Learning Outcomes for Mathematics and Statistics Classes

Pending approval by the Department of Mathematics and Statistics
Intended for the 2023-2024 Academic Year

1 Introduction

We begin with the Learning Outcomes for our LOPER 4 General Studies classes, followed by our Learning Outcomes for our two Experiential Learning classes. After that, we list the Learning Outcomes for our developmental classes, followed by our MATH and STAT classes in numerical order.

Finally, for our LOPER 4 General Studies classes, we give the class specific Learning Outcomes and detail the course concepts and assessments that are used to satisfy the LOPER 4 General Studies Learning Outcomes.

2 General Studies Mathematics and Statistics Classes

Our LOPER 4 General Studies classes are **MATH 102** (College Algebra), **MATH 103** (Plane Trigonometry), **MATH 106** (Mathematics for Liberal Arts), **MATH 115** (Calculus I with Analytic Geometry), **MATH 120** (Finite Mathematics), **MATH 123** (Applied Calculus I), **MATH 230** (Math for Elementary Teachers I), **STAT 235** (Introduction to Statistics for Social Sciences), and **STAT 241** (Elementary Statistics). The learning outcomes for LOPER 4 classes are

(1) Can describe problems using mathematical, statistical, or programming language.

(2) Can solve problems using mathematical, statistical, or programming techniques.

(3) Can construct logical arguments using mathematical, statistical, or programming concepts.

(4) Can interpret and express numerical data or graphical information using mathematical, statistical, or programming concepts and methods.

3 Experiential Learning Mathematics and Statistics Classes

Our Experiential Learning (EL) classes are **MATH 300** (Tutoring in Mathematics) and **MATH 390** (Research Experience in Mathematics). The learning outcomes for Experiential Learning classes are

(1) Student reflects critically on their experience, describing the experience including reactions, observations, and thoughts.

(2) Student reflects critically on their experience, articulating connections between experiential learning activities and coursework.

(3) Student communicates effectively verbally and/or in writing.

(4) Student demonstrates dispositions appropriate to their chosen field.

(5) Student demonstrates mastery of the practical use of skills within their chosen field.

The course specific Learning Outcomes for MATH 300 are

(1) Student reflects critically on their tutoring experience, describing the experience including reactions, observations, and thoughts on tutoring students in mathematics.

(2) Student reflects critically on their tutoring experience, articulating connections between experiential learning in tutoring and their coursework in mathematics.

(3) Student communicates mathematical concepts, ideas, methods, and results effectively in oral form.

(4) Student demonstrates dispositions appropriate to mathematics and tutoring of peers.

(5) Student demonstrates mastery of the practical use of mathematical skills and tutoring skills to support peers' learning.

And for MATH 390, our course specific Learning Outcomes are

(1) Student reflects critically on their research experience, describing the experience including reactions, observations, and thoughts on research problems in mathematics.

(2) Student reflects critically on their research experience, articulating connections between experiential learning in mathematical research and their coursework in mathematics.

(3) Student communicates mathematical concepts, ideas, methods, and results effectively in both oral and written form.

(4) Student demonstrates dispositions appropriate to mathematics and possibly other related areas (e.g., physics, computer sciences, etc.).

(5) Student demonstrates mastery of the practical use of mathematical skills in solving research problems.

4 Learning Outcomes for Developmental Classes

4.1 MATH 90, Elementary Algebra

On completion of this course, students will be able to

(1) Translate written sentences to algebraic expressions and solve applied problems.

(2) Understand arithmetic operations on whole numbers, fractions, decimals, and percents.

(3) Simplify algebraic expressions and solve linear and quadratic equations.

(4) Apply factoring techniques for quadratics and for the prime factorization of whole numbers.

(5) Identify, write, and graph linear equations and introduce the quadratic.

(6) Apply algebraic operations to polynomials and rational expressions.

4.2 MATH 101, Intermediate Algebra

On completion of this course, students will be able to

(1) Solve linear equations and inequalities.

(2) Set up and solve applications with linear equations.

(3) Apply operations to polynomial and rational expressions.

(4) Factor polynomials.

(5) Simplify rational expressions and solve rational inequalities.

(6) Use the properties of exponents to simplify expressions.

(7) Solve radical equations.

(8) Analyze quadratic expressions and equations algebraically and graphically.

4.3 MATH 104, Concepts in Mathematics and Statistics

On completion of this course, students will be able to

(1) Identify, write, and graph linear functions.
(2) Write and graph quadratic functions.
(3) Solve linear and quadratic equations and inequalities.
(4) Solve two-variable systems of linear equations.
(5) Determine probabilities for independent events.
(6) Use the multiplication principle, permutations, and combinations.
(7) Use measures of center including mean, median, and mode.
(8) Use measures of variation including standard deviation, range, and variance.
(9) Describe distributions and create box plots.

5 Learning Outcomes for Mathematics Major Sequence Classes

5.1 MATH 202, Calculus II with Analytic Geometry

On completion of this course, students will be able to

(1) use definite integrals to solve problems involving volume, arc length, surface area, work, and center of mass.
(2) use integration by parts, trigonometric substitution, and partial fractions to evaluate definite and indefinite integrals.
(3) apply the concepts of limits, convergence, and divergence to evaluate improper integrals.
(4) determine convergence or divergence of sequences and series.
(5) use Taylor and MacLaurin series to represent functions and integrate functions.
(6) use parametrizations and polar coordinates to find areas and arc lengths.

5.2 MATH 250, Foundations of Math

On completion of this course, students will

(1) gain an understanding of naïve set theory.
(2) gain an understanding of symbolic logic, quantifiers, and functions.
(3) gain an understanding of direct proofs, proofs by contradiction, proofs by contrapositive, and proofs by induction.
(4) gain the ability to read and understand mathematical proofs.
(5) gain the problem-solving skills that are needed to create a mathematical proof.

5.3 MATH 251, Inquiry and Proof in 9–12 Mathematics

On completion of this course, students will be able to

(1) Articulate and utilize mathematical practices essential for 9–12 mathematics.
(2) Articulate the roles proof can play in secondary mathematics instruction.
(3) Engage in mathematical inquiry using technological and mathematical tools.

(4) Articulate mathematical arguments with precise mathematical language and symbols.

(5) Communicate technical mathematical justifications in a manner appropriate for secondary students.

(6) Determine how essential understanding of proof is embedded across mathematical content.

5.4 MATH 260, Calculus III

On completion of this course, students will

(1) be able to use vectors to solve geometric problems and basic engineering statics problems.

(2) understand the concept of partial derivatives and limits of multivariable functions.

(3) understand the concept of a parameterized curve and understand the concept of curvature.

(4) be able to use partial derivatives to solve multivariable optimization problems.

(5) understand the concept of a line integral and apply it to basic physics problems involving energy and work.

(6) be able to set up and evaluate multiple integrals using Cartesian, polar, and spherical coordinates to find volumes, surface areas, centroids, and moments of inertia.

(7) understand the concepts of the vector divergence, gradient, and curl in three-dimensional space.

(8) understand the Green theorem and the Divergence theorem and be able to apply these theorems to problems involving surface and line integrals.

5.5 MATH 270, Methods in Middle and High School Mathematics Teaching I

On completion of this course, students will be able to

(1) Thoroughly describe what is meant by "doing, teaching, and learning" mathematics in their own words and with the support of mathematics educational research.

(2) Explain and provide real-life examples of the eight research-based mathematics teaching practices.

(3) Identify and begin creating opportunities for high-quality instruction that includes mathematical discourse, productive struggle, purposeful questioning, and the connecting of multiple representations.

(4) Articulate the essential mathematical concepts of 6–12 mathematics curriculum in regard to number, algebra/functions, statistics/probability, and geometry/measurement.

(5) Explain the organization and benefits of the NCTM Standards, the Common Core State Standards, and the Nebraska State Standards.

(6) Explain the history and current trends in mathematics education.

(7) Define NCTM and NATM, explain membership benefits associated with each organization, and articulate the importance of professional affiliations.

(8) Build upon foundational understanding of mathematics education and research-based mathematics teaching.

(9) Be reflective of your own learning and realize how his/her own understanding influences student learning.

5.6 MATH 271, Field Experience in Middle and High School Mathematics I

On completion of this course, students will be able to

(1) Identify research-based mathematics teaching practices that are included in the classroom, as well as how they could be incorporated.

(2) Engage 6–12 students in developmentally appropriate mathematical activities.

(3) Work with a diverse range of students individually, in small groups, and in large class settings.

(4) Plan, facilitate, and reflect upon mathematical tasks that promote reasoning and sense making.

(5) Collect and analyze data to determine if 6–12 students have built new knowledge.

(6) Meet expectations of all Teacher Education Dispositions, including

   (a) Demonstrate effective oral communication skills
   (b) Demonstrate effective written communication skills
   (c) Demonstrate professionalism
   (d) Demonstrate a positive and enthusiastic attitude
   (e) Demonstrate preparedness in teaching and learning
   (f) Exhibits an appreciation of and value for cultural and academic diversity
   (g) Collaborates effectively with stakeholders
   (h) Demonstrates self-regulated learner behaviors/takes initiative
   (i) Exhibits the social and emotional intelligence to promote personal and educational goals/stability

5.7 MATH 280, Linear Algebra

On completion of this course, students will

(1) Be able to solve systems of linear equations using multiple methods, including row reduction to echelon form, row reduction to reduced echelon form, and multiplication by a matrix inverse.

(2) Be able to carry out matrix operations, including finding sums, products, transposes, inverses, and determinants of matrices.

(3) Demonstrate an understanding of the concepts of vector space and subspace.

(4) Demonstrate an understanding of linear independence, span, and basis.

(5) Be able to determine eigenvalues and eigenvectors and solve eigenvalue problems.

(6) Be able to apply the principles of matrix algebra to linear transformations.

(7) Demonstrate an understanding of inner products and their associated norms.

5.8 MATH 304, Introduction to Cryptography

On successful completion of this course, students will be able to

(1) use congruences, primes, the Chinese Remainder Theorem, Euler's formula, quadratic reciprocity, group theory, combinatorics, probability, and elliptic curves in cryptosystems and digital signature schemes,

(2) understand the complexity of primality testing, factorization, discrete logarithm, and other important processes in cryptography,

(3) carry out relatively small examples of various encryption/decryption algorithms and digital signature schemes.

5.9 MATH 305, Differential Equations

On completion of this class, students will

(1) Know the basic methods for solving first order differential equations (ODEs).
(2) Be able to set up and solve applied problems involving first order ODEs.
(3) Know the basic methods for solving second order ODEs.
(4) Know the basic methods for solving systems of first order ODEs.
(5) Be able to solve initial value problems for first and second order ODEs and for systems of ODEs.

5.10 MATH 310, College Geometry

On completion of this course, students will be able to

(1) understand the basic definitions, axioms, and important theorems in neutral geometry.
(2) compare Euclidean geometry, hyperbolic geometry, and elliptical geometry.
(3) use the axiomatic or transformational approach to prove theorems in neutral/Euclidean geometry.
(4) use interactive geometry software for constructions in plane geometry, and explain geometric concepts and results in concrete models.

5.11 MATH 313, Graph Theory

On completion of this course, students will be able to

(1) Understand the fundamental definitions and concepts of Graph theory.
(2) Understand trees and distance in a graph and including understanding Dijkstra's algorithm.
(3) Gain a basic understanding of matchings and graph factors
(4) Understand the main theorems about connectivity in graphs including max flow-min cut and the Ford Fulkerson algorithm.
(5) Gain a basic understanding of graph colorings and how the greedy coloring algorithm runs on interval graphs.
(6) Understand planarity and planarity testing algorithm from Demoucron, Malgrange, and Pertuiset.
(7) Gain a basic understanding about random graphs and probabilistic graph theory, including the Erdós-Rényi model.

5.12 MATH 330, Math for Elementary Teachers II

On completion of this course, students will be able to

(1) Explain and perform operations with fractions and decimals.
(2) Apply understanding of ratios, percentages, and proportions to real-life situations.
(3) Identify, categorize, compare and contrast various shapes and solids.
(4) Determine the area, surface area, and volume of two and three-dimensional objects.
(5) Approach mathematics problems using a variety of methods.
(6) Explain mathematical concepts to students at their level of understanding.

5.13 MATH 350, Abstract Algebra

On completion of this course

(1) Students will be familiar with and able to grasp algebraic mathematical structures.

(2) Students will be able to understand the concept of equivalence relation by applying different examples to the definition.

(3) Students will be able to rigorously prove theorems in all the standard ways including using mathematical induction, some other direct method, and using proof by contradiction.

(4) Students will have a firm grasp on Group theory including cyclic groups, permutation groups, homomorphisms, normal subgroups, and simple groups, with some real world applications of groups acting on a set.

(5) Students will have an understanding of the differences between rings, integral domains, unique factorization domains, Euclidean domains, and fields.

(6) Students will comprehend correct proofs of formal statements and be able to formulate some of the proofs clearly and concisely.

5.14 MATH 365, Complex Analysis

On completion of this course, students will

(1) be able to represent complex numbers algebraically and geometrically.

(2) be able to use the definition of the limit to prove that a function has a limit.

(3) be able to find derivatives of complex valued functions from the limit definition.

(4) understand the connection between the complex exponential and the trigonometric functions and be able to prove trigonometric identities using these connections.

(5) be able to use the Cauchy-Riemann equations to determine if a function is analytic.

(6) be able to represent functions using Laurent and power series and be able to find function residues, poles, and pole order.

(7) be able to evaluate contour integrals using residues.

(8) understand the Cauchy integral formula and its consequences, including the fundamental theorem of algebra.

5.15 MATH 395, Introduction to Mathematical Research

On completion of this course, students will

(1) become familiar with the basic design of a research paper in Mathematics or Mathematics Education.

(2) become familiar with the library databases for journals, online journals, and online paper repositories.

(3) conduct a literature search to identify areas of interest and a paper to analyze.

(4) gain a satisfactory understanding of the paper through studying the paper and researching the topic through library, online, and bibliography resources.

(5) identify an area in the paper where additional work could be done or questions could be asked to further research/generalizations.

(6) be reflective on the process and next steps for research.

5.16 MATH 399, Internship

The Learning Outcomes are the following:

(1) Write a two-page description of the activities of the internship.

(2) Give three examples in which topics you learned in undergraduate mathematics courses came up and/or were used in an activity of the internship. Describe and discuss. If three examples cannot be given, list one, or two, if possible, and say that there were less than three.

(3) Give any examples of mathematical topics that came up and/or were used in an activity of the internship that you had not seen before. Describe and discuss.

(4) Describe two jobs and/or careers for which the experience of the internship made you more qualified than you were before.

(5) Fill in the blank: I would have been better prepared for the internship if I had previously _____.

(6) Fill in the blank: My next step(s) in developing a career path is(are) _____.

5.17 MATH 400, History of Mathematics

On completion of this course, students will

(1) understand the progression of mathematics through history.

(2) understand the history of a variety of mathematical topics.

(3) gain an understanding of several mathematicians through history.

5.18 MATH 404, Theory of Numbers

On completion of this course, students will be able to

(1) explain the concepts of divisibility, prime number, and congruence.

(2) calculate the greatest common divisor using the Euclidean algorithm and the prime factorization.

(3) solve linear congruence and quadratic congruence equations.

(4) understand Wilson's Theorem and Fermat's Little Theorem.

(5) compute Euler's torsion function and other important multiplicative functions.

(6) use primitive roots and index arithmetic to solve higher-order congruence equations.

(7) solve linear Diophantine equations and find primitive Pythagorean triples.

(8) understand how rational numbers are related to repeating decimals and continued fractions.

5.19 MATH 413, Discrete Mathematics

On completion of MATH 413, students will

(1) gain an understanding of counting principles and how to apply them.

(2) gain an understanding of discrete structures and how to use and analyze them, including induction, recursion, and probabilistic methods.

5.20 MATH 420, Numerical Analysis

On completion of this course, students will

(1) understand IEEE arithmetic and know the rules for accurate computation.

(2) understand the concepts of linear and quadratic convergence and use these concepts to analyze the efficiency of an algorithm.

(3) develop an understanding of the algorithms for solving linear and nonlinear equations, interpolation, quadrature, least squares methods, and solution of differential equations.

(4) be able to use a programming language and graphical tools to solve problems numerically.

5.21 MATH 430, Middle School Mathematics

On completion of this course, students will be able to

(1) Conceptualize the real number system, including rational and irrational numbers.

(2) Explain algebraic procedures (i.e. solving equations/inequalities, laws of exponents).

(3) Simplify exponential and radical expressions.

(4) Apply transformation properties of congruent and similar figures.

(5) Identify and interpret graphs and functions.

(6) Compare and contrast different types of functions.

(7) Apply the Pythagorean Theorem to variety of situations.

(8) Use the coordinate plane to solve problems and display mathematics.

(9) Calculate, display, and interpret statistical measures.

(10) Perform probability simulations and interpret results.

(11) Approach mathematical problems using a variety of methods.

(12) Use various teaching models and techniques of curriculum delivery including effective questioning, cooperative learning, inquiry, and constructivist learning.

(13) Explain mathematical concepts to students at their level of understanding.

(14) Be reflective of your own learning and realize how his/her own understanding influences student learning.

5.22 MATH 445, Actuarial Science Seminar

This course will help prepare the student to take the Actuarial exam P1.

5.23 MATH 460, Advanced Calculus I

On completion of this class, students will

(1) be able to prove basic propositions that involve the fundamentals of point set topology, including the concepts of open sets, closed sets, boundary points, and limit points.

(2) be able to prove basic propositions that involve the concept of the infimum and supremum.

(3) demonstrate competence with basic properties of sequences including determining convergence and proving results involving the sum, difference, product, and quotient of sequences.

(4) be able to use the definitions of continuity, uniform continuity, the limit, and the derivative to prove basic propositions involving these concepts as well as be able to prove facts about specific functions.

(5) demonstrate the ability to use the Mean Value Theorem to prove theorems.

(6) be able to define and evaluate the lower, upper, and general Riemann sums.

(7) demonstrate a solid understanding of the fundamental theorem of calculus.

5.24 MATH 465, Advanced Study in 9–12 Mathematics

On completion of this course, students will be able to

(1) Connect higher level content knowledge to essential content in secondary mathematics.

(2) Explain the impact of higher-level mathematical content knowledge on their teaching of high school students.

(3) Articulate and utilize mathematical practices essential for 9–12 mathematics.

(4) Describe essential understandings for 9–12 students in number theory, algebra/functions, statistics, probability, and calculus.

(5) Demonstrate the interconnectedness of mathematics among mathematical ideas.

(6) Utilize technological tools to explore essential mathematical content in number/quantity, algebra, statistics/probability, and calculus.

5.25 MATH 470, Methods in Middle and High School Mathematics Teaching II

On completion of this course, students will be able to

(1) Develop effective unit and lessons that support district, state and national standards and are developmentally appropriate.

(2) Incorporate various forms of communication and connections (including within the subject area, to other disciplines and to real life) into lessons.

(3) Diagnose and assess student performance in a variety of ways, including formative, summative, open-ended, and performance assessments.

(4) Address student diversity and various learning needs in lessons and units.

(5) Use teaching methods and techniques of curriculum delivery including effective questioning, cooperative learning, inquiry, technology, and problem-solving.

(6) Incorporate various classroom organization and management techniques when teaching students.

(7) Develop mathematical experiences for students, which will lead to positive dispositions toward math.

(8) Explain the organization and benefits of the NCTM Standards, the Common Core State Standards, Nebraska State Standards, and current trends in mathematics education.

(9) Define NCTM and NATM, and explain membership benefits associated with each organization, and articulate the importance of professional affiliations.

(10) Be reflective of your own learning and realize how his/her own understanding influences student learning.

5.26 MATH 471, Field Experience in Middle and High School Mathematics II

On completion of this course, students will

(1) Utilize research-based mathematics teaching practices in the classroom.
(2) Engage 6–12 students in developmentally appropriate mathematics lessons.
(3) Incorporate technology and tools into the 6–12 class in order to enhance mathematical understanding.
(4) Work with a diverse range of students individually, in small groups, and in large class settings.
(5) Plan, facilitate, and reflect upon mathematics lessons that promote reasoning and sense making.
(6) Collect and analyze data to determine if 6–12 students have built new knowledge.
(7) Collaborate with colleagues, other school professionals, families, and stakeholders.
(8) Continue to develop as a reflective practitioner.
(9) Meet expectations of all Teacher Education Dispositions, including
    (a) Demonstrate effective oral communication skills
    (b) Demonstrate effective written communication skills
    (c) Demonstrate professionalism
    (d) Demonstrate a positive and enthusiastic attitude
    (e) Demonstrate preparedness in teaching and learning
    (f) Exhibits an appreciation of and value for cultural and academic diversity
    (g) Collaborates effectively with stakeholders
    (h) Demonstrates self-regulated learner behaviors/takes initiative
    (i) Exhibits the social and emotional intelligence to promote personal and educational goals/stability

5.27 MATH 490, Special Topics in Mathematics

The learning outcomes for MATH 490 vary by the course content.

5.28 MATH 495, Independent Study in Mathematics

The learning outcomes for MATH 495 vary by the course content.

5.29 MATH 496, Mathematics Seminar

The learning outcomes for MATH 496 vary by the course content.

5.30 STAT 345, Applied Statistics I

(missing)

5.31 STAT 399, Internship

The Learning Outcomes are the following:

(1) Write a two-page description of the activities of the internship.
(2) Give three examples in which topics you learned in undergraduate mathematics courses came up and/or were used in an activity of the internship. Describe and discuss. If three examples cannot be given, list one, or two, if possible, and say that there were less than three.

(3) Give any examples of mathematical topics that came up and/or were used in an activity of the internship that you had not seen before. Describe and discuss.

(4) Describe two jobs and/or careers for which the experience of the internship made you more qualified than you were before.

(5) Fill in the blank: I would have been better prepared for the internship if I had previously _____.

(6) Fill in the blank: My next step(s) in developing a career path is(are) _____

5.32 STAT 441, Probability and Statistics

On completion of this course, students will be able to

(1) Demonstrate an understanding of the concepts of sample space, random variable, and probability of an event.

(2) Demonstrate an understanding of the axioms and basic theorems regarding probability measures.

(3) Demonstrate an understanding of conditional probability.

(4) Calculate the probability of an event in a discrete sample space when all the outcomes are equally likely using the sample-point method and basic counting techniques.

(5) Calculate the probability of an event in a sample space and when the outcomes are not equally likely using the event-composition method.

(6) Calculate the mean, variance, and standard deviation of an arbitrary discrete or continuous distribution.

(7) Demonstrate an understanding of the mathematical derivations of the formulas for the mean and variance of an assortment of special discrete and continuous distributions including the binomial, geometric, hypergeometric, Poisson, uniform, and normal distributions.

(8) Demonstrate an understanding of the similarities and differences between the cumulative distribution function of a discrete random variable and that of a continuous random variable.

(9) Demonstrate an understanding of moments and how moment generating functions for various distributions can be found and used to determine formulas for the mean and variance of distributions.

(10) Demonstrate an understanding of the mathematical derivations of an assortment of the techniques of statistical analysis, particularly in the areas of estimation (of means, variances, and standard deviations) and of hypothesis testing.

5.33 STAT 442, Mathematical Statistics

The class STAT 442 has not been offered in over five years. The department does not have a current syllabus for this course. Should we offer this course, we will need to revise the course description and create a syllabus. Accordingly, we have no Learning Outcomes for this class.

5.34 STAT 495, Independent Study in Statistics

The learning outcomes for STAT 495 vary by the course content.

6 Addendum: Math specific Learning Outcomes for LOPER 4 classes

For our LOPER 4 General Studies classes, we give the course specific Learning Outcomes and we detail the course concepts and assessments that are used to satisfy the LOPER 4 General Studies Learning Outcomes.

6.1 MATH 102, College Algebra

In this course students will learn the concepts of relations and functions, properties and graphing of various types functions, and other topics such as systems of equations, matrices, and/or sequences and series. Students will investigate applied problems from various disciplines and algebraic principles used in the study of calculus, linear programming, and other areas of mathematics. Through this course, students will be able to

(1) Solve algebraic equations and inequalities in one or two variables and illustrate these solutions graphically on the real number line and/or the rectangular coordinate system.

(2) Use the Pythagorean Theorem to develop distance computations and circular relationships in two variables on the coordinate system.

(3) Understand the concepts of slope and the linear relationship, using graphic, algebraic, and verbal descriptions of this relationship.

(4) Apply the definition of the function, function notation, and the connections between graphic, algebraic, and verbal descriptions of functions.

(5) Understand the domain and the range of a function, how to determine domain using equations and graphs of functions, and to determine range of a function by graph analysis. The students will be able to recognize other properties of several types of functions.

(6) Understand the concepts of composite functions, one-to-one functions and inverse functions, and their importance in mathematics.

(7) Sketch and analyze graphs of functions and use transformations. The students will be able to analyze the relationships between the parent and the resulting functions using analytic and graphical techniques. These function types include general functions, linear functions, piecewise-defined functions, quadratic functions and quadratic inequalities, rational functions, polynomial functions, exponential functions, and logarithmic functions.

(8) Develop an understanding of end behaviors of quadratic, rational, polynomial, exponential, and logarithmic functions.

(9) Use functions algebraically, numerically, and graphical to model real life applications.

(10) Set up and use systems of equations and inequalities to solve equations simultaneously.

(11) Develop an understanding of sequences and series; be able to differentiate between geometric and arithmetic.

(12) Appreciate other conic sections including the ellipse and hyperbola and their practical applications.

The LOPER 4 Learning Outcome 'a' is broadly met mathematically in this course. This includes developing the concepts of distance in the rectangular coordinate system (2), timing of projectiles (7, 8), population and natural phenomena modeling (3, 5, 6,7, 8, 9), and modeling economic and financial criteria using functions and mathematical reasoning (4, 5, 7). These are assessed via homework, quizzes, and exams where a portion of the grade for a solution is based on the mathematical set up, describing the problem, and defending the concluding results.

The LOPER 4 Learning Outcomes 'b' and 'c' are achieved throughout the course through assigned homework, quizzes, exams, collaborative work and/or other assignments that are assessed by logically defending their solutions (1, 9, 10), and producing graphical, numerical, and/or algebraic support of their work (1, 2, 3, 4, 7, 8, 10, 11, 12).

The LOPER 4 Learning Outcome 'd' is met directly (2, 3, 4, 7, 8, 10, 11, 12) and indirectly (5, 6, 9) in this course. It is assessed by homework, quizzes, exams, and/or other work where a portion of the grade is based on the accuracy of their work and graphs and their interpretation of the data presented in the problems.

6.2 MATH 103, Plane Trigonometry

The first LOPER 4 Learning outcome (item 'a') is met by the mathematical set up and preparation of solutions to various problems encountered in this course about trigonometric functions and trigonometric identities as well as their applications. The second and third learning outcomes (items 'a' and 'b') are met in solving such problems using mathematical skills and logical arguments. The fourth learning outcome (item 'd') is met by understanding those problems which involve graphs and data and by giving solutions to those problems.

The four learning outcomes are assessed by grading homework, quizzes, exams, and/or projects based on the set-up and defense of the submitted work, the validity of the submitted solution's logical reasoning, the accuracy of the answers, the accuracy of the graphs and data in the submitted solutions and/or the accuracy of the interpretation of the graphs and data from the assigned problem.

6.3 MATH 106, Mathematics for Liberal Arts

LOPER 4 Learning Outcome 'a' will be achieved by describing how much power each person has in weighted voting systems by explaining quotas, veto power, dictators, dummies and other terms.

Outcome 'b' will be achieved by describing the best route to take using various algorithms such as brute force, cheapest link, and nearest neighbor algorithms.

Outcome 'c' will be achieved by using various fair division methods to divide assets in a fair and logical way so that everyone feels they received a fair share.

Outcome 'd' will be achieved by organizing the data into graphs such as bar graphs and histograms, and by finding the five number summary of the data and finding the standard deviation.

6.4 MATH 115, Calculus I with Analytic Geometry

Students will learn the concepts of continuity, the limit, the derivative, and the indefinite and definite integrals. Students will apply these concepts to problems involving the sciences and to applied problems of mathematics including geometry and the extreme values of functions. Specifically, the calculus specific learning outcomes (CSLO) are as follows: On completion of this class, students will

(1) understand and compute limits and directional limits of functions in one variable and be able to determine (directional) continuity of such functions using the limit point definition of continuity.

(2) be able to discuss asymptotic behavior in terms of limits.

(3) understand the definition of derivative and its geometric interpretations.

(4) compute derivatives using both the definition of derivative and derivative rules.

(5) use and apply the concept of the derivative as a rate of change to related rates, linearization, and differential problems.

(6) apply differentiation concepts through the mean value theorem and to curve sketching using concavity and intervals of increase/decrease, and to optimization and root finding (Newton's method).

(7) understand the basics of anti-derivatives and integration.

(8) develop a deeper understanding of summation notation and the relationship to integration and Riemann sums.

(9) compute basic definite integrals using Riemann sums and the fundamental theorem of calculus.

(10) compute basic integrals using integration by substitution techniques.

(11) be able to set up and find the area between curves using integration.

Learning outcome ‘a’ is met most directly by the mathematical set up and preparation of solutions to problems involving related rates and optimization in the calculus specific learning outcomes (CSLO) 5 and 6. It is also met directly in discussion of asymptotic behavior CSLO 2. It is met indirectly through word problems related to many of the other CSLO. It is assessed by the grading of problems related to these CSLO on homework, quizzes, exams, and/or projects where a portion of the grade for a solution is based on the set-up and defend of the submitted work. Learning outcomes ‘b’ and ‘c’ are closely related in this course and are met in solving problems related to every single CSLO. These are assessed via homework, quizzes, exams, and/or projects where a portion of the grade for a solution is based on the validity of the submitted solution’s logical reasoning and the accuracy of answers. Learning outcome ‘d’ is met most directly by CSLO 3, 6, and 11 as well as through reading and creating graphs and/or tabular data related all the CSLO. It is assessed by homework, quizzes, exams, and/or projects where a portion of the grade is based on the accuracy of the graphs and tables in the submitted solutions and/or the accuracy of the interpretation of such data from the assigned problem.

6.5 MATH 120, Finite Mathematics

To meet LOPER 4 outcome ‘a,’ students will define terms associated with matrices, probability, mathematics of finance, game theory, and logic. To meet outcome ‘b,’ they will solve problems in systems of equations using the algebraic method and matrices; solve linear programming problems by simplex method, and geometric approach. To meet outcome ‘c,’ they will discuss conditional statements and equivalent statements, and form valid arguments. To meet outcome ‘d,’ they will interpret the graph of the linear regression lines, and the outcomes of game theory problems.

6.6 MATH 123, Applied Calculus I

LOPER 4 Outcome ‘a’ will be satisfied through setting up and solving problems involving related rates, optimization, and curve sketching. Outcomes ‘b’ and ‘c’ are satisfied by nearly all the homework and exam problems and students will be evaluated through grading of the homework and exams. Outcome ‘d’ is achieved through curve sketching, geometrical definitions of limits and derivatives, and finding area using integration.

6.7 MATH 230, Math for Elementary Teachers I

On completion of this course, students will be able to

(1) Explain and apply the problem-solving process, using a variety of problem-solving strategies.

(2) Perform mathematical operations in varied bases.

(3) Explain and use traditional and non-traditional algorithms.

(4) Identify specific qualities of a number and number relations.

(5) Demonstrate integer operations using a variety of strategies.

(6) Approach mathematics problems using a variety of methods.

(7) Explain mathematical concepts to students at their level of understanding.

(8) Represent numerical data in graphical forms and with descriptive statistics.

LOPER 4 Outcome ‘a’ will be achieved as students engage in a variety of instructional activities aimed at meeting the Course Specific Objectives (CSO) 1, 3, 5, 6, and 7. For example, students work in groups in class to translate word problems into pictorial and symbolic representations in order to meet CSO 1. They also practice using correct mathematical terminology when explaining the foundations of a variety of computational algorithms in pairs in class to meet CSO 3. Competence on this GS outcome is assessed

throughout the course using some problems on Practice and Preparation assignments, all Teaching Tasks, and all Problem-Solving Tasks.

Outcome 'b' will be achieved as students engage in a variety of instructional activities aimed at meeting the CSO 1-6. In class, students are given opportunities to approach problems using mathematical techniques every class session. Their understanding of these techniques is supported by appropriate instruction regarding the appropriate contexts for the techniques, the foundation ensuring the efficacy of the techniques, and ways to help their future students learn to use the same techniques. Competence on this GS outcome is assessed throughout the course using most problems on Practice and Preparation assignments, most problems on Cumulative Tasks, and all Problem-Solving Tasks.

Outcome 'c' will be achieved as students engage in a variety of instructional activities aimed at meeting the CSO 3, 4, 6, and 7. For example, when we use computational algorithms to solve problems, students do not merely describe the procedural steps in performing a computational algorithm, but are required to provide mathematical reasoning that supports the efficacy and justifies the accuracy of the algorithm. We support their explanations by allowing students to wrestle with their own ideas and providing well-timed direct instruction to help them build on their explanations to achieve more mathematically sound justifications. Competence on this GS outcome is assessed throughout the course using some problems on Practice and Preparation assignments, some problems on Cumulative Tasks, all Teaching Tasks, and all Problem–Solving Tasks.

Outcome 'd' will be achieved as students engage in instructional activities aimed at meeting the CSO 8. Students will learn how to calculate descriptive statistics and represent data in a variety of graphical forms in class or through online learning modules. We help students to interpret descriptive statistics in context and identify conceptual understanding of the computed measures. Competence on this GS outcome is assessed on the third teaching task and/or Practice and Preparation assignments.

6.8 STAT 235, Introduction to Statistics for Social Sciences

The class specific Learning Outcomes are

(1) Learn to construct frequency distributions. Learn to graph and interpret quantitative data sets using histograms, frequency polygons, relative frequency histograms, and ogives.

(2) Learn to graph and interpret qualitative data sets using pie charts.

(3) Learn how to find the mean, median and mode of a data set.

(4) Learn how to find a weighted mean and estimate the mean of grouped data.

(5) Be able to describe the shapes of a distribution as symmetric, uniform, or skewed and how to compare the mean and median for each.

(6) Learn how to find the range, variance, standard deviation, quartiles, percentiles and standard score of a data set and use the information interpret the data and make logical arguments concerning the data.

(7) How to identify the sample space of a probability experiment and identify simple events.

(8) How to find the probability of one or two events, the probability of two or more events occurring in sequence and how to find conditional probabilities.

(9) How to construct and graph a discrete probability distribution and how to compute the mean, variance, standard deviation and expected value of a discrete probability distribution.

(10) How to find binomial probabilities using the binomial probability formula.

(11) How to construct, graph, and find the mean, variance, and standard deviation of a binomial probability distribution.

(12) Learn how to interpret graphs and find the areas under the standard normal curve.

(13) Learn how to find probabilities for normally distributed variable using a table and/or technology.

(14) Learn how to find a z–score and transform a z–score to a raw data value.

(15) Learn to apply the Central Limit Theorem to find the probability of a sample mean.

(16) How to use a normal distribution to approximate binomial probabilities.

(17) Learn how to construct and interpret confidence intervals for a mean, proportion, variance and standard deviation.

(18) How to determine the minimum sample size required when estimating a population mean or proportion.

(19) Use inferential statistics to analyze situation by preforming hypothesis tests on one or two samples.

(20) Use hypothesis tests in order to test claims about population parameters including means, proportion, variances, and standard deviations.

(21) Use the Goodness–of–fit test and the chi–square distribution to test whether a frequency distribution fits an expected distribution.

The first two LOPER 4 Learning Outcomes (items 'a' and 'b') of describing and solving problems using statistical/mathematical language and techniques are used throughout the course and most specifically through course specific outcomes 3, 4, 6, 7, 8, 9, 10, 13, 14, 15, 16, and 18 listed below. These learning outcomes involve the set-up and solutions to such concepts as the measures of central tendency, measures of variation, measures of position, basic concepts of probability, and the binomial distributions.

The third LOPER 4 Learning Outcome (item 'c') is most directly met through inferential statistics and the process of constructing and interpreting confidence intervals and through hypothesis testing. Course specific outcomes that met this learning outcome would include 6, 17, 19, 20, and 21.

The final LOPER 4 Learning Outcome (item 'd') of interpreting and expressing numerical data or graphical information is directly met through methods used in descriptive statistics and the processes of constructing and interpreting frequency distributions, frequency histograms, frequency polygons, relative frequency histograms, ogives and pie charts. Course specific outcomes that met this learning outcome include 1, 2, 5, 11, and 12.

All four learning outcomes are assessed by grading homework, quizzes, exams and extra course work as may be assigned to better the understanding of individual concepts that may pose difficulty throughout the term. All assessment is based on the accuracy of the work and the interpretation of the results.

6.9 STAT 241, Elementary Statistics

LOPER 4 Learning Outcomes 'a,' 'b,' 'c,' and 'd' will be achieved by requiring the students to work problems of a statistical nature on homework and exams. In particular, these problems will require students to

(1) understand and use accepted statistical language and symbols (outcome 'a').

(2) solve problems using standard statistical techniques (outcome 'b').

(3) clearly communicate their work/procedure and/or explain the argument which led them to their answer (outcome 'c'). (This is especially true of exam and select handwritten homework problems.)

(4) interpret the numerical result(s) of a computation or procedure in the context of the real–world scenario in which the problem originated (This interpretation will often require the students to say what their numerical answer means in a short, clear English sentence.) (outcome 'd').

LOPER 4 Outcome 'd' will also be achieved by requiring students to

(1) calculate the mean, median, mode, variance, and standard deviation of numerical data sets.

(2) create histograms, frequency polygons, ogives, and pie charts to depict/summarize data sets.

(3) use tables and graphs describing various binomial, hypergeometric, geometric, and Poisson distributions to solve problems.

(4) use tables and graphs describing various normal distributions, t–distributions, and chi-squared distributions to solve problems.