ELECTRICAL ENGINEERING TECHNOLOGY TRANSFER ASSURANCE GUIDE (TAG)
May 31, 2017

Ohio Transfer Module:		
Ohio Transfer Module (OTM) Requirements: 36-40 semester 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 Semester Hours	
Area II. Mathematics	3 Semester Hours	College Algebra (TMM001) and Pre-Calculus (TMM002)
Area III. Arts & Humanities	6 Semester Hours	
Area IV. Social Sciences	6 Semester Hours	
Area V. Natural & Physical Science	6 Semester Hours	Algebra-Based Physics I (OSC014). Full sequence may be required by some institutions.
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).		
Advising Note: Students should consult with receiving institution to ensure courses are completed in proper sequence. Students wanting cooperative education programs should consult with target institution as soon as possible.		

Major Courses – Hours/Courses listed below that count toward the major or pre-major requirements	
OET001 – DC Circuits	Credits: 3 Semester Hours
Advising Notes: This course should be taken as a sequence with AC circuits before transferring. Corequisite or Prerequisite: College Algebra (TMM001) or equivalent	
OET002 – Digital Electronics	Credits: 3-4 Semester Hours
Advising Notes: This course should be taken as a sequence with AC circuits before transferring.	
OET003 – AC Circuits	Credits:3 Semester Hours
Advising Notes: This course should be taken as a sequence with DC circuits before transferring. Corequisite or Prerequisite: Trigonometry (TMM003) (Trigonometry requirement may be met by embedded course objectives). Prerequisite: DC Circuits (OET001)	
OET004 – Microprocessors/Microcontrollers	Credits: 3-4 Semester Hours
Advising Notes: Prerequisite: Digital Electronics (OET002)	
OET005 – Electronics	Credits: 3-4 Semester Hours
Advising Notes: Prerequisite: DC Circuits (OET001)	
OET022 – Programmable Logic Controllers	Credits: 3 Semester Hours
Advising Notes:	

Transfer Assurance Guides Total Guaranteed Credits (Range)	
Ohio Transfer Module (OTM)	36 – 40 Semester Hours
Pre-major/Major	0 – 18 Semester Hours

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.

OET001 – DC Circuits
3 Semester Hours

Corequisite or Prerequisite: College Algebra (TMM001) or equivalent

Related TAGs: Electrical Engineering Technology, Solar Energy, Wind Energy

General Course Description:
A detailed study of direct current electric circuits and related bilateral devices. This course covers DC fundamentals, the systems that use them, and the basic sources of DC electricity. Conventional and computer circuit analysis will be used. Includes hands-on labs.

Student Learning Outcomes marked with an asterisk (*) are essential and must be met.

Students will be able to:

1. Demonstrate an understanding of and application for electrical components and quantities.*
2. Define voltage, current, electrical resistance, and power.*
3. Utilize Ohm's law and Kirchhoff's Laws to analyze circuits.*
4. Determine resistance, current, voltage, and power for series circuits, parallel circuits, and series-parallel circuits.*
5. Apply circuit theorems such as superposition, Thevenin's and Norton's to the analysis of circuits.*
6. Employ mesh and/or nodal analysis techniques to analyzing circuits.*
7. Demonstrate an understanding of the properties of capacitors and their behavior under DC conditions.*
8. Demonstrate an understanding of the properties of inductors and their behavior under DC conditions.*

OET002 – Digital Electronics
3-4 Semester Hours

Prerequisite: None

Related TAG: Electrical Engineering Technology

General Course Description:
Principles and applications of digital systems. Emphasis placed on the study of combinational and sequential logic from a systems approach. Actual ICs and Programmable logic devices (PLDs) are used, as well as digital timing diagrams and waveforms. Includes hands-on labs.

Student Learning Outcomes marked with an asterisk (*) are essential and must be met.

Students will be able to:

1. Demonstrate an understanding of and application for number systems, operations, and codes.*
2. Identify various types of logic gates and explain their truth tables.*
3. Utilize Boolean Algebra to describe and simplify digital logic circuits.*
4. Apply DeMorgan's theorem to simplify combinational logic circuits.*
5. Design combinational logic circuits to meet specified system requirements.*
6. Demonstrate an understanding of and applications for Encoders/decoders.*
7. Demonstrate an understanding of and applications for multiplexers/demultiplexers.*
8. Demonstrate an understanding of and applications for adders, subtractors, and Arithmetic Logic Units (ALUs).*
9. Explain the types of, operation of, and applications for flip-flops and related devices.*
10. Demonstrate an understanding of and applications for counters.*
11. Demonstrate an understanding of and applications for shift registers.*
12. Utilize and explain the types of memory and storage in digital circuits.*
13. Explain the development of and applications for integrated circuit technologies.*

OET003 – AC Circuits
3 Semester Hours

Corequisite or Prerequisite: Trigonometry (TMM003) (Trigonometry requirement may be met by embedded course objectives)
Prerequisite: DC Circuits (OET001)

Related TAGs: Electrical Engineering Technology, Solar Energy, Wind Energy

General Course Description:
A detailed study of analog alternating current electric networks, including resistive, reactive, and combinational thereof. This course covers AC fundamentals, the systems that use them, and the basic sources of AC electricity. Analysis techniques include conventional and computerized modeling methodology.

Student Learning Outcomes marked with an asterisk (*) are essential and must be met.

Students will be able to:

1. Demonstrate an understanding of the properties of sinusoidal waves.*
2. Demonstrate an understanding of and application for phasors and use complex numbers to perform addition and subtraction of phasors.*
3. Demonstrate a working knowledge of transformer characteristics and applications.*
4. Analyze the steady-state behavior of RC, RL, and RCL circuits under AC conditions.*
5. Design, analyze, and demonstrate an understanding of basic filter circuits.*
6. Apply superposition, Thevenin's, and Norton's theorems to the analysis of AC circuits.*
7. Demonstrate a basic working knowledge of three-phase and/or poly-phase systems.*
8. Calculate power factor and demonstrate an understanding of the impact of low power factor.*

OET004 – Microprocessors/Microcontrollers
3-4 Semester Hours

Prerequisite: Digital Electronics (OET002)

Related TAG: Electrical Engineering Technology

General Course Description:
This course includes microprocessor/microcontroller architecture, instruction sets, software development, interrupt handling, memory, interfacing techniques, and hardware used in control applications designed with microprocessor/ microcontrollers. Includes hands-on labs.

Student learning outcomes marked with an asterisk (*) are essential and must be met.

Students will be able to:

1. Explain microprocessor architecture.*
2. Utilize assembly language programming to develop code for a microprocessor.*
3. Explain and utilize bus timing diagrams.*
4. Demonstrate an understanding of and applications for bus structures.*
5. Utilize memory technologies and interfacing in microprocessors.*
6. Implement input/output (I/O) systems, I/O interface requirements, and interrupt based I/O.*
7. Utilize direct memory access (DMA) in microprocessor applications.*
8. Utilize microprocessors/microcontrollers in a variety of applications.*

OET005 – Electronics
3-4 Semester Hours

Prerequisite: DC Circuits (OET001)

Related TAG: Electrical Engineering Technology

General Course Description:
This course is an introduction to the theory, operation, and practical applications of solid state devices. Topics include diodes, bipolar junction transistors, amplifiers, frequency response, operational amplifiers, oscillators, power supplies, and voltage regulators. Includes hands-on labs.

Student Learning Outcomes marked with an asterisk (*) are essential and must be met.

Students will be able to:

1. Demonstrate an understanding and working knowledge of semiconductor properties.*
2. Identify common and special purpose diode types and their operations. Utilize diodes and special purpose diodes in an electrical circuit.*
3. Demonstrate an understanding and working knowledge of BJT biasing circuits, positive and negative feedback, circuits stability, and frequency response.*
4. Design and build BJT amplifier circuits, including multi-stage and power amplifier circuits, to meet specifications.*
5. Demonstrate an understanding and working knowledge of oscillators, voltage regulators, and power supplies.*
6. Demonstrate an understanding and working knowledge of Op-Amps. Design and build Op-Amps circuits for various applications.*
7. Demonstrate an understanding and working knowledge of field effect transistors (FETs), JFET and MOSFET circuits and applications.*

OET022 – Programmable Logic Controllers
3 Semester Hours

Prerequisite: None

Related TAG: Electrical Engineering Technology

General Course Description:
This course includes the principles and application of Programmable Logic Controllers including ladder logic, program control, data manipulation, math instructions, sequencers, shift registers, networking, PLC-mechanism interfacing and human-machine interfacing. Students will install, program, and document PLCs used in a variety of applications. The course will include advanced control circuits, advanced design of ladder and wring diagrams to meet a given set of criteria, PLC programming, development of a human-machine interface, and data transfer in PLC networks. Includes hands-on labs.

Student Learning Outcomes marked with an asterisk (*) are essential and must be met.

Students will be able to:

1. Recall the history of control systems and programmable logic controllers (PLCs).*
2. Explain and describe the use of number systems.*
3. Demonstrate the use of ladder logic programming devices.*
4. Employ ladder logic in control circuit design.*
5. Use addressing to control Input/Output (I/O) modules.*
6. Demonstrate the use of relays, contacts, coils, and timers.*
7. Demonstrate counters and sequencers.*
8. Demonstrate fundamental PLC programming (e.g., comparators, block transfers, I/O forcing).*
9. Demonstrate data transfer in PLC networks.*

TMM001 – College Algebra (Revised December 8, 2015; updated samples April 30, 2016)
Typical Range: 3-4 Semester Hours

Recommendation: This course should significantly reflect the Mathematical Association of America's Committee on the Undergraduate Program in Mathematics (CUPM) subcommittee, Curriculum Renewal Across the First Two Years (CRAFTY), College Algebra Guidelines.

College Algebra provides students a college level academic experience that emphasizes the use of algebra and functions in problem solving and modeling, where solutions to problems in real-world situations are formulated, validated, and analyzed using mental, paper-and-pencil, algebraic and technology-based techniques as appropriate using a variety of mathematical notation. Students should develop a framework of problem-solving techniques (e.g., read the problem at least twice; define variables; sketch and label a diagram; list what is given; restate the question asked; identify variables and parameters; use analytical, numerical and graphical solution methods as appropriate; determine the plausibility of and interpret solutions).

– Adapted from the MAA/CUPM CRAFTY 2007 College Algebra Guidelines

To qualify for TMM001 (College Algebra), a course must achieve all of the following essential learning outcomes listed in this document (marked with an asterisk). The Sample Tasks are recommendations for types of activities that could be used in the course.

1. **Functions:** Successful College Algebra students demonstrate a deep understanding of functions whether they are described verbally, numerically, graphically, or algebraically (both explicitly and implicitly). Students should be proficient working with the following families of functions: linear, quadratic, higher-order polynomial, rational, exponential, logarithmic, radical, and piecewise-defined functions (including absolute value).

   The successful College Algebra student can:

   1a. Analyze functions. Routine analysis includes discussion of domain, range, zeros, general function behavior (increasing, decreasing, extrema, etc.). In addition to performing rote processes, the student can articulate reasons for choosing a particular process, recognize function families and anticipate behavior, and explain the implementation of a process (e.g., why certain real numbers are excluded from the domain of a given function).*
   1b. Convert between different representations of a function.*
   1c. Perform operations with functions including addition, subtraction, multiplication, division, composition, and inversion; connect properties of constituent functions to properties of the resultant function; and resolve a function into a sum, difference, product, quotient, and/or composite of functions.*

2. **Equations and Inequalities:** Successful College Algebra students are proficient at solving a wide array of equations and inequalities involving linear, quadratic, higher-order polynomial, rational, exponential, logarithmic, radical, and piecewise-defined functions (including absolute value).

   The successful College Algebra student can:

   2a. Recognize function families as they appear in equations and inequalities and choose an appropriate solution methodology for a particular equation or inequality and can communicate reasons for that choice.*
   2b. Use correct, consistent, and coherent notation throughout the solution process to a given equation or inequality.*
   2c. Distinguish between exact and approximate solutions and which solution methodologies result in which kind of solutions.*
   2d. Demonstrate an understanding of the correspondence between the solution to an equation, the zero of a function, and the point of intersection of two curves.*
   2e. Solve for one variable in terms of another.*
   2f. Solve systems of equations using substitution and/or elimination.*

3. **Equivalencies:** Successful College Algebra students are proficient in creating equivalencies in order to simplify expressions, solve equations and inequalities, or take advantage of a common structure or form.

   The successful College Algebra student can:

   3a. Purposefully create equivalences and indicate where they are valid.
   3b. Recognize opportunities to create equivalencies in order to simplify workflow.*

4. **Modeling with Functions:** Successful College Algebra students should have experience in using and creating mathematics which model a wide range of phenomena.

   The successful College Algebra student can:

   4a. Interpret the function correspondence and behavior of a given model in terms of the context of the model.*
   4b. Create linear models from data and interpret slope as a rate of change.*
   4c. Determine parameters of a model given the form of the model and data.*
   4d. Determine a reasonable applied domain for the model as well as articulate the limitations of the model.*

5. **Appropriate Use of Technology:** Successful College Algebra students are proficient at choosing and applying technology to assist in analyzing functions.

The successful College Algebra student can:

5a. Anticipate the output from a graphing utility and make adjustments, as needed, in order to efficiently use the technology to solve a problem.*
5b. Use technology to verify solutions to equations and inequalities obtained algebraically.*
5c. Use technology to obtain solutions to equations to equations and inequalities which are difficult to obtain algebraically and know the difference between approximate and exact solutions.*
5d. Use technology and algebra in concert to locate and identify exact solutions.*

6. Reasons Mathematically: Successful college algebra students demonstrate a proficiency at reasoning mathematically.

The successful College Algebra student can:

6a. Recognize when a result (theorem) is applicable and use the result to make sound logical conclusions and provide counter-examples to conjectures.*

TMM002 – Pre-Calculus (Updated June 3, 2015)
Typical Range: 5-6 Semester Hours

Recommendation: This course should significantly reflect the Mathematical Association of America's Committee on the Undergraduate Program in Mathematics (CUPM) subcommittee, Curriculum Renewal Across the First Two Years (CRAFTY), College Algebra Guidelines and the CUPM Curriculum Guide.

A Pre-Calculus course is an intensive, more accelerated course for students preparing for a traditional calculus sequence and would generally include essential topics covered in both College Algebra and Trigonometry and as such is only recommended for the more able and prepared student.
Pre-Calculus provides students a college level academic experience that emphasizes the use of algebra and functions in problem solving and modeling, where solutions to problems in real-world situations are formulated, validated, and analyzed using mental, paper-and-pencil, algebraic and technology-based techniques as appropriate using a variety of mathematical notation. Students should develop a framework of problem-solving techniques (e.g., read the problem at least twice; define variables; sketch and label a diagram; list what is given; restate the question asked; identify variables and parameters; use analytical, numerical and graphical solution methods as appropriate; determine the plausibility of and interpret solutions).

– Adapted from the MAA/CUPM CRAFTY 2007 College Algebra Guidelines

Students who are preparing to study calculus need to develop conceptual understanding as well as computational skills. Appropriately designed Pre-Calculus courses can enable students to be successful in calculus. Often, creation of an effective Pre-Calculus course requires learning about different curricular and pedagogical approaches and experimenting with how the most promising ones might be adapted for local implementation. No course should have value *only* as a preparation for a subsequent course; it should have intrinsic value on its own as well as offering preparation for further study.

A Pre-Calculus course should develop mathematical thinking and communications skills by incorporating activities that will help all students progress in developing analytical, critical reasoning, problem-solving, and communication skills and acquiring mathematical habits of mind. More specifically, these activities should be designed to advance and measure students' progress in learning to:

- State problems carefully, modify problems when necessary to make them tractable, articulate assumptions, appreciate the value of precise definition, reason logically to conclusions, and interpret results intelligently;
- Approach problem solving with a willingness to try multiple approaches, persist in the face of difficulties, assess the correctness of solutions, explore examples, pose questions, and devise and test conjectures;

- Read mathematics with understanding and communicate mathematical ideas with clarity and coherence through writing and speaking.

A Pre-Calculus course should communicate the breadth and interconnections of the mathematical sciences by:

- Presenting key ideas and concepts from a variety of perspectives;
- Employing a broad range of examples and applications to illustrate and motivate the material;
- Promoting awareness of connections to other subjects (both in and out of the mathematical sciences), and strengthen each student's ability to apply the course material to these subjects;
- Introducing contemporary topics from the mathematical sciences and their applications and enhancing student perceptions of the vitality and importance of mathematics in the modern world.

– Adapted from the MAA/CUPM 2004 Curriculum Guide

To qualify for TMM002 (Pre-Calculus), a course must cover as a minimum the essential learning outcomes, noted by an asterisk *, which include all the topics under Functions, Equations/Systems, Sequences/Series, More Trigonometry, and Vectors. A course in Pre-Calculus 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 Pre-Calculus student should be able to:

1. Functions *
   - 1.1 Represent functions verbally, numerically, graphically and algebraically, including linear, quadratic, polynomial, rational, root/radical/power, piecewise-defined, exponential, logarithmic, trigonometric and inverse trigonometric functions.*
   - 1.2 Determine whether an algebraic relation or given graph represents a function.*
   - 1.3 Perform transformations of functions – translations, reflections and stretching and shrinking.*
   - 1.4 Perform operations with functions – addition, subtraction, multiplication, division and composition.*
   - 1.5 Analyze the algebraic structure and graph of a function, including those listed in (1.1), to determine intercepts, domain, range, intervals on which the function is increasing, decreasing or constant, the vertex of a quadratic function, asymptotes, whether the function is one-to-one, whether the graph has symmetry (even/odd), etc., and given the graph of a function to determine possible algebraic definitions.*
   - 1.6 Find inverses of functions listed in (1.1) and understand the relationship of the graph of a function to that of its inverse.*
   - 1.7 Use the Remainder and Factor Theorems for polynomial functions.*

1.8 Use functions, including those listed in (1.1), to model a variety of real-world problem-solving applications.*

2. Equations/Systems*
   - 2.1 Understand the difference between an algebraic equation of one, two or more variables and a function, and the relationship among the solutions of an equation in one variable, the zeros of the corresponding function, and the coordinates of the x-intercepts of the graph of that function.*
   - 2.2 Determine algebraically and graphically whether the graph of an equation exhibits symmetry.*
   - 2.3 Solve a variety of equations, including polynomial, rational, exponential, and logarithmic, trigonometric and inverse trigonometric, including equations arising in application problems.*
   - 2.4 Solve a system of linear equations graphically and algebraically by substitution and elimination, and solve application problems that involve systems of linear equations.*
   - 2.5 Identify and express the conics (quadratic equations in two variables) in standard rectangular form, graph the conics, and solve applied problems involving conics.*
   - 2.6 Solve polynomial and rational inequalities graphically and algebraically.*

3. Sequences/Series *
   - 3.1 Represent sequences verbally, numerically, graphically and algebraically, including both the general term and recursively.*
   - 3.2 Write series in summation notation, and represent sequences of partial sums verbally, numerically and graphically.*
   - 3.3 Identify and express the general term of arithmetic and geometric sequences, and find the sum of arithmetic and geometric series.*

4. More Trigonometry *
   - 4.1 Express angles in both degree and radian measure.*
   - 4.2 Define the six trigonometric functions in terms of right triangles and the unit circle.*
   - 4.3 Solve right and oblique triangles in degrees and radians for both special and non-special angles, and solve application problems that involve right and oblique triangles.*
   - 4.4 Verify trigonometric identities by algebraically manipulating trigonometric expressions using fundamental trigonometric identities, including the Pythagorean, sum and difference of angles, double-angle and half-angle identities.*
   - 4.5 Solve a variety of trigonometric and inverse trigonometric equations, including those requiring the use of the fundamental trigonometric identities listed in (4.4), in degrees and radians for both special and non-special angles. Solve application problems that involve such equations.*

5. Vectors *
   - 5.1 Represent vectors graphically in both rectangular and polar coordinates and understand the conceptual and notational difference between a vector and a point in the plane.*
   - 5.2 Perform basic vector operations both graphically and algebraically – addition, subtraction and scalar multiplication.*
   - 5.3 Solve application problems using vectors.*

6. Perform operations with matrices – addition, subtraction, scalar multiplication and matrix multiplication, including applications with matrices. Use matrices to solve systems of linear equations, including the Gaussian and Gauss-Jordan elimination methods, using a matrix inverse to solve a matrix equation, and Cramer's Rule.

7. Model real-world data with functions for prediction and analysis, including determining the appropriateness of a model and using hand-held calculator or computer regression capability.

8. Use the Rational Zeros Theorem and the Fundamental Theorem of Algebra to find the zeros of and factor a polynomial into linear factors over the complex numbers.

9. Solve a nonlinear system of equations graphically and algebraically, including nonlinear systems of equations arising in application problems.

10. Solve a linear and nonlinear system of inequalities, including linear and nonlinear systems of inequalities arising from application problems.

11. Use the Binomial Theorem.

12. Understand how to eliminate the xy-term in the general quadratic equation in two variables by the rotation of axes, and identify and graph conics with rotated axes.

13. Graph complex numbers in the complex plane in both rectangular and polar form, perform operations on such numbers – addition, subtraction, multiplication and division, and use DeMoivre's Theorem to find the nth roots of a complex number.

14. Convert points and equations between rectangular and polar form, graph polar functions, solve polar equations, identify and express the conics in standard polar form for graphing, and solve applied problems involving conics in polar form.

15. Identify and graph a curve defined by parametric equations by making a table of values and, when possible, eliminating the parameter.

16. Understand the average rate of change of the graph of a function or equation on an interval, and informally understand the instantaneous rate of change of the graph of a function or equation at a point and its connection to the slope of the graph at the point, including application problems.

OSC014 – ALGEBRA-BASED PHYSICS I (w/labs)
4-5 Semester Hours

Co-requisites: College Algebra and Pre-calculus.

Related TAGs: Biology, Chemistry, Civil/Construction Engineering Technology, Electrical Engineering Technology, Mechanical Engineering Technology

Understanding and/application of the following topics using algebra 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

ELECTRICAL ENGINEERING TECHNOLOGY TAG
FACULTY PARTICIPANTS

November 2016 – May 2017

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