CS 3B. Functions.

Students will use and investigate properties of functions and their graphs involving monotonicity, extrema, concavity, and other salient features.

CS 4B. Limits and Continuity.

Students will demonstrate knowledge of and be able to use concepts and techniques related to limits and continuity including:

- Performing analytic and graphical interpretations of concepts;
- Evaluating limits;
- Determining points of continuity/discontinuity of functions;
- Applying properties of limits and continuity related to operations on functions.

CS 5A. Analytic Geometry.

Students will demonstrate knowledge of and be able to use analytic geometry concepts and related techniques including:

- Conic sections;
- Representations and transformations involving rectangular coordinate systems.

CS 6B. Differentiation.

Students will demonstrate an understanding of the derivative at a point, derivative functions, and related concepts including:

- Interpretation of the derivative at a point in terms of difference quotients, slopes of tangent lines and (instantaneous and average) rates of change;
- The Mean Value Theorem for derivatives and related results;
- Applying properties of differentiation related to elementary functions and operations on functions;
- Application of the derivative to investigating properties of functions;
- Implicit differentiation and differentials.

CS 7B. Integration.

Students will demonstrate an understanding of integration and related concepts including:

- The definite integral as an accumulation of small quantities;
- The Fundamental Theorem of Calculus and antiderivatives;
- The Mean Value Theorem for integrals;
- Applying properties of integration related to elementary functions, operations on functions, and elementary substitutions;
- Applications of integration in a variety of contexts.

CS 8A. Applications.

While applying analytic, algebraic, geometric, and algorithmic techniques to solving applied problems students will:

- Use appropriate technology;
- Communicate how the problem is modeled by a mathematical formulation, and how to interpret the result of the mathematical analysis.

CS 9A. Mathematical Proof.

Students will demonstrate an understanding of mathematical proof and related concepts including:

- Analysis of the logical structure of mathematical proofs and derivations;
- Use contradictions and counter examples appropriately;
- Use mathematical induction.

CS 9B. Mathematical Proof.

Students will demonstrate an understanding of the rudiments of e,d- proofs.

MATH 2212– Content Standards

Title: Calculus of one Variable II

Course Description: Prerequisite: Math 2211
Applications and techniques of integration; transcendental and trigonometric functions; polar coordinates; infinite sequences and series; indeterminate forms; improper Integrals.

Goals.

Course Content Standards. The following content standards are offered as guidelines for assessing student progress, judging the effectiveness of instructional programs, and developing curricular units. These standards describe what a student should be able to demonstrate at the completion of the course.

The content standards are labeled CS1 through CS10 and carry a further designation such as CS1A, CS4B, or both. The “A” designation indicates topics that are used explicitly in the course, but introduced in earlier courses. Although these topics are reinforced in Math 2212, they may be considered prerequisite material. The “B” designation indicates that topics are introduced in Math 2212.

CS 1A. Quantitative Reasoning

Students will use quantitative reasoning in problem solving situations including:

- Geometric, symbolic, algebraic, and analytic representation and manipulation of quantitative information;
- Pattern recognition.

CS 2A. The Real Number System

Students will use algebraic and order properties of the real number system and subsystems of the set of real numbers.

CS 3A. Functions.

Students will use and investigate functions and related concepts including:

- Representations of functions using formulas, graphs, and parameters;
- Operations on functions defined by arithmetic operations, composition, and inversion;
- Types of elementary functions such as polynomial, rational, radical, absolute value, trigonometric, and piecewise-defined functions.
- Properties of functions and their graphs involving monotonicity, extrema, concavity, and other salient features.

CS 4A. Limits and Continuity.

Students will demonstrate knowledge of and be able to use concepts and techniques related to limits and continuity including:

- Performing analytic and graphical interpretations of concepts;
- Evaluating limits;
- Determining points of continuity/discontinuity of functions;
- Applying properties of limits and continuity related to operations on functions.

CS 4B. Limits and Continuity.

Students will evaluate limits of indeterminate form.

CS 5A. Analytic Geometry.

Students will demonstrate knowledge of and be able to use analytic geometry concepts and related techniques including conic sections.

CS 5B. Analytic Geometry.

Students will demonstrate knowledge of and be able to use representations and transformations involving rectangular and polar coordinate systems.

CS 6A. Differentiation.

Students will demonstrate an understanding of the derivative at a point, derivative functions, and related concepts including:

- Interpretation of the derivative at a point in terms of difference quotients, slopes of tangent lines and (instantaneous and average) rates of change;
- The Mean Value Theorem for derivatives and related results;
- Applying properties of differentiation related to elementary functions and operations on functions;
- Application of the derivative to investigating properties of functions;
- Implicit differentiation and differentials.

CS 6B. Differentiation.

Students will use the derivatives of exponential/logarithmic functions, and apply the technique of logarithmic differentiation.

CS 7A. Integration.

Students will demonstrate an understanding of integration and related concepts including:

- The definite integral as an accumulation of small quantities;
- The Fundamental Theorem of Calculus and antiderivatives;
- The Mean Value Theorem for integrals;
- Applying properties of integration related to elementary functions, operations on functions, and elementary substitutions;
- Applications of integration in a variety of contexts.

CS 7B. Integration.

Students will demonstrate an understanding of integration and related concepts including:

- Integrals involving exponential and logarithmic functions;
- Integration by parts and other techniques of integration;
- Evaluation of improper integrals.

CS 8B. Sequences and Series.

Students will demonstrate an understanding of sequences, series, and related concepts including:

- Limits of sequences, sums of series, and radii of convergence;
- Geometric series, alternating series, power series, and Taylor polynomials;
- Tests of convergence and absolute convergence.

CS 9A. Applications.

While applying analytic, algebraic, geometric, and algorithmic techniques to solving applied problems students will:

- Use appropriate technology;
- Communicate how the problem is modeled by a mathematical formulation, and how to interpret the result of the mathematical analysis.

CS 10A. Mathematical Proof.

Students will demonstrate an understanding of mathematical proof and related concepts including:

- Analysis of the logical structure of mathematical proofs and derivations;
- Use contradictions and counter examples appropriately;
- Use mathematical induction.
- The rudiments of e,d- proofs.

MATH 2420 – Content Standards

Title: Discrete Mathematics

As a result of completing the course Discrete Mathematics, MATH 2420, students will be able to:

1. Identify logical form, form compound statements using the connectives **and**, **or** and **not**, determine truth tables of more general compound statements, determine whether two statement forms are logically equivalent or nonequivalent, apply De Morgan's laws to form negations of **and** and **or**, determine whether a statement is a tautology or a contradiction, and use logical equivalences to simplify statement forms.
2. Determine truth tables for compound statements containing conditional and biconditional connectives, represent **if-then** as **or**, and then use this representation to negate an **if-then**statement, determine the negation, contrapositive, converse and inverse of a conditional statement, rewrite a conditional statement as an "**only if**" statement, and as sufficient and necessary conditions.
3. Determine whether and argument is valid or invalid, use valid argument forms such as modus ponens, modus tollens, etc. to do complex deductions, and illustatrate a proof by contradiction using the knights and knaves example.

4. Give the input/output table for the following gates: **OR**, **AND** and **NOT**, find a Boolean expression (input/output table, respectively) of a circuit, find a circuit corresponding to a Boolean circuit (input/output table, respectively) by finding the disjunctive-normal or sum-of-products form, determine whether two logical circuits are equivalent, and simplify a combinatorial circuit.
5. Represent a binary (hexadecimal, octal) number as a decimal number, represent a decimal (hexadecimal, octal) number in binary notation, represent a binary number in hexadecimal (octal) notation, and add and subtract binary numbers.
6. Determine the domain and the truth set of a predicate variable, identify universal and existential statements, be able to write these statements in formal and informal language, and identify universal conditional statements, negate universal and existential statements, as well as statements containing both universal and existential statements.
7. Define an even (odd) integer, prove an existential statement using an example, use a direct proof to prove universal statements such as “The sum of an even integer and an odd integer is odd”, “If the difference of any two integers is odd, then so is their sum”, etc., disprove a universal statement by an example, follow the directions for writing proofs of universal statements, and identify common mistakes in proving statements.
8. Use direct proofs or counterexamples to prove or disprove statements involving the rational numbers.
9. Use direct proofs or counterexamples to prove or disprove statements involving the divisibility of integers, and use the quotient-remainder theorem to illustrate a proof by division into cases.
10. Use methods of proofs by contradiction and contraposition to prove various statements.
11. Find the explicit formula for a sequence, and be able to do calculations involving factorial, summation and product notations.
12. Be able to prove statements using mathematical induction.
13. Determine whether one set is a subset of another, whether two sets are equal, whether an element is in a set or not, be able to determine the union, intersection, difference and complement of sets, illustrate sets using Venn diagrams, determine the Cartesian product of two or more sets, prove set identities, use set identities to derive new set properties from old set properties, use Venn diagrams to prove set identities, determine whether sets form a partition of a given set, and determine the power set of a set.
14. Determine whether a relationship is a function or not, determine the domain, co-domain, range of a function, and the inverse image of x, prove or disprove whether a function is one-to-one or not, determine whether a function is onto or not, determine the inverse of a one-to-one correspondence, determine the composition of two functions, and show that if two functions are one-to-one (onto) so too is their composition.
15. Determine the arrow diagram of a relation, whether a relation is a function or not, determine the inverse of a relation, whether a relation is reflexive, symmetric or transitive, determine the transitive closure of a relation, show that the binary relation induced by a partition is an equivalence relation, and show that the set of equivalence classes of an equivalence relation on A forms a partition of A.
16. Identify loops, parallel edges, etc. in a graph, draw the complete graph on n vertices, and the complete bipartite graph on (m,n) vertices, determine whether a graph is bipartite or not, list all the subgraphs of a given graph, determine the degree of a vertex in a graph, prove that the sum of the degrees of the vertices is equal to twice the number of edges, show that in any graph there is an even number of vertices of odd degree, apply these results, and determine the complement of a simple graph.
17. Determine whether a walk is a path, simple path, closed walk, circuit or a simple circuit, determine whether a graph is connected or not, prove that a graph has an Euler circuit if and only if the graph is connected and every vertex of the graph has even degree, determine whether a given graph has an Euler circuit and, if so, indicate one, prove that a graph has an Euler path if and only if the graph is connected and has exactly two vertices of odd degree, determine whether a given graph has an Euler path and, if so, indicate one, and determine whether a graph has a Hamiltonian circuit and, if so, indicate one.
18. Determine whether a graph is a tree or not, show that any tree with more than one vertex has two leaves, show that any tree with n vertices has n-1 edges, show that if G is an connected graph with n vertices and n-1 edges, then G is a tree, determine in a rooted tree, the root, level of a given vertex, height of the tree, children, parent, siblings, ancestors and descendants of a vertex, determine whether a given tree is a binary or full binary tree, and prove results regarding binary trees.
19. Apply Kruskal’s algorithm or Prim’s algorithm to determine a minimal spanning tree for a given graph.

MATH 3000 – Learning Outcomes

Title: Bridge to Higher Mathematics

After successfully completing Math 3000, a student should be able to:

- Develop a truth table for a logical expression
- Express the negation of a logic statement
- Correctly decide if two statements are logically equivalent
- Express the converse, inverse and contrapositive of a logic statement
- Express universally and existentially quantified statements, and their negations
- Understand the definition of a set
- Correctly express the union, intersection and complement of sets
- Do a direct proof

- Correctly decide if a given proof is valid
- Do a proof by contrapositive, contradiction or exhaustion
- Understand indexed families of sets, their unions, intersections and complements
- Do a proof using mathematical induction: the statement to be proved may be an equality or an inequality
- Correctly decide if a given relation is an equivalence relation
- Correctly determine the equivalence classes of an equivalence relation
- Understand the division algorithm and its implications in divisibility problems
- Correctly express the power set of a given set, and its cardinality
- Correctly decide if a function is one-to-one, onto, or has an inverse
- Correctly formulate the composition of two functions
- Correctly decide if a set is finite, countable or uncountable
- Correctly use the epsilon definition of greatest lower bound and least upper bound in proofs
- Correctly apply the concepts of open and closed sets to proofs
- Correctly apply the concepts of limit points, deleted neighborhoods and closure to Proofs
- Correctly decide if a sequence is monotone and/or bounded
- Prove that a sequence converges to a limit, using the definition of convergence
- Correctly decide if a function is bounded or monotone

MATH 3050 – Content Standards (Learning Outcomes)

Title: Geometry and Spatial Sense

Goal: Apply geometric concepts, properties and relations and communicate the reasoning used in the application.

Outcomes

- Describe, sort, and classify shapes.
- Investigate the results by subdividing, combining, and changing shapes.
- Construct two- and three-dimensional shapes with physical models.
- Identify, draw and interpret two- and three-dimensional shapes.
- Develop spatial sense (include *near, between,* etc.)
- Describe, model, draw, and classify shapes.
- Investigate and predict the results of combining, subdividing, and changing shapes.
- Identify, describe, and draw lines, line segments, lines of symmetry, rays, angles, and parallel and perpendicular lines.
- Relate geometric ideas to number and measurement ideas.
- Determine when figures are congruent and similar.
- Identify, describe, compare, and classify geometric figures.
- Visualize and represent geometric figures with special attention to developing spatial sense.
- Explore transformations of geometric figures.
- Determine when figures are congruent and similar.
- Represent and solve problems using geometric models.
- Understand and apply geometric properties and relationships.
- Recognize geometric relationships in the world.
- Investigate properties of triangles and develop connections among right triangle ratios.
- Represent problem situations with geometric models and apply properties of figures.
- Classify figures in terms of congruence and similarity and apply these relationships.
- Deduce properties of, and relationships between, figures from given assumptions and from using transformations.

- Deduce properties of figures using transformations.
- Synthesize geometric concepts into algebraic, functional, and problem-solving activities.
- Develop the relationship between the Golden Section and the pentagon.
- Deduce the geometry of the Fibonnaci numbers.
- Apply curved surfaces.
- Applications of geometry to Origami and Celtic knots.

MATH 3070 – Content Standards (Learning Outcomes)

Title: Introduction to Probability and Statistics

Goal 1: Use probability and statistical models to analyze data and make inferences about real-world situations.

Outcomes

- Formulate and solve problems that involve collecting, organizing, and analyzing data.
- Explore concept of fairness, uncertainty, and chance.
- Collect, organize, and describe data.
- Construct, read, and interpret displays of data, including picture, bar, circle, and line graphs.
- Formulate and solve problems that involve collecting, organizing, and analyzing data.
- Determine probability of an event.
- Explore concepts of fairness, uncertainty, and chance.
- Collect, organize, and describe data.
- Construct, read, and interpret tables, charts, and graphs.
- Apply measures of central tendency.
- Make inferences and convincing arguments and evaluate arguments that are based on data analysis.
- Recognize statistical methods and probability models as powerful decision-making tools.
- Devise and conduct experiments or simulations to determine probabilities.
- Construct a sample space to determine the theoretical probabilities.
- Make predictions that are based on experimental or theoretical probabilities.
- Construct and draw inferences from charts, tables, and graphs.
- Use curve fitting to predict from data.
- Understand and apply measures of central tendency, variability, and correlations.
- Use experimental or theoretical probability, as appropriate, to represent and solve problems involving uncertainty.
- Use and analyze probability models.
- Use descriptive and inferential statistics.

Goal 2: Use discrete mathematical algorithms and combinatorial concepts to solve problems.

Outcomes

- Represent data in tables and graphs.
- Exhibit relationships graphically.
- Use Venn diagrams and truth tables in problem solving involving set theory and logic.
- Use inductive and deductive reasoning.
- Use counting principles.
- Synthesize the use of algorithmic and combinatorial techniques into problem solving situations.

MATH 3300– Content Standards

Title: Problem Solving with Computers

- **To use technology to explore** problem solving in mathematics as
- . . . a curricular goal
- . . . an instructional strategy
- . . . the essential core of mathematics
- . . . a process for doing mathematics
- **To use technology** to solve mathematics problems.
- **To develop** a "can do" approach to mathematics problems solving.
- **To understand and describe** mathematics problem solving as more process than product.
- **To become** a mathematics problem solver.
- **To use problem contexts** to create mathematics demonstrations.
- **To use problem solving** to construct new ideas of mathematics for yourself.
- **To engage** in mathematical investigations.
- **To engage** in some independent investigations of mathematics topics from the secondary school curriculum or appropriate for that level.
- **To communicate** mathematics ideas that arise from mathematics investigations.
- **To** consider ways to **assess** problem solving performance.

MATH 3435– Content Standards

Title: Introductory Linear Algebra

Catalog course description: Prerequisites: Math 2215 and Math 3000.
Theory and applications of matrix algebra and linear transformations. Topics include linear equations, vector spaces, matrices, subspaces, and bases.

Goals

To provide students with a solid background in linear algebra and basic matrix theory, including applications.

Course Content Standards

The following standards are offered as guidelines for assessing student progress, judging the effectiveness of instructional programs, and developing curricular units. The subject matter outlined in these standards represents the minimum knowledge in which a student should demonstrate proficiency at the successful completion of the course.

- Students will be able to identify a system of linear equations and form the augmented matrix for the system.
- Students will be able to identify when a matrix is in row echelon form or reduced row echelon form.
- Students will be able to identify when an augmented matrix in row echelon form corresponds to an inconsistent system, a system with a single solution, or a system with multiple solutions.
- Students will be able to use elementary row operations to reduce an augmented matrix to row echelon form and to use the form, together with back-substitution, to solve the corresponding system.
- Students will be able to perform algebraic operations on vectors in n-dimensional space.
- Students will be able to interpret the geometric properties of vectors in R n and of algebraic operations on vectors in R n.
- Students will know the definitions of a linear combination and of the span of a set of vectors and the geometric significance of a vector being in the span of a set of vectors.
- Students will be able to represent a set of linear equations as a combination of the columns of the system matrix A and also as the matrix-vector product Ax.
- Students will recognize consistent systems as those in which the right hand side is a combination of the columns of the system matrix A.
- Students will be able to computationally determine if a given set of vectors is linearly independent and determine if a given vector is in the span of a set of vectors.
- Students will know the definition of a linear transformation and will be able to represent linear transformations as matrices.
- Students will be able to identify one to one and onto linear transformations.

- Students will be able to apply the theory of linear systems to simple applied problems.
- Students will be able to apply basic matrix operations, including products, sums and transposes.
- Students will be able to determine if two matrices are inverses of each other.
- The student will be able to deduce the uniqueness of solutions from invertibility.
- Students will be able to compute the inverse matrix using elementary row operations.
- Students will be able to apply the equivalent conditions of the invertible matrix theorem to determine if matrices are invertible.
- Students will be able to apply the definition of the determinant to compute the determinant of a matrix.
- The student will know the effect of elementary row operations on the determinant.
- Students will be able to compute determinants using elimination.
- Students will know the properties and definition of a vector space and be able to apply these properties in computations involving vectors.
- Students will be able to tell if a given set is a subspace.
- Students will be able to find the null space and column space of a matrix and be able to relate them to kernel and range of a linear transformation.
- Students will be able to apply the definition of linear independence and to recognize linearly independent and linearly dependent sets of vectors.
- Students will be able to recognize a basis for a subspace and be able to construct a basis for the span of a set of vectors.
- Students will be able to define a coordinate system with a basis and be able to find the coordinates of a vector with respect to a given basis.
- Students will be able to change a basis and represent the basis change as a matrix.
- Students will be able to determine the dimension of a subspace.
- Students will be able to compute the rank of a matrix and to relate the rank to the dimension of the null and column spaces of a matrix.
- Students will be able to describe a Markov chain using its probability transition matrix.
- Students will be able to find the steady state of a Markov chain.

MATH 4441/6441– Content Standards

Title: Abstract Algebra I

Prerequisite: Math 3435 with grade C or higher.

Axiomatic approach to algebraic structures, groups, permutations, homomorphisms, and factor groups.

Goals

To provide students with a solid background in abstract algebra including an axiomatic approach to algebraic structures, groups, permutations, homomorphisms, and factor groups.

Content Standards

The following standards are offered as guidelines for assessing student progress, judging the effectiveness of instructional programs, and developing curricular units. The subject matter outlined in these standards represents the minimum knowledge in which a student should demonstrate proficiency at the successful completion of the course.

1. Elements of set theory.

2. Equivalence and order relations.

3. Semigroups, monoids.

4. Groups, subgroups, normal subgroups, Lagrange's theorem. Construction of the integers.

5. Homomorphisms, isomorphisms, kernel, image.

6. Quotient groups.

7. Isomorphisms theorems for groups.

8. Center, normalizer, centralizer.

9. Direct products.

10. Cauchy's theorem.

11. Permutation groups.

12. Structure of finitely generated abelian groups (time permitting).

13. Action of groups on sets, Sylow theorems, semidirect products (time permitting).

.A higher level of proficiency will be required for those enrolled in Math 6441.

MATH 4544/6544, Biol 4744/6744 – Learning Outcomes

Title: Biostatistics

- Students will be able to use descriptive statistics to analyze categorical and continuous data.
- Students will have the ability to use a popular statistical analysis software package, such as SAS, Excel.
- Students will understand measures of validity of medical test results including sensitivity, specificity, predictive value and others in practice.
- Students will understand the basic concept of probability theory.
- Students will understand the most commonly used discrete and continuous probability distributions.
- Students will understand how to design randomized clinical trials.
- Students will be able to construct confidence intervals for population proportions, means and variances.
- Students will be able to interpret and draw conclusions from the results of hypothesis testing.
- Students will be able to make comparisons by using two-sample inference.
- Students will understand real problems and then appropriately use data analysis, statistical methods and computer software in solving the problems.
- Students will be able to appreciate the role of statistics in medicine and biological science.
- Students will know when and how to apply basic biostatistical methods.

Assessment of Learning Outcomes

Assessment of Student Learning will be accomplished by utilizing assessment tools such as*Quizzes, Homework Assignments, Written Exams,* and *Computer project.*

- Quizzes are used to assess students' understanding of newly presented topics and previously covered material.
- Homework Assignments serve as both learning and assessment tools for understanding and getting familiar with the materials covered in class.
- Written Exams will be taken to evaluate the effectiveness of students learning. The exams provide opportunities for students to apply the statistical methods learned in class in the fields of medicine and biological science.
- Computer project is designed for students to assess the ability to define a problem and determine appropriate use of data mining and statistical methods for solving the problem.

MATH 4547/6547– Learning Outcomes

Title: Introduction to Statistical Methods

- Students will understand graphical methods of describing data sets and be able to calculate and interpret numerical descriptive statistical measures.
- Students will understand basic probability theory, including rules for finding probabilities of complex events, conditional probability, and probabilities for repeated independent and dependent trials.
- Students will understand the concepts of sampling, including the use of random number tables to select samples.
- Students will understand the probability distributions of discrete random variables, including calculation of means and variances of such distributions.
- Students will understand the binomial probability distribution, including calculation of probabilities, means, and variances.
- Students will understand the use of density functions to describe distributions of continuous random variables.
- Students will be able to calculate probabilities and percentiles for random variables with uniform and normal probability distributions.

- Students will be able to use the normal distribution to approximate binomial probabilities.
- Students will understand the concept of sampling distribution of a statistic and be able to calculate the sampling distribution for simple sampling situations.
- Students will understand the Central Limit Theorem and be able to use it to find probabilities for sample statistics.
- Students will be able to use confidence intervals to estimate unknown population means using large or small samples (with z- or t-distributions) for numerical variables and to estimate unknown proportions in populations for categorical variables.
- Students will understand the concept tests of hypotheses and be able to perform hypothesis tests for means and proportions for one-sample data.
- Students will be able to extend confidence intervals and tests of hypotheses to two-sample situations, including differences in means and proportions for independent samples and differences in means for paired data.
- Students will understand the multinominal probability model and will be able test hypotheses for categorical data in one-way and two-way tables using chi-squared methods.
- Students will be able use the SAS computer software system for basic statistical calculations and basic inferential procedures.

Assessment of Learning Outcomes

Problems based on the learning outcome objectives will be assigned on a regular basis and may appear in a variety of contexts

- Homework problems serve as both learning and assessment tools for both familiarization with and understanding of the topics covered. Evaluation of homework may include grading of assignments or quizzes covering homework assignments.
- Classroom discussion of homework problems and other topics provides additional assessment of students' understanding of the topics covered.
- Questions in class are used to assess the students' understanding of concepts covered.
- Computer assignments will be used to evaluate the students' ability to use the SAS computer software system.
- Midterm and final examinations will be used to evaluate the students' mastery of the topics covered.

MATH 4548/6548 – Learning Outcomes

Title: Methods of Regression and Analysis of Variance

- Students will understand how to conduct inferences and interpret tests for the slope, intercept, and the regression line in straight-line linear regression analysis.
- Students will understand the relationship between the correlation coefficient and straight-line regression analysis.
- Students will be able to conduct tests of hypothesis and construct confidence intervals for the correlation coefficient of one population and the difference between the correlation coefficients of two populations.
- Students will understand and apply the assumptions concerning multiple regression analysis and the analysis of variance table for a multiple regression.
- Students will be able to conduct test of hypothesis in a multiple regression such as the test for significant overall regression, partial and multiple partial *F*-tests.
- Students will be able to compute multiple, partial and multiple partial correlation coefficient coefficients and conduct the corresponding *F*-tests.
- Students will be able to determine interaction and confounding in regression.
- Students will be able to apply regression diagnostics that include residual analysis to treat outliers and collinearity and scaling problems.
- Students will be able to use dummy variables in the comparison two straight lines and in the comparison of four regression equations.
- Students will be able to select the best regression equation using procedures such as the step-wise, forward elimination, the backward elimination and the all-possible regression procedures.
- Students will be able to conduct one-way and two-way analysis of variance with multiple comparisons.

Assessment of Learning Outcomes

Problems based on the learning objectives will be assigned on a regular basis and may appear in a variety of contexts:

- *Quizzes* are used to assess students' understanding of newly presented topics and previously covered material.
- *Programming assignments in SAS* are designed to assess the students' ability to analyze the various data output and to draw inferences from the outputs.
- *Take-home Exams* are course projects. They provide an opportunity for students to work on more complicated problems that involve large data sets and to effectively apply various methods learned in class to solve these problems. The take-home exams are also used to determine whether the students learned the statistical methods.

- *Presentations* are designed to assess the students' ability to express their thought clearly and to demonstrate their understanding of the ideas covered.
- *Homework problems* are important and essential in the course. They provide a tool for immediate assessment of students' understanding of basic concepts and theory underlying multiple regressions.

CSc/MATH 4610– Learning Outcomes

Title: Numerical Analysis I

- Students will understand the basic theory of and use *O* notation appropriately.
- Students will understand floating-point arithmetic including issues of overflow and underflow.
- Students will understand the different issues surrounding errors in using numerical methods including machine epsilon, error analysis, convergence, rounding error, truncation error, and norms.
- Students will understand the difficulties involved in finding reliable solutions as well as be able to apply various methods for estimating errors in solutions in order to judge how reliable those solutions are.
- Students will understand conditioning of problems and stability of algorithms and the difference between the two.
- Students will be able to compute a Taylor polynomial and bound its error term.
- Students will be able to apply iterative methods, including Bisection, Newton, Secant and Fixed Point, to compute solutions of nonlinear equations to within a specified tolerance
- Students will be able to construct polynomial and piecewise polynomial interpolants of functions of one or two variables in a variety of ways including Lagrange Interpolants, Divided Differences, Chebychev polynomials, and Splines.
- Students will be able to derive approximation formulae for derivatives using Taylor's Theorem and use these formulae and their error bounds.
- Students will be able to o btain approximate values of definite integrals in one or two dimensions, as well as bound their error terms, via Newton-Cotes methods, Gaussian Quadrature methods, and Adaptive methods.

Assessment of Learning Outcomes

Problems based on the learning objectives will be assigned on a regular basis and may appear in a variety of contexts:

- Classroom discussion provides an indication of the students' understanding of newly presented topics, of old material, and of their ability to relate new topics to old ones. Class meetings may involve a combination of lecture, questions and discussion, and small group work.
- Homework problem sets serve as both learning and assessment tools for understanding how numerical methods work and for their theoretical underpinnings. Homework is an important part of the course (numerical work is done to illustrate concepts and justification for the ideas behind the methods is investigated)
- Programming assignments are designed to assess the students' ability to synthesize the ideas discussed in class by writing programs that solve problems for which numerical solution has clear advantages over analytical techniques. The analysis of the output of these programs will give students the opportunity to compare the accuracy of their implementation of numerical schemes to theoretical bounds.
- Exams may be in-class, take-home or both. In-class exams give students the opportunity to demonstrate their ability to work simple problems and to demonstrate their understanding of fundamental concepts. Take-home exams provide the opportunity for students to delve more deeply into the subject, to work more complicated problems, and thus arrive at a deeper understanding of the material. The exams are used to determine whether the student understands the concepts behind the methods.

CSc/MATH 4620– Learning Outcomes

Title: Numerical Analysis II

- Students will understand the basic theory of and use *O* notation appropriately. Students will understand floating-point arithmetic including issues of overflow and underflow.
- Students will understand the different issues surrounding errors in using numerical methods including machine epsilon, error analysis, convergence, rounding error, truncation error, and norms.
- Students will understand the difficulties involved in finding reliable solutions as well as be able to apply various methods for estimating errors in solutions in order to judge how reliable those solutions are.
- Students will understand conditioning of problems and stability of algorithms and the difference between the two.
- Students will be able to compute a Taylor polynomial and bound its error term.
- Students will be able to apply methods to compute solutions of systems of linear equations via Gaussian Elimination (including pivoting), Iterative techniques (Gauss-Seidel, Jacobi, SOR), and Least Squares.

- Students will be able to obtain approximate solutions to Initial Value Problems via Euler's method, Runge-Kutta methods, and Multi-step methods.
- Students will be able to obtain approximate solutions to Boundary Value Problems via Difference methods and Shooting methods.
- Students will be able to o btain approximate solutions of Partial Differential Equations using finite difference methods including Explicit methods, Implicit Methods, and Iterative methods.

Assessment of Learning Outcomes

Problems based on the learning objectives will be assigned on a regular basis and may appear in a variety of contexts:

- *Classroom discussion* provides an indication of the students' understanding of newly presented topics, of old material, and of their ability to relate new topics to old ones. Class meetings may involve a combination of lecture, questions and discussion, and small group work.
- *Homework problem sets* serve as both learning and assessment tools for understanding how numerical methods work and for their theoretical underpinnings. Homework is an important part of the course (numerical work is done to illustrate concepts and justification for the ideas behind the methods is investigated)
- *Programming assignments* are designed to assess the students' ability to synthesize the ideas discussed in class by writing programs that solve problems for which numerical solution has clear advantages over analytical techniques. The analysis of the output of these programs will give students the opportunity to compare the accuracy of their implementation of numerical schemes to theoretical bounds.
- *Exams* may be in-class, take-home or both. In-class exams give students the opportunity to demonstrate their ability to work simple problems and to demonstrate their understanding of fundamental concepts. Take-home exams provide the opportunity for students to delve more deeply into the subject, to work more complicated problems, and thus arrive at a deeper understanding of the material. The exams are used to determine whether the student understands the concepts behind the methods.

MATH 4661 – Content Standards

Title: ADVANCED CALCULUS I
(We propose the title be changed to Mathematical Analysis I.

Catalog Description: The real number system, basic topology of metric spaces, sequences and series, limits and continuity.
Prerequisite: Math 3435. Corequisite: Math 4435.

Goals: Students will study the fundamental concepts of and results in Mathematical Analysis. They will gain a deeper insight into the subject including sequences and series, limits and continuity in the setting of metric spaces. Students will be introduced to the basic proof techniques in Mathematical Analysis. They will be required to present proofs.

CS 1. The Real Number System.

Students will demonstrate an understanding of the axiomatic structure of the real number system. This includes notions such as countable and uncountable sets, completeness and ordering principles, and Cantor sets.

CS2. Topology of Metric Spaces.

Students will exhibit knowledge of metric properties and topological concepts including open and closed sets, compact and connected sets in the context of metric spaces.

CS3. Sequences.

Students will understand and be able to use various concepts regarding sequences such as the limit of a sequence, subsequences, Cauchy sequences, comparison theorems, and the Bolzano-Weierstrass Theorem.

CS4. Series.

Students will demonstrate an understanding of the main theorem on convergence of series, and notions like positive series, absolutely convergent series, alternating series, and power series. They should be able to apply various criteria for convergence of a series.

CS5. Limits and Continuity.

Students will be familiar with the rigorous epsilon and delta treatment of limits of functions between metric spaces and different characterizations of continuity. They will understand the notion of uniform continuity, will know the properties of continuous function on compact and connected sets, and will be able to classify discontinuities of real functions.

CS6. Mathematical Proofs.

All results in this course will be rigorously proven. Students will develop an ability to read, understand, and reproduce proofs in this course.

MATH 4662– Content Standards

Title: ADVANCED CALCULUS II (We proposed title be changed to MATH ANALYSIS II).

Catalog Description: The real number system, basic topology of metric spaces, sequences and series, limits and continuity.

Catalog Description: Differentiation of real functions, Riemann integrals, sequences and series of functions, differentiation and integration of functions of several variables.

Prerequisite: Math 4661.

Goals: This courseis a continuation of Math 4661and is aimed at presenting further

fundamental results in Mathematical Analysis in the area of differentiation, Riemann integration, sequences and series of functions, and functions of several variables. Students will be introduced to new proof techniques in analysis.

CS 1. Differentiation.

Students will understand the concept of derivative of a real function and different Mean-Value Theorems and their consequences. They will also understand and be able to apply L'Hospital's Rule and various theorems involving derivates of higher order.

CS2. Integrability.

Students will demonstrate an understanding of the rigorous treatment of the Riemann Integral based on Riemann and Darboux sums, the properties of the integral, and the Fundamental Theorem of Calculus.

CS3. Sequences and Series of Functions.

Students will exhibit understanding of the concepts of pointwise and uniform convergence of sequences of functions and uniform convergence of series of functions. They will be able to apply theorems on uniform convergence of sequences of continuous, differentiable, and integrable functions as well as power and Taylor series, respectively analytic functions.

CS4. Functions of Several Variables.

Students will understand the generalization of the concept of derivative and Riemann integral to several variables.

CS5. Mathematical Proofs.

All results in this course will be presented with proofs. Students will further develop their ability to read, understand, and reproduce proofs in the area of Mathematical Analysis. They will become familiar with various new proof techniques.

MATH 4751/6751– Learning Outcomes

Title: Mathematical Statistics I

- Students will understand the basic probability theory.
- Students will understand the concepts of probability distributions and distribution functions.
- Students will understand how the most commonly used discrete as well as continuous distributions arise in the real world.
- Students will understand the random variables and their distributions.
- Students will understand the concept of joint distributions.
- Students will understand the mathematical expectations of random variables.
- Students will understand the moments, joint moments and moment generating functions of the random variables.
- Students will be able to apply the various techniques they learned in calculus to the field of Statistics.
- Students will be able to derive the marginal and conditional distributions from the joint distributions.
- Students will be able to derive the distributions of the functions of random variables by various different methods.

Assessment of Learning Outcomes

Problems based on the learning objectives will be assigned on a regular basis and may appear in variety of contexts:

- Homework problems serve as both learning and assessment tools for understanding and getting familiar with the topics covered. Working on the homework problems is very important in order to mastering the material.
- Classroom discussion of the problems provides an indication of students' understanding of the topics covered previously. It also can stimulate students' thinking on the new topics.
- Classroom questions are designed to assess the students' ability of theoretical thinking and concept understanding.

- Giving in-class exams is one of the most powerful methods of encouraging students to study the material covered in class. The exams are used to determine whether the students understand the concepts of chance mechanism and other important materials.

MATH 4752/6752– Learning Outcomes

Title: Mathematical Statistics II

- Students will understand the concepts of sampling distributions and central limit theorem.
- Students will understand the concepts of parameter estimation and various criteria to gauge the estimators.
- Students will be able to derive the maximum likelihood estimates for the parameters of various distributions.
- Students will be able to construct confidence intervals for the parameters of various distributions.
- Students will understand the concept of statistical hypothesis testing.
- Students will be able to derive the likelihood ratio test statistics.
- Students will be able to perform various statistical tests concerning means, proportions, variances and correlations.
- Students will be able to perform statistical tests involving contingency tables and goodness-of-fit.
- Students will understand the concept of regression analysis.
- Students will be able to obtain the least squares estimations, and perform the statistical inferences in a simple linear regression.

Assessment of Learning Outcomes

Problems based on the learning objectives will be assigned on a regular basis and may appear in variety of contexts:

- Homework problems serve as both learning and assessment tools for understanding and getting familiar with the topics covered. Working on the homework problems is very important in order to mastering the material.
- Classroom discussion of the problems provides an indication of students' understanding of the topics covered previously. It also can stimulate students' thinking on the new topics.
- Classroom questions are designed to assess the students' ability of theoretical thinking and concept understanding.
- Giving in-class exams is one of the most powerful methods of encouraging students to study the material covered in class. The exams are used to determine whether the students understand the concepts of chance mechanism and other important materials.