# MATHEMATICS TRANSFER ASSURANCE GUIDE (TAG)
# January 20, 2010

## Ohio Transfer Module:

**Ohio Transfer Module (OTM) Requirements:** 36-40 semester hours / 54-60 quarter hours. Students should select courses within the OTM that complement the selected major and meet any specific general education requirements. Students are encouraged to complete the OTM to ensure maximum transferability and application of credits.

| Required Disciplines | Minimum Required Hours | Recommended Courses |
|---|---|---|
| Area I. English Composition | 3 sem. / 5-6 qtr. | |
| Area II. Mathematics | 3 sem. / 3 qtr. | **Calculus I & II (Prerequisites)** |
| Area III. Arts & Humanities | 6 sem. / 9 qtr. | |
| Area IV. Social Sciences | 6 sem. / 9 qtr. | |
| Area V. Natural & Physical Science | 6 sem. / 9 qtr. | College Physics I & II w/lab (Calculus-based) |

Additional courses beyond the minimum required hours, from any of the disciplines listed above, will count toward the completion of the OTM (36-40 semester hours or 54-60 quarter hours).

**Foreign Language** - Demonstrate competencies through the 200 level. Credits: Up to 16 semester hours / 24 quarter hours.

**Major Courses– Hours/courses listed below that count toward the major or pre-major requirements.**

| | |
|---|---|
| **a. Calculus III – OMT018** | Credits: 4-5 semester hours /6-8 quarter hours |
| Advising Notes: | |
| **b. Elementary Linear Algebra – OMT019** | Credits: 3-4 semester hours /4-5 quarter hours |
| Advising Notes: | |
| **c. Elementary Differential Equations – OMT020** | Credits: 3-4 semester hours /4-5 quarter hours |
| Advising Notes: | |

| **Transfer Assurance Guides Total Guaranteed Credits (Range)** | | |
|---|---|---|
| • Ohio Transfer Module | 36 – 40 sem. | 54 – 60 qtr. |
| • Foreign Language | 0 – 16 sem. | 0 – 24 qtr. |
| • Pre-major / Major | 0 – 10 to 13 sem. | 0 – 14 to 18 qtr. |

**Institutional Requirements:** For entrance and graduation, a transfer student must meet all institutional requirements which would include, but may not be limited to: minimum grade point average, residency requirements, upper division credits attained, minimum grades in specific courses, performance requirements (ex. dance, music) and other requirements of native students from the same institution

**OMT018 - CALCULUS III**
**4-5 Semester Hours/6-8 Quarter Hours**

**Related TAGs:** Chemistry, Computer/Electrical Engineering, Mathematics, Physics

In a Calculus III course, students should:

- develop mathematical thinking and communication skills and learn to apply precise, logical reasoning to problem solving, as emphasized in the calculus renewal movement.
- be able to communicate the breadth and interconnections of the mathematical sciences through being presented key ideas and concepts from a variety of perspectives, a broad range of examples and applications, connections to other subjects, and contemporary topics and their applications.
- experience geometric as well as algebraic viewpoints and approximate as well as exact solutions.
- use computer technology to support problem solving and to promote understanding (e.g., graphics packages enhance multivariable calculus).
- for students in the mathematical sciences, progress from a procedural/computational understanding of mathematics to a broad understanding encompassing logical reasoning, generalization, abstraction, and formal proof; gain experience in careful analysis of data; and become skilled at conveying their mathematical knowledge in a variety of settings, both orally and in writing.

– Adapted from the MAA/CUPM 2004 Curriculum Guide

The prerequisite for Calculus III is generally by TMM 006 Calculus II.

To qualify for TAG equivalency of OMT018 (Calculus III), a course must cover as a minimum the essential learning outcomes, denoted by an asterisk (*). A Calculus III course may also commonly include some of the listed nonessential learning outcomes. These optional topics should be included only if there is adequate course time to do so beyond giving primary course attention to the essential learning outcomes. At least 70% of the classroom instructional time has to be spent on the essential learning outcomes. The optional learning outcomes are learning experiences that enhance, reinforce, enrich or are further applications of the essential learning outcomes. If review of prerequisite course content is necessary, only a minimal amount of time should be devoted to such review.

The successful Calculus III student should be able to:

1. Perform and apply vector operations, including the dot and cross product of vectors, in the plane and space. Graph and find equations of lines, planes, cylinders and quadratic surfaces.
2. **Differentiate and integrate vector-valued functions. For a position vector function of time, interpret these as velocity and acceleration.***
3 **Evaluate limits and determine the continuity and differentiability of functions of several variables. ***
4. **Describe graphs, level curves and level surfaces of functions of several variables.***
5. Find arc length and curvature of space curves, including the use of unit tangents and unit normals; identify and interpret tangential and normal components of acceleration.
6. **Find partial derivatives, directional derivatives, and gradients and use them to solve applied problems.***
7. Find differentials of functions of several variables and use them to solve applied problems.
8. **Find equations of tangent planes and normal lines to surfaces that are given implicitly or parametrically.***
9. **Use the chain rule for functions of several variables (including implicit differentiation).***
10. **For functions of several variables, find critical points using first partials and interpret them as relative extrema/saddle points using the second partials test. Find absolute extrema on a closed region. Apply these techniques to optimization problems.***
11 Use Lagrange multipliers to solve constrained optimization problems.
12. **Evaluate multiple integrals in appropriate coordinate systems such as rectangular, polar, cylindrical and spherical coordinates and apply them to solve problems involving volume, surface area, density, moments and centroids.***
13. Use Jacobians to change variables in multiple integrals.
14. **Evaluate line and surface integrals. Identify when a line integral is independent of path and use the Fundamental Theorem of Line Integrals to solve applied problems.***
15. **Identify conservative and inverse square fields.***
16. **Find the curl and divergence of a vector field, the work done on an object moving in a vector field, and the flux of a field through a surface. Use these ideas to solve applied problems.***
17. **Introduce and use Green's Theorem, the Divergence (Gauss's) Theorem and Stokes's Theorem.***

# MATHEMATICS TRANSFER ASSURANCE GUIDE (TAG)
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**OMT019 - ELEMENTARY LINEAR ALGEBRA**
**3-4 Semester Hours/4-5 Quarter Hours**

**Related TAGs:** Math, Physics

In an Elementary Linear Algebra course, students should:

- develop mathematical thinking and communication skills and learn to apply precise, logical reasoning to problem solving (e.g., teaching computational techniques should not override the goal of leading students to understand fundamental mathematical relationships).
- be able to communicate the breadth and interconnections of the mathematical sciences through being presented key ideas and concepts from a variety of perspectives, a broad range of examples and applications, connections to other subjects, and contemporary topics and their applications.
- experience geometric as well as algebraic viewpoints and approximate as well as exact solutions.
- use computer technology to support problem solving and to promote understanding (e.g., linear algebra courses can use technology for matrix manipulation or for visualizing the effects of linear transformations in two or three dimensions, and technology makes large linear systems tractable).
- for students in the mathematical sciences, progress from a procedural/computational understanding of mathematics to a broad understanding encompassing logical reasoning, generalization, abstraction, and formal proof; gain experience in careful analysis of data; and become skilled at conveying their mathematical knowledge in a variety of settings, both orally and in writing.

– Adapted from the MAA/CUPM 2004 Curriculum Guide

The prerequisite for an Elementary Linear Algebra course is generally either a year-long sequence in calculus (TMM005 Calculus I & TMM006 Calculus II) or OMT018 Calculus III. Adapted statements regarding Calculus in the MAA/CUPM 2004 Curriculum Guide also generally apply to Elementary Linear Algebra.

In addition, any elementary linear algebra course should

- respond to the needs of client disciplines;
- focus on a being a matrix-oriented course;
- maintain a strong geometric emphasis;

- consider the needs and interests of students as learners;
- utilize technology to reinforce concepts, contribute to discoveries, and support finding solutions to realistic applied problems; and
- lead to a second course in matrix theory/linear algebra.

– Adapted from the 1993 Linear Algebra Curriculum Study Group Recommendations

To qualify for TAG equivalency of OMT019 (Elementary Linear Algebra), a course must cover as a minimum the essential learning outcomes, denoted by an asterisk (*). An Elementary Linear Algebra course may also commonly include some of the listed nonessential learning outcomes. These optional topics should be included only if there is adequate course time to do so beyond giving primary course attention to the essential learning outcomes. At least 70% of the classroom instructional time has to be spent on the essential learning outcomes. The optional learning outcomes are learning experiences that enhance, reinforce, enrich or are further applications of the essential learning outcomes. If review of prerequisite course content is necessary, only a minimal amount of time should be devoted to such review.

The successful Linear Algebra student should be able to:

***1. Understand algebraic and geometric representations of vectors in $R^n$ and their operations, including addition, scalar multiplication and dot product. Understand how to determine the angle between vectors and the orthogonality of vectors.**

***2. Solve systems of linear equations using Gauss-Jordan elimination to reduce to echelon form. Solve systems of linear equations using the inverse of the coefficient matrix when possible. Interpret existence and uniqueness of solutions geometrically.**

***3. Perform common matrix operations such as addition, scalar multiplication, multiplication, and transposition. Discuss associativity and noncommutativity of matrix multiplication.**

***4. Discuss spanning sets and linear independence for vectors in $R^n$. For a subspace of $R^n$, prove all bases have the same number of elements and define the dimension. Prove elementary theorems concerning rank of a matrix and the relationship between rank and nullity.**

***5. Interpret a matrix as a linear transformation from $R^n$ to $R^m$. Discuss the transformation's kernel and image in terms of nullity and rank of the matrix. Understand the relationship between a linear transformation and its matrix representation, and explore some geometric transformations in the plane. Interpret a matrix product as a composition of linear transformations.**

***6. Use determinants and their interpretation as volumes. Describe how row operations affect the determinant. Analyze the determinant of a product algebraically and geometrically.**

***7. Define eigenvalues and eigenvectors geometrically. Use characteristic polynomials to compute eigenvalues and eigenvectors. Use eigenspaces of matrices, when possible, to diagonalize a matrix.**

***8. Use axioms for abstract vector spaces (over the real or complex fields) to discuss examples (and non-examples) of abstract vector spaces such as subspaces of the space of all polynomials.**

9. Discuss the existence of a basis of an abstract vector space. Describe coordinates of a vector relative to a given basis. For a linear transformation between vector spaces, discuss its matrix relative to given bases. Discuss how those matrices changes when the bases are changed.

10. Discuss orthogonal and orthonormal bases, Gram-Schmidt orthogonalization, orthogonal complements and projections. Discuss rigid motions and orthogonal matrices.

11. Discuss general inner product spaces and symmetric matrices, and associated norms. Explain how orthogonal projections relate to least square approximations.

**OMT020 - ELEMENTARY DIFFERENTIAL EQUATIONS**
**3-4 Semester Hours/4-5 Quarter Hours**

**Related TAGs:** AACM Engineering, Chemical Engineering, Math, Physics

In an Elementary Differential Equations course, students should:

- develop mathematical thinking and communication skills and learn to apply precise, logical reasoning to problem solving, as emphasized in the calculus renewal movement.
- be able to communicate the breadth and interconnections of the mathematical sciences through being presented key ideas and concepts from a variety of perspectives, a broad range of examples and applications, connections to other subjects, and contemporary topics and their applications.
- experience geometric as well as algebraic viewpoints and approximate as well as exact solutions.
- use computer technology to support problem solving and to promote understanding (e.g., most modern texts make use of a differential equation solver that can permit the early introduction of modeling with systems of differential equations).
- for students in the mathematical sciences, progress from a procedural/computational understanding of mathematics to a broad understanding encompassing logical reasoning, generalization, abstraction, and formal proof; gain experience in careful analysis of data; and become skilled at conveying their mathematical knowledge in a variety of settings, both orally and in writing.

– Adapted from the MAA/CUPM 2004 Curriculum Guide

The prerequisite for an Elementary Differential Equations course is generally either a year-long sequence in calculus (TMM005 Calculus I & TMM006 Calculus II) or OMT018 Calculus III. Since an Elementary Differential Equations course follows from differential and integral calculus, adapted statements regarding Calculus in the MAA/CUPM 2004 Curriculum Guide also apply to Elementary Differential Equations.

To qualify for OMT020 (Elementary Differential Equations), a course must cover as a minimum the essential learning outcomes, denoted by an asterisk *. A course in Elementary Differential Equations may also commonly include some of the listed nonessential learning outcomes. These optional topics should be included only if there is adequate course time to do so beyond giving primary course attention to the essential learning outcomes. At least 70% of the classroom instructional time has to be spent on the essential learning outcomes. The optional learning outcomes are learning experiences that enhance, reinforce, enrich or are further applications

of the essential learning outcomes. If review of prerequisite course content is necessary, only a minimal amount of time should be devoted to such review.

The successful Elementary Differential Equations student should be able to:

1. **Solve first-order differential equations that are separable, linear or exact. ***
2. **Solve first-order differential equations by making the appropriate substitutions, including homogeneous and Bernoulli equations.***
3. **Use linear or nonlinear first-order differential equations to solve application problems such as exponential growth and decay, population logistics growth, velocity, solution mixtures, two component series circuits and chemical reactions.***
4. **Understand the relationship between slope fields and solution curves for differential equations. Use a slope field and an initial condition to estimate a solution curve to a differential equation.***
5. Approximate solutions of first-order differential equations using Euler and Runge-Kutta methods.
6. Use the method of reduction of order.
7. **Solve higher-order homogeneous linear equations with constant coefficients. ***
8. **Solve higher-order nonhomogeneous linear equations with constant coefficients by the method of undetermined coefficients. ***
9. **Solve higher-order nonhomogeneous linear equations by the method of variation of parameters. ***
10. **Use linear second-order differential equations to solve application problems such as spring/mass system motion problems, acceleration, or three component series circuits. ***
11. Solve application problems requiring the use of higher-order differential equations with boundary conditions, such as the whirling string, the deflection of a uniform beam and the buckled rod.
12. Use power series to solve higher-order differential equations about ordinary or singular points.
13. Solve special classes of equations such as Cauchy-Euler, Bessel and Legendre equations.
14. **Perform operations with Laplace and inverse Laplace transforms to solve higher-order differential equations.***
15. Solve systems of differential equations.

**OSC022 - COLLEGE PHYSICS SEQUENCE**
**8-10 Semester Hours/12-15 Quarter Hours**

**This is a combination of OSC016 and OSC017, Calculus-based Physics I and II.**

**OSC016 - PHYSICS I – CALCULUS BASED PHYSICS FOR THE MAJOR (W/LABS)**
**4-5 Semester Hours/8-10 Quarter Hours**
**Co-requisites:** Calculus I.

**Related TAGs:** Bioengineering, Biology, Chemistry, Computer/Electrical Engineering, Geology, Industrial Engineering, Math, Physics

Understanding and/application of the following topics using calculus concepts and methods where appropriate:

1. Kinematics – one and two dimensional
2. Vectors – vector Arithmetic
3. Force and Newton's Laws of Motion
4. Work, Energy, Conservation of Energy
5. Linear momentum
6. Collisions
7. Rotational kinematics and dynamics
8. Angular momentum and rotational energy
9. Simple harmonic motion
10. Waves and sound
11. Solid and fluid properties
12. Heat and thermodynamics
13. Kinetic theory of gases

**OSC017 - PHYSICS II – CALCULUS BASED PHYSICS FOR THE MAJOR (W/LABS)**
**4-5 Semester Hours/8-10 Quarter Hours**

**Related TAGs:** Bioengineering, Chemistry, Computer/Electrical Engineering, Industrial Engineering, Math, Physics

14. Electric field, potential, forces
15. Current, magnetic field integration over continuous charge/current distribution
16. Quantum physics
17. Atomic physics
18. Nuclear physics
19. Induction and Inductance
20. Resistance
21. Capacitance
22. Basic circuit analysis
23. Electric power
24. Energy stored fields
25. EMF
26. Electromagnetic waves
27. Gauss Law
28. Kirchhoff's Law
29. R-L-C circuits
30. Ampere's Law
31. Faraday's Law
32. Conductivity
33. Geometric optics
34. Diffraction
35. Interference
36. Polarization

**TMM017– CALCULUS I & II SEQUENCE**
**8-10 Semester Hours/15 Quarter Hours**

**Related TAGs**: AACM Engineering, Bioengineering, Chemical Engineering, Chemistry, Electrical Engineering, Industrial Engineering, Mathematics, Physics

This sequence OTM is a combination of the outcomes in TMM005 and TMM006

**TMM005 -CALCULUS I**
**4-5 Semester Hours/8-10 Quarter Hours**

**Related TAGs:** AACM Engineering, Biology, Bioengineering, Chemical Engineering, Chemistry, Economics, Electrical Engineering, Industrial Engineering, Math, Physics

In a Calculus I course, students should:

- develop mathematical thinking and communication skills and learn to apply precise, logical reasoning to problem solving.
- be able to communicate the breadth and interconnections of the mathematical sciences through being presented key ideas and concepts from a variety of perspectives, a broad range of examples and applications, connections to other subjects, and contemporary topics and their applications.
- experience geometric as well as algebraic viewpoints and approximate as well as exact solutions.
- use computer technology to support problem solving and to promote understanding, as most calculus students, especially those who may take only one semester, profit from the use of a graphing utility and a tool for numerical integration.
- for students in the mathematical sciences, progress from a procedural/computational understanding of mathematics to a broad understanding encompassing logical reasoning, generalization, abstraction, and formal proof; gain experience in careful analysis of data; and become skilled at conveying their mathematical knowledge in a variety of settings, both orally and in writing.

– Adapted from the MAA/CUPM 2004 Curriculum Guide

The prerequisite for Calculus I is generally by placement, TMM002 (Precalculus) or by a sequence of TMM001 and TMM003 (College Algebra and Trigonometry, respectively).

To qualify for OTM equivalency of TMM005 (Calculus I), a course must cover as a minimum the essential learning outcomes, denoted by an asterisk (*). A Calculus I course may also commonly include some of the listed nonessential learning outcomes. These optional topics should be included only if there is adequate course time to do so beyond giving primary course attention to the essential learning outcomes. At least 70% of the classroom instructional time has to be spent on the essential learning outcomes. The

optional learning outcomes are learning experiences that enhance, reinforce, enrich or are further applications of the essential learning outcomes. If review of prerequisite course content is necessary, only a minimal amount of time should be devoted to such review.

The successful Calculus I student should be able to apply the following competencies to a wide range of functions, including piecewise, polynomial, rational, algebraic, trigonometric, inverse trigonometric, exponential and logarithmic:

1. **Determine the existence of, estimate numerically and graphically and find algebraically the limits of functions. Recognize and determine infinite limits and limits at infinity and interpret them with respect to asymptotic behavior.***

2. **Determine the continuity of functions at a point or on intervals and distinguish between the types of discontinuities at a point.***

3. **Determine the derivative of a function using the limit definition and derivative theorems. Interpret the derivative as the slope of a tangent line to a graph, the slope of a graph at a point, and the rate of change of a dependent variable with respect to an independent variable.***

4. **Determine the derivative and higher order derivatives of a function explicitly and implicitly and solve related rates problems.***

5. **Determine absolute extrema on a closed interval for continuous functions and use the first and second derivatives to analyze and sketch the graph of a function, including determining intervals on which the graph is increasing, decreasing, constant, concave up or concave down and finding any relative extrema or inflection points. Appropriately use these techniques to solve optimization problems.***

6. Determine when the Mean Value Theorem can be applied and use it in proofs of other theorems such as L'Hopital's rule.

7. Use differentials and linear approximations to analyze applied problems.

8. **Determine antiderivatives, indefinite and definite integrals, use definite integrals to find areas of planar regions, use the Fundamental Theorems of Calculus, and integrate by substitution.***

**TMM006 - CALCULUS II**
**4-5 Semester Hours/8-10 Quarter Hours**

**Related TAGs**: AACM Engineering, Bioengineering, Chemical Engineering, Chemistry, Electrical Engineering, Industrial Engineering, Mathematics, Physics

In a Calculus II course, students should:

- develop mathematical thinking and communication skills and learn to apply precise, logical reasoning to problem solving, as emphasized in the calculus renewal movement.
- be able to communicate the breadth and interconnections of the mathematical sciences through being presented key ideas and concepts from a variety of perspectives, a broad range of examples and applications, connections to other subjects, and contemporary topics and their applications.
- experience geometric as well as algebraic viewpoints and approximate as well as exact solutions.
- use computer technology to support problem solving and to promote understanding (e.g., technology allows students easy access to the graphs of planar curves and visualization helps students understand concepts such as approximation of integrals by Riemann sums or functions by Taylor polynomials; symbolic manipulation can be handled allowing students to focus their attention on understanding concepts; computer algorithms can be explored; and conjectures can be posited, investigated and refined, such as manipulating parameters on classes of functions and fitting functional models to data).
- for students in the mathematical sciences, progress from a procedural/computational understanding of mathematics to a broad understanding encompassing logical reasoning, generalization, abstraction, and formal proof; gain experience in careful analysis of data; and become skilled at conveying their mathematical knowledge in a variety of settings, both orally and in writing.

– Adapted from the MAA/CUPM 2004 Curriculum Guide

The prerequisite for Calculus II is generally by TMM005 Calculus I.

To qualify for OTM equivalency of TMM006 (Calculus II), a course must cover as a minimum the essential learning outcomes, denoted by an asterisk (*). A Calculus II course may also commonly include some of the listed nonessential learning outcomes. These optional topics should be included only if there is adequate course time to do so beyond giving primary course attention to the essential learning outcomes. At least 70% of the classroom instructional time has to be spent on the essential learning outcomes. The optional learning outcomes are learning experiences that enhance, reinforce, enrich or are further applications of the essential learning outcomes. If review of prerequisite course content is necessary, only a minimal amount of time should be devoted to such review.

The successful Calculus II student should be able to:

1. **Use antiderivatives to evaluate definite integrals and apply definite integrals in a variety of applications to model physical, biological or economic situations. Whatever applications (e.g. determining area, volume of solids of revolution, arc length, area of surfaces of revolution, centroids, work, and fluid forces) are chosen, the emphasis should be on setting up an approximating Riemann sum and representing its limit as a definite integral.***

2. Approximate a definite integral by the Trapezoidal Rule and Simpson's Rule.

3. **Employ a variety of integration techniques to evaluate special types of integrals, including substitution, integration by parts, trigonometric substitution, and partial fraction decomposition.***

4. **Evaluate limits that result in indeterminate forms, including the application of L'Hôpital's Rule.***

5. **Evaluate improper integrals, including integrals over infinite intervals, as well as integrals in which the integrand becomes infinite on the interval of integration.***

6. Find, graph, and apply the equations of conics, including conics where the principal axes are not parallel to the coordinate axes.

7. **Determine the existence of, estimate numerically and graphically, and find algebraically the limits of sequences. Determine whether a series converges by using appropriate tests, including the comparison, ratio, root, integral and alternating series tests.***

8. **Find the $n^{th}$ Taylor polynomial at a specified center for a function and estimate the error term. Use appropriate techniques to differentiate, integrate and find the radius of convergence for the power series of various functions.***

9. **Analyze curves given parametrically and in polar form and find the areas of regions defined by such curves.***

10. Perform and apply vector operations, including the dot and cross product of vectors, in the plane and space.

11. Solve separable differential equations. Understand the relationship between slope fields and solution curves for differential equations. Use Euler's method to find numerical solutions to differential equations.

# MATHEMATICS TAG – FACULTY PARTICIPANTS

| Name | Institution |
|---|---|
| Judith Johnson | Central State University |
| Dave Hare | Clark State Community College |
| Jerry Mueller | Columbus State Community College |
| Dottie Walton | Cuyahoga Community College |
| Rodney Null | James A. Rhodes State College |
| Andrew Tonge | Kent State University |
| James Smolko | Lakeland Community College |
| Sheldon Davis | Miami University |
| John Falls | North Central State College |
| Maria Rizzo | Ohio University |
| Chris O'Connor | Shawnee State University |
| Barbara Carruth | Sinclair Community College |
| David Stott | Sinclair Community College |
| Joanna Mitro | University of Cincinnati |
| Ricardo Moena | University of Cincinnati |
| John Buoni | Youngstown State University |