DEPARTMENT Mathematics COURSE Multivariable Calculus Honors

Curriculum Development Timeline

School: Ocean Township High School

Course: Multivariable Calculus Honors

Department: Mathematics

Board Approval	Supervisor	Notes
June 2015	Janet Bluefield	Born Date
August 2017	Nichole Kerney	Revisions
August 2019	Nichole Kerney	Review
August 2022	Gerard Marrone	Alignment to Standards

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DEPARTMENT Mathematics COURSE Multivariable Calculus Honors

Pacing Guide			
Week	Marking Period 1	**Week**	Marking Period 3
1	Integration Techniques	21	Functions of Several Variables
2	Integration Techniques	22	Functions of Several Variables
3	Integration Techniques	23	Functions of Several Variables
4	Integration Techniques	24	Functions of Several Variables
5	Parametric Equations & Polar Coordinates	25	Functions of Several Variables
6	Parametric Equations & Polar Coordinates	26	Multiple Integration
7	Parametric Equations & Polar Coordinates	27	Multiple Integration
8	Parametric Equations & Polar Coordinates	28	Multiple Integration
8	Vectors & The Geometry of Space	29	Multiple Integration
10	Vectors & The Geometry of Space	30	Multiple Integration
Week	Marking Period 2	**Week**	Marking Period 4
11	Vectors & The Geometry of Space	31	Multiple Integration
12	Vectors & The Geometry of Space	32	Multiple Integration
13	Vector-Valued Functions	33	Multiple Integration
14	Vector-Valued Functions	34	Vector Analysis
15	Vector-Valued Functions	35	Vector Analysis
16	Vector-Valued Functions	36	Vector Analysis
17	Vector-Valued Functions	37	Vector Analysis

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18	Functions of Several Variables	38	Vector Analysis
19	Functions of Several Variables	39	Vector Analysis
20	Functions of Several Variables	40	Vector Analysis

Core Instructional & Supplemental Materials including various levels of Texts
Textbook: Calculus 10th Edition, Larson Supplemental: Calculus AP Edition, 3rd Edition, Pearson Prentice Hall

Time Frame	4 Weeks (10 blocks)

Topic

Integration Techniques

Alignment to Standards

A.SSE.1a, A.SSE.1b, A.SSE.2, A.CED.2, A.CED.4, A.REI.10, A.REI.11, F.IF.4, F.IF.5, F.IF.6, F.IF.6, F.IF.7, G.MG.3

Learning Objectives and Activities

SWBAT answer the following questions:

- What are differential equations?
- How is integration related to differentiation?
- How is integration used in chemistry, physics, and space?

SWBAT demonstrate understanding of the following:

- Know the relationship between integration and differentiation.
- Use specific integration techniques when appropriate – integration by parts, partial fractions, trigonometric substitution, completing the square, and trigonometric powers.
- The units of a particular solution or computation and how it relates to the question.

Learning Activities:

- Find an antiderivative using integration by parts.
- Recognize when tabular integration is applied.
- Understand the concept of partial fraction decomposition.

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- Use partial fraction decomposition with linear factors to integrate rational functions.
- Use partial fraction decomposition with quadratic factors to integrate rational functions.
- Use long division with partial fraction decomposition to integrate rational functions
- Recognize the appropriate trigonometric substitution and relate that substitution to an appropriate right triangle.
- Know that integration by trigonometric substitution may require additional integration techniques.
- Use the method of completing the square to find an antiderivative.
- Use trigonometric identities to find antiderivatives of functions defined by trigonometric powers
- Exploration – unique challenges to study concepts as reinforcement and/or to study concepts not yet formally covered.
- Note taking – students actively engaged with teacher in conversation about concepts and ideas, continuously questioning and practicing during this process.
- Projects – real life exercises solved by students using concepts and techniques generated in class.
- Think Pair Share – students work together by taking a moment to gather their thoughts and share them with their peers

Assessments

Formative:
- Classwork and Homework
- Teacher Observation
- Class Debate of Approaches/Mathematical Methods

Summative:
- Mid-unit Quizzes
- Topic Tests

Alternative:
- Kahoot/Quizizz
- Individual or group productive struggle assessment during introductory lessons

Interdisciplinary Connections

Career Readiness, Life Literacies, and Key Skills

Technology Integration

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All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaboratively and to create and communicate knowledge.

- 9.4.8.TL.6: Collaborate to develop and publish work that provides perspectives on a real-world problem.

Students will access the Big Ideas online ebook to further investigate lesson concepts and demonstrate understanding of standards.

- 9.4.8.TL.3: Select appropriate tools to organize and present information digitally.

Students will use internet based game sites such as Quizizz, Kahoot, and Quizlet live to reflect on their learning progress.

- 9.4.5.CT.3: Describe how digital tools and technology may be used to solve problems.

Supplemental instruction and math games will be presented using IXL Math and Video Tutor bigideasmath.com.

- 9.4.12.TL.1: Assess digital tools based on features such as accessibility options, capacities, and utility for accomplishing a specified task

Students will use Google Classroom to collaborate, work towards solving authentic problems, or participate in an online classroom discussion utilizing pre-learned etiquette about blended learning platforms.

- 9.4.12.TL.4: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Students will use graphing calculators to use math tools strategically and attend to precision and will use Desmos in order to discover new concepts involving graphing and functions.

- 9.4.8.IML.3: Create a digital visualization that effectively communicates a data set using formatting techniques such as form, position, size, color, movement, and spatial grouping

Career Education
CRP6: Demonstrate creativity and innovation. CRP11: Use technology to enhance productivity.

Time Frame	4 Weeks (10 blocks)

Topic
Parametric Equations & Polar Coordinates

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Alignment to Standards

A.SSE.3, A.CED.2, F.IF.1, F.IF.5

Learning Objectives and Activities

SWBAT answer the following questions:

- What is the intensity of radiation emitted from an antenna?
- How far does a planet travel along its orbit?
- How much area is needed to fill a parabolic shaped window bounded below by a circle?

SWBAT demonstrate understanding of the following:

- Represent curves or parts of curves parametrically.
- Represent conic sections with rectangular and polar relations.
- Understand the representation of area and arc length in rectangular and polar coordinates.

Learning Activities:

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Assessments

Formative:

- Daily Practice Problems
- Teacher Observation
- Entrance/Exit Cards

Summative:

- Mid-unit Quizzes
- Topic Tests

Alternative:

- Project - area of a surface of revolution
- Kahoot/Quizizz

Interdisciplinary Connections

DEPARTMENT Mathematics COURSE Multivariable Calculus Honors

Career Readiness, Life Literacies, and Key Skills

Technology Integration

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Career Education

CRP2: Apply appropriate academic and technical skills.
CRP8: Utilize critical thinking to make sense of problems and persevere in solving them.

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Time Frame	4 Weeks (10 blocks)

Topic

Vectors and the Geometry of Space

Alignment to Standards

N.VM.1, N.VM.2, N.VM.3, N.VM.4, N.VM.5, G.GMD.4

Learning Objectives and Activities

SWBAT answer the following questions:

- How much work is needed to pull a sled up an incline?
- How can we use vectors to analyze the flight of a plane?
- How much torque is being applied to the fulcrum of a crankshaft?
- How can we use vectors to write equations of plane?
- How can the equations of functions in three dimensions be constructed visually?
- How can we create equations for three dimensional space?
- What are the defining characteristics for quadric surfaces and how are they determined?
- What is the right hand rule for vectors and how does it apply in determining a solution?

SWBAT demonstrate understanding of the following:

- Represent position and motion in space using vectors.
- Relation of vectors to their dot product and cross product.
- Relation of two-space to three space via vectors.
- Use of vectors to represent planes in space.

Learning Activities:

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Assessments

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Formative:
- Classwork and Homework
- Teacher Observation
- Entrance/Exit Cards

Summative:
- Mid-unit Quizzes
- Topic Tests

Alternative:
- Kahoot/Quizizz
- Individual or group productive struggle assessment during introductory lessons

Interdisciplinary Connections

Career Readiness, Life Literacies, and Key Skills

Technology Integration

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- 9.4.12.TL.4: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

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- 9.4.8.IML.3: Create a digital visualization that effectively communicates a data set using formatting techniques such as form, position, size, color, movement, and spatial grouping

Career Education

CRP6: Demonstrate creativity and innovation.
CRP8: Utilize critical thinking to make sense of problems and persevere in solving them.

Time Frame	5 Weeks (12 blocks)

Topic

Vector-Valued Functions

Alignment to Standards

N.VM.3, G.C.5

Learning Objectives and Activities

SWBAT answer the following questions:

- How can vector-valued functions be used to predict speed and velocity in space?
- How can vector-valued functions be used in athletics?
- How do we model three-dimensional structures using vector-valued functions?

SWBAT demonstrate understanding of the following:

- Extend the concepts of limits and continuity to vector-valued functions.
- Analyze speed and velocity in space using vector-valued functions.
- Determine the calculus of vector-valued functions.

Learning Activities:

- Exploration – unique challenges to study concepts as reinforcement and/or to study concepts not yet formally covered.
- Note taking – students actively engaged with teacher in conversation about concepts

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and ideas, continuously questioning and practicing during this process.
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Assessments

Formative:
- Classwork and Homework
- Teacher Observation
- Class Debate of Approaches/Mathematical Methods

Summative:
- Mid-unit Quizzes
- Topic Tests
- Problem-based Quiz/Test

Alternative:
- Project - velocity and acceleration science application
- Kahoot/Quizizz

Interdisciplinary Connections

Career Readiness, Life Literacies, and Key Skills

Technology Integration

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Career Education
CRP2: Apply appropriate academic and technical skills. CRP11: Use technology to enhance productivity.

Time Frame	8 Weeks (20 blocks)

Topic
Functions of Several Variables

Alignment to Standards
F.IF.2, F.IF.3, F.IF.4, F.IF.8, G.C.4

Learning Objectives and Activities
SWBAT answer the following questions: • How can real-life problems be characterized by functions of several variables? Such as logging, business, and chemistry? • How do the concepts from single variable calculus apply and take form in multivariable calculus? • What is a function of several variables?

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- How do the concepts and rules of differentiation for functions of one variable extrapolate to functions of several variables?
- How do you determine maximum, minimum and saddle points for functions of several variables?
- What is the gradient of a function?
- How does the method of Lagrange Multipliers work?

SWBAT demonstrate understanding of the following:

- Compute rates of change of functions of several variables.
- Use gradient and normal vectors describe characteristics of curves.
- Determine extrema of functions of several variables.
- Lagrange multipliers as a method to solve boundary (constraint) problems.

Learning Activities:

- Exploration – unique challenges to study concepts as reinforcement and/or to study concepts not yet formally covered.
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Assessments

Formative:

- Daily Practice Problems
- Teacher Observation
- Entrance/Exit Cards

Summative:

- Mid-unit Quizzes
- Topic Tests

Alternative:

- Kahoot/Quizizz
- Individual or group productive struggle assessment during introductory lessons

Interdisciplinary Connections

Science: HS-ETS1-2: Students will design a solution to a complex real-world problem involving maximum and minimum by breaking it down into smaller, more manageable problems that can be solved through engineering.

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Career Readiness, Life Literacies, and Key Skills

Technology Integration

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Career Education

CRP8: Utilize critical thinking to make sense of problems and persevere in solving them.
CRP11: Use technology to enhance productivity.

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Time Frame	8 Weeks (20 blocks)

Topic

Multiple Integration

Alignment to Standards

N.CN.4, G.GMD.4, A.CED.2, A.SSE.2, F.IF.8

Learning Objectives and Activities

SWBAT answer the following questions:

- How can real-life problems be described by multiple integrals? Such as average production of automobiles, population density, and center pressure on a sail.
- How do the concepts of the definite integral relate to multiple integrals in multivariable calculus?
- What is the definition of a multiple integral?
- How can an integral from Cartesian coordinates be converted to Polar, Cylindrical or Spherical coordinates?
- How are multiple and iterated integrals applied to real world problems?

SWBAT demonstrate understanding of the following:

- Represent area and volume with multiple integrals.
- Change variables of a multiple integral.
- Represent and evaluate multiple integrals that determine the center of mass.
- Lagrange multipliers as a method to solve boundary (constraint) problems.

Learning Activities:

- Exploration – unique challenges to study concepts as reinforcement and/or to study concepts not yet formally covered.
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Assessments

Formative:

- Classwork and Homework

- Teacher Observation
- Class Debate of Approaches/Mathematical Methods
- Graphic Organizer
- Entrance/Exit Cards

Summative:

- Mid-unit Quizzes
- Topic Tests
- Problem-based Quiz/Test

Alternative:

- Observation Assessment with Problem-solving
- Kahoot/Quizizz
- Individual or group productive struggle assessment during introductory lessons

Interdisciplinary Connections

Career Readiness, Life Literacies, and Key Skills

Technology Integration

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Students will use Google Classroom to collaborate, work towards solving authentic

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problems, or participate in an online classroom discussion utilizing pre-learned etiquette about blended learning platforms.

- 9.4.12.TL.4: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Students will use graphing calculators to use math tools strategically and attend to precision and will use Desmos in order to discover new concepts involving graphing and functions.

- 9.4.8.IML.3: Create a digital visualization that effectively communicates a data set using formatting techniques such as form, position, size, color, movement, and spatial grouping

Career Education

CRP2: Apply appropriate academic and technical skills.
CRP11: Use technology to enhance productivity.

Time Frame	7 Weeks (17 blocks)

Topic

Vector Analysis

Alignment to Standards

F.LE.5, N.VM.1, N.VM.5.b, N.VM.6, N.VM.11

Learning Objectives and Activities

SWBAT answer the following questions:

- How are vector fields determined to be conservative? What does this mean?
- How can a line integral be used to find the mass of a spring?
- How can curl be used to analyze the motion of a rotating liquid?
- What is a vector field?
- What is the fundamental theorem for line-integrals?
- What is Green's Theorem?
- What is the relationship between curl and divergence?
- What is the relationship between the Fundamental Theorem of Calculus, Fundamental Theorem for Line Integrals, Green's Theorem, and Stoke's Theorem and the Divergence Theorem?

SWBAT demonstrate understanding of the following:

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- Different applications of vector fields.
- Determining the conservation of a vector field.
- Meaning of the theorems of Green and Stoke.

Learning Activities:

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Assessments

Formative:

- Classwork and Homework
- Teacher Observation
- Class Debate of Approaches/Mathematical Methods
- Entrance/Exit Cards

Summative:

- Mid-unit Quizzes
- Topic Tests
- Problem-based Quiz/Test

Benchmark:

- Cumulative final exam with multiple choice, short answer, and extended constructed response questions.

Alternative:

- Observation Assessment with Problem-solving
- Kahoot/Quizizz
- Individual or group productive struggle assessment during introductory lessons

Interdisciplinary Connections

ELA: W.11-12.1: When students are justifying their reasoning on short answer and extended constructed response questions they write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.

Career Readiness, Life Literacies, and Key Skills

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9.3.ST.5: Demonstrate an understanding of the breadth of career opportunities and means to those opportunities in each of the Science, Technology, Engineering & Mathematics Career Pathways.

Technology Integration

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Career Education

CRP6: Demonstrate creativity and innovation.
CRP11: Use technology to enhance productivity.

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Modifications (ELL, Special Education, At Risk Students, Gifted & Talented, & 504 Plans)

ELL:

- Work toward longer passages as skills in English increase
- Use visuals
- Introduce key vocabulary before lesson
- Teacher models reading aloud daily
- Provide peer tutoring
- Use of Bilingual Dictionary
- Guided notes and/or scaffold outline for written assignments
- Provide students with English Learner leveled readers.

Supports for Students With IEPs:

- Allow extra time to complete assignments or tests
- Guided notes and/or scaffold outline for written assignments
- Work in a small group
- Allow answers to be given orally or dictated
- Use large print books, Braille, or books on CD (digital text)
- Follow all IEP modifications

At-Risk Students:

- Guided notes and/or scaffold outline for written assignments
- Introduce key vocabulary before lesson
- Work in a small group
- Lesson taught again using a differentiated approach
- Allow answers to be given orally or dictated
- Use visuals / Anchor Charts
- Leveled texts according to ability

Gifted and Talented:

- Create an enhanced set of introductory activities (e.g. advance organizers, concept maps, concept puzzles)
- Provide options, alternatives and choices to differentiate and broaden the curriculum
- Organize and offer flexible small group learning activities
- Provide whole group enrichment explorations
- Teach cognitive and methodological skills
- Use center, stations, or contracts
- Organize integrated problem-solving simulations

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- Propose interest-based extension activities
- Expose students to beyond level texts.

Supports for Students With 504 Plans:

- Follow all the 504 plan modifications
- Text to speech/audio recorded selections
- Amplification system as needed
- Leveled texts according to ability
- Fine motor skill stations embedded in rotation as needed
- Modified or constrained spelling word lists
- Provide anchor charts with high frequency words and phonemic patterns