Columbus State Community College
Division: Arts and Sciences
Department: Mathematics

COURSE NUMBER: MATH2177 **COURSE TITLE:** Mathematical Topics for Engineering

INSTRUCTOR: **CONTACT:**

CREDITS: 6 **CLASS/CONTACT HOURS PER WEEK:** 6 **PREREQUISITES:** MATH 1172 or 2153 with a C or higher

DESCRIPTION OF COURSE (as it appears in the college catalog)
This course covers multiple integrals, line integrals, matrix theory, linear (ordinary and partial) differential equations, with applications to science and engineering.

COURSE STUDENT LEARNING OUTCOMES (covered in this course)
- Unit of Instruction: Maxima and Minima of Functions of Several Variables
- Student Learning Outcomes: Upon completion of this unit the student will be able to…

- Find the relative extrema and saddle points of a function of two variables.
- Find the absolute extrema of a function over a given region.
- Use the Second Partials Test to determine if a critical point is a relative maximum, a relative minimum, or a saddle point, or if the test is inconclusive.
- Solve applications of extrema of functions of two variables.
- Interpret geometrically the rationale of using Lagrange multipliers to optimize a function given a constraint.
- Use Lagrange multipliers to optimize functions of several variables with a given constraint.
- Solve applications involving Lagrange multipliers

- Unit of Instruction: Multiple Integration
- Student Learning Outcomes: Upon completion of this unit the student will be able to…

- Evaluate iterated integrals.
- Evaluate double integrals over a rectangular region, and find the volume using a double integral.
- Sketch the solid whose volume is represented by a double integral.
- Choose an appropriate order of integration to evaluate a double integral over a region, and switch the order of integration.
- Use a double integral to find the volume of a given solid.
- Solve applications involving double integrals.
- Evaluate a double integral in polar coordinates.
- Use a double integral in polar coordinates to find the area of a region.
- Convert from rectangular to polar coordinates to evaluate a double integral.
- Use a double integral in polar coordinates to find the volume of a given solid.
- Solve applications involving double integrals in polar coordinates.
- Evaluate triple integrals.
- Sketch the solid whose volume is given by a triple integral, and rewrite the integral in a particular order of integration.
- Use triple integrals to find the volume of a given solid.
- Solve applications involving triple integrals.

- Evaluate triple integrals in both cylindrical and spherical coordinates.
- Find the volume of a solid by a triple integral in cylindrical or spherical coordinates.
- Convert triple integrals from rectangular coordinates to both cylindrical and spherical coordinates, and choose an appropriate one to evaluate.
- Solve applications involving triple integrals in cylindrical and spherical coordinates.
- Find the Jacobian for a given change of variables.
- Sketch the resulting image of a region given a transformation.
- Evaluate double integrals using a given change of variables.

- Unit of Instruction: Vector Fields and Line Integrals
- Student Learning Outcomes: Upon completion of this unit the student will be able to…

- Use representative vectors to sketch a vector field
- Verify a function is the potential function for a vector field
- Evaluate a line integral over a given path.
- Evaluate line integrals of vector fields over a given path.
- Compute the work done by a force field on an object moving along a given path.
- Solve applications involving line integrals.
- Identify inverse square vector fields.
- Determine whether a vector field is conservative, and if so, find its potential function.
- Identify when a line integral is independent of path
- Apply the Fundamental Theorem of Line Integrals to evaluate line integrals.
- Solve applications involving the work done by a force field.

- Unit of Instruction: Matrices and Linear Systems of Equations
- Student Learning Outcomes: Upon completion of this unit the student will be able to…

- Represent systems of linear equations in matrix form.
- Solve systems of linear equations.
- Demonstrate the ability to perform elementary row operations to reduce a matrix to (reduced) echelon form.
- Employ matrix reduction techniques to solve systems of linear equations and identify inconsistent and dependent systems.
- Recognize solution possibilities for a consistent linear system of equations
- Perform algebraic operations with matrices
- Compute sums, scalar products, and differences using matrices.
- Multiply matrices, and understand associativity and noncommutativity of matrix multiplication.
- Compute the transpose of a matrix.
- Compute the inverse of an invertible matrix.
- Solve systems of linear equations using the inverse of the coefficient matrix.
- Understand the invertible matrix theorem.
- Apply algebraic properties of matrices
- Identify independent and dependent sets of vectors.
- Apply matrix methods to data fitting, numerical integration and differentiation
- Solve engineering applications.

- Unit of Instruction: Second Order Linear Ordinary Differential Equations
- Student Learning Outcomes: Upon completion of this unit the student will be able to…

- Perform arithmetic operations with complex numbers and convert between rectangular, trigonometric/polar and complex exponential forms

- Write the characteristic equation of a homogeneous linear equation with constant coefficients and use it to find the general solution of the equation for all three cases: distinct roots, repeated roots, and complex roots.
- Explain the general theory behind finding the general solutions to second order homogeneous and non-homogeneous equations.
- Compute the Wronskian and use it to determine if a set of solutions is a fundamental set of solutions to a given homogeneous equation on a given interval.
- Given one solution of a linear second-order differential equation, use reduction of order to find a second solution.
- Verify that a given solution is the general solution to a non-homogeneous ODE.
- Use the method of undetermined coefficients to solve second order non-homogeneous ODEs.
- Use linear second-order differential equations to solve application problems such as those involving spring-mass systems and/or three component series circuits.

- Unit of Instruction: Partial Differential Equations and Fourier Series
- Student Learning Outcomes: Upon completion of this unit the student will be able to…

- Describe the model for heat flow at an introductory level
- Solve two-point boundary value problems using the method of separation of variables, or show that no solution exists.
- Determine if a given function is periodic; if it is, find its fundamental period.
- Find the Fourier series for a given function.
- Describe how a Fourier series seems to be converging.
- Find the Fourier series for a given function periodically extended outside a given interval.
- Determine whether a given function is even, odd, or neither.
- Given a function on an interval of length L, sketch the graphs of its even and odd extensions of period 2L.
- Find Fourier Sine and Cosine Series.
- Use the method of separation of variables to solve the heat equation for one space variable.
- Solve heat conduction problems with various boundary conditions.
- Solve the wave equation and problems involving vibrations of an elastic string.

PROGRAM OUTCOMES (covered in this course)
(Career & Technical courses align to the program outcomes. Arts & Sciences courses align to the General Education outcomes)

1. Critical Thinking:
    a. Recognize, define, & analyze a problem.
    b. Examine issues by identifying and challenging assumptions and biases, including one's own, and by distinguishing substantiated fact from opinion or misinformation.
    c. Apply learned concepts and knowledge to make decisions relevant to problem solving.
    d. Develop problem-solving strategies and evaluate their practical and/or ethical implications.
    e. Draw logical, well-supported conclusions by testing them against relevant criteria and standards.
    f. Adjust conclusions and viewpoints if new information becomes available.
3. Quantitative Skills:
    a. Perform mathematical computations using appropriate methods to arrive at accurate results.
    b. Analyze, interpret, and/or formulate inferences from data such as graphs, charts, tables, or other quantified data.

OUTCOMES BASED ASSESSMENT OF STUDENT LEARNING
For this course, students are expected to demonstrate the skills associated with the Institutional Learning Goals (ILG) identified below:

[1. Critical Thinking]
[3. Quantitative Reasoning]

In class students are assessed on their achievement of these outcomes. Names will not be used when reporting results. Outcomes-based assessment is used to improve instructional planning and design and the quality of student learning throughout the college.

COURSE MATERIALS REQUIRED: None, but a graphing calculator is recommended.

TEXTBOOK(S), MANUALS, REFERENCES, AND OTHER READINGS
Custom CSCC edition (*Mathematical Topics for Engineers*, Pearson), which includes:

- Textbook Sections from *Calculus for Scientists and Engineers: Early Transcendentals,* Briggs, Cochran, Gillett and Shulz, Chapters 13-15
- Textbook Sections from *Introduction to Linear Algebra*, by Johnson, Riess, and Arnold, 5th edition, Chapter 1: Matrices and Systems of Linear Equations
- Textbook Sections from *Fundamentals of Differential Equations and Boundary Value Problems*, by Nagle, Saff and Snider, 8th Edition, Chapter 10

GENERAL INSTRUCTIONAL METHODS: Instructional methods may include face-to-face or video lectures or demonstration, face-to-face or virtual discussion, individual or group activities including the use of visual aids, graphing calculators, computers and/or other technologies. Students may be expected to participate in these activities during class and/or outside of class. Instructors may require class participation, collaborative learning, and peer review.

STANDARDS AND METHODS FOR EVALUATION:
Varies by instructor, but below is one possible scheme.

- Sample Grading Scheme:
    - 15% Written Assignments
    - 10% Quizzes
    - 10% WebAssign Assignments
    - 65% Tests (including comprehensive final exam)

GRADING SCALE
Letter grades for the course will be awarded using a 90% - 80% - 70% - 60% scale.

SPECIAL COURSE REQUIREMENTS: None

ATTENDANCE POLICY: to be determined by the individual instructor

COLLEGE SYLLABUS STATEMENTS
Columbus State Community College required College Syllabus Statements on College Policies and Student Support Services can be found at www.cscc.edu/syllabus or on the College website Quick Links "Syllabus Statements".

WEATHER RELATED DEPARTMENT SPECIFIC POLICY
If not covered by College Policy, relative to clinical, practicum, of other missed time due to weather related college closings.

UNITS OF INSTRUCTION)

Week 1
- Unit of Instruction: Maxima and Minima of Functions of Several Variables
- Learning Objectives/Goals:
- Find the relative extrema and saddle points of a function of two variables.
- Find the absolute extrema of a function over a given region.
- Use the Second Partials Test to determine if a critical point is a relative maximum, a relative minimum, or a saddle point, or if the test is inconclusive.
- Solve applications of extrema of functions of two variables.
- Interpret geometrically the rationale of using Lagrange multipliers to optimize a function given a constraint.
- Use Lagrange multipliers to optimize functions of several variables with a given constraint.
- Solve applications involving Lagrange multipliers

- Assignment: Sections 1.6 and 1.8 – 1.9
- Assessment Methods: Daily questioning and discussion, graded homework assignments, quizzes and in-class tests as well as out of class assignments allowing for greater computational and conceptual complexity.

Week 2
- Unit of Instruction: Multiple Integration
- Learning Objectives/Goals:
- Evaluate iterated integrals.
- Evaluate double integrals over a rectangular region, and find the volume using a double integral.
- Sketch the solid whose volume is represented by a double integral.
- Choose an appropriate order of integration to evaluate a double integral over a region, and switch the order of integration.
- Use a double integral to find the volume of a given solid.
- Solve applications involving double integrals.
- Evaluate a double integral in polar coordinates.
- Use a double integral in polar coordinates to find the area of a region.
- Convert from rectangular to polar coordinates to evaluate a double integral.
- Use a double integral in polar coordinates to find the volume of a given solid.
- Solve applications involving double integrals in polar coordinates.
- Evaluate triple integrals.
- Sketch the solid whose volume is given by a triple integral, and rewrite the integral in a particular order of integration.
- Use triple integrals to find the volume of a given solid.
- Solve applications involving triple integrals.

- Assignment: Sections 2.1 – 2.4
- Assessment Methods: Daily questioning and discussion, graded homework assignments, quizzes and in-class tests as well as out of class assignments allowing for greater computational and conceptual complexity.

Week 3

- Unit of Instruction: Multiple Integration

- Evaluate triple integrals in both cylindrical and spherical coordinates.
- Find the volume of a solid by a triple integral in cylindrical or spherical coordinates.
- Convert triple integrals from rectangular coordinates to both cylindrical and spherical coordinates, and choose an appropriate one to evaluate.
- Solve applications involving triple integrals in cylindrical and spherical coordinates.
- Find the Jacobian for a given change of variables.
- Sketch the resulting image of a region given a transformation.
- Evaluate double integrals using a given change of variables.

- Learning Objectives/Goals:

- Assignment: Sections 2.4 – 2.5

- Assessment Methods: Daily questioning and discussion, graded homework assignments, quizzes and in-class tests as well as out of class assignments allowing for greater computational and conceptual complexity.

Week 4

- Unit of Instruction: Vector Fields and Line Integrals

- Learning Objectives/Goals:

- Use representative vectors to sketch a vector field
- Verify a function is the potential function for a vector field
- Evaluate a line integral over a given path.
- Evaluate line integrals of vector fields over a given path.
- Compute the work done by a force field on an object moving along a given path.
- Solve applications involving line integrals.

- Assignment: Sections 3.1 – 3.2

- Assessment Methods: Daily questioning and discussion, graded homework assignments, quizzes and in-class tests as well as out of class assignments allowing for greater computational and conceptual complexity.

Week 5

- Unit of Instruction: Vector Fields and Line Integrals

- Learning Objectives/Goals:

- Identify inverse square vector fields.
- Determine whether a vector field is conservative, and if so, find its potential function.
- Identify when a line integral is independent of path
- Apply the Fundamental Theorem of Line Integrals to evaluate line integrals.
- Solve applications involving the work done by a force field.

- Assignment: Section 3.3

- Assessment Methods: Daily questioning and discussion, graded homework assignments, quizzes and in-class tests as well as out of class assignments allowing for greater computational and conceptual complexity. Test 1 is typically given this week.

Week 6

- Unit of Instruction: Matrices and Linear Systems of Equations

- Learning Objectives/Goals:

- Represent systems of linear equations in matrix form.

- Solve systems of linear equations.
- Demonstrate the ability to perform elementary row operations to reduce a matrix to (reduced) echelon form.
- Employ matrix reduction techniques to solve systems of linear equations and identify inconsistent and dependent systems.

- Assignment: Sections 4.1 – 4.2

- Assessment Methods: Daily questioning and discussion, graded homework assignments, quizzes and in-class tests as well as out of class assignments allowing for greater computational and conceptual complexity.

Week 7

- Unit of Instruction: Matrices and Linear Systems of Equations

- Learning Objectives/Goals:

- Recognize solution possibilities for a consistent linear system of equations
- Perform algebraic operations with matrices
- Compute sums, scalar products, and differences using matrices.
- Multiply matrices, and understand associativity and noncommutativity of matrix multiplication.

- Assignment: Sections 1.3 and 1.5

- Assessment Methods: Daily questioning and discussion, graded homework assignments, quizzes and in-class tests as well as out of class assignments allowing for greater computational and conceptual complexity.

Week 8

- Unit of Instruction: Matrices and Linear Systems of Equations

- Learning Objectives/Goals:

- Compute the transpose of a matrix.
- Compute the inverse of an invertible matrix.
- Solve systems of linear equations using the inverse of the coefficient matrix.
- Understand the invertible matrix theorem.
- Apply algebraic properties of matrices
- Identify independent and dependent sets of vectors.

- Assignment: Sections 1.6 – 1.7

- Assessment Methods: Daily questioning and discussion, graded homework assignments, quizzes and in-class tests as well as out of class assignments allowing for greater computational and conceptual complexity.

Week 9

- Unit of Instruction: Matrices and Linear Systems of Equations

- Learning Objectives/Goals:

- Apply matrix methods to data fitting, numerical integration and differentiation
- Solve engineering applications.

- Assignment: Sections 1.8 and 4.4

- Assessment Methods: Daily questioning and discussion, graded homework assignments, quizzes and in-class tests as well as out of class assignments allowing for greater computational and conceptual complexity.

Week 10

- Unit of Instruction: Second Order Linear Ordinary Differential Equations

- Learning Objectives/Goals:

- Explain the general theory behind finding the general solutions to second order homogeneous and non-homogeneous equations.
- Compute the Wronskian and use it to determine if a set of solutions is a fundamental set of solutions to a given homogeneous equation on a given interval.

- Assignment: Section 5.1

- Assessment Methods: Daily questioning and discussion, graded homework assignments, quizzes and in-class tests as well as out of class assignments allowing for greater computational and conceptual complexity. Test 2 is typically given this week.

Week 11

- Unit of Instruction: Second Order Linear Ordinary Differential Equations

- Learning Objectives/Goals:

- Perform arithmetic operations with complex numbers and convert between rectangular, trigonometric/polar and complex exponential forms
- Write the characteristic equation of a homogeneous linear equation with constant coefficients and use it to find the general solution of the equation for all three cases: distinct roots, repeated roots, and complex roots.
- Given one solution of a linear second-order differential equation, use reduction of order to find a second solution.

- Assignment: Appendix C and Section 16.2

- Assessment Methods: Daily questioning and discussion, graded homework assignments, quizzes and in-class tests as well as out of class assignments allowing for greater computational and conceptual complexity.

Week 12

- Unit of Instruction: Second Order Linear Ordinary Differential Equations & Partial Differential Equations and Fourier Series

- Learning Objectives/Goals:

- Verify that a given solution is the general solution to a non-homogeneous ODE.
- Use the method of undetermined coefficients to solve second order non-homogeneous ODEs.
- Use linear second-order differential equations to solve application problems such as those involving spring-mass systems and/or three component series circuits.
- Describe the model for heat flow at an introductory level

- Assignment: Sections 5.3 – 5.4 and 6.1

- Assessment Methods: Daily questioning and discussion, graded homework assignments, quizzes and in-class tests as well as out of class assignments allowing for greater computational and conceptual complexity.

Week 13

- Unit of Instruction: Partial Differential Equations and Fourier Series

- Learning Objectives/Goals:

- Solve two-point boundary value problems using the method of separation of variables, or show that no solution exists.
- Determine if a given function is periodic; if it is, find its fundamental period.
- Find the Fourier series for a given function.
- Describe how a Fourier series seems to be converging.
- Find the Fourier series for a given function periodically extended outside a given interval.

- Assignment: Sections 6.2 – 6.3

- **Assessment Methods:** Daily questioning and discussion, graded homework assignments, quizzes and in-class tests as well as out of class assignments allowing for greater computational and conceptual complexity.

Week 14

- **Unit of Instruction:** Partial Differential Equations and Fourier Series
- **Learning Objectives/Goals:**
    - Determine whether a given function is even, odd, or neither.
    - Given a function on an interval of length L, sketch the graphs of its even and odd extensions of period 2L.
    - Find Fourier Sine and Cosine Series.
- **Assignment:** Section 6.4
- **Assessment Methods:** Daily questioning and discussion, graded homework assignments, quizzes and in-class tests as well as out of class assignments allowing for greater computational and conceptual complexity. Test 3 is typically given this week.

Week 15

- **Unit of Instruction:** Partial Differential Equations and Fourier Series
- **Learning Objectives/Goals:**
    - Use the method of separation of variables to solve the heat equation for one space variable.
    - Solve heat conduction problems with various boundary conditions.
    - Solve the wave equation and problems involving vibrations of an elastic string.
- **Assignment:** Sections 6.5 – 6.6
- **Assessment Methods:** Daily questioning and discussion, graded homework assignments, quizzes and in-class tests as well as out of class assignments allowing for greater computational and conceptual complexity.