COLLEGE TECH PREP

Emerging Engineering Technologies

Technical Competency Profile (TCP)

2005

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Introduction

The Emerging Engineering Technologies Technical Competency Profile (TCP) consists of a foundation core encompassing the National Project Lead-The-Way curriculum and state-of-the-art engineering pathways. The Emerging Engineering Technologies TCP core and pathways are grounded in academic subject areas and built in concert with emerging engineering career fields. The Ohio Board of Regents, the Ohio Department of Education Career-Technical and Adult Education, and the College Tech Prep Curriculum Service Center at The University of Toledo collaboratively developed the TCP. A model and model descriptor of the Ohio Emerging Engineering Technologies Model appears on pages xii and xiii.

The Emerging Engineering Technologies Technical Competency Profile (TCP) includes essential competencies for programs from secondary through a post-secondary associate degree. Each area contains competencies common to a variety of emerging engineering careers. Consequently, this profile design reflects programming flexibility that supports many options for broad-based educational studies and career planning.

In addition to the Project Lead-The-Way curriculum, representatives from a broad cross-section of engineering and engineering technology professionals played a critical role in defining the vision and scope of the TCP, and in defining the essential and recommended skills for current and future engineering and engineering technology employees. Secondary and post-secondary educators representing Ohio schools and colleges leveled the competencies to create career pathways from secondary to associate degree programs. A list of business and industry representatives and educators participating in the development of the profile appears in Appendix A.

The Emerging Engineering Technologies Technical Competency Profile (TCP) is the basis for the development of an integrated delivery system that provides opportunities for new and challenging programs and courses. The Technical Competency Profile will also enhance and expand the Career-Technical Education, College Tech Prep, and post-secondary degree programs.

The profile is available on the Internet at www.techprepohio.org. Users can download copies of the entire profile or conduct searches on a number of key variables from this location.

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Materials Joining Technology (Emerging Technology Elective)

Engineering and Engineering Technology Design and Development

Appendices

College Tech Prep Program Standards

College Tech Prep programs are rigorous programs of study starting at the secondary school level and continuing through the associate degree and beyond. In accordance with the Carl D. Perkins Vocational Technical Education Enhancement Act of 1998, College Tech Prep programs are seamless, non-duplicative programs of study combining high-level academic and technical preparation in a variety of career fields.

The Carl D. Perkins Vocational and Technical Education Act of 1998 defines College Tech Prep as:

> A program that provides technical preparation in a career field such as engineering, applied science, mechanical, industrial or practical arts or trade, agriculture, health occupations, business or applied economics, and must do the following:
> - Combines at least two years of secondary and two years of post-secondary education in a sequential course of study without duplication of coursework
> - Integrates academic, vocational and technical education, and if appropriate and available, work-based learning
> - Provides technical preparation for careers
> - Leads to an associate or a baccalaureate degree or post-secondary certificate in a specific career field
> - Leads to placement in appropriate employment or further education.

The Ohio College Tech Prep Advisory Council recommended to the Ohio Board of Regents and the Ohio Department of Education the following standards for all College Tech Prep programs:

Academics are taught at a college-preparatory level and are aligned with state models and academic content standards.

In addition to Ohio graduation requirements specified in SB 55, required academic components for College Tech Prep programs include:

a. Mathematics taught at a minimum level of Algebra II by the completion of high school.
b. An integrated or stand alone senior-year math component
c. Three units of science including at least two lab-based science courses

College Tech Prep programs will use a state-developed Technical Competency Profile (TCP) as the basis for pathway development. The pathway document should reflect secondary and post-secondary course work and should be made available for stakeholders. All secondary and post-secondary TCP competencies must be clearly identified and addressed. The TCP is the framework used to develop all associated curricular documents; however, components from other competency profiles such as OCAP's (Occupational Competency Analysis Profile), ITAC's (Integrated Technical and Academic Competencies) and SCANS (The Secretary's Commission on Achieving Necessary Skills—America 2000) may be included and are not mutually excluded from a TCP.

Articulated pathways will be reviewed every two-years at the consortia level.

Pathways operate under an articulation agreement between/among partners in a consortium.

College Tech Prep programs at the secondary level will operate as state-approved, career-technical education programs.

Academic and technical instruction is integrated and delivered in a contextual approach where possible.

Programs have common representation from secondary education, higher education, business, and labor members.

Post-secondary programs contain advanced skills in the TCP document.

Programs must operate under either regionally accredited post-secondary institutions/degrees or approved apprenticeship programs meeting U.S. Department of Labor standards.

College Tech Prep programs, secondary and post-secondary, must comply with the state College Tech Prep Advisory Council's performance measures.

State College Tech Prep Advisory Council
Revised and Approved: May 1, 2002

Project Lead-The-Way

Overview

Project Lead the Way, Inc., (PTLW) is a not-for-profit organization partnering with public schools, organizations, in the private sector, and higher education institutions to increase the number and quality of engineers graduating from our educational system. The program is partially funded by Charitable Venture Foundation, a private foundation located in Clifton Park, New York. PLTW has a support staff of experience technology educators and college and university partners to support schools as they implement PLTW curricula.

PLTW has developed a four year, flexible sequence of courses which, when combined with college preparatory mathematics and science courses in high school, introduces students to the scope, rigor and discipline of engineering and engineering technology prior to entering college. The courses are:

- Principles of Engineering
- Introduction to Engineering Design
- Digital Electronics
- Computer Integrated Manufacturing
- Engineering Design and Development
  (Additional courses in development)

Introduction at this level will attract more students to engineering, and will allow students, while still in high school, to determine if engineering is the career they desire. Students participating in PTLW courses are better prepared for college engineering programs and more likely to be successful, thus reducing the attrition rate in these college programs, which currently exceeds 50% nationally.

PLTW has a comprehensive organizational structure in place to ensure continued participation and success. Key elements provide support at every level of the program. PLTW provides local, state and national organization for leadership and support, a model curriculum, professional development and consultant services. The participating school districts implement the five course sequence based on a plan developed in partnership with colleges and universities, operate a partnership team with members drawn from higher education and the private sector, and serve as models for other school districts. Colleges and universities provide strategic regional leadership, involve industry, and assist school districts to establish partnership teams. Private sector members provide advisors, supporters, mentors and financial support, and assist the colleges and school districts to achieve the goals of the program. School Partnership Teams advise and support the school districts in their operational plans.

A critical component of the Project Lead The Way program is its professional development model. It was developed to provide the most intensive and comprehensive training to teachers becoming part of Project Lead The Way, Inc. The curriculum these teachers are required to teach utilizes cutting-edge technology and software requiring specialized training. Significant attention is paid to assessing teachers' readiness training through online assessment. This

familiarizes teachers with the types of skills they will need during the intensive core training at one of PLTW's National Training Centers during the summer. Ongoing training supports the teachers as they implement the program and provides for continuous improvement of skills.

Understanding that another key to success is awareness, PLTW makes a concerted effort to inform school counselors about the benefits of the program, as well as the wide array of technology jobs and careers available to students who enter the field upon graduation from high school and college. Counselors are supplied with PLTW materials, (available at www.pltw.org) including brochures and a video, to use with students and their parents.

In addition, PLTW has developed an exciting Middle School Technology Curriculum: *Gateway to Technology*. This project-based, cutting-edge curriculum is 40 weeks in length and is divided into four 10-week units: Design and Modeling; The Magic of Electrons; The Science of Technology; Automation and Robotics. Designed for all students the units address national standards in math, science and technology. One of the goals is to increase interest and awareness of females and minority students in technology and related careers. *Gateway to Technology* will also encourage increasing numbers of students to elect the high school program.

Mission Statement

We will create dynamic partnerships with our nation's schools to prepare an increasing and more diverse group of students to be successful in engineering and engineering technology programs. The mission is achieved by providing:

- A Fully-developed Curriculum for High School and Middle School
- Extensive Professional Development for Teachers
- School Counselor Professional Development Conferences
- Affordability through an Optional National Bid
- Key Partnerships with State Education Departments
- College Level Certification, College Course Credit and Middle School Recognition
- Systematic Evaluation
- Continuous Improvement, using *Curriculum Development Framework*

Strategic Objectives

- By the end of the second year of membership in PLTW, each school will have an effective school partnership team
- By June 2001, a set of criteria and review standards will be established for all PLTW instructional materials; and by the end of 2002, all PLTW instructional materials will meet those criteria and review standards
- By 2004, 100% of PLTW students will meet college entrance requirements for engineering and engineering technology; of those students, as least 90% will successfully complete their first year of further study and at least 75% will graduate from two or four year engineering and engineering technology programs.
- By 2004, the enrollment of females in PLTW courses will be 10 percentage points higher than the current female national enrollment in engineering and engineering technology programs.

- By 2005, the racial and ethnic minority student population in schools with PLTW courses will be collectively proportionate to the overall state populations.
- By 2006, we will have at least 1000 schools in PLTW and additional, geographically located, university affiliates.
- By 2006, we will increase by 20% the number of graduates from high schools in PLTW who are accepted in engineering and engineering technology programs.

Ohio Emerging Engineering Technologies Model

The Ohio Emerging Engineering Technologies Model provides a solid foundation for the College Tech Prep career plan. This plan generally consists of two years of programming in high school, two years of learning at the community college level, and for many, two additional years of study at the baccalaureate level. The nucleus of the model is grounded in rigorous academic requirements and an Emerging Engineering Technologies Core. Although College Tech Prep generally begins in the junior year of high school, the Emerging Engineering Technologies TCP may be completed through a two, three, or four year delivery model (see p.14).

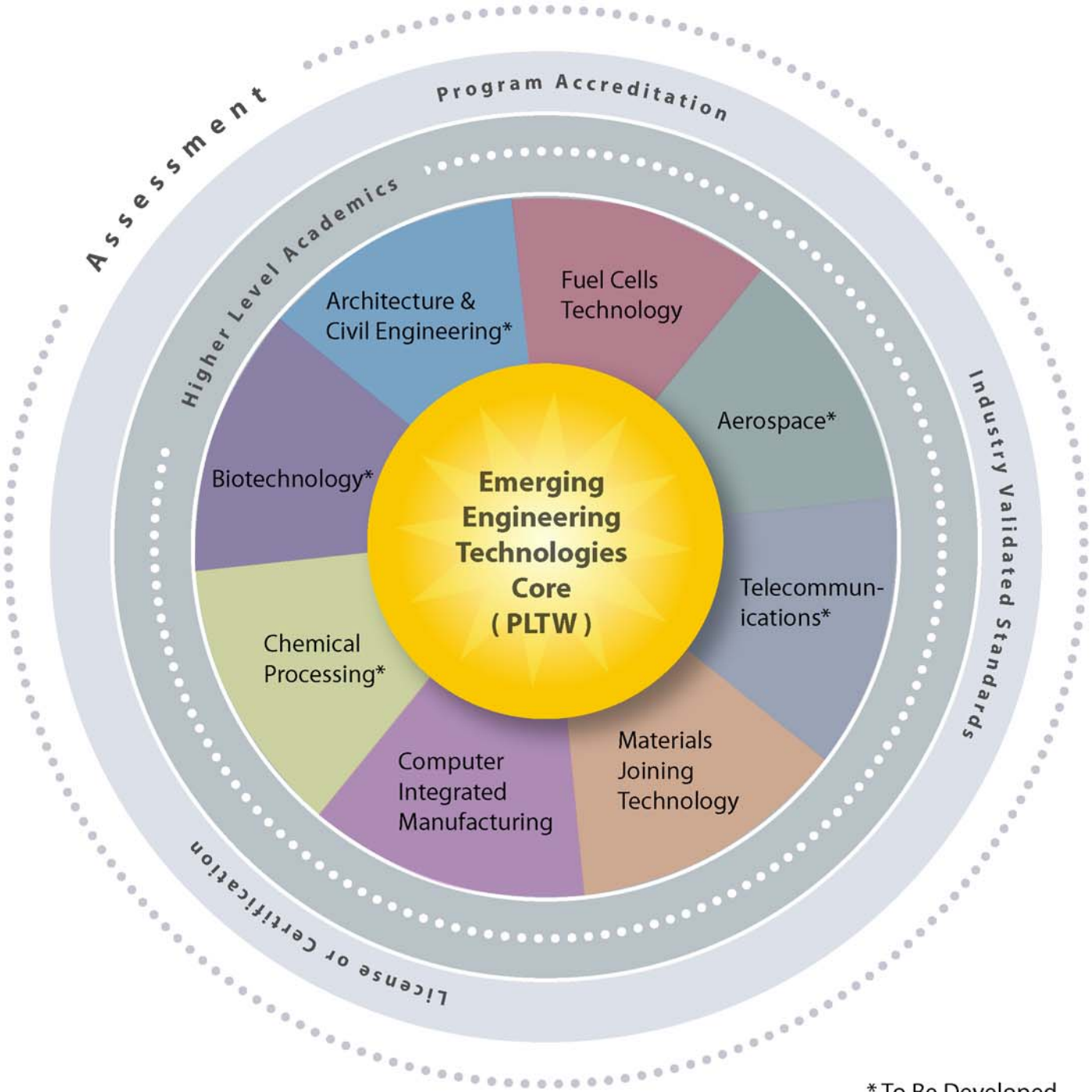
The Emerging Engineering Technologies Core illustrates the fact that there are common skills and knowledge required for each of the pathways. Experiences grounded within the core are designed to assist students to select the appropriate pathway. Located on the perimeter of the Emerging Engineering Technologies Core are the various pathways associated with careers in engineering and engineering technology. Each career pathway enhances, expands, and customizes units from the core to reflect the needs of the career professionals.

As research and development progresses, multiple career options and opportunities will become available within each pathway, some at the associate degree level and many at the baccalaureate degree level. For example, individuals desiring a career in fuel cells technology will see opportunities develop in research, production, distribution, storage, etc. Other pathways, such as aerospace, materials joining technology, etc., will offer similar options and career opportunities.

The model is designed to support lifelong learning beyond the formal classroom by requiring high-level academic, as well as, technical skills and knowledge. Individuals undertaking the Emerging Engineering Technologies Core and any one of the career pathways should view their College Tech Prep experience as preparation for more than an entry-level position. Successful career pursuits and advancement in the future will rely on an individual's ability to change and adapt to a changing workforce. The implementation of the Ohio Emerging Engineering Technologies Delivery Model will enhance a student's ability to address those changes.

Ohio Emerging Engineering Technologies Model

Secondary → Associate Degree → Bachelor's Degree



* To Be Developed

Key to Profile Codes

Importance of Competencies

All of the competencies in this document represent the minimum requirements for a College Tech Prep program. It is the responsibility of the local consortia to further define and/or expand, as needed, the key indicators for each competency. Each competency will be taught at either the introductory or proficiency level by the completion of the Tech Prep program, which is the minimum of an Associate Degree. A minimal number of competencies have been identified as Introduce (I) at the Associate Degree level. These may require further higher education.

This document integrates college prep academics with technical skill. Technical skills are a required component.

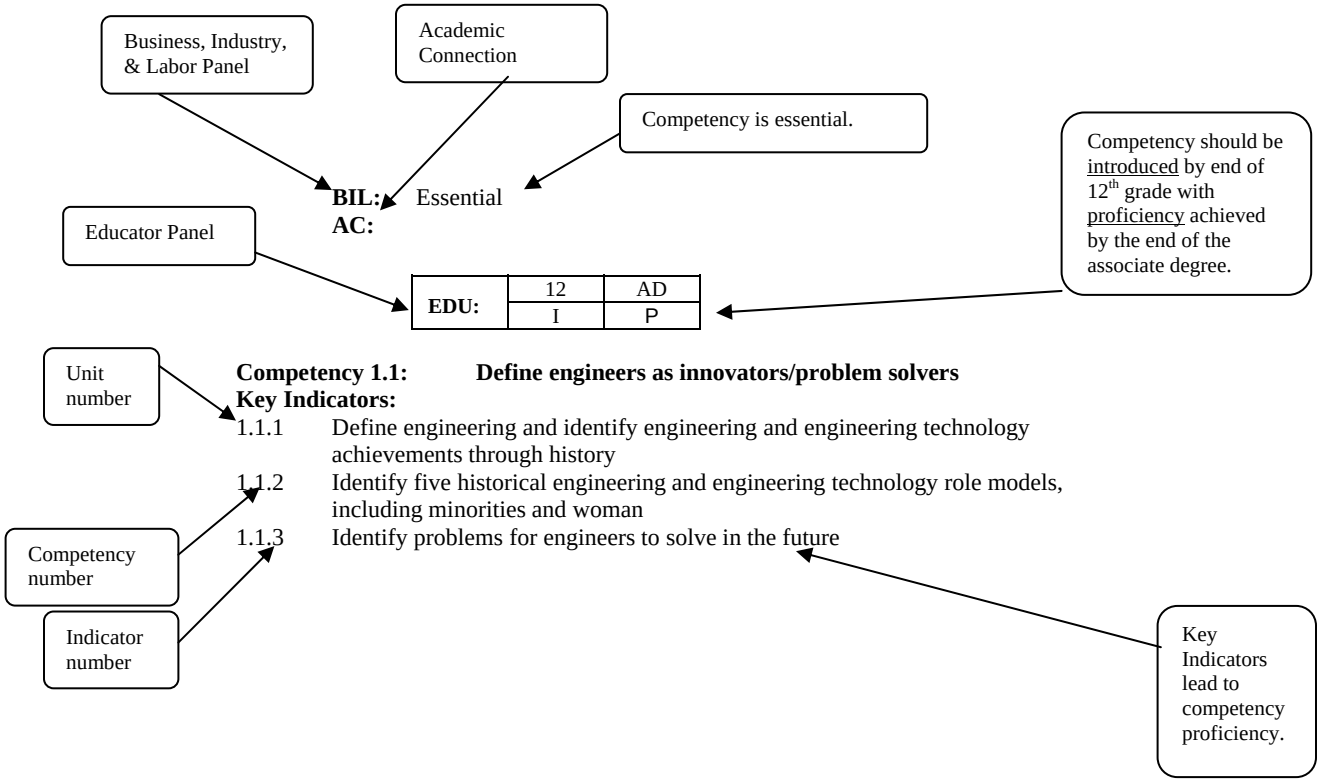
- **I** = **Introduce** (Learner will demonstrate knowledge and comprehension of the competency.)
- **P** = **Proficient** (Learner will demonstrate ability to apply knowledge of and/or perform the competency.)
- **R** = **Reinforced** (Competencies marked proficient at the secondary level are to be reinforced at the associate degree level.)

Grade Level: **12** = by the end of grade 12
AD = by the end of the Associate Degree

ACADEMIC CONNECTION

As rigorous programs of study, College Tech Prep programs require academics to be taught at a college-preparatory level, and contextually within the technical content. State academic mathematics, language arts, science, and social studies benchmarks are embedded within each Technical Curriculum Profile (TCP).

EXAMPLE:


Business, Industry, & Labor Panel
Academic Connection
Competency is essential.
Competency should be introduced by end of 12th grade with proficiency achieved by the end of the associate degree.
BIL: Essential
AC:
Educator Panel
EDU: 12 AD
I P
Unit number
Competency 1.1: Define engineers as innovators/problem solvers
Key Indicators:
1.1.1 Define engineering and identify engineering and engineering technology achievements through history
1.1.2 Identify five historical engineering and engineering technology role models, including minorities and woman
1.1.3 Identify problems for engineers to solve in the future
Competency number
Indicator number
Key Indicators lead to competency proficiency.

Emerging Engineering Technologies Careers

As emerging engineering technologies continue to evolve it becomes difficult to identify specific engineering and engineering technology occupations. The very nature of emerging engineering infers current research and development will continually reveal new occupations. Architecture and civil engineering, fuel cells, telecommunications and aerospace are just a few of the career fields that have established potential for future occupations. As these career fields continue to expand, individuals pursuing these occupations will be on the cutting edge of the latest technology.

In addition, the educational level required for the emerging engineering technologies will also fluctuate in response to the evolving occupations. For example, some specific occupations may require an associate's degree, while others may require a baccalaureate, or possibly a graduate degree. The underlying trend that governs career opportunities in emerging engineering technology seems to be - the more education and training an individual has in engineering or engineering technology, the more career opportunities are available to them.

Concerning this TCP, the intent is to prepare individuals for emerging careers in engineering and engineering technology. Individuals completing the curriculum will have a minimum of an associate's degree, with an option for a baccalaureate or higher degree. Although the associate's degree will provide entrance to engineering occupations, the advanced careers will require additional education.

Engineering Technologies: Emerging Cluster

Post-Secondary Engineering and Engineering Technology Programs
(including both 2 and 4 year programs)

Senior Year (6 Credits)
- English IV
- Trigonometry or Pre-calculus
- Physics
- *Engineering Design & Development*
- *Emerging Technology Elective**
  - *AND*
- *Intro to Engineering Design*
  - *OR*
- *Digital Electronics*
  - *OR*
- *Principles of Engineering*
- *Electives (1 Credit)*

Junior Year (7 Credits)
- English III
- Algebra II
- Chemistry
- Government
- Foreign Language
- *Intro to Engineering Design*
  - *AND/OR*
- *Digital Electronics*
  - *AND/OR*
- *Principles of Engineering*

Sophomore Year (6 credits)
- English II
- Geometry
- Biology
- American History
- Foreign Language

Freshman Year (6 credits)
- English I
- Algebra I
- Physical Science
- World History
- Physical Education/Health

Sample Delivery Model
2 Year Program

*** Emerging Technology Electives**
(1-2 Credits)

- Aerospace **
- Architecture and Civil Engineering **
- Biotechnology **
- Telecommunications **
- Chemical Processing **
- Computer Integrated Manufacturing
- Fuel Cell Technology
- Materials Joining Technology

Schools may offer more than one elective.

** To Be Developed

Engineering Technologies: Emerging Cluster

Post-Secondary Engineering and Engineering Technology Programs
(including both 2 and 4 year programs)

Senior Year (6 Credits)
- English IV
- Trigonometry OR Pre-calculus
- Physics
- *Engineering Design & Development*
- *Emerging Technology Elective**
- Electives (1 or 2 credits)

Junior Year (7 Credits)
- English III
- Algebra II
- Chemistry
- Government
- Foreign Language
- *Intro to Engineering Design*
  - *AND / OR*
- *Digital Electronics*
  - *AND / OR*
- *Principles of Engineering*

Sophomore Year (6 credits)
- English II
- Geometry
- Biology
- American History
- Foreign Language
- *Intro to Engineering Design*
  - *OR*
- *Digital Electronics*
  - *OR*
- *Principles of Engineering*

Freshman Year (6 credits)
- English I
- Algebra I
- Physical Science
- World History
- Physical Education/Health
- Foreign Language

Sample Delivery Model
3 Year Program

*** Emerging Technology Electives**

- Aerospace **
- Architecture and Civil Engineering **
- Biotechnology **
- Telecommunications **
- Chemical Processing **
- Computer Integrated Manufacturing
- Fuel Cell Technology
- Materials Joining Technology

Schools may offer more than one elective.

** To Be Developed

Engineering Technologies: Emerging Cluster

Post-Secondary Engineering and Engineering Technology Programs
(including both 2 and 4 year programs)

Sample Delivery Model
4 Year Program

Senior Year (6 Credits)
- English IV
- Trigonometry OR Pre-calculus
- Physics
- *Engineering Design & Development*
- Electives (2 credits)

Junior Year (7 Credits)
- English III
- Algebra II
- Chemistry
- Government
- Foreign Language
- *Emerging Technology Elective**
  - AND
- *Intro to Engineering Design*
  - *OR*
- *Digital Electronics*
  - *OR*
- *Principles of Engineering*

Sophomore Year (6 credits)
- English II
- Geometry
- Biology
- American History
- Foreign Language
- *Intro to Engineering Design*
  - *OR*
- *Digital Electronics*
  - *OR*
- *Principles of Engineering*

Freshman Year (6 credits)
- English I
- Algebra I
- Physical Science
- World History
- Physical Education
- *Intro to Engineering Design*
  - *OR*
- *Digital Electronics*
  - *OR*
- *Principles of Engineering*

*** Emerging Technology Electives**

- Aerospace **
- Architecture and Civil Engineering **
- Biotechnology **
- Telecommunications **
- Chemical Processing **
- Computer Integrated Manufacturing
- Fuel Cell Technology
- Materials Joining Technology

Schools may offer more than one elective.

** To Be Developed

EMERGING ENGINEERING TECHNOLOGY PROGRAM PROFILE

The Emerging Engineering Technologies Program Profile includes a core and three emerging pathways – Computer Integrated Manufacturing, Fuel Cells and Materials Joining Technology. The core (four separate courses) illustrates common skills and knowledge required for each pathway and is taught primarily at the secondary level. Each career pathway enhances, expands, and customizes units from the core to reflect the needs of the career professionals.

Emerging Engineering Technology
Competency Chart

At the end of the secondary program (12) and associate degree (AD) each competency is coded: I = Introductory; P = Proficient; R = Reinforce. In addition, the business, industry, and labor partnership (BIL) validated each competency: BIL: E = Essential; R = Recommended

INTRODUCTION TO ENGINEERING AND ENGINEERING TECHNOLOGY DESIGN		**12**	**AD**	**BIL**
Unit 1	**Introduction**			
1.1	Discuss the history of engineering and engineering technology design	P	R	E
1.2	Explore career pathways in engineering and engineering technology related to design	P	R	E
Unit 2	**Introduction to Design**			
2.1	Apply the steps of the design process to solve a variety of design problems	P	R	E
2.2	Describe the application of the principles and elements of design utilized in products, print media, and art forms	P	R	E
Unit 3	**Student Portfolio Development**			
3.1	Develop a portfolio to organize and display evidence of work	P	R	E
3.2	Use the portfolio to make a presentation that defends current proficiency	P	R	E
Unit 4	**Sketching and Visualization**			
4.1	Utilize sketching and visualization techniques	P	R	E
4.2	Select and produce the appropriate pictorial style to best	P	R	E
4.3	Evaluate and select the necessary view to graphically communicate design solutions	P	R	E
Unit 5	**Geometric Relationships**			
5.1	Construct various geometric forms and shapes	P	R	E
5.2	Describe geometric constraints	P	R	E
5.3	Demonstrate the Cartesian Coordinated System	P	R	E
Unit 6	**Modeling**			
6.1	Communicate conceptual ideas through written and verbal formats	P	R	E
6.2	Analyze and develop graphical representation of given data	P	R	E
6.3	Select the appropriate modeling materials to complete a three-dimensional prototype/mockup	P	R	E
6.4	Critique design solution using mathematical applications (e.g., volume of a bottle, etc.)	P	R	E
6.5	Evaluate a sketch and generate a model utilizing CAD software	P	R	E
Unit 7	**Assembly Modeling**			
7.1	Explore and demonstrate assembly modeling skills to solve a variety of design problems	P	R	E

Competency	12	AD	BIL
7.2 Explore and demonstrate assembly constraints, part libraries, sub-assemblies, driving constraints, and adaptive design	P	R	E
Unit 8 Model Analysis and Verification			
8.1 Evaluate the accuracy of mass properties calculations	I	P	E
8.2 Interpret and use correct tolerancing techniques when dimensioning solid models	I	P	E
Unit 9 Model Documentation			
9.1 Translate a three-dimensional drawing or model into corresponding orthographic drawing views	P	R	E
9.2 Demonstrate appropriate dimensioning rules and practices	P	R	E
9.3 Apply appropriate annotations on sketches and drawings	P	R	E
Unit 10 Presentation			
10.1 Practice effective oral communication techniques	P	R	E
10.2 Utilize the most appropriate presentation aids in oral and written presentations	P	R	E
Unit 11 Production			
11.1 Evaluate material characteristics for manufacturing a specific product and identify the correct manufacturing process needed to produce that product	I	P	E
11.2 Examine and apply the most appropriate machine process	I	P	E
11.3 Discuss trends in automated manufacturing	P	R	E
11.4 Explain material procurement, handling, and cost analysis	I	P	E
Unit 12 Marketing			
12.1 Demonstrate a working knowledge of product cost analysis	I	P	E
12.2 Design a package for a given product (e.g., egg drop)	I	P	E
PRINCIPLES OF ENGINEERING AND ENGINEERING TECHNOLOGY			
Unit 13 Definition and Types of Engineering and Engineering Technology			
13.1 Define engineers as innovators/problem solvers	P	R	E
13.2 Interpret the role of an engineering and engineering technology team	I	P	E
13.3 Explore careers in engineering and engineering technology	P	R	E
Unit 14: Communication and Documentation			
14.1 Compose sketches using proper sketching techniques in the solution of design problems	P	R	E
14.2 Plan and compose a written technical report about the research conducted about a career field in engineering and engineering technology	P	R	E
14.3 Prepare and deliver a technical presentation	P	R	E
Unit 15 Design Process			
15.1 Compose and diagram the product development lifecycle of an invention	P	R	E
15.2 Design a product	P	R	E
Unit 16 Engineering and Engineering Technology Systems			
16.1 Select simple machines to create mechanical systems in the solution of design problem	P	R	E
16.2 Create an energy transfer model of a structure and calculate the heat loss through walls and windows	I	P	E

Competency	12	AD	BIL
16.3 Configure proper setup and adjustment of a fluid power system	P	R	E
16.4 Estimate current flow through a circuit and be able to compare estimates to accurate measurements	P	R	E
16.5 Design, diagram, and implement a program to control a device constructed to perform a sorting operatio	P	R	E
Unit 17: Statics and Strength of Materials			
17.1 Evaluate a simple truss mathematically to determine types and magnitude of forces supported in the truss	P	R	E
17.2 Explain the effects that stress has on a material and explain how the material will react	P	R	E
Unit 18 Materials and Materials Testing in Engineering and Engineering Technology			
18.1 Compare/contrast and analyze the physical properties of organics, metals, polymers, ceramics, and composites	I	P	E
18.2 Assess and document the properties of materials	P	R	E
18.3 Specify the production processes used to create products from categories of materials	I	P	E
18.4 Explain the difference between the characteristics of quality in a final product and the control of quality in each step of a process	I	P	E
18.5 Analyze a material failure	I	P	E
Unit 19 Engineering and Engineering Technology for Reliability			
19.1 Determine mathematically the chance of failure of a system given information on certain components	I	P	E
19.2 Analyze an engineering failure which identifies causes, damage done, design failures, and other areas where the failure has impacted the environment or society	I	P	E
Unit 20 Introduction to Dynamics/Kinematics			
20.1 Construct a device that will illustrate linear motion	P	R	E
20.2 Summarize test data to explain trajectory motion	P	R	E
DIGITAL ELECTRONICS ENGINEERING AND ENGINEERING TECHNOLOGY			
Unit 21 Fundamentals			
21.1 Appraise hazards in the lab, record locations of the safety equipment, and describe how to use the safety equipment	P	R	E
21.2 Explain basic electron theory	P	R	E
21.3 Utilize prefixes and engineering and engineering technology notation	P	R	E
21.4 Calculate the tolerance levels of various resistors to determine if the measured value is within specifications	P	R	E
21.5 Select and utilize electrical meters to determine voltage, resistance, and current in simple circuits	P	R	E
21.6 Calculate the value of capacitors mathematically and through the use of instrumentation	P	R	E
21.7 Calculate the output frequency of circuits using observations and the oscilloscope	P	R	E
21.8 Obtain electronic component data sheets	P	R	E
Unit 22 Number Systems			
22.1 Identify and describe the number systems appropriate to electronic components	P	R	E

Competency	12	AD	BIL
22.2 Convert values from one number system to another	P	R	E
Unit 23 Gates			
23.1 Identify and recognize the gates and their truth table	P	R	E
23.2 Apply logic gates to solve a problem	P	R	E
Unit 24 Boolean Algebra			
24.1 Create Boolean expressions, logic circuit diagrams or truth tables from information provided in the solution of design problems	P	R	E
24.2 Apply the rules of Boolean algebra to logic diagrams and truth tables to minimize the circuit size necessary to solve a design problem	P	R	E
24.3 Assess duality of logic functions	P	R	E
Unit 25 Combinational Circuit Design			
25.1 Design a paradigm for combinational logic problems	P	R	E
25.2 Design a specific MSI Gate application	P	R	E
25.3 Evaluate programmable logic devices (PLD)	P	R	E
Unit 26 Adding			
26.1 Design, construct and test adder circuits using discrete gates	P	R	E
26.2 Design, construct and test adder circuits using MSI gates	P	R	E
Unit 27 Flip-Flops			
27.1 Interpret, design, draw, and evaluate circuits using the logic symbols for latches and flip-flops	P	R	E
27.2 Compare and contrast operation of synchronous with asynchronous flip-flop circuits they construct	P	R	E
27.3 Evaluate triggers used by latches and flip-flops	P	R	E
27.4 Assemble circuits and interpret information about the various applications of flip flops	P	R	E
Unit 28 Shift Registers and Counters			
28.1 Evaluate the use of shift registers in product design and the speeds at which those products run	P	R	E
28.2 Evaluate asynchronous counter operations and characteristics	P	R	E
28.3 Evaluate synchronous counter operations and characteristics	P	R	E
Unit 29 Families and Specifications			
29.1 Define, calculate, and measure fan-out delay	I	P	E
29.2 Define, calculate, and measure propagation delay	I	P	E
Unit 30 Microprocessors			
30.1 Assess microcontrollers	I	P	E
30.2 Assess interfacing with motors	I	P	E
COMPUTER INTEGRATED MANUFACTURING (Emerging Technology Elective)			
Unit 31 Computer Modeling			
31.1 Demonstrate the fundamentals of computer modeling	P	R	E
31.2 Utilize object construction techniques	P	R	E
31.3 Illustrate parts modeling techniques	P	R	E
31.4 Develop multi-view drawings such as top, front, right side, isometric, section and auxiliary views from the solid model	P	R	E
31.5 Create assembly models through the integration of individual parts and sub-assemblies	P	R	E
31.6 Prepare a rapid prototype file from a drawing database	P	R	E

Competency	12	AD	BIL
Unit 32 Programmable Machines			
32.1 Summarize the history of programmable machining	P	R	E
32.2 Explain the different elements of a CNC machine	P	R	E
32.3 Select and demonstrate CNC programming techniques	P	R	E
32.4 Operate a CNC machine to machine a part to specifications	P	R	E
32.5 Make precision measurements to the degree of accuracy required by plan specification using appropriate instruments	P	R	E
32.6 Use a CAM package to generate and edit tool paths by applying appropriate machining processes to geometry imported from a CAD program	P	R	E
Unit 33 Introduction to Robotics			
33.1 Describe the development of robotics	P	R	E
33.2 Discuss robotics and automated systems	P	R	E
33.3 Contrast different working models of a robot	P	R	E
33.4 Utilize mechanical components in computer integrated manufacturing operations	I	P	E
33.5 Develop a feeder system with sensors to detect if parts are present and will alert the operator if the quantity of parts is below the required number	P	R	E
33.6 Program a robot to perform several tasks	P	R	E
33.7 Analyze and generate a tooling solution to a robotic manufacturing problem	I	P	E
Unit 34 Computer Integrated Manufacturing			
34.1 Discuss the rationale for CIM manufacturing	P	R	E
34.2 Compare/Contrast types of CIM systems	P	R	E
34.3 Explain components of a CIM system for a given industrial application	P	R	E
34.4 Assemble and test individual component designs by integrating them into a complete miniature FMS built from the Fischertechnik models	P	R	E
FUEL CELLS (Emerging Technology Elective)			
Unit 35 Introduction			
35.1 Explain the key issues of fuel cell research and development	P	R	E
35.2 Trace the history of fuel cells	P	R	E
35.3 Describe career opportunities in fuel cell technologies and applications	P	R	E
Unit 36 Function			
36.1 Describe a fuel cell	P	R	E
36.2 Demonstrate the conversion of chemical energy into electrical energy	P	R	E
Unit 37 Components			
37.1 Analyze the function of the cathode	P	R	E
37.2 Assess the function of the electrolyte	P	R	E
37.3 Explain the role the anode plays in a fuel cell	P	R	E
37.4 Analyze the fuel cell stack	P	R	E
Unit 38 Fuels Processing			
38.1 Evaluate hydrogen as a fuel	P	R	E
38.2 Evaluate hydrogen safety practices and procedures	P	R	E
38.3 Explain how fuel processors work	P	R	E

Competency	12	AD	BIL
Unit 39 Alternate Structures of Fuel Cells			
39.1 Analyze PEM fuel cell technology	I	P	E
39.2 Analyze solid oxide fuel cell technology	I	P	E
39.3 Analyze alkali fuel cell technology	I	P	E
39.4 Analyze phosphoric-acid fuel cell technology	I	P	E
39.5 Analyze molten carbonate fuel cell technology	I	P	E
39.6 Analyze direct methanol fuel cell technology	I	P	E
39.7 Analyze the regenerative fuel cell technology	I	P	E
39.8 Discuss fuel cell systems integration	I	P	E
Unit 40 Implementation Strategies and Challenges			
40.1 Explore applications and markets for fuel cells	P	R	E
40.2 Examine fuel cell emissions	P	R	E
40.3 Describe the market entry challenges associated with fuel cells	I	P	E
Unit 41 Fuel Cell System Capstone Project			
41.1 Design a fuel cell system	P	R	E
41.2 Build a fuel cell system	P	R	E
41.3 Evaluate project performance	P	R	E
Material Joining Technology (Emerging Technology Elective)			
Unit 42 Introduction to Materials Joining Technology			
42.1 Define welding engineers and material joining technicians	P	R	E
42.2 Describe the background related to materials joining	P	R	E
42.3 Classify the categories of welding and joining processes	P	R	E
Unit 43 Arc Welding Processes			
43.1 Contrast the classification of arc welding processes and describe how they fit in all fusion welding processes	P	R	E
43.2 Explain the shielded metal arc welding process and its uses	P	R	E
43.2 Explain the shielded metal arc welding process and its uses	P	R	E
43.3 Explain the gas metal arc welding process and its uses	P	R	E
43.4 Explain the flux cored arc welding process and its uses	P	R	E
43.5 Explain the submerged arc welding process and its uses	P	R	E
43.6 Explain the gas tungsten arc welding process and its uses	P	R	E
43.7 Explain the plasma arc welding process and its uses	P	R	E
43.8 Explain the electroslag (ES) and electrogas (EG) welding process and its uses	P	R	R
43.9 Explain the arc stud welding process and its uses	P	R	R
43.10 Develop an automated Arc Welding procedure for the manufacture of a real part (e.g. pacemaker body, bellows, etc.)	P	R	E
Unit 44 Non-Arc Welding Processes			
44.1 Summarize the non-arc welding processes	P	R	E
44.2 Explain the resistance welding process	P	R	E
44.3 Explain the oxy-fuel gas welding processes	P	R	R
44.4 Explain the thermit welding process	P	R	R
44.5 Explain the solid state bonding processes	P	R	R
44.6 Explain the high energy density fusion welding processes	P	R	E
44.7 Explain the brazing and soldering processes	P	R	E
44.8 Explain the processes used for joining of plastics	P	R	E
44.9 Explain adhesive bonding of parts	P	R	E
44.10 Develop a manual welding procedure for the bonding of thermoplastic parts using a hot air gun	P	R	E

Competency		12	AD	BIL
44.11	Develop a resistance weldability "Lobe Curve" using a virtual on-line resistance welding machine	P	R	E
Unit 45	**Physics of Welding**			
45.1	Explain the concept of welding heat input	P	R	E
45.2	Describe the characteristics of the welding arc	P	R	E
45.3	Describe the physics of metal transfer	P	R	E
45.4	Describe the physics of the arc welding power sources	P	R	E
45.5	Describe the physics of arc blow	P	R	E
Unit 46	**Heat Flow**			
46.1	Describe heat flow in welds	P	R	E
46.2	Describe how heat flow affects the temperature profile around a weld	I	P	E
46.3	Develop a thermal profile around a moving weld	I	P	E
Unit 47	**Metallurgical Background**			
47.1	Define phases of matter and phase changes during solidification	P	R	E
47.2	Explain the common crystal structures in metallic materials	P	R	E
47.3	Explain imperfection in crystal structure	I	P	E
47.4	Define phase changes and phase diagrams	I	P	E
47.5	Define phase changes of eutectoid steels	I	P	E
47.6	Explain tie line	I	P	E
47.7	Explain transformation strengthening	I	P	E
47.8	Explain deformation strengthening	I	P	E
47.9	Explain precipitation strengthening	I	P	E
Unit 48	**Welding Metallurgy**			
48.1	Define weld regions	P	R	E
48.2	Define fusion and unmixed zones	I	P	E
48.3	Define the partially melted zone	I	P	E
48.4	Define the heat affected zone	I	P	E
48.5	Define the base metal zone	I	P	E
Unit 49	**Design**			
49.1	Explain mechanical properties of materials	P	R	E
49.2	Explain fatigue properties of materials	I	P	E
49.3	Explain fracture toughness properties of materials	I	P	E
49.4	Explain hardness properties of materials	P	R	E
49.5	Explain creep testing of materials	I	P	R
49.6	Explain other physical properties	P	R	R
49.7	Explain weld joint design	P	R	E
49.8	Explain the use of codes and standards	P	R	E
49.9	Explain the use of codes and standards in weldment joint design	P	R	E
49.10	Explain the use of welding symbols to communicate weld design	P	R	E
49.11	Explain residual stresses and distortion in weldments	I	P	E
49.12	Explain the development of welding procedures and weld qualifications	P	R	E
49.13	Design a welded structure	P	R	E
49.14	Evaluate a failed structure	P	R	E
Unit 50	**Testing and Inspection**			
50:1	Explain the factors considered in weld quality	P	R	E
50.2	Explain discontinuity and defect	P	R	E
50.3	Explain destructive weldment testing techniques	P	R	E

Competency	12	AD	BIL
50.4 Explain weldability tests	I	P	R
50.5 Explain the need for nondestructive examination	P	R	E
50.6 Perform visual examination	P	R	E
50.7 Describe dye penetrant examination	P	R	E
50.8 Describe magnetic particle examination	P	R	E
50.9 Explain radiographic examination	I	P	E
50.10 Describe eddy current examination	P	R	R
50.11 Describe ultrasonic examination	P	R	E
50.12 Describe acoustic emission examination	P	R	R
50.13 Examine a weld structure	P	R	E
50.14 Appraise the quality of a welded part by non-destructive examination	P	R	E
Unit 51 Safety			
51.1 Describe the importance of safety training	P	R	E
51.2 Assess work area safety	P	R	E
51.3 Practice personal safety and select appropriate equipment	P	R	E
51.4 Describe fumes, gasses and toxic materials	P	R	E
51.5 Demonstrate gas storage safety	P	R	E
51.6 Demonstrate fire safety	P	R	E
51.7 Demonstrate electrical safety	P	R	E
51.8 Demonstrate radiation safety	P	R	E
51.9 Demonstrate proper ergonomic practices	P	R	E
ENGINEERING DESIGN AND DEVELOPMENT			
Unit 52 Introduction to Engineering Design and Development			
52.1 Identify the scope and purpose of an engineering design and development research project	P	R	E
52.2 Determine the structure for evaluating a research project	P	R	E
Unit 53 Elements of Formal Research			
53.1 Use a journal as the source for returning to any desired previously encountered information	P	R	E
53.2 Use conventional library resources as a starting point for all research	P	R	E
53.3 Use the computer as a research tool	P	R	E
53.4 Contact the experts	P	R	E
Unit 54 Guided Research			
54.1 Demonstrate methods of brainstorming	P	R	E
54.2 Research a topic	P	R	E
54.3 Formulate a hypothesis and a problem statement	P	R	E
54.4 Research and develop alternative solutions	I	P	E
54.5 Redefine and justify alternative solutions	I	P	E
54.6 Demonstrate presentation methods	P	R	E
Unit 55 Independent Research			
55.1 Describe procedures to completing an independent research project	P	R	E
55.2 Develop a prototype	P	R	E
55.3 Prepare a research paper	P	R	E
Unit 56 Formal Presentations			
56.1 Create a presentation	P	R	E
56.2 Make a formal presentation	P	R	E

INTRODUCTION TO ENGINEERING AND ENGINEERING TECHNOLOGY DESIGN

Unit 1: Introduction

BIL: Essential

EDU:	12	AD
	P	R

Competency 1.1: Discuss the history of engineering and engineering technology design

Key Indicators:

1.1.1 Describe how the history of art has influenced innovations in the field of engineering and engineering technology, and explain the impact of artistic expression as it relates to consumer products

1.1.2 Discuss how artistic period and style have influenced product and architectural design

1.1.3 Describe the design concept of form and function and explain its use in product design

1.1.4 Describe the evolution of technology and be able to identify engineering and engineering technology achievements through history

1.1.5 Describe the chronological development and accelerating rate of change that innovations in tools and materials have brought about over time as it relates to a given consumer product

1.1.6 Review the history of measurement tools and identify innovations that have led to improved functionality of that tool

BIL: Essential

EDU:	12	AD
	P	R

Competency 1.2: Explore career pathways in engineering and engineering technology related to design

Key Indicators:

1.2.1 Identify career opportunities in design engineering and engineering technology and explain their job functions

1.2.2 Explore career opportunities in a given engineering and engineering technology field and list the educational requirements for each profession

1.2.3 Explore a given professional organization and summarize the range of services provided by the organization

Unit 2: Introduction to Design

BIL: Essential

EDU:	12	AD
	P	R

Competency 2.1: Apply the steps of the design process to solve a variety of design problems

Key Indicators:

2.1.1 List the seven steps of the design process and explain the activities that occur during each phase

2.1.2 Describe the value of working as a team and discuss the benefits of collaboration

2.1.3 Recognize the importance of focusing on detail when executing the design process

BIL: Essential

EDU:	12	AD
	P	R

Competency 2.2: Describe the application of the principles and elements of design utilized in products, print media, and art forms

Key Indicators:

2.2.1 Investigate the principles and elements of design and demonstrate their use in the design process

2.2.2 Identify the use of the principles and elements of design in various products, print media, and art forms

2.2.3 Incorporate the principles and elements of design by incorporating them in design solutions

Unit 3: Student Portfolio Development

BIL: Essential

EDU:	12	AD
	P	R

Competency 3.1: Develop a portfolio to organize and display evidence of work

Key Indicators:

3.1.1 Identify the proper elements of a fully developed portfolio

3.1.2 Identify and discuss the ethical issues surrounding portfolio artifacts

3.1.3 Compare and contrast defined elements of a good portfolio specified in the PowerPoint presentation to the sample provided in the PLTW® Design Resource Guide

BIL: Essential

EDU:	12	AD
	P	R

Competency 3.2 Use the portfolio to make a presentation that defends current proficiency

Key Indicators:

3.2.1 Prepare the presentation

3.2.2 Deliver the presentation, receive and process the feedback

Unit 4: Sketching and Visualization

BIL: Essential

EDU:	12	AD
	P	R

Competency 4.1: Utilize sketching and visualization techniques

Key Indicators:

4.1.1 Integrate proper sketching techniques and styles in the creation of sketches

4.1.2 Demonstrate the ability to produce two-dimensional geometric figures

BIL: Essential

EDU:	12	AD
	P	R

Competency 4.2: Select and produce the appropriate pictorial style to best communicate solutions in the design process

Key Indicators:

4.2.1 Formulate pictorial sketches to develop ideas, solve problems, and understand relationships during the design process

4.2.2 Create sketches utilizing both the additive and subtractive methods to assess underlying geometric and perceptual principles

4.2.3 Select a sketching method that is efficient in its use of color, form, and symbols representing abstract data

4.2.4 Augment pictorial sketches with shading to improve communication

BIL: Essential

EDU:	12	AD
	P	R

Competency 4.3: Evaluate and select the necessary view to graphically communicate design solutions

Key Indicators:

4.3.1 Interpret annotated sketches in the design analysis process

4.3.2 Integrate annotated sketches in presentations, portfolio, and documentation process

4.3.3 Develop properly annotated sketches to accurately convey data in a design solution

Unit 5: Geometric Relationships

BIL: Essential

EDU:	12	AD
	P	R

Competency 5.1: Construct various geometric forms and shapes
Key Indicators:

5.1.1 Define and contrast points, lines, and line segments
5.1.2 Identify major geometric shapes (isosceles triangle, right triangle, scalene triangle, rectangles, squares, rhombus, trapezoid, pentagon, hexagon, and octagon)
5.1.3 Construct various geometric shapes using a compass, ruler, and triangle
5.1.4 Define the elements and types of angles
5.1.5 Construct and bisect various types of angles using a compass, ruler, and triangle
5.1.6 Define terminology associated with arcs and circles
5.1.7 Construct arcs, circles, and ellipses using a compass, ruler, and triangle

BIL: Essential

EDU:	12	AD
	P	R

Competency 5.2: Describe geometric constraints
Key Indicators:

5.2.1 Distinguish and define geometric constraints
5.2.2 Identify the following geometric constraints in given three-dimensional models: horizontal, vertical, parallel, perpendicular, tangent, concentric, collinear, coincident, and equal

BIL: Essential

EDU:	12	AD
	P	R

Competency 5.3: Demonstrate the Cartesian Coordinated System
Key Indicators:

5.3.1 Apply the right hand rule to identify the X, Y, and Z axes of the Cartesian Coordinate System
5.3.2 Apply a combination of absolute, relative, and polar coordinates to construct a three-dimensional model
5.3.3 Define the origin planes in the Cartesian Coordinate System
5.3.4 Identify the origin and planar orientations of each side of a three-dimensional model

Unit 6: Modeling

BIL: Essential

EDU:	12	AD
	P	R

Competency 6.1: Communicate conceptual ideas through written and verbal formats
Key Indicators:
6.1.1 Experience the creative thinking process
6.1.2 Recognize the difference between vertical and lateral thinking
6.1.3 Categorize and select a solution to a problem

BIL: Essential

EDU:	12	AD
	P	R

Competency 6.2: Analyze and develop graphical representation of given data
Key Indicators:
6.2.1 Identify the different graphical methods of data representation
6.2.2 Illustrate the appropriate graphical format to a problem

BIL: Essential

EDU:	12	AD
	P	R

Competency 6.3: Select the appropriate modeling materials to complete a three-dimensional prototype/mockup
Key Indicators:
6.3.1 Identify and select the different physical modeling materials
6.3.2 Build and present a model with its correct proportions

BIL: Essential

EDU:	12	AD
	P	R

Competency 6.4: Critique design solution using mathematical applications (e.g., volume of a bottle, etc.)
Key Indicators:
6.4.1 Evaluate a problem using mathematical formulae
6.4.2 Analyze a solution to a problem using the correct format of analysis

BIL: Essential

EDU:	12	AD
	P	R

Competency 6.5: Evaluate a sketch and generate a model utilizing CAD software
Key Indicators:

6.5.1 Explain the difference between parametric and adaptive designs and be able to specify their uses
6.5.2 Draw a two-dimensional sketch using a CAD package
6.5.3 Apply geometrical and dimensional constraints to a sketch
6.5.4 Demonstrate the ability to generate a three-dimensional model
6.5.5 Demonstrate the use of work features and how they are applied while constructing a solid model
6.5.6 Recognize the use and need of work planes, axes, and points in the development of a computer model
6.5.7 Demonstrate the ability to modify a sketch or feature of a model

Unit 7: Assembly Modeling

BIL: Essential

EDU:	12	AD
	P	R

Competency 7.1: Explore and demonstrate assembly modeling skills to solve a variety of design problems

Key Indicators:

7.1.1 Apply the base component effectively in the assembly environment
7.1.2 Place and create components in the assembly modeling environment
7.1.3 Construct circular and rectangular patterns of components within an assembly model
7.1.4 Replace components with modified external parts
7.1.5 Perform part manipulation during the creation of an assembly model

BIL: Essential

EDU:	12	AD
	P	R

Competency 7.2: Explore and demonstrate assembly constraints, part libraries, sub-assemblies, driving constraints, and adaptive design

Key Indicators:

7.2.1 Perform part manipulation during the creation of an assembly model
7.2.2 Apply assembly constraints to successfully construct a multi-part object
7.2.3 Utilize part libraries effectively during the assembly modeling process
7.2.4 Employ sub-assemblies during the production of assemblies
7.2.5 Apply drive constraints to simulate the motion of parts in assemblies
7.2.6 Explore and apply adaptive design concepts during the development of sketches, features, parts, and assemblies

Unit 8: Model Analysis and Verification

BIL: Essential

EDU:	12	AD
	I	P

Competency 8.1: Evaluate the accuracy of mass properties calculations

Key Indicators:

8.1.1 Demonstrate how to extract mass properties data from their solid models

8.1.2 Describe how analysis of data can be used to update parametric models

8.1.3 List and explain the various mass property calculations, such as, volume, density, mass, surface area, centroid, moment of inertia, products of inertia, radii of gyration, principal axes, and principal moments, and how they are used to evaluate a parametric model

BIL: Essential

EDU:	12	AD
	I	P

Competency 8.2: Interpret and use correct tolerancing techniques when dimensioning solid models

Key Indicators:

8.2.1 Solve tolerance problems, including limits and fits

8.2.2 Compare and contrast the differences between clearance fit, interference fit, and allowance

Unit 9: Model Documentation

BIL: Essential

EDU:	12	AD
	P	R

Competency 9.1: Translate a three-dimensional drawing or model into corresponding orthographic drawing views

Key Indicators:

9.1.1 Identify the appropriate sheet size and title block for creating a drawing layout

9.1.2 Describe the purpose, and/or application, of the following drawing views: isometric view, section view, auxiliary view, and detail view

9.1.3 Generate an isometric view from orthographic drawing views

9.1.4 Determine the correct application for the various section views required to illustrate an object's internal detail

9.1.5 Describe the purpose and application of hatch lines and a cutting plane line, as used in a section view

9.1.6 Create the appropriate section view for a specified application

9.1.7 Create a detail view that corresponds to the appropriate orthographic drawing view

9.1.8 Create an auxiliary view to show the detail on an inclined surface of a drawing object

BIL: Essential

EDU:	12	AD
	P	R

Competency 9.2: Demonstrate appropriate dimensioning rules and practices

Key Indicators:

9.2.1 List the common dimensioning standards

9.2.2 Identify and demonstrate the use of common dimensioning systems

9.2.3 Describe the characteristics and demonstrate the use of unidirectional and aligned dimensions

9.2.4 Differentiate the use of and demonstrate and understanding of size and location dimensions by applying these types of dimensions to annotated sketches and drawings

9.2.5 Set up and integrate the use of a customized common dimensioning standard

9.2.6 Identify and demonstrate the use of dimensioning practices on section, auxiliary, and assembly models

9.2.7 Define tolerancing, and solve tolerance problems

BIL: Essential

EDU:	12	AD
	P	R

Competency 9.3: Apply appropriate annotations on sketches and drawings
Key Indicators:
9.3.1 Identify annotations on sketches and drawings
9.3.2 Formulate general and proprietary specifications to further communicate information relating to product design

Unit 10: Presentation

BIL: Essential

EDU:	12	AD
	P	R

Competency 10.1: Practice effective oral communication techniques

Key Indicators:

10.1.1 Discuss the impact of voice variation, eye contact, posture, and attire when delivering an oral presentation

10.1.2 Demonstrate the following communication techniques: voice variation, eye contact, posture, attire, practice and preparation, and projecting confidence

BIL: Essential

EDU:	12	AD
	P	R

Competency 10.2: Utilize the most appropriate presentation aids in oral and written presentations

Key Indicators:

10.2.1 Describe various forms of visual aids and identify when to use them in a presentation

10.2.2 Identify the most appropriate type of visual aid for a presentation considering the audience and level of formality

10.2.3 Describe the most appropriate type of written documentation for a presentation considering the audience and level of formality

10.2.4 Identify the elements of the various forms of written documentation

Unit 11: Production

BIL: Essential

EDU:	12	AD
	I	P

Competency 11.1: Evaluate material characteristics for manufacturing a specific product and identify the correct manufacturing process needed to produce that product

Key Indicators:

11.1.1 Identify all of the manufacturing team members in the decision making process of designing a product

11.1.2 Categorize manufacturing specifications and constraints needed to produce a product

BIL: Essential

EDU:	12	AD
	I	P

Competency 11.2: Examine and apply the most appropriate machine process

Key Indicators:

11.2.1 Recognize the need to limit the number of processes used to manufacture a product

11.2.2 Develop an understanding of process routing

11.2.3 Interpret data, which has been statistically analyzed, to ensure product quality

11.2.4 Identify the need to evaluate the areas of manpower and facility requirements

BIL: Essential

EDU:	12	AD
	P	R

Competency 11.3: Discuss trends in automated manufacturing

Key Indicators:

11.3.1 Distinguish the differences between CNC, FMS, and CIM

11.3.2 Identify applications for CNC, FMS, and CIM

BIL: Essential

EDU:	12	AD
	I	P

Competency 11.4: Explain material procurement, handling, and cost analysis
Key Indicators:

11.4.1 Explain the need for a company to minimize material handling by procurement of materials in a timely fashion.
11.4.2 Identify the need to perform a cost analysis of a product
11.4.3 Explain the JIT process
11.4.4 Explain how a business creates value

Unit 12: Marketing

BIL: Essential

EDU:	12	AD
	I	P

Competency 12.1: Demonstrate a working knowledge of product cost analysis
Key Indicators:
12.1.1 Define common vocabulary words used in association with product cost analysis
12.1.2 Formulate a product cost analysis for a given product

BIL: Essential

EDU:	12	AD
	I	P

Competency 12.2: Design a package for a given product (e.g., egg drop)
Key Indicators:
12.2.1 Explain packaging design requirements
12.2.2 Recognize the need to protect a product for shipping
12.2.3 Illustrate aesthetic requirements to enhance packaging for the customer

PRINCIPLES OF ENGINEERING AND ENGINEERING TECHNOLOGY

Unit 13: Definition and Types of Engineering and Engineering Technology

BIL: Essential

EDU:	12	AD
	P	R

Competency 13.1: Define engineers as innovators/problem solvers
Key Indicators:

13.1.1 Define engineering and identify engineering and engineering technology achievements through history
13.1.2 Identify five historical engineering and engineering technology role models, including minorities and women
13.1.3 Identify problems for engineers to solve in the future
13.1.4 Define attributes associated with being a successful engineer
13.1.5 Explore the resources and constraints within the engineering environment
13.1.6 Compare and contrast differences in the role of an engineer and a scientist
13.1.7 Envision an emerging technology and describe the impact on the world (e.g. macro, micro, nanofabrication)

BIL: Essential

EDU:	12	AD
	I	P

Competency 13.2: Interpret the role of an engineering and engineering technology team
Key Indicators:

13.2.1 Describe why an engineering team must work together to solve problems, with each team member having individual and collective responsibilities
13.2.2 Discuss the role of out-sourcing in the engineering and engineering technology process, and how effective communication is essential
13.2.3 Indicate how gender-bias, racial-bias and other forms of stereotyping and discrimination can adversely affect communications within an engineering and engineering technology team
13.2.4 Recognize how ethics influences the engineering and engineering technology process
13.2.5 Describe how social, environmental, regulatory, and financial constraints influence the engineering and engineering technology process

BIL: Essential

EDU:	12	AD
	P	R

Competency 13.3: Explore careers in engineering and engineering technology

Key Indicators:

13.3.1 Recognize the difference between engineering (macro, micro and nanofabrication) and engineering technology disciplines and job functions

13.3.2 Identify the professional and legal responsibilities associated with being an engineer (e.g. patent, copyright protection)

13.3.3 Identify the educational requirements to become an engineer

13.3.4 Examine an area of engineering by preparing for and conducting an interview with an engineer in that field of engineering or engineering technology

Unit 14: Communication and Documentation

BIL: Essential

EDU:	12	AD
	P	R

Competency 14.1: Compose sketches using proper sketching techniques in the solution of design problems

Key Indicators:

14.1.1 Select the appropriate sketching styles for presentation of a design problem to a group

14.1.2 Use proper proportioning while producing annotated sketches

BIL: Essential

EDU:	12	AD
	P	R

Competency 14.2: Plan and compose a written technical report about the research conducted about a career field in engineering and engineering technology

Key Indicators:

14.2.1 Formulate an organized outline for a technical paper

14.2.2 Design and create tables, charts, and graphs to illustrate data they have collected

14.2.3 Select an appropriate type of table, chart, or graph to accurately communicate collected data for written work or presentations

BIL: Essential

EDU:	12	AD
	P	R

Competency 14.3 Prepare and deliver a technical presentation

Key Indicators

14.3.1 Design and deliver a presentation utilizing appropriate support materials about a research project

14.3.2 Create and assemble support materials to appropriately demonstrate concepts in the presentation

Unit 15: Design Process

BIL: Essential

EDU:	12	AD
	P	R

Competency 15.1: Compose and diagram the product development lifecycle of an invention

Key Indicators:

15.1.1 Trace the history of an invention and evaluate its effects on society and the environment

15.1.2 Examine the evolution of an invention to observe and report on how the design process is applied to continuously redesign and improve the product

15.1.3 Identify and explain the assumptions that relate to the development of a product and constraints of commercialization

BIL: Essential

EDU:	12	AD
	P	R

Competency 15.2 Design a product

Key Indicators:

15.2.1 Develop a scope statement

15.2.2 Determine a cost analysis

Unit 16: Engineering and Engineering Technology Systems

BIL: Essential

EDU:	12	AD
	P	R

Competency 16.1: Select simple machines to create mechanical systems in the solution of design problem

Key Indicators:

16.1.1 Identify and explain the function of the essential components of a mechanical system on a display they create

16.1.2 Create a display of a mechanical system from a household item they disassemble

16.1.3 Explain mathematically the mechanical advantage gained and function of the six different types of simple machines

16.1.4 Construct a model of the six different types of simple machines SMET (Simple Machine Energy Transformation device)

BIL: Essential

EDU:	12	AD
	I	P

Competency 16.2: Create an energy transfer model of a structure and calculate the heat loss through walls and windows

Key Indicators:

16.2.1 Describe the heat transfer concepts of conduction, convection, and radiation

16.2.2 Sketch a room and calculate heat loss through walls and windows

BIL: Essential

EDU:	12	AD
	P	R

Competency 16.3: Configure proper setup and adjustment of a fluid power system

Key Indicators:

16.3.1 Select specific fluid power sources for different functions

16.3.2 Create a flow diagram schematic sketch and compare it to an actual fluid power circuit

16.3.3 Calculate mathematically and explain the work being done by a specific fluid power device

BIL: Essential

EDU:	12	AD
	P	R

Competency 16.4: Estimate current flow through a circuit and be able to compare estimates to accurate measurements

Key Indicators:

16.4.1 Create schematic drawings to facilitate experimental measurements of electrical circuits

16.4.2 Apply Ohm's and Watt's laws in designing safe electrical circuits

16.4.3 Identify community needs and describe the impact supplying electrical generation has on their communities

16.4.4 Describe mathematical relationship between voltage, resistance and the current found in all electronics circuits

16.4.5 Construct electrical circuits and test for voltage, current and resistance using electronic test equipment and calculate power

BIL: Essential

EDU:	12	AD
	P	R

Competency 16.5: Design, diagram, and implement a program to control a device constructed to perform a sorting operation

Key Indicators:

16.5.1 Apply concepts of mechanical, electrical, and control systems in solving design problems

16.5.2 Formulate a plan for evaluating the functions of a sorting device and to make appropriate changes in design, circuitry or programming

16.5.3 Defend the solution to the design problem

Unit 17: Statics and Strength of Materials

BIL: Essential

EDU:	12	AD
	P	R

Competency 17.1: Evaluate a simple truss mathematically to determine types and magnitude of forces supported in the truss

Key Indicators:

17.1.1 Define, describe, and analyze the stresses and forces acting on an object

17.1.2 Design, construct, and test a model bridge to support the greatest amount of weight per gram of bridge mass

17.1.3 Prepare and present a mathematical analysis of a truss design

BIL: Essential

EDU:	12	AD
	P	R

Competency 17.2: Explain the effects that stress has on a material and explain how the material will react

Key Indicators:

17.2.1 Explain the use of factors of safety in the design process

17.2.2 Explain the difference between the area of a cross section of an object and the second moment of the area (Moment of Inertia) and predict the relative strength of one shape vs. another

17.2.3 Use a computer aided engineering package to analyze a shape

Unit 18: Materials and Materials Testing in Engineering and Engineering Technology

BIL: Essential

EDU:	12	AD
	I	P

Competency 18.1: Compare/contrast and analyze the physical properties of organics, metals, polymers, ceramics, and composites

Key Indicators:

18.1.1 Identify and differentiate the five basic categories of solid engineering and engineering technology materials

18.1.2 Trace the production of raw material to finished product

18.1.3 Identify practical applications of each material category to engineering and engineering technology products and processes

18.1.4 Collect, analyze, and test samples of the four basic materials

18.1.5 Document and present laboratory data related to studies of material classifications

BIL: Essential

EDU:	12	AD
	P	R

Competency 18.2: Assess and document the properties of materials

Key Indicators:

18.2.1 Design an experiment to identify an unknown material

18.2.2 Formulate conclusions through analysis of recorded laboratory test data in the form of charts, graphs, written, verbal, and multimedia formats

BIL: Essential

EDU:	12	AD
	I	P

Competency 18.3: Specify the production processes used to create products from categories of materials

Key Indicators:

18.3.1 Define and state examples of the major categories of Production Processes

18.3.2 Analyze a component of a product and describe the processes used in its creation

18.3.3 Interpret a drawing and produce a part

BIL: Essential

EDU:	12	AD
	I	P

Competency 18.4: Explain the difference between the characteristics of quality in a final product and the control of quality in each step of a process

Key Indicators:

18.4.1 Utilize a variety of precision measurement tools to measure appropriate dimensions, mass, and weight

18.4.2 Explain why companies have a need for quality control and describe what customers and companies refer to when the term "quality" is used

18.4.3 Calculate the mean, median, mode, and standard deviation for a set of data and apply that information to quality assurance

18.4.4 Explain the difference between process and product control

18.4.5 Explain how control charts are used in industry and will predict whether a process is "in or out of control" by using a control chart

18.4.6 Explain the role of diagnostics and diagnostics technology in accessing product quality

BIL: Essential

EDU:	12	AD
	I	P

Competency 18.5: Analyze a material failure

Key Indicators:

18.5.1 Describe the various material testing processes

18.5.2 Describe and safely conduct destructive and non-destructive material testing and use the data collected through these tests to compute and document mechanical properties

18.5.3 Explain how the material failed

Unit 19: Engineering and Engineering Technology for Reliability

BIL: Essential

EDU:	12	AD
	I	P

Competency 19.1: Determine mathematically the chance of failure of a system given information on certain components

Key Indicators:

19.1.1 Diagram a system and identify the critical components

19.1.2 List the causes of failure and be able to propose solutions

19.1.3 Prepare and defend a position on an ethical engineering and engineering technology dilemma

BIL: Essential

EDU:	12	AD
	I	P

Competency 19.2: Analyze an engineering failure which identifies causes, damage done, design failures, and other areas where the failure has impacted the environment or society

Key Indicators:

19.2.1 Research the engineering and engineering technology, legal, social, and ethical issues related to a final design developed in a case study

19.2.2 Prepare a written report explaining their analysis of an engineering and engineering technology failure (e.g. Root Cause Analysis)

Unit 20: Introduction to Dynamics/Kinematics

BIL: Essential

EDU:	12	AD
	P	R

Competency 20.1: Construct a device that will illustrate linear motion
Key Indicators:

20.1.1 Explain the difference between distance traveled and displacement
20.1.2 Design and build a device for the purpose of conducting experiments of acceleration, displacement, and velocity
20.1.3 Identify the different analytical tools used to predict performance and failure of parts, systems, materials

BIL: Essential

EDU:	12	AD
	P	R

Competency 20.2: Summarize test data to explain trajectory motion
Key Indicators:

20.2.1 Explain how velocity and acceleration are calculated
20.2.2 Calculate range and initial acceleration from data they record from experiments
20.2.3 Design and produce a presentation to include an explanation of their ballistic device, drawings and summarization of data recorded from experiments
20.2.4 Analyze test data and utilize the results to make decisions

DIGITAL ELECTRONICS ENGINEERING AND ENGINEERING TECHNOLOGY

Unit 21: Fundamentals

BIL: Essential

EDU:	12	AD
	P	R

Competency 21.1: Appraise hazards in the lab, record locations of the safety equipment, and describe how to use the safety equipment

Key Indicators:

21.1.1 Describe the causes and the dangers of electric shock and explain methods to prevent it

21.1.2 Specify the process of designing an electronic circuit taking into account many factors, including environment concerns, and precautionary measures

BIL: Essential

EDU:	12	AD
	P	R

Competency 21.2: Explain basic electron theory

Key Indicators:

21.2.1 Label the parts of the atom

21.2.2 Explain the relationship of energy required to strip away electrons from atoms to being classified as an insulator or conductor

21.2.3 Define and explain the difference between direct and alternating currents

BIL: Essential

EDU:	12	AD
	P	R

Competency 21.3: Utilize prefixes and engineering and engineering technology notation

Key Indicators:

21.3.1 Define prefixes and engineering notations (e.g., pico, nano, micro, etc.)

21.3.2 Re-write any number using conventional prefix definitions

BIL: Essential

EDU:	12	AD
	P	R

Competency 21.4: Calculate the tolerance levels of various resistors to determine if the measured value is within specifications

Key Indicators:

21.4.1 Describe the material makeup of resistors and how they are used in circuit design

21.4.2 Identify the symbols associated with resistors

21.4.3 Setup lab equipment to measure resistor values in order to compare measured and rated values

BIL: Essential

EDU:	12	AD
	P	R

Competency 21.5: Select and utilize electrical meters to determine voltage, resistance, and current in simple circuits

Key Indicators:

21.5.1 Draw and label the parts of a simple circuit

21.5.2 Build and test a variety of series and parallel circuits, using simulation software and proto-boards, to prove the accuracy of Ohm's and Kirchhoff's laws

21.5.3 Calculate the resistance, current, and voltage in a circuit using Ohm's law

BIL: Essential

EDU:	12	AD
	P	R

Competency 21.6: Calculate the value of capacitors mathematically and through the use of instrumentation

Key Indicators:

21.6.1 Describe the component parts of a capacitor and describe how a capacitor holds a static charge

21.6.2 Use and describe the units of measurement for capacitors

21.6.3 Identify different types of capacitors and their voltage polarity requirements

BIL: Essential

EDU:	12	AD
	P	R

Competency 21.7: Calculate the output frequency of circuits using observations and the oscilloscope

Key Indicators:

21.7.1 Draw a digital waveform and identify the anatomy of the waveform
21.7.2 Differentiate between digital and analog signals when given the waveforms
21.7.3 Wire and test a free-running clock circuit using a 555 timer

BIL: Essential

EDU:	12	AD
	P	R

Competency 21.8: Obtain electronic component data sheets

Key Indicators:

21.8.1 Successfully complete an Internet search for data sheets for integrated circuits
21.8.2 Describe the information contained on a data sheet

Unit 22: Number Systems

BIL: Essential

EDU:	12	AD
	P	R

Competency 22.1 Identify and describe the number systems appropriate to electronic components

Key Indicators:

22.1.1 Describe numerical place value

22.1.2 Use mathematical symbols to represent different bases and communicate concepts using different number systems

BIL: Essential

EDU:	12	AD
	P	R

Competency 22.2: Convert values from one number system to another

Key Indicators:

22.2.1 Demonstrate the relationship of binary and hexadecimal to bits and bytes of information used in computers

22.2.2 Calculate converted values from one system to another

Unit 23: Gates

BIL: Essential

EDU:	12	AD
	P	R

Competency 23.1: Identify and recognize the gates and their truth table
Key Indicators:
23.1.1 Identify the name and symbol of each gate
23.1.2 Identify function and create the truth table

BIL: Essential

EDU:	12	AD
	P	R

Competency 23.2: Apply logic gates to solve a problem
Key Indicators:
23.2.1 Use schematics and symbolic Algebra to represent digital gates in the creation of solutions to design problems
23.2.2 Solve using software
23.2.3 Verify with experimentation

Unit 24: Boolean Algebra

BIL: Essential

EDU:	12	AD
	P	R

Competency 24.1: Create Boolean expressions, logic circuit diagrams or truth tables from information provided in the solution of design problems

Key Indicators:

24.1.1 Recognize the relationship between the Boolean expression, logic diagram, and truth table

24.1.2 Select the Sum-of-Products or the Product-of-Sums form of Boolean expression to use in the solution of a problem

BIL: Essential

EDU:	12	AD
	P	R

Competency 24.2: Apply the rules of Boolean algebra to logic diagrams and truth tables to minimize the circuit size necessary to solve a design problem

Key Indicators:

24.2.1 Use DeMorgan's theorem to simplify a negated expression and to convert a SOP to a POS and visa versa in order to save resources in the production of circuits

24.2.2 Formulate and employ a Karnaugh Map to reduce Boolean expressions and logic circuits to their simplest forms

BIL: Essential

EDU:	12	AD
	P	R

Competency 24.3: Assess duality of logic functions

Key Indicators:

24.3.1 Create circuits to solve a problem using NAND or NOR gates to replicate all logic functions

24.3.2 Summarize the working of NOR and NAND gates to make comparisons with standard combinational logic solutions to determine amount of resource reduction

Unit 25: Combinational Circuit Design

BIL: Essential

EDU:	12	AD
	P	R

Competency 25.1: Design a paradigm for combinational logic problems
Key Indicators:

25.1.1 Restate and simplify a digital design problem as part of the systematic approach to solving a problem
25.1.2 Design, construct, build, troubleshoot, and evaluate a solution to a design problem
25.1.3 Present a solution and evaluation of a design problem

BIL: Essential

EDU:	12	AD
	P	R

Competency 25.2: Design a specific MSI Gate application
Key Indicators:

25.2.1 Discover the code to create numbers on a seven segment display by experimentation
25.2.2 Design a circuit to control a seven segment display with a decimal to BCD encoder and a display driver
25.2.3 Control the flow of data by utilizing Multiplexers and Demultiplexers

BIL: Essential

EDU:	12	AD
	P	R

Competency 25.3: Evaluate programmable logic devices (PLD)
Key Indicators:

25.3.1 Describe programmable logic devices (PLD)
25.3.2 Design and implement combinational logic circuits using reprogrammable logic devices

Unit 26: Adding

BIL: Essential

EDU:	12	AD
	P	R

Competency 26.1: Design, construct and test adder circuits using discrete gates
Key Indicators:

26.1.1 Create and prove the truth table for both half and full adders

26.1.2 Demonstrate binary addition and subtraction by designing circuits to produce correct answers

BIL: Essential

EDU:	12	AD
	P	R

Competency 26.2: Design, construct and test adder circuits using MSI gates
Key Indicators:

26.2.1 Create and prove the truth table for both half and full adders

26.2.2 Demonstrate binary addition and subtraction by designing circuits to produce correct answers

Unit 27: Flip-Flops

BIL: Essential

EDU:	12	AD
	P	R

Competency 27.1: Interpret, design, draw, and evaluate circuits using the logic symbols for latches and flip-flops

Key Indicators:

27.1.1 Construct and test simple latches and flip-flops from discrete gates

27.1.2 Interpret waveform diagrams from constructed circuits and compare them with combinational waveforms

BIL: Essential

EDU:	12	AD
	P	R

Competency 27.2: Compare and contrast operation of synchronous with asynchronous flip-flop circuits they construct

Key Indicators:

27.2.1 Identify synchronous and asynchronous flip-flop circuits

27.2.2 Interpret timing diagrams and truth tables from J-K Flip-Flops

BIL: Essential

EDU:	12	AD
	P	R

Competency 27.3: Evaluate triggers used by latches and flip-flops

Key Indicators:

27.3.1 Identify the different types of triggers used by latches and flip-flops and select the appropriate one for the circuits they design

27.3.2 Analyze timing diagrams that reflect triggering to identify distinguishing characteristics

BIL: Essential

EDU:	12	AD
	P	R

Competency 27.4: Assemble circuits and interpret information about the various applications of flip flops

Key Indicators:

27.4.1 Describe flip-flops timing considerations

27.4.2 Conduct experiments with clock pulse width to determine the effect on the accuracy of data transmission

Unit 28: Shift Registers and Counters

BIL: Essential

EDU:	12	AD
	P	R

Competency 28.1: Evaluate the use of shift registers in product design and the speeds at which those products run

Key Indicators:

28.1.1 Define Shift registers

28.1.2 Conduct experiments to determine the basic principles of how shift registers work

BIL: Essential

EDU:	12	AD
	P	R

Competency 28.2: Evaluate asynchronous counter operations and characteristics

Key Indicators:

28.2.1 Create a circuit using discrete flip-flops to discover the operation and characteristics of asynchronous counters

28.2.2 Design, simulate, build, and test Mod counters using discrete gates in the solution to a design problem

28.2.3 Design, simulate, build, and test asynchronous Mod counters using an integrated counter chip (MSI)

BIL: Essential

EDU:	12	AD
	P	R

Competency 28.3: Evaluate synchronous counter operations and characteristics

Key Indicators:

28.3.1 Design, simulate, build, and test synchronous Mod counters using discrete gates to solve a problem

28.3.2 Design, simulate, build, and test synchronous Mod counters using an integrated counter chip in the solution to a design problem

Unit 29: Families and Specifications

BIL: Essential

EDU:	12	AD
	I	P

Competency 29.1: Define, calculate, and measure fan-out delay
Key Indicators:
29.1.1 Calculate the fan-out for TTL and CMOS
29.1.2 Calculate the noise margin based on information for a data sheet

BIL: Essential

EDU:	12	AD
	I	P

Competency 29.2: Define, calculate, and measure propagation delay
Key Indicators:
29.2.1 Describe switching delays that occur in Integrated Circuits
29.2.2 Calculate propagation delay and compare an actual delay to the delay time on a data sheet

Unit 30: Microprocessors

BIL: Essential

EDU:	12	AD
	I	P

Competency 30.1: Assess microcontrollers
Key Indicators:

30.1.1 Formulate a flow chart to apply basic programming concepts in the planning of a project

30.1.2 Design and create a program, using correct syntax, to evaluate data and make decision based on information gathered from the environment using external digital and analog sensors

30.1.3 Create an interface to be able to inspect, evaluate and manage program parameters in the microprocessor during the operation of a program

BIL: Essential

EDU:	12	AD
	I	P

Competency 30.2: Assess interfacing with motors
Key Indicators:

30.2.1 Design and create a program in correct syntax allowing a microprocessor to evaluate external data in order to operate motors and other devices to control the external environment

30.2.2 Select, size, and implement interface devices to control external devices

30.2.3 Design and create programming to control the position of stepper motors

COMPUTER INTEGRATED MANUFACTURING

Unit 31: Computer Modeling

BIL: Essential

EDU:	12	AD
	P	R

Competency 31.1: Demonstrate the fundamentals of computer modeling
Key Indicators:
31.1.1 Demonstrate the ability to store, retrieve, copy, and output drawing files depending upon system setup
31.1.2 Utilize 2D computer sketching functions
31.1.3 Incorporate various coordinate systems in the construction of 2D geometrical shapes
31.1.4 Calculate the x and y coordinates given a radius and angle

BIL: Essential

EDU:	12	AD
	P	R

Competency 31.2: Utilize object construction techniques
Key Indicators:
31.2.1 Produce 2D sketches using available sketching features
31.2.2 Apply editing techniques to produce accurate sketches
31.2.3 Describe and apply sketch constraints
31.2.4 Examine drawings with appropriate inquiry functions

BIL: Essential

EDU:	12	AD
	P	R

Competency 31.3: Illustrate parts modeling techniques
Key Indicators:
31.3.1 Define sketched objects with dimensions and geometric constraints
31.3.2 Apply necessary sketched features to generate a solid model
31.3.3 Demonstrate the application and modifying of placed features

BIL: Essential

EDU:	12	AD
	P	R

Competency 31.4: Develop multi-view drawings such as top, front, right side, isometric, section and auxiliary views from the solid model

Key Indicators:

31.4.1 Demonstrate the proper application of annotations and reference dimensions while conforming to established drafting standards

31.4.2 Update model and drawing views using revision specification sheets provided by the instructor

BIL: Essential

EDU:	12	AD
	P	R

Competency 31.5: Create assembly models through the integration of individual parts and sub-assemblies

Key Indicators:

31.5.1 Identify the fundamentals creating assembly models

31.5.2 Generate an assembly drawing, which include views, balloons, and bills of materials (BOM)

BIL: Essential

EDU:	12	AD
	P	R

Competency 31.6: Prepare a rapid prototype file from a drawing database

Key Indicators:

31.6.1 Recognize the wide array of industry-wide prototyping methods in use

31.6.2 Identify the need for rapid-prototyping

Unit 32: Programmable Machines

BIL: Essential

EDU:	12	AD
	P	R

Competency 32.1: Summarize the history of programmable machining
Key Indicators:

32.1.1 Explain the history of computer controlled machines charting the growth of NC and how it has been implemented into private industry
32.1.2 Explain how the application of CNC machines has impacted manufacturing
32.1.3 Explain the advantages and disadvantages of CNC Machining
32.1.4 Explore career opportunities and educational requirements within the field of programmable machines

BIL: Essential

EDU:	12	AD
	P	R

Competency 32.2: Explain the different elements of a CNC machine
Key Indicators:

32.2.1 Identify the axes relevant to various CNC machines
32.2.2 Contrast open and closed loop control systems
32.2.3 Identify the types of drive systems used in CNC machines
32.2.4 Use the CNC control program to indicate the machine position and then contrast that position to the relative position of the part origin (PRZ)
32.2.5 Identify and explain the function of the major components of a CNC machine tool
32.2.6 Examine and apply various work holding devices commonly used for CNC machining
32.2.7 Identify various types of tool changers used in CNC machine tools
32.2.8 Define the three primary axes used in CNC machining and explore the remaining axes used in advanced machining
32.2.9 Explain the importance of cutting tool materials and how they affect the speed and feed rates used by machine tools
32.2.10 Examine different types of tool holding devices used in CNC machine tools

BIL: Essential

EDU:	12	AD
	P	R

Competency 32.3: Select and demonstrate CNC programming techniques
Key Indicators:

32.3.1 Describe the difference between reference and position points
32.3.2 Identify the CNC machine movements that are identified by axes
32.3.3 Describe the axis system as a worldwide standard for machine movement
32.3.4 Plot points using absolute, relative (incremental) and polar coordinates
32.3.5 Identify Significant Points on geometric shapes (ex. Center point, end point)
32.3.6 Identify the optimum location for the Program reference Zero (PRZ) point
32.3.7 Identify the three categories of machine movement: straight line, curved line, and non-regular shape
32.3.8 Complete a preliminary planning sheet to identify necessary work holding devices, cutting tools, reference points, machining sequences and safe operation
32.3.9 Define the term “Alphanumeric Coding”
32.3.10 Define the term “G codes”
32.3.11 Define the term “M code”
32.3.12 Identify the three sections of a program; Initial Commands, Program Body, and Program End
32.3.13 Write a basic NC part program using necessary G and M codes including remarks that describe the function of each code
32.3.14 Explore the advantages and disadvantages of shop floor programming as well as off line programming
32.3.15 Create a simple NC part program using a text editor and a CAM package
32.3.16 Employ a CAD/CAM/CNC software solution to create a part
32.3.17 Examine, identify, and correct errors found in NC part program files
32.3.18 Use simulation software to graphically verify NC program operation
32.3.19 Perform a “Dry Run” to verify the machine setup and program operation

BIL: Essential

EDU:	12	AD
	P	R

Competency 32.4: Operate a CNC machine to machine a part to specifications

Key Indicators:

32.4.1 Demonstrate the ability to safely setup, maintain and operate a CNC machine center using appropriate documentation and procedures

32.4.2 Examine part geometry to select appropriate cutting tools and fixturing devices needed to create the part using a CNC machine

32.4.3 Setup and edit the tool library of a CNC control program providing offset values and tool geometry

32.4.4 Calculate and verify appropriate spindle speeds and feed rates specific to each cutting tool utilized in an NC part program

32.4.5 Safely and accurately fixture a part in a CNC machine and set the program reference zero (PRZ)

32.4.6 Verify NC part programs using a simulation software before machining the part on a CNC device

32.4.7 List and demonstrate all possible methods of disabling a CNC machine in the event of an emergency

32.4.8 Follow a safety checklist prior to running an NC part program on a CNC machine

32.4.9 Perform a Dry Run to verify the machine setup and program operation

32.4.10 Machine the part to specifications

BIL: Essential

EDU:	12	AD
	P	R

Competency 32.5: Make precision measurements to the degree of accuracy required by plan specification using appropriate instruments

Key indicators:

32.5.1 Measure using standard and metric systems

32.5.2 Convert measurements between metric and standard inch systems

32.5.3 Read technical drawings identifying the dimensional tolerances and limits

32.5.4 Describe how comparison instruments can be used to check dimensions, compare shapes, indicate centers and check parallel surfaces

32.5.5 Describe advanced and automated measurement systems that are applied in industry (ex. Coordinate Measuring Systems, Digital Probes and Optical scanners)

32.5.6 Describe the importance of precision measurement in SPC and quality control

BIL: Essential

EDU:	12	AD
	P	R

Competency 32.6: Use a CAM package to generate and edit tool paths by applying appropriate machining processes to geometry imported from a CAD program

Key Indicators:

32.6.1 Define the acronym CAM and explain the purpose of a CAM package

32.6.2 Demonstrate the ability to operate the user interface with a CAM package and access help using appropriate documentation and help screens

32.6.3 Perform basic file operations using a CAM package such as saving, opening, printing and editing part program files

32.6.4 Demonstrate an ability to import and export CAD files using a CAM package

32.6.5 Setup a CAM package by editing the material and tool libraries, defining stock sizes, selecting the appropriate post processor and defining the units of measure to be used

32.6.6 Define and apply the fundamental and advanced milling and turning procedures used in CAM packages

Unit 33: Introduction to Robotics

BIL: Essential

EDU:	12	AD
	P	R

Competency 33.1: Describe the development of robotics
Key Indicators:
33.1.1 Discuss the chronological development of automation leading to robotics
33.1.2 Review career opportunities in the robotics career fields
33.1.3 Describe the development of robotics from Science Fiction
33.1.4 Identify a minimum of four dangerous and repetitive jobs that robots are used for

BIL: Essential

EDU:	12	AD
	P	R

Competency 33.2: Discuss robotics and automated systems
Key Indicators:
33.2.1 Formulate a definition of a robot
33.2.2 Classify different types of robots
33.2.3 Identify the positive impact robots have on manufacturing
33.2.4 Discuss the social implications of robots

BIL: Essential

EDU:	12	AD
	P	R

Competency 33.3: Contrast different working models of a robot
Key Indicators:
33.3.1 Identify and compare the four classifications of robots
33.3.2 Investigate a classification of robot
33.3.3 Identify and report specifications and work envelopes of robots

BIL: Essential

EDU:	12	AD
	I	P

Competency 33.4: Utilize mechanical components in computer integrated manufacturing operations

Key Indicators:

33.4.1 Identify and sketch the mechanical components of a robot
33.4.2 Develop an end effector
33.4.3 Indicate the way end effectors are specific to a process
33.4.4 Describe the various drive systems used in robotics and discuss the advantages and disadvantages of each

BIL: Essential

EDU:	12	AD
	P	R

Competency 33.5: Develop a feeder system with sensors to detect if parts are present and will alert the operator if the quantity of parts is below the required number

Key Indicators:

33.5.1 Describe the basic components of robot controllers
33.5.2 Describe control techniques and computer simulations
33.5.3 Load a continuous path program and compare the differences between this program and pick and place
33.5.4 Assemble sensing systems and recognize the differences between tactile and non-tactile sensing systems

BIL: Essential

EDU:	12	AD
	P	R

Competency 33.6: Program a robot to perform several tasks

Key Indicators:

33.6.1 Program a robot to solve a materials handling program
33.6.2 Recognize the need for end of arm tooling and how this tooling affects the robot's operation

BIL: Essential

EDU:	12	AD
	I	P

Competency 33.7: Analyze and generate a tooling solution to a robotic manufacturing problem

Key Indicators:

33.7.1 Describe the necessity for specialty tooling applications in robotics

33.7.2 Prepare and document a presentation on end of arm tooling

Unit 34: Computer Integrated Manufacturing

BIL: Essential

EDU:	12	AD
	P	R

Competency 34.1: Discuss the rationale for CIM manufacturing
Key Indicators:

34.1.1 Describe how the individual components of a flexible manufacturing system are interrelated
34.1.2 Recognize the benefits and problems associated with CIM technology and how they affect the manufacturing process
34.1.3 Identify some basic characteristics of a manufacturing operation that lend themselves to computer integrated manufacturing
34.1.4 Identify some of the typical components and sub systems that make up an automated machining, assembly and process-type manufacturing operation

BIL: Essential

EDU:	**12**	**AD**
	P	R

Competency 34.2: Compare/Contrast types of CIM systems
Key Indicators:

34.2.1 Identify the three categories of CIM manufacturing systems
34.2.2 Compare and contrast the benefits and drawbacks of the three categories of CIM manufacturing systems
34.2.3 Recognize the working relationship between the CNC mill and the robot
34.2.4 Identify the components of a FMS

BIL: Essential

EDU:	**12**	**AD**
	P	R

Competency 34.3: Explain components of a CIM system for a given industrial application
Key Indicators:

34.3.1 Identify the relationship between a CNC milling machining interface and a jointed arm robot interface through a communication handshaking process
34.3.2 Examine the individual components used in selected CIM systems
34.3.3 Discuss the various applications of a Programmable Logic Controller as related to its use in a CIM system

BIL: Essential

EDU:	12	AD
	P	R

Competency 34.4: Assemble and test individual component designs by integrating them into a complete miniature FMS built from the Fischertechnik models

Key Indicators:

34.4.1 Recognize the necessary safety precautions associated with a fully automated CIM system

34.4.2 Recognize and explain the significance of teamwork and communication when the designs of the individual groups are combined into a complete miniature FMS

34.4.3 Demonstrate how individual components work together to form a complete CIM system

34.4.4 Construct and test a complete miniature FMS

FUEL CELLS TECHNOLOGY

Unit 35: Introduction

BIL: Essential

EDU:	12	AD
	P	R

Competency 35.1: Explain the key issues of fuel cell research and development
Key Indicators:

35.1.1 Discuss alternative energy and power sources (e.g., coal, natural gas, methane, wind, hydro, biomass, nuclear, solar, batteries, etc.)
35.1.2 Distinguish between primary energy sources, conversion and storage devices
35.1.3 Summarize the advantages and disadvantages of fuels cells
35.1.4 Examine the environmental impact of fuel cells (e.g., wells to wheels, etc.)
35.1.5 Discuss the value and challenges of transitioning to a hydrogen economy
35.1.6 Compare the economic impact of fuel cells to current technology

BIL: Essential

EDU:	12	AD
	P	R

Competency 35.2: Trace the history of fuel cells
Key Indicators:

35.2.1 Trace the growth of fuel cells (e.g., Allis Chalmers fuel cell tractor demo, General Motors “demonstration van”, Karl Kordesch, Frances Thomas Bacon’s cell, etc.)
35.2.2 Describe the “Grove Cell” developed by William Robert Grove
35.2.3 Describe Ludwig Mond’s contribution to fuel cell development
35.2.4 Discuss Friedrich Wilhelm Ostwald solution to Grove’s gas battery
35.2.5 Discuss William W. Jacques’s carbon battery and its efficiency
35.2.6 Describe Emil Baur’s work with high temperature devices
35.2.7 Describe Frances Thomas Bacon’s research with electrolyte fuel cells

BIL: Essential

EDU:	12	AD
	P	R

Competency 35.3: Describe career opportunities in fuel cell technologies and applications

Key Indicators:

35.3.1 Match educational and skill levels with career opportunities

35.3.2 Identify industrial trends in fuel cell development

35.3.3 Identify existing and future application for fuel cell technology (e.g., chlor-alkali, space, military, etc.)

Unit 36: Function

BIL: Essential

EDU:	12	AD
	P	R

Competency 36.1: Describe a fuel cell
Key Indicators:
36.1.1 Define fuel cell technology
36.1.2 Identify the component elements in a fuel cell
36.1.3 Compare and contrast fuel cell efficiency to other technologies (e.g., Carnot cycle)
36.1.4 Differentiate AC versus DC power

BIL: Essential

EDU:	12	AD
	P	R

Competency 36.2: Demonstrate the conversion of chemical energy into electrical energy
Key Indicators:
36.2.1 Trace the energy conversion processes within a fuel cell
36.2.2 Compare the fuel cell to a battery (e.g., hearing aid 'battery')
36.2.3 Describe the role of a fuel cell in a power system

Unit 37: Components

BIL: Essential

EDU:	12	AD
	P	R

Competency 37.1: Analyze the function of the cathode

Key Indicators:

37.1.1 Identify the common cathode materials
37.1.2 Compare and contrast various materials (e.g., functionality, catalyst, etc.)
37.1.3 Explain the role of the cathodes in fuel cell performance (e.g., theoretical versus actual)
37.1.4 Explain electrons conduction from the external circuit to the catalyst

BIL: Essential

EDU:	12	AD
	P	R

Competency 37.2: Assess the function of the electrolyte

Key Indicators:

37.2.2 Compare and contrast ionic conductivity versus electronic conductivity
37.2.2 Discuss various electrolyte materials (PEM, alkaline, acid, solid oxide, molten carbonate, etc)
37.2.3 Discuss the structure, function, advantages and disadvantages of electrolyte materials

BIL: Essential

EDU:	12	AD
	P	R

Competency 37.3: Explain the role the anode plays in a fuel cell

Key Indicators:

37.3.1 Identify the common anode materials
37.3.2 Compare and contrast various materials (e.g., functionality, catalyst, etc.)
37.3.3 Explain the role of the anodes in fuel cell performance (e.g., theoretical versus actual)
37.3.4 Explain electrons conduction from the external circuit to the catalyst

BIL: Essential

EDU:	12	AD
	P	R

Competency 37.4: Analyze the fuel cell stack
Key Indicators:
37.4.1 Describe a fuel cell stack
37.4.2 Classify interconnect and bipolar plates
37.4.3 Analyze series versus parallel electrical conduction

Unit 38: Fuels Processing

BIL: Essential

EDU:	12	AD
	P	R

Competency 38.1: Evaluate hydrogen as a fuel
Key Indicators:
38.1.1 Identify hydrogen sources and ways to produce it
38.1.2 List the properties of hydrogen
38.1.3 Explore the positive attributes of hydrogen in fuel cell technology
38.1.4 Research the uses of hydrogen today
38.1.5 Explore the problems associated with hydrogen and fuel cell development
38.1.6 Discuss hydrogen storage technology (e.g., compressed gas, hydrides, cryogenics, etc.)
38.1.7 Explore cost considerations (e.g., economic, environmental, national security, etc.)

BIL: Essential

EDU:	12	AD
	P	R

Competency 38.2: Evaluate hydrogen safety practices and procedures
Key Indicators:
38.2.1 Compare and contrast hydrogen versus liquid hydrocarbons
38.2.2 Illustrate and debunk the Hindenburg Myth
38.2.3 Discuss legal and regulatory requirements

BIL: Essential

EDU:	12	AD
	I	P

Competency 38.3: Explain how fuel processors work
Key Indicators:
38.3.1 Describe the purpose of fuel processors
38.3.2 Identify common fuels for fuel processing
38.3.3 Explain the function of the steam reformer
38.3.4 Explain how the fuel processor and fuel cell work together
38.4.5 Discuss the disadvantages of fuel processing (e.g. pollution, carbon dioxide poisoning efficiency, etc.)

Unit 39: Alternate Structures of Fuel Cells

BIL: Essential

EDU:	12	AD
	I	P

Competency 39.1: Analyze PEM fuel cell technology
Key Indicators:

39.1.1 Explain the PEM fuel cell process
39.1.2 Analyze and explain the structure and function of PEM fuel cells
39.1.3 Explain how the PEM fuel cell handles-waste heat and water management
39.1.4 Compare operating characteristics (waste heat quality, efficiency, fuel requirements, catalysis, failure analysis, etc.) of the PEM to other fuel cells
39.1.5 Identify technical and economic considerations for applications of PEM fuel cells
39.1.6 Discuss actual real-world examples of PEM fuel cell
39.1.7 Discuss the characteristics of materials used and their effect on the cell operation (e.g., anodes, cathodes, electrolytes, etc.)

BIL: Essential

EDU:	12	AD
	I	P

Competency 39.2: Analyze solid oxide fuel cell technology
Key Indicators:

39.2.1 Explain the solid oxide fuel cell process
39.2.2 Analyze and explain the structure and function of solid oxide fuel cell stack
39.2.3 Explain how the solid oxide fuel cell (SOFC) handles-waste heat and water management
39.2.4 Compare operating characteristics (waste heat quality, efficiency, fuel requirements, catalysis, failure analysis, etc.) of the solid oxide fuel cell (SOFC) to other fuel cells
39.2.5 Identify technical and economic considerations for applications of solid oxide fuel cell (SOFC)
39.2.6 Discuss actual real-world examples of solid oxide fuel cell
39.2.7 Discuss the characteristics of materials used and their effect on the cell operation (e.g., anodes, cathodes, electrolytes, etc.)

BIL: Essential

EDU:	12	AD
	I	P

Competency 39.3: Analyze alkali fuel cell technology
Key Indicators:

39.3.1 Explain the alkali fuel cell process
39.3.2 Analyze and explain the structure and function of alkali fuel cell stack
39.3.3 Explain how the alkali fuel cell handles waste heat and water management
39.3.4 Compare operating characteristics (waste heat quality, efficiency, fuel requirements, catalysis, failure analysis, etc.) of the alkali fuel cell to other fuel cells
39.3.5 Identify technical and economic considerations for applications of alkali fuel cell
39.3.6 Discuss actual real-world examples of alkali fuel cell
39.3.7 Discuss the characteristics of materials used and their effect on the cell operation (e.g., anodes, cathodes, electrolytes, etc.)

BIL: Essential

EDU:	12	AD
	I	P

Competency 39.4: Analyze phosphoric-acid fuel cell technology
Key Indicators:

39.4.1 Explain the phosphoric-acid fuel cell process (e.g., 4.8 megawatts New York City demo)
39.4.2 Analyze and explain the structure and function of phosphoric-acid fuel stack
39.4.3 Explain how the phosphoric-acid fuel cell handles waste heat and water management
39.4.4 Compare operating characteristics (waste heat quality, efficiency, fuel requirements, catalysis, failure analysis, etc.) of the phosphoric-acid fuel cell to other fuel cells
39.4.5 Identify technical and economic considerations for applications of phosphoric-acid fuel cell
39.4.6 Discuss actual real-world examples of phosphoric-acid fuel cell
39.4.7 Discuss the characteristics of materials used and their effect on the cell operation (e.g., anodes, cathodes, electrolytes, etc.)

BIL: Essential

EDU:	12	AD
	I	P

Competency 39.5: Analyze molten carbonate fuel cell technology
Key Indicators:

39.5.1 Explain the molten carbonate fuel cell process
39.5.2 Analyze and explain the structure and function of molten carbonate fuel stack
39.5.3 Explain how the molten carbonate fuel cell handles waste heat and water management
39.5.4 Compare operating characteristics (waste heat quality, efficiency, fuel requirements, catalysis, failure analysis, etc.) of the molten carbonate fuel cell to other fuel cells
39.5.5 Identify technical and economic considerations for applications of molten carbonate fuel cell
39.5.6 Discuss actual real-world examples of molten carbonate fuel cell
39.5.7 Discuss the characteristics of materials used and their effect on the cell operation (e.g., anodes, cathodes, electrolytes, etc.)

BIL: Essential

EDU:	12	AD
	I	P

Competency 39.6: Analyze direct methanol fuel cell technology
Key Indicators:

39.6.1 Explain the direct methanol fuel cell process
39.6.2 Analyze and explain the structure and function of direct methanol fuel stack
39.6.3 Explain how the direct methanol fuel cell handles waste heat and water management
39.6.4 Compare operating characteristics (waste heat quality, efficiency, fuel requirements, catalysis, failure analysis, etc.) of the direct methanol fuel cell to other fuel cells
39.6.5 Identify technical and economic considerations for applications of direct methanol fuel cell
39.6.6 Discuss actual real-world examples of direct methanol fuel cell
39.6.7 Discuss the characteristics of materials used and their effect on the cell operation (e.g., anodes, cathodes, electrolytes, etc.)

BIL: Essential

EDU:	12	AD
	I	P

Competency 39.7: Analyze the regenerative fuel cell technology
Key Indicators:

39.7.1 Explain the regenerative fuel cell process
39.7.2 Analyze and explain the structure and function of regenerative fuel stack
39.7.3 Explain how the regenerative fuel cell handles waste heat and water management
39.7.4 Compare operating characteristics (waste heat quality, efficiency, fuel requirements, catalysis, failure analysis, etc.) of the regenerative fuel cell to other fuel cells
39.7.5 Identify technical and economic considerations for applications of regenerative fuel cell
39.7.6 Discuss actual real-world examples of regenerative fuel cell
39.7.7 Discuss the characteristics of materials used and their effect on the cell operation (e.g., anodes, cathodes, electrolytes, etc.)

BIL: Essential

EDU:	12	AD
	I	P

Competency 39.8: Discuss fuel cell systems integration
Key Indicators:

39.8.1 Define fuel cell system building blocks
39.8.2 Differentiate system requirements based on fuel cell technology
39.8.3 Discuss interface with power grid
39.9.4 Discuss legal and regulatory issues (PUCO)
39.8.5 Discuss systems for vehicular power
39.8.6 Discuss systems integration for portable power
39.8.7 Describe the weight and volume implications
39.8.8 Discuss cost, design, and high volume manufacturing (e.g., vehicular, stationary, mobile, etc.)

Unit 40: Implementation Strategies and Challenges

BIL: Essential

EDU:	12	AD
	P	R

Competency 40.1: Explore applications and markets for fuel cells
Key Indicators:
40.1.1 Discuss application in the vehicular industry (e.g., cars, buses, etc.)
40.1.2 Describe portable power applications
40.1.3 Identify home power generation applications
40.1.4 Examine large power generation applications and markets
40.1.5 Discuss industrial applications (e.g., chlor-alkali, etc.)
40.1.6 Discuss experiments with real-world experiences

BIL: Essential

EDU:	12	AD
	P	R

Competency 40.2: Examine fuel cell emissions
Key Indicators:
40.2.1 Describe the elements emitted from each of the fuel cell technologies (e.g., normal operation, failure mode, etc.)
40.2.2 Contrast the fuel processing emissions to the fuel cell emissions
40.2.3 Compare fuel cell emissions to motor vehicle emissions
40.2.4 Illustrate the effect of emissions on the environment

BIL: Essential

EDU:	12	AD
	I	P

Competency 40.3: Describe the market entry challenges associated with fuel cells
Key Indicators:
40.3.1 Discuss technical challenges (e.g. water management, heat management, etc.)
40.3.2 Describe hydrogen infrastructure challenges associated with fuel cells
40.3.3 Discuss funding challenges to development and commercialization
40.3.4 Discuss economies-of-scale in commercialization
40.3.5 Predict socio-political implications

Unit 41: Fuel Cell System Capstone Project

BIL: Essential

EDU:	12	AD
	P	R

Competency 41.1: Design a fuel cell system
Key Indicators:
41.1.1 Select a market need
41.1.2 Select the technology
41.1.3 Determine components and balance of plant (e.g., reformer, processor, heat exchanger, etc.)
41.1.4 Develop cost justification
41.1.5 Document design process
41.1.6 Present project proposal

BIL: Essential

EDU:	12	AD
	P	R

Competency 41.2: Build a fuel cell system
Key Indicators:
41.2.1 Create a bill of materials
41.2.2 Procure necessary materials
41.2.3 Document methodology
41.2.4 Assemble a model system

BIL: Essential

EDU:	12	AD
	P	R

Competency 41.3: Evaluate project performance
Key Indicators:
41.3.1 Compare outcomes to expectations (e.g., calculated versus actual energy efficiency, reliability, cost, etc.)
41.3.2 Recommend improvements

MATERIALS JOINING TECHNOLOGY

Unit 42: Introduction to Materials Joining Technology

BIL: Essential

EDU:	12	AD
	P	R

Competency 42.1: Define welding engineers and material joining technicians
Key Indicators:

42.1.1 Describe the role of welding engineers and material joining technicians within industry.
42.1.2 Distinguish the differences between welding engineers, welding technicians, and welders.
42.1.3 Identify the industries currently employing welding engineers and material joining technicians.
42.1.4 Identify various welding career pathways in industry.

BIL: Essential

EDU:	12	AD
	P	R

Competency 42.2: Describe the background related to materials joining
Key Indicators:

42.2.1 Describe why materials joining is important to the world economy
42.2.2 Distinguish between joining and mechanical fastening processes
42.2.3 Define what materials are considered in material joining
42.2.4 Define the general categories of materials joining processes
42.2.5 Define the engineering and economic considerations needed to produce a manufactured part fit for its intended service.

BIL: Essential

EDU:	12	AD
	P	R

Competency 42.3: Classify the categories of welding and joining processes
Key Indicators:

42.3.1 Differentiate between fusion and non-fusion joining
42.3.2 Identify the various fusion joining processes
42.3.3 Identify the various non-fusion joining processes.
42.3.4 Recognize welding processes utilizing standard and nonstandard terms (e.g. American Welding Society [AWS] glossary)

Unit 43: Arc Welding Processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 43.1: Contrast the classification of arc welding processes and describe how they fit in all fusion welding processes

Key Indicators:

43.1.1 Recognize the fusion welding classification chart and where the arc welding processes fit into the chart

43.1.2 Describe the difference between the gas and flux based shielding systems in arc welding, and list the various types of flux and inert gases

43.1.3 Differentiate between consumable and non-consumable electrodes.

BIL: Essential

EDU:	12	AD
	P	R

Competency 43.2: Explain the shielded metal arc welding process and its uses

Key Indicators:

43.2.1 Describe the basics of the shielded metal arc welding (SMAW) process.

43.2.2 Classify the various types of SMAW electrodes

43.2.3 Describe the various components of the electrode and their function

43.2.4 List the advantages, quality issues and limitations in relation to other arc welding processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 43.3: Explain the gas metal arc welding process and its uses

Key Indicators:

43.3.1 Describe the basics of the gas metal arc welding (GMAW) process.

43.3.2 Describe the various components of the welding gun and the function of each part

43.3.3 Classify the various types of GMAW electrodes

43.3.4 Describe the various modes of metal transfer through the arc

43.3.5 Describe the effect of shielding gas on metal transfer

43.3.6 List the advantages, quality issues and limitations in relation to other arc welding processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 43.4: Explain the flux cored arc welding process and its uses
Key Indicators:

43.4.1 Describe the basics of the flux cored arc welding (FCAW) process.
43.4.2 Describe the difference between the self shielded flux cored arc welding process and the gas shielded flux cored arc welding process
43.4.3 Classify the various types of FCAW electrodes
43.4.4 List the advantages, quality issues and limitations in relation to other arc welding processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 43.5 Explain the submerged arc welding process and its uses
Key Indicators:

43.5.1 Describe the basics of the submerged arc welding (SAW) process.
43.5.2 Describe the various components of the welding torch (gun) and the function of each part
43.5.3 Classify the various types of SAW electrodes and fluxes.
43.5.4 List the advantages, quality issues and limitations in relation to other arc welding processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 43.6 Explain the gas tungsten arc welding process and its uses
Key Indicators:

43.6.1 Describe the basics of the gas tungsten arc welding (GTAW) process.
43.6.2 Describe the various components of the welding torch and the function of each part
43.6.3 Classify the various types of electrodes
43.6.4 Explain the effect of shielding gas, current polarity, and electrode tip geometry
43.6.5 List the advantages, quality issues and limitations in relation to other arc welding processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 43.7 Explain the plasma arc welding process and its uses

Key Indicators:

43.7.1 Describe the basics of the plasma arc welding (PAW) process.
43.7.2 Describe the various components of the welding torch and the function of each part
43.7.3 Explain the characteristics of transferred arc and non-transferred arc systems
43.7.4 Explain keyhole welding mode.
43.7.5 List the advantages, quality issues and limitations in relation to other arc welding processes

BIL: Recommended

EDU:	12	AD
	P	R

Competency 43.8: Explain the electroslag (ES) and electrogas (EG) welding process and its uses

Key Indicators:

43.8.1 Describe the basics of the electroslag and electrogas arc welding processes.
43.8.2 Describe the various components of the welding gun and the function of each part
43.8.3 Describe the electrode and flux combination.
43.8.4 List the advantages, quality issues and limitations in relation to other arc welding processes

BIL: Recommended

EDU:	12	AD
	P	R

Competency 43.9 Explain the arc stud welding process and its uses

Key Indicators:

43.9.1 Describe the basics of the arc stud welding processes.
43.9.2 Describe the various components of the stud gun and the function of each part
43.9.3 List the advantages, quality issues and limitations in relation to other welding processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 43.10 Develop an automated Arc Welding procedure for the manufacture of a real part (e.g. pacemaker body, bellows, etc.)

Key Indicators:

43.10.1 Prepare an automated turning table for part manipulation
43.10.2 Construct a GTAW arc welding system for part welding
43.10.3 Perform welds with various welding current levels
43.10.4 Analyze weld quality and heat input
43.10.5 Prepare a written report describing the best welding procedure for part manufacture.

Unit 44: Non-Arc Welding Processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 44.1 Summarize the non-arc welding processes
Key Indicators:
44.1.1 List the non-arc welding processes
44.1.2 Explain where the non-arc welding processes fit into the fusion welding chart
44.1.3 Explain why the non-arc welding processes are different from the arc welding processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 44.2 Explain the resistance welding process
Key Indicators:
44.2.1 Explain the resistance welding (RW) processes including essential parameters for spot, seam, and projection welding
44.2.2 Describe electrode design
44.2.3 Identify the Lobe Curve Weldability concept for resistance spot welding (RSW)
44.2.4 List the advantages, quality issues and limitations in relation to other joining processes

BIL: Recommended

EDU:	12	AD
	P	R

Competency 44.3 Explain the oxy-fuel gas welding processes
Key Indicators:
44.3.1 Explain the oxy-fuel gas welding equipment
44.3.2 Explain the differences of neutral, reducing and oxidizing flames
44.3.3 List the advantages, quality issues and limitations in relation to other joining processes

BIL: Recommended

EDU:	12	AD
	P	R

Competency 44.4 Explain the thermit welding process
Key Indicators:
44.4.1 Explain the thermit chemical reaction and consumables
44.4.2 Identify the uses of thermit welding
44.4.3 Compare thermit welding process to other joining processes

BIL: Recommended

EDU:	12	AD
	P	R

Competency 44.5 Explain the solid state bonding processes
Key Indicators:
44.5.1 List the solid state bonding processes and explain where they fit in relation to the welding process chart
44.5.2 Explain the various types of solid state bonding processes (friction welding (FRW) solid state, diffusion welding, etc.)
44.5.3 Explain the diffusion welding (DFW) process.
44.5.4 Explain the ultrasonic welding (USW) process
44.5.5 Explain the explosion welding (EXW) process
44.5.6 Explain the friction stir welding (FSW) process
44.5.7 Compare solid state bonding to other joining processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 44.6 Explain the high energy density fusion welding processes
Key Indicators:
44.6.1 Explain the laser and electron beam welding processes.
44.6.2 Explain beam focusing
44.6.3 Explain keyhole welding mode
44.6.4 Explain how these processes can be used
44.6.5 Explain advantages and limitations of laser welding and electron beam welding

BIL: Essential

EDU:	12	AD
	P	R

Competency 44.7 Explain the brazing and soldering processes
Key Indicators:
44.7.1 Explain the differences between the brazing and soldering processes and where they fit in the welding chart
44.7.2 Explain the advantages and limitations of brazing and soldering
44.7.3 List the various heat sources used in brazing and soldering

BIL: Essential

EDU:	12	AD
	P	R

Competency 44.8 Explain the processes used for joining of plastics
Key Indicators:
44.8.1 Explain the different types of polymeric materials
44.8.2 Describe the processes used for plastic welding including: hot plate, hot gas, infrared, vibration, and ultrasonic
44.8.3 Explain the advantages and limitations of each process

BIL: Essential

EDU:	12	AD
	P	R

Competency 44.9 Explain adhesive bonding of parts
Key Indicators:
44.9.1 Explain the different types of adhesive materials (thermosets & thermoplastics)
44.9.2 Describe the benefits (problems) of the various modes
44.9.3 Describe adhesive selection criteria
44.9.4 Explain the advantages and limitations of adhesive bonding

BIL: Essential

EDU:	12	AD
	P	R

Competency 44.10 Develop a manual welding procedure for the bonding of thermoplastic parts using a hot air gun

Key Indicators:

44.10.1 Select a hot air gun for the bonding of three different plastics
44.10.2 Determine the welding parameters for welding the three plastics
44.10.3 Perform welds with the determined welding procedures
44.10.4 Analyze weld quality
44.10.5 Prepare a written report describing the best welding procedure for part manufacture

BIL: Essential

EDU:	12	AD
	P	R

Competency 44.11 Develop a resistance weldability "Lobe Curve" using a virtual on-line resistance welding machine

Key Indicators:

44.11.1 Examine the resistance welding press type welder by disassembling the machine
44.11.2 Document the various systems (cooling, mechanical, power) in the welding using written text and figures
44.11.3 Perform welds at a variety of weld currents and weld times using constant squeeze pressure
44.11.4 Analyze the effects of weld current and weld time on surface and internal expulsion
44.11.5 Analyze weld quality of actual RW weld samples
44.11.6 Develop the weldability "Lobe Curve" and prepare a written report describing the best welding procedure for part manufacture

Unit 45: Physics of Welding

BIL: Essential

EDU:	12	AD
	P	R

Competency 45.1 Explain the concept of welding heat input
Key Indicators:

45.1.1 Explain the concept of heat input from welding arcs
45.1.2 Explain Heat transfer efficiency
45.1.3 Explain melting efficiency
45.1.4 Describe other energy sources used for welding

BIL: Essential

EDU:	12	AD
	P	R

Competency 45.2 Describe the characteristics of the welding arc
Key Indicators:

45.2.1 Describe the conduction of current through the arc and the relationship of conducting particles to temperature
45.2.2 Describe the Cathode Drop, Anode Drop and Plasma regions
45.2.3 Describe the importance of thermionic work function and ionization potential to arc establishment
45.2.4 Describe the arc voltage-current characteristic curves for various arc welding processes
45.2.5 Describe the effect of arc length and shielding gases on the arc voltage-current characteristic curve

BIL: Essential

EDU:	12	AD
	P	R

Competency 45.3: Describe the physics of metal transfer
Key Indicators:

45.3.1 Describe the metal transfer in various welding processes
45.3.2 Describe the pinch effect on molten droplet formation
45.3.3 Describe the transfer mode transition between short circuit, globular, and spray transfer with current
45.3.4 Describe the effects of wire feed rate on welding current
45.3.5 Describe pulsed arc transfer mode
45.3.6 Describe the effect of wire size on deposition rate and current ranges

BIL: Essential

EDU:	12	AD
	P	R

Competency 45.4: Describe the physics of the arc welding power sources
Key Indicators:

45.4.1 Using the power sources table, describe the different types of arc welding machines including AC, DC, Constant Current and Constant Voltage
45.4.2 Construct the machine voltage-current characteristic curves
45.4.3 Describe methods to convert input power to output power (e.g. inverters)
45.4.4 Describe the relationship between arc characteristics and machine characteristics and the stable arc position
45.4.5 Describe self regulation of arcs

BIL: Essential

EDU:	12	AD
	P	R

Competency 45.5: Describe the physics of arc blow
Key Indicators:

45.5.1 Describe conditions when arc blow occurs
45.5.2 List ways to reduce arc blow

Unit 46: Heat Flow

BIL: Essential

EDU:	12	AD
	P	R

Competency 46.1: Describe heat flow in welds
Key Indicators:
46.1.1 Describe conduction, convection and radiation heat transfer
46.1.2 Describe heat flow in the welding arc
46.1.3 Describe the effect of shielding gas on arc heat flow

BIL: Essential

EDU:	12	AD
	I	P

Competency 46.2: Describe how heat flow affects the temperature profile around a weld
Key Indicators:
46.2.1 Describe Fourier's law of heat flux
46.2.2 Describe conservation of energy as it applies to heat flow

BIL: Essential

EDU:	12	AD
	I	P

Competency 46.3 Develop a thermal profile around a moving weld
Key Indicators:
46.3.1 Examine the thermal profile from a moving arc weld provided in the thermal modeling tool
46.3.2 Prepare a virtual test sample by placing one with thermocouples in the plate.
46.3.3 Produce heating and cooling curves from the thermocouples when the weld profile moves across the plate.
46.3.4 Prepare a written report describing the thermal traces obtained.
46.3.5 Develop the thermal profile of a moving weld

Unit 47: Metallurgical Background

BIL: Essential

EDU:	12	AD
	P	R

Competency 47.1: Define phases of matter and phase changes during solidification
Key Indicators:
47.1.1 Describe the phases of matter
47.1.2 Describe the phase nucleation and growth in solidification
47.1.3 Describe the temperature time cooling curve for solidification of a pure metal

BIL: Essential

EDU:	12	AD
	P	R

Competency 47.2: Explain the common crystal structures in metallic materials
Key Indicators:
47.2.1 Draw a cubic, face centered cubic, body centered cubic and hexagonal close packed crystal structures
47.2.2 Describe what “close packed” means
47.2.3 Calculate the number of atoms per cell in the crystal structures illustrated above

BIL: Essential

EDU:	12	AD
	I	P

Competency 47:3: Explain imperfection in crystal structure
Key Indicators:
47.3.1 Define point line and surface imperfection in metal crystal structure
47.3.2 Illustrate the type of point imperfections and indicate their effect on material properties
47.3.3 Define edge and screw dislocations and illustrate their effect on material properties
47.3.4 Define grain boundaries

BIL: Essential

EDU:	12	AD
	I	P

Competency 47.4: Define phase changes and phase diagrams
Key Indicators:
47.4.1 Define allotropic phase changes as a function of temperature (use iron as an example)
47.4.2 Define the production of alloys by substitution and interstitial alloying
47.4.3 Define an equilibrium phase diagram for iron alloys
47.4.4 Define “Component” “Phase” and “Constituent”

BIL: Essential

EDU:	12	AD
	I	P

Competency 47.5: Define phase changes of eutectoid steels
Key Indicators:
47.5.1 Define the constituent structure when slowly cooling a eutectoid steel from austenite to pearlite
47.5.2 Define the constituent structure when rapidly cooling a eutectoid steel from austenite to martensite

BIL: Essential

EDU:	12	AD
	I	P

Competency 47.6: Explain tie line
Key Indicators:
47.6.1 Define the tie line concept for calculating percent of a phase in the two phase region of equilibrium diagrams
47.6.2 Calculate and show illustrations of the phases present in the two phase pro-eutectoid ferrite region

BIL: Essential

EDU:	12	AD
	I	P

Competency 47.7: Explain transformation strengthening
Key Indicators:
47.7.1 Define martensite structure
47.7.2 Define the continuous cooling curve and critical cooling rate
47.7.3 Compare structures and properties obtained with different cooling rates
47.7.4 Define tempering of martensite

BIL: Essential

EDU:	12	AD
	I	P

Competency 47.8: Explain deformation strengthening
Key Indicators:
47.8.1 Define cold work, and demonstrate increased strength with reduced ductility
47.8.2 Define annealing with recover, recrystalization and grain growth

BIL: Essential

EDU:	12	AD
	I	P

Competency 47.9: Explain precipitation strengthening
Key Indicators:
47.9.1 Define solution annealing
47.9.2 Define precipitation
47.9.3 Define overaging

Unit 48: Welding Metallurgy

BIL: Essential

EDU:	12	AD
	P	R

Competency 48.1: Define weld regions
Key Indicators:
48.1.1 Define composite zone
48.1.2 Define heat affected zone
48.1.3 Define base metal

BIL: Essential

EDU:	12	AD
	I	P

Competency 48.2: Define fusion and unmixed zones
Key Indicators:
48.2.1 Define composite zone solidification describing epitaxial nucleation and growth
48.2.2 Define constitutional supercooling and its effect on dendrite morphology
48.2.3 Define competitive growth
48.2.4 Define composite zone hot cracking
48.2.5 Define the unmixed zone

BIL: Essential

EDU:	12	AD
	I	P

Competency 48.3: Define the partially melted zone
Key Indicators:
48.3.1 Define the partially melted zone
48.3.2 Define non homogeneity liquation
48.3.3 Define constitutional liquation

BIL: Essential

EDU:	12	AD
	I	P

Competency 48.4: Define the heat affected zone
Key Indicators:

48.4.1 Define the heat affected zone
48.4.2 Define the thermal cycles associated with the heat affected zone
48.4.3 Define the HAZ differences between material with allotropic and non-allotropic transformations
48.4.4 Define HAZ effects on cold worked alloy
48.4.5 Define HAZ structure effect on precipitation strengthened alloys and effect of welding in the solution annealed and as aged conditions
48.4.6 Define the effect of cooling rate on HAZ structure in materials with allotropic transformations
48.4.7 Define cold cracking in the HAZ and preventative measures
48.4.8 List post weld heat treatment methods and their effects on the material properties of the heat affected zone

BIL: Essential

EDU:	12	AD
	I	P

Competency 48.5: Define the base metal zone
Key Indicators:

48.5.1 Define the base metal zone
48.5.2 Define Lamellar Tearing in the base metal and ways of prevention
48.5.3 Define the problems associated with multi-pass welds in HAZ and base metal reheat cracking

Unit 49: Design

BIL: Essential

EDU:	12	AD
	P	R

Competency 49.1: Explain mechanical properties of materials
Key Indicators:

49.1.1 Define the difference between structure sensitive properties and structure insensitive properties
49.1.2 Describe the tensile test and measure engineering properties like stress, strain, yield stress, ultimate tensile stress, elongation and modulus
49.1.3 Define elastic and plastic deformation
49.1.4 Describe the bend test

BIL: Essential

EDU:	12	AD
	I	P

Competency 49.2: Explain fatigue properties of materials
Key Indicators:

49.2.1 Define fatigue and its effect on materials
49.2.2 Describe fatigue fracture appearance
49.2.3 Define the fatigue stress-number of cycles to failure (SN) curve
49.2.4 Describe the metallurgical and design factors that promote fatigue losses

BIL: Essential

EDU:	12	AD
	I	P

Competency 49.3: Explain fracture toughness properties of materials
Key Indicators:

49.3.1 Describe fracture toughness and toughness testing
49.3.2 Describe the factors that effect fracture toughness
49.3.3 Describe Charpy Toughness Testing
49.3.4 Interpret the data obtained from Charpy toughness testing to define the ductile-brittle transition.
49.3.5 Describe the effect of discontinuities on toughness

BIL: Essential

EDU:	12	AD
	P	R

Competency 49.4: Explain hardness properties of materials
Key Indicators:
49.4.1 Describe hardness indentation testing
49.4.2 Describe the relationship between hardness and other material properties

BIL: Recommended

EDU:	12	AD
	I	P

Competency 49.5: Explain creep testing of materials
Key Indicators:
49.5.1 Describe the creep stages in materials
49.5.2 Describe creep testing and creep testing machines

BIL: Recommended

EDU:	12	AD
	P	R

Competency 49.6: Explain other physical properties
Key Indicators:
49.6.1 Describe physical properties in materials
49.6.2 Describe corrosion, optical, wear and nuclear properties of materials

BIL: Essential

EDU:	12	AD
	P	R

Competency 49.7: Explain weld joint design
Key Indicators:
49.7.1 Describe the various joint designs used in weldments
49.7.2 Describe the various parts of the weld joint
49.7.3 Describe the various positions in which the weld joint can be welded
49.7.4 Describe the loading of joints

BIL: Essential

EDU:	12	AD
	P	R

Competency 49.8 Explain the use of codes and standards
Key Indicators:
49.8.1 Describe the differences between codes and standards
49.8.2 Describe the types of standards writing bodies
49.8.3 Describe what is covered by codes and standards

BIL: Essential

EDU:	12	AD
	P	R

Competency 49.9: Explain the use of codes and standards in weldment joint design
Key Indicators:
49.9.1 Describe pre-qualified joint designs and specifications
49.9.2 Describe the use of codes and standards in static loaded joints
49.9.3 Describe the use of codes and standards in dynamic loaded joints
49.9.4 Describe the use of codes and standards in welding economics

BIL: Essential

EDU:	12	AD
	P	R

Competency 49.10: Explain the use of welding symbols to communicate weld design
Key Indicators:
49.10.1 Describe the AWS welding symbol system
49.10.2 Demonstrate the application of welding symbols to weld joint design

BIL: Essential

EDU:	12	AD
	I	P

Competency 49.11: Explain residual stresses and distortion in weldments
Key Indicators:
49.11.1 Describe the formation of residual stresses
49.11.2 Illustrate the formation of weld residual stresses
49.11.3 Explain the residual stress effects on weldment function (e.g. distortion, fatigue limits, etc.)
49.11.4 Explain pre and post weld methods for residual stress reduction

BIL: Essential

EDU:	12	AD
	P	R

Competency 49.12: Explain the development of welding procedures and weld qualifications

Key Indicators:

49.12.1 Describe the basic steps in weld procedure qualification
49.12.2 Describe procedure qualification records
49.12.3 Describe welder qualifications
49.12.4 Describe the welding procedure specification
49.12.5 Describe the purpose of procedure qualification records (PQR), welding procedure specification. (WPS), welder performance qualification record (WPQR)

BIL: Essential

EDU:	12	AD
	P	R

Competency 49.13 Design a welded structure

Key Indicators:

49.13.1 Define the various aspects involved in designing a structure including: mechanical and physical properties of materials, joint design, weld stresses and distortion, codes and standards
49.13.2 Select (from a list of examples or propose from your own experience) a useful device which can be manufactured with a welded construction.
49.13.3 Utilize proper design criteria to engineer this welded structure fit for service structure
49.13.4 Document the design project with engineering drawings and process procedure using isometric and orthographic drawings of the part complete with welding symbols.
49.13.5 Construct the welded structure with the most desirable welding process and material with cost justification

BIL: Essential

EDU:	12	AD
	P	R

Competency 49.14 Evaluate a failed structure
Key Indicators:

49.14.1 Describe the samples required from a failed aircraft structural component in order to evaluate the cause of failure.
49.14.2 Select the appropriate metallurgical and mechanical samples
49.14.3 Test the samples
49.14.4 Analyze data
49.14.5 Prepare a written report describing the cause of the failure, proper repair techniques, and primary design or material selection changes to avoid such failures in the future

Unit 50: Testing and Inspection

BIL: Essential

EDU:	12	AD
	P	R

Competency 50:1: Explain the factors considered in weld quality
Key Indicators:
50.1.2 Describe weld quality related to design, fabrication and operation
50.1.3 Describe visual weld examination in regard to: size, shape, contour and soundness

BIL: Essential

EDU:	12	AD
	P	R

Competency 50.2: Explain discontinuity and defect
Key Indicators:
50.1.1 Describe the differences between discontinuity and defect in a welded structure
50.1.2 Classify the occurrences of discontinuities
50.1.3 Define ways to reduce or eliminate each type of discontinuity

BIL: Essential

EDU:	12	AD
	P	R

Competency 50.3: Explain destructive weldment testing techniques
Key Indicators:
50.3.1 Describe how destructive test help reveal discontinuities
50.3.2 Describe tensile tests and test sample locations
50.3.3 Describe bend tests and sample selection
50.3.4 Describe fatigue tests and sample locations
50.3.5 Describe corrosion tests

BIL: Recommended

EDU:	12	AD
	I	P

Competency 50.4: Explain weldability tests
Key Indicators:
50.4.1 Describe weldability tests for hydrogen cracking
50.4.2 Describe weldability tests for Lamellar Tearing
50.4.3 Describe weldability tests for hot cracking
50.4.4 Describe weldability tests for hot ductility

BIL: Essential

EDU:	12	AD
	P	R

Competency 50.5: Explain the need for nondestructive examination
Key Indicators:
50.5.1 Describe the need for nondestructive testing techniques
50.5.2 List the type of NDE procedures that can be performed

BIL: Essential

EDU:	12	AD
	P	R

Competency 50.6: Perform visual examination
Key Indicators:
50.6.1 Describe visual examination techniques
50.6.2 Describe benefits and limitations of visual examination
50.6.3 Use the tools needed for visual examination

BIL: Essential

EDU:	12	AD
	P	R

Competency 50.7: Describe dye penetrant examination
Key Indicators:
50.7.1 Describe dye penetrant techniques
50.7.2 Describe benefits and limitations of dye penetrant
50.7.3 Describe the tools needed for dye penetrant

BIL: Essential

EDU:	12	AD
	P	R

Competency 50.8: Describe magnetic particle examination
Key Indicators:
50.8.1 Describe magnetic particle techniques
50.8.2 Describe benefits and limitations of magnetic particle
50.8.3 Describe the tools needed for magnetic particle

BIL: Essential

EDU:	12	AD
	I	P

Competency 50.9: Explain radiographic examination
Key Indicators:
50.9.1 Describe radiographic examination techniques
50.9.2 Describe benefits and limitations of radiographic examination
50.9.3 Describe the equipment needed for radiographic examination
50.9.4 Describe exposure enhancement
50.9.5 Examine radiographs

BIL: Recommended

EDU:	12	AD
	P	R

Competency 50.10: Describe eddy current examination
Key Indicators:
50.10.1 Describe eddy current examination techniques
50.10.2 Describe benefits and limitations of eddy current examination
50.10.3 Describe the equipment needed for eddy current examination

BIL: Essential

EDU:	12	AD
	P	R

Competency 50.11: Describe ultrasonic examination
Key Indicators:
50.11.1 Describe ultrasonic examination techniques
50.11.2 Describe benefits and limitations of ultrasonic examination
50.11.3 Describe the tools needed for ultrasonic examination

BIL: Recommended

EDU:	12	AD
	P	R

Competency 50.12: Describe acoustic emission examination
Key Indicators:
50.12.1 Describe acoustic emission examination techniques
50.12.2 Describe benefits and limitations of acoustic emission examination
50.12.3 Describe the equipment needed for acoustic emission examination

BIL: Essential

EDU:	12	AD
	P	R

Competency 50.13: Examine a weld structure
Key Indicators:
50.13.1 Define the various aspects involved in designing a structure including: mechanical and physical properties of materials, joint design, weld stresses and distortion, codes and standards
50.13.2 Utilize proper design criteria to engineer a welded structure fit for service.
50.13.3 Document the design project with engineering drawings and process procedure.
50.13.4 Construct the welded structure with the most desirable welding process and material with cost justification

BIL: Essential

EDU:	12	AD
	P	R

Competency 50.14 Appraise the quality of a welded part by non-destructive examination
Key Indicators:
50.14.1 Select a welded part from a supply of parts. (This might be the part designed/built above, or representative parts from auto sales firm or junk yard etc.)
50.14.2 Determine a suitable non-destructive testing technique to be used to examine the part (visual, dye penetrant, magnetic particle, etc.)
50.14.3 Perform an inspection using one or more techniques
50.14.4 Prepare a written report describing the results of the NDE

Unit 51: Safety

BIL: Essential

EDU:	12	AD
	P	R

Competency 51.1: Describe the importance of safety training
Key Indicators:
51.1.1 Describe safety training importance
51.1.2 Describe safety warnings and material safety data sheets (MSDS)
51.1.3 Describe a variety of AWS safety and health materials
51.1.4 Review OSHA standards for workplace safety
51.1.5 Employ lock-out tag-out procedures

BIL: Essential

EDU:	12	AD
	P	R

Competency 51.2: Assess work area safety
Key Indicators:
51.2.1 Describe importance of general housekeeping and tripping hazards
51.2.2 Prepare for unexpected emergencies
51.2.3 Describe proper storage and handling of equipment
51.2.4 Describe protection from inhalation hazards
51.2.5 Identify workplace safety hazards and corrective actions

BIL: Essential

EDU:	12	AD
	P	R

Competency 51.3: Practice personal safety and select appropriate equipment
Key Indicators:
51.3.1 Describe protective clothing
51.3.2 Describe eye protection equipment
51.3.3 Employ proper lens shade selection for selected processes
51.3.4 Assess protection needs of other personnel
51.3.5 Demonstrate proper use of hearing protection

BIL: Essential

EDU:	12	AD
	P	R

Competency 51.4: Describe fumes, gasses and toxic materials
Key Indicators:
51.4.1 Describe fume generation and its dangers
51.4.2 Describe potential safety hazards with gasses
51.4.3 Describe the possibility of toxic materials
51.4.4 Describe ventilation and other means of protection
51.4.5 List methods used to measure fume exposure levels

BIL: Essential

EDU:	12	AD
	P	R

Competency 51.5: Demonstrate gas storage safety
Key Indicators:
51.5.1 Describe gas storage bottles and threads
51.5.2 Describe gas safety equipment
51.5.3 Demonstrate gas handling

BIL: Essential

EDU:	12	AD
	P	R

Competency 51.6: Demonstrate fire safety
Key Indicators:
51.6.1 Describe components needed to support a fire
51.6.2 Describe the classes of fire extinguishers
51.6.3 Describe welding conditions which may result in fires and the proper extinguishing techniques

BIL: Essential

EDU:	12	AD
	P	R

Competency 51.7: Demonstrate electrical safety
Key Indicators:
51.7.1 Describe sources of electrical shock
51.7.2 Describe electrical safety procedures

BIL: Essential

EDU:	12	AD
	P	R

Competency 51.8: Demonstrate radiation safety
Key Indicators:
51.8.1 Describe sources of radiation hazards
51.8.2 Describe radiation safety procedures

BIL: Essential

EDU:	12	AD
	P	R

Competency 51.9 Demonstrate proper ergonomic practices
Key Indicators:
51.9.1 Describe ergonomic hazards
51.9.2 Explain ergonomic corrective actions
51.9.3 Explain the relationship between ergonomics safety and cost

ENGINEERING AND ENGINEERING TECHNOLOGIES DESIGN AND DEVELOPMENT

Unit 52: Introduction to Engineering and Engineering Technology Design and Development

BIL: Essential

EDU:	12	AD
	P	R

Competency 52.1: Identify the scope and purpose of an engineering design and development research project

Key Indicators:

52.1.1 Describe and define the purpose and rationale of the course skills and knowledge base

52.1.2 Describe the characteristics of a successfully completed project based on previously completed projects

52.1.3 Distinguish the differences between the goals of this class and the type of projects done in other classes

BIL: Essential

EDU:	12	AD
	P	R

Competency 52.2: Determine the structure for evaluating a research project

Key Indicators:

52.2.1 List examples of levels of performance within the grading structure of this course

52.2.2 Create a resume to record their academic achievements and extra-curricular activities in school

52.2.3 Construct a portfolio of past accomplishments and research projects

Unit 53: Elements of Formal Research

BIL: Essential

EDU:	12	AD
	P	R

Competency 53.1: Use a journal as the source for returning to any desired previously encountered information

Key Indicators:

53.1.1 Recognize a need for retaining in one location all information relevant to the research project

53.1.2 Identify information encountered in the research process that belongs in the journal

53.1.3 Identify a format for the journal, which is well-organized and easy to use

BIL: Essential

EDU:	12	AD
	P	R

Competency 53.2: Use conventional library resources as a starting point for all research

Key Indicators:

53.2.1 Describe the procedure for accessing library resources

53.2.2 Choose the appropriate media to obtain the desired information

BIL: Essential

EDU:	12	AD
	P	R

Competency 53.3: Use the computer as a research tool

Key Indicators:

53.3.1 Distinguish relevant from irrelevant web sites

53.3.2 Manipulate search engines to find specific information

53.3.3 Classify strategies for identifying key terms that narrow their search topic

53.3.4 Examine on-line databases to search for patents, people, business, Government and Academic information

53.3.5 Correspond by e-mail including the use of attachments

53.3.6 Differentiate between an e-mail address and web site address

BIL: Essential

EDU:	12	AD
	P	R

Competency 53.4: Contact the experts
Key Indicators:

53.4.1 Compose a business letter and a thank you letter
53.4.2 Define the positive characteristics for personal interviewing (e.g. courtesy, professionalism, listening skills, personal hygiene, etc.)
53.4.3 Employ communication skills to converse over the phone and conduct a face to face interview

Unit 54: Guided Research

BIL: Essential

EDU:	12	AD
	P	R

Competency 54.1: Demonstrate methods of brainstorming
Key Indicators:
54.1.1 Use a decision matrix in narrowing a topic of research
54.1.2 Define constraints and specifications for use in a decision matrix
54.1.3 Use a decision matrix to rank order alternatives
54.1.4 Use decision matrices to develop a concise problem statement

BIL: Essential

EDU:	12	AD
	P	R

Competency 54.2: Research a topic
Key Indicators:
54.2.1 Discuss and explain key issues and terminology within the topical area
54.2.2 Narrow the topic focus using the decision matrix
54.2.3 Give an oral presentation
54.2.4 Evaluate the quality of research material (e.g., creditability, source, accuracy, error analysis, etc.)

BIL: Essential

EDU:	12	AD
	P	R

Competency 54.3 Formulate a hypothesis and a problem statement
Key Indicators:
54.3.1 Based on the research, develop hypothesis and a problem statement
54.3.2 Apply the decision matrix to a problem, justifying the hypothesis and problem statements based on previous research findings and decision matrices

BIL: Essential

EDU:	12	AD
	I	P

Competency 54.4: Research and develop alternative solutions
Key Indicators:

54.4.1 Generate a list of existing solutions to the research problem
54.4.2 Evaluate the advantages and disadvantages of present solutions to the research problem using decision matrices
54.4.3 Develop a list of alternative solutions to the stated problem following a review of the specifications and constraints identified in the decision matrices.

BIL: Essential

EDU:	12	AD
	I	P

Competency 54.5: Redefine and justify alternative solutions
Key Indicators:

54.5.1 Conduct preliminary patent searches to determine the originality of their alternative choices
54.5.2 Conduct research to determine the merit of their alternative choices based on the state of the art in the field

BIL: Essential

EDU:	12	AD
	P	R

Competency 54.6: Demonstrate presentation methods
Key Indicators:

54.6.1 Identify techniques for delivering formal presentations
54.6.2 Choose an appropriate formal presentation format and prepare a presentation
54.6.3 Construct and deliver a PowerPoint presentation centered on the topic of research

Unit 55: Independent Research

BIL: Essential

EDU:	12	AD
	P	R

Competency 55.1: Describe procedures to completing an independent research project
Key Indicators:

55.1.1 Define and demonstrate time management planning skills as they pertain to a project
55.1.2 Identify methods and sources for obtaining materials and supplies

BIL: Essential

EDU:	12	AD
	P	R

Competency 55.2: Develop a prototype
Key Indicators:

55.2.1 Provide a detailed set of instructions for producing a testable prototype based upon the research and the information gained through the research
55.2.2 Identify safe practices for the use of tools and equipment
55.2.3 Create and justify a process for testing the prototype design that will yield valid data concerning the design's attempt at solving the problem statement
55.2.4 Review their testing procedures to determine the validity of the testing procedures
55.2.5 Apply the appropriate statistical analysis tools to the test results to ensure the validity and significance
55.2.6 Identify, define, and implement needed modifications to the design based upon the ongoing research
55.2.7 Examine and explain the effectiveness of the design at solving the problem

BIL: Essential

EDU:	12	AD
	P	R

Competency 55.3: Prepare a research paper
Key indicators:

55.3.1 Arrange the data and information compiled throughout the project and compose a technical research paper
55.3.2 Use a standardized format for composing the research paper

Unit 56: Formal Presentations

BIL: Essential

EDU:	12	AD
	P	R

Competency 56.1: Create a presentation
Key Indicators:
56.1.1 Gather data pertaining to the topic
56.1.2 Organize data sequentially
56.1.3 Create a topical outline of the presentation
56.1.4 Select delivery method for presentation

BIL: Essential

EDU:	12	AD
	P	R

Competency 56.2: Make a formal presentation
Key Indicators:
56.2.1 Discuss research findings in a formal presentation before an audience
56.2.2 Utilize presentation aids to enhance and clarify the presentation

Appendix A

Review Panels

Emerging Engineering Technology TCP
Business Panel Participants

Project Lead The Way Business:

Pete Buca, Branch Technology Director, Aerospace group-Parker Hannifin Corporation

Tony Dennis, President, OMERIS

Terry Marovich, Manager of Human Resources & Corporate Communications, Diagnostic Hybrids, Inc.

Dave Powell, Human Resources Assistant, American Electric Power

Dick Schorr, President, MetaMateria

Donald Wiff, Program Manager-Retired, Western Reserve/Nano-Micro Sensors

Fuel Cell Business:

Ken Alfred, Executive Director, Ohio Fuel Cell Coalition

Mark W. Miller, P.E., Project Engineer, Thermal Tech Engineering

Jerry Hutton, Director, Hocking College

William P. Schweizer, President, e4 Management Group, LLC

Rich Smith, Executive Director, Ohio Energy Project

E. Jennings Taylor, Chief Technical Office/President, Faraday Technology, Inc.

Materials Joining Technology Business:

Chris Anderson, Motorman, Inc.

Dr. Dave Dickerson, Professor, Ohio State University

Chuck Drews, Honda of America

Christopher Hayes, Whirlpool

Richard McGuire, National Board of Boiler and Pressure Vessel Inspectors

Sean Moran, Product Manager, Miller Electric Manufacturing Company

Troy Paskell, President, WeldQC

Chris Pollock, Director of Education, American Welding Society

Ken Smith, Manager of Training Projects, Nord Advanced Technologies Center of Lorain Community College

Gary Trewiler, Senior Staff Engineer, Material Joining and Advanced Repair Technology, GET –Aircraft Engines

Emerging Engineering Technology TCP
Educator Panel Participants

Project Lead the Way Educators:

Steven Carter, Pre-Engineering Instructor, Akron Garfield High School

David Dickinson, Professor, Ohio State University

Meg Draeger, Program Manager, Miami Valley Tech Prep Consortium

Edward Evans, Associate Professor, University of Akron

Michael Haydn, Engineering Technology Instructor, Polaris Career Center

Paul R. Lenz, Math Chairperson, Miller City High School

Dennis Maas, Instructor, James A. Rhodes State College

Dennis J. O'Brien, Instructor & Engineering Technologies & Design, Medina County Career Center

Frank J. Tinus, Dean, Corporate & Community Services, Stark State College

Fuel Cell Educators:

Ken Alfred, Executive Director, Ohio Fuel Cell Coalition

Steve Carter, Project Lead the Way Instructor, Garfield High School

Dorey Diab, Executive Director, Stark State College

Jerry Hutton, Director, Hocking Technical College

Sarah Jackson, Project Lead the Way Instructor, Timken High School

Judith Maxson, Provost, Hocking Technical College

Jim McGuffin-Cawley, Associate Dean of Undergraduate Programs, Case Western Reserve University

Jennie Royer, Director, Stark County College Tech Prep Consortium

Frank J. Tinus, Dean, Stark State College

Materials Joining Technology Educators:

Tom Annable, Associate Professor, Lorain County Community College

Ken Bentley, Welding Instructor, Collins CC Lawrence County JVS

Dr. Dave Dickinson, Professor, Ohio State University

Deanna Duche, Welding Trainer, Zane State College

Daniel Harrison, Welding Instructor, Medina County Career Center

Paul Nabor, Project Lead the Way Instructor, Vermilion High School

Steve Spriggs, Project Lead the Way Instructor, Ehove Career Center

Larry Waller, Technical Specialist, Lorain County Community College

Appendix B

College Tech Prep Pathway Template

CAREER PATHWAY_____
TEMPLATE

Adult Learner Entry Points

	Grade	English	Mathematics	Science	Social Studies	Other Required and Recommended Academic Courses	Recommended Career and Other Elective Courses
High School Required and Recommended Academic and Career Courses	9						
	10						
	11						
	After 10th or 11th grade, assess for college readiness; provide academic/career advising and apply appropriate enrichments						
	12						
	Administer college placement exams (reading, math, and writing) and other assessments to determine academic readiness and career skill preparedness; provide academic/career advising and additional preparation						
College Required and Recommended Academic and Career Specialization Courses	Year 1 1st Quarter						
	Year 1 2nd Quarter						
	Year 1 3rd Quarter						
	Year 2 1st Quarter						
	Year 2 2nd Quarter						
	Year 2 3rd Quarter						

The shading provides an example; your site may have a different number of required and recommended courses in each area. We recommend that support documentation such as competencies/learning objectives be attached.

- High School Required Courses
- Mandatory Assessments, Advising, and Additional Preparation
- Recommended Academic Courses
- Recommended Career-Related Courses
- Credit-Based Transition Programs (e.g. Dual/Concurrent Enrollment, Articulated Courses, 2+2+2)
- College Required and Recommended Academic and Career Specialization Courses

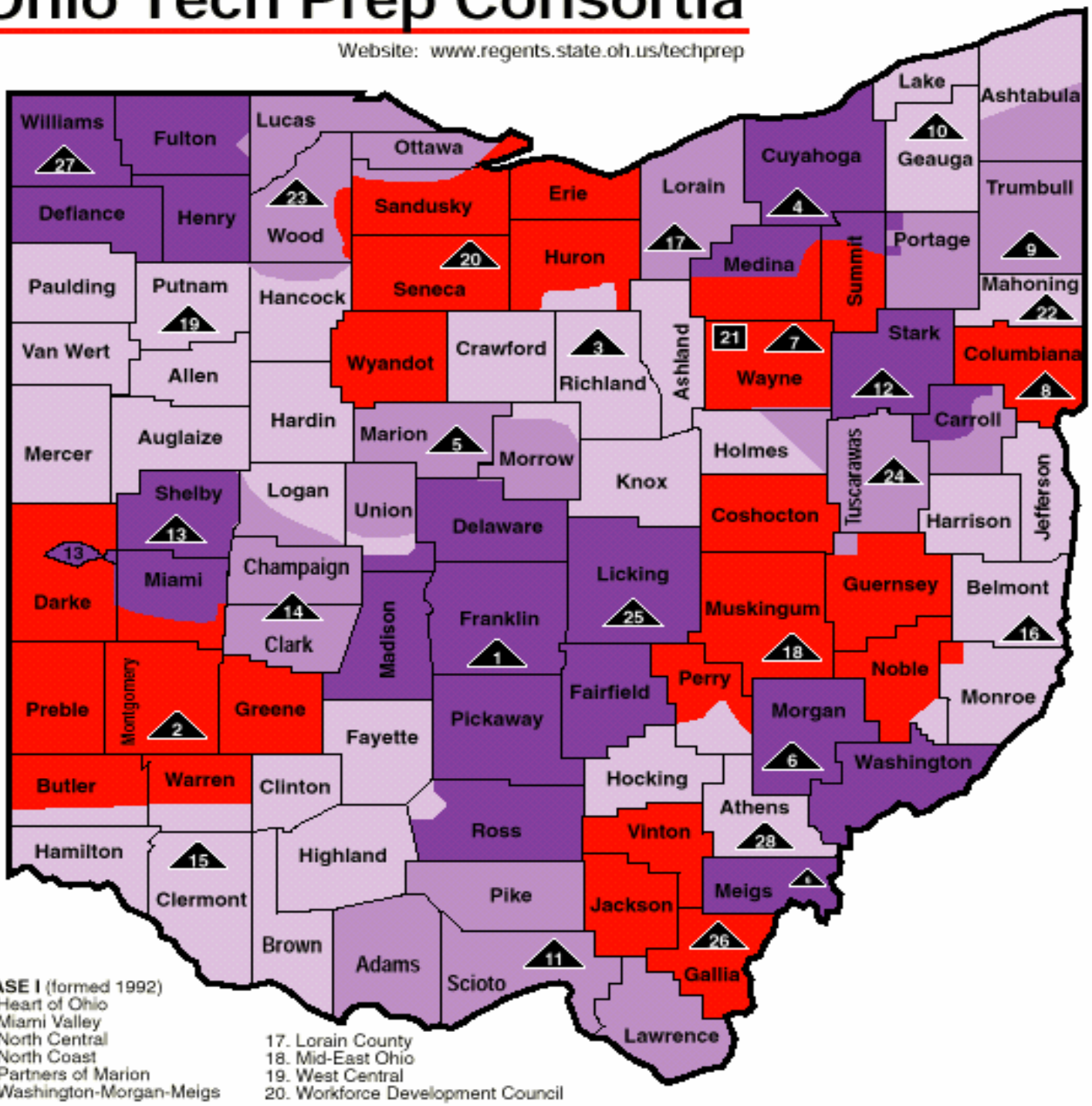
League.org FOR INNOVATION IN THE COMMUNITY COLLEGE
CCTI College and Career Transitions Initiative

Appendix C

Ohio Tech Prep Consortia

Ohio Tech Prep Consortia

Website: www.regents.state.oh.us/techprep



PHASE I (formed 1992)
1. Heart of Ohio
2. Miami Valley
3. North Central
4. North Coast
5. Partners of Marion
6. Washington-Morgan-Meigs

PHASE II (formed 1993)
6. Columbiana County
9. Kent
10. Lakeland
11. Ohio South
12. Stark County
13. Upper Miami Valley

PHASE III (formed 1994)
14. Clark State
15. Greater Cincinnati
16. Eastern Ohio Valley

17. Lorain County
18. Mid-East Ohio
19. West Central
20. Workforce Development Council

PHASE IV (formed 1995)
(with programs at locations throughout Ohio)
22. Mahoning Area
23. Northwest Ohio
24. Tuscarawas Valley

PHASE V (formed 1996)
25. East Central Ohio
26. Ohio Valley
27. Maumee Valley
28. Southeast

10/99
dll

Note: Consortia 8, 9 and 24 merged with headquarters at #9