Massachusetts Department of Elementary & Secondary Education

Office for Career/Vocational Technical Education

Vocational Technical Education Framework

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Manufacturing, Engineering & Technology Services Occupational Cluster

Electronics (VETRON)

CIP Code 150303

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Massachusetts Department of Elementary and Secondary Education
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Mitchell D. Chester, Ed.D.
Commissioner

July 2014

Dear Colleagues,

I am pleased to present to you the *Massachusetts Vocational Technical Education Frameworks,* adopted by the Department of Elementary and Secondary Education in June 2014. These frameworks, one for each of the 44 vocational technical programs, include standards in multiple strands representing all aspects of the industries that students in the vocational technical education program are preparing to enter.

The frameworks also include a crosswalk between the technical standards and relevant standards in Massachusetts Curriculum Frameworks to support effective integration of academic and technical content.

The comments and suggestions received during revision of the 2007 *Massachusetts Vocational Technical Education Frameworks* have strengthened these frameworks. We will continue to work with schools and districts to implement the 2014 *Massachusetts Vocational Technical Education Frameworks* over the next several years, and we encourage your comments.

I want to thank everyone who worked with us to create challenging learning standards for Massachusetts students. I am proud of the work that has been accomplished.

Sincerely,

Mitchell D. Chester, Ed.D.
Commissioner of Elementary and Secondary Education

Introduction

Overview & Organization and Key Changes

Overview

The Massachusetts Department of Elementary and Secondary Education understands the necessity of maintaining current Vocational Technical Education Frameworks which ensure career/vocational technical education students across the Commonwealth are taught the most rigorous standards aligned to the needs of business and industry.

With the advent of the Massachusetts Teaching & Learning System the Office for Career/Vocational Technical Education (CVTE) recognized the significance of including career/vocational technical education in the system and developed a comprehensive plan for including vocational technical education. The plan was designed in a Two Phase Process. Phase One included the revision of strands two, three, and six, of all of the Vocational Technical Education Frameworks. Phase Two consisted of three major components (projects) all equally crucial;

1. The revision of Strands One, Four, and Five to complete the revision of all six strands of the Vocational Technical Education Frameworks;

2. Statewide Professional Development on all revised strands, with training on strands two, three, and six delivered fall 2013, and training on strands one, four, and five delivered spring 2014;

3. The creation and development of additional Model Curriculum Unit (MCU) Teams.

The Office for Career/Vocational Technical Education Framework Team, with support from consultants, began Phase One in the 2012-2013 school year, to revise three of the six strands contained in all of the Vocational Technical Education (VTE) Frameworks. The state was organized into "Collaborative Partnerships" comprised of teams of project administrators, highly qualified subject matter educators, and business and industry partners, whose task was to revise Strand Two – Technical, Strand Three – Embedded Academics, and Strand Six – Technology Literacy. Each team met with a vocational advisory committee which included business and industry representatives and postsecondary education professionals, whose mission was to review and revise the team's draft document during the revisionary process. Once strand two was revised, academic teachers (typically one English Language Arts teacher, one Mathematics teacher, and one Science teacher) worked with the technical subject matter teachers to develop a crosswalk between academic curricula standards and the technical standards, and provided examples of embedded academic content.

The Office for Career/Vocational Technical Education solicited statewide input from technical and academic teachers and administrators at the annual Massachusetts Association of Vocational Administrators (MAVA)/Massachusetts Vocational Association (MVA) - Connecting for Success Conference. Each framework team met with their content colleagues and reviewed the draft revisions and obtained valuable feedback. Additionally, all drafts were reviewed and revised by the Massachusetts Vocational Technical Teacher Testing Program, to ensure appropriate measurable language.

Project consultants designed a new template to ensure all framework teams entered new standards and additional resources in a consistent manner. The framework teams created an "Appendix" listing potential industry recognized credentials attainable by secondary students; lists of professional, student, and relevant government organizations; and useful resources and websites. ** It is important to note that although most Framework Teams provided information for the "Appendix", not all teams did. Therefore, sub-headings within the "Appendix" without information have been deleted. Disclaimer: Reference in the Appendices Section to any specific commercial products, processes, or services, or the use of any trade, firm or corporation name is for the information and convenience of the public, and does not constitute endorsement or recommendation by the Massachusetts Department of Elementary and Secondary Education.*

The Office for Career/Vocational Technical Education facilitated a comprehensive vetting process throughout the Commonwealth. During the fall of 2012 districts throughout Massachusetts solicited feedback from each Vocational Program's Advisory Committee members at the Fall Board meetings. Additionally, the Office for Career/Vocational Technical Education met with various licensing boards at the Massachusetts Division of Professional Licensure and provided the applicable draft framework to each board for review. All framework drafts were posted on the CVTE website for public comment. Comments and suggested revisions received were shared with each framework team for response and edits, as appropriate.

The Phase I Process was completed on an accelerated timetable and resulted in all Vocational Technical Education Frameworks; Stand Two and Strand Six, revised with current, rigorous, relevant standards. Strand Three has been redesigned into a crosswalk which directly correlates academic and technical standards. An appendix of useful material for technical teachers recommended by their peers was added to each framework.

Phase II of the Framework Revision Process consisted of three major projects;

1. The Strands One, Four & Five Project, to complete the revision of all six strands of the Vocational Technical Education Frameworks;
2. Statewide Professional Development on all revised strands, with training on strands two, three, and six delivered fall 2013, and training on strands one, four, and five delivered spring 2014;
3. The creation and development of additional Model Curriculum Unit (MCU) Teams.

The Strands One, Four, & Five Project began in the fall of 2013 with the formation of a leadership team and three work groups. Co-Managers led the leadership team comprised of three Strand Coordinators who facilitated work teams and reviewed, researched, and revised these common strands. All skills specific to the vocational technical program have been included into Strand Two Technical.

The Strand One Team revised the safety knowledge and skills that all students need to acquire. The team included relevant issues (i.e., bullying, climate), laws, regulations, guidelines and policies pertaining to safety.

The Strand Four Team revised the Employability Knowledge and Skills that all students need to acquire. Teams considered current research on career readiness, including the work of the College Career Readiness Task Force convened by the Department, changes in workplace, technological changes that impact how people perform their work (i.e., communications methods), and included standards that

emphasize the need for lifelong learning and adaptability given the multiple career changes over and an individual's working life. The team recommended this strand be renamed to: Career Readiness.

The Strand Five Team revised the Management & Entrepreneurship Knowledge and Skills that all students need to acquire. All business owners and employees must possess management and financial skills to be productive members of society. Skills included financial knowledge and basic business management skills.

All Strand One, Four and Five Project Teams worked collaboratively with staff from the Department of Elementary and Secondary Education and the Advisors of the Massachusetts Career and Technical Student Organizations to crosswalk standards to national Career & Technical Student Organizations Curricula, as applicable.

The Office for Career/Vocational Technical Education contracted the MAVA Consultant Team to work closely with the office to complete all of the work accomplished during Phase II of the Project.

A remarkable amount of work was accomplished through the efforts of hundreds of professionals who collaborated and diligently supported this work. The Office for Career/Vocational Technical Education is grateful for all the support received from the field, particularly all of the teachers (technical and academic), administrators, advisory committee members, business and industry representatives, the Division of Professional Licensure - boards, the Massachusetts Association of Vocational Administrators, the MAVA Consultants, and the Massachusetts Vocational Association, whose contributions were tremendous.

Special thanks to all staff in the Office for Career/Vocational Technical Education and the CVTE Framework Revision Team who provided guidance and numerous contributions during Phase One of the project.

Organization and Key Changes

This section contains the following:

- Highlights of Changes to the Vocational Technical Education Frameworks; which includes a summary of changes made to each strand.
- Organization of the Frameworks – Strand Two illustrates structure of topic headings, standards and objectives, and performance examples.

Highlights of Changes to the Vocational Technical Education Frameworks:

Strand One:

Safety and Health Knowledge and Skills have been revised to contain the safety standards that are common to all programs. The Strand One Team worked collaboratively with staff from the Department of Elementary and Secondary Education and the Advisors of the Career and Technical Student Organizations (CTSO) to crosswalk standards to national CTSO Curricula, as applicable.

- No objectives were deleted, only modified.
- Language and wording was clarified.
- Additions included a focus on maintaining a safe school and workplace in terms of creating a positive climate/environment.
- Student safety credential program has been revised.
- Safety attire has been revised.
- Emergency equipment and fire safety has been revised.
- Many new Performance Examples have been included.
- Within each strand, standards and objectives were grouped under Topic Headings, which are displayed in bold. Each standard is followed by a performance example. See the section below titled: "Organization of the Frameworks – Strand Two". All strands were organized in that manner, with the exception of the former Strand Three.

Strand Two:

The Technical Standards Knowledge and Skills have been revised to reflect business and industry changes since the adoption of the 2007 Vocational Technical Education Frameworks (VTEF). There are additional changes to Strand Two below:

- The Technical Knowledge and Skills (Strand Two) section contains standards specific to the particular vocational program; suffix "a" (as common to all programs) and suffix "c" (as common within a cluster) have been removed.
- Each VTEF Strand Two begins with safety and health knowledge and skills specific to the particular vocational program.
- Within each strand, standards and objectives were grouped under Topic Headings, which are displayed in bold. Each standard is followed by a performance example. See the section below titled: "Organization of the Frameworks – Strand Two". All strands were organized in that manner, with the exception of the former Strand Three.

- Strand Two of the Frameworks for Animal Science, Environmental Science and Technology, and Horticulture, begin with core standards required for all participants in the programs, followed by a series of standards organized in concentrations. See the section below titled: "Organization of the Frameworks – Strand Two" for more information.
- An update to some of the vocational programs framework is the addition of advanced or supplemental standards which are noted in Strand Two by an asterisk (*). *These standards are not required, but are provided as suggestions that districts may choose to use to increase the depth of a particular topic, or add additional topics, particularly for advanced students or for those seniors who do not participate in cooperative education.* See the section below titled: "Organization of the Frameworks – Strand Two" for more information.

Strand Three:

Since the purpose of Strand Three was to correlate academic content that was *embedded* in the knowledge and skills necessary to perform certain technical skills, it was logical to highlight those connections through a crosswalk between the academic curriculum standards and the technical standards (Strand Two). The crosswalk directly correlates the English Language Arts (2011) and Mathematics (2011) Frameworks, incorporating the Common Core Standards and the Science and Technology/Engineering Frameworks. The crosswalk can be found in the appendix of each vocational framework. The crosswalk also includes performance examples which illustrate integrated academic and technical content.

- Embedded Academics has been replaced with a crosswalk between the academic curriculum standards and the technical knowledge and skills standards. The crosswalk is located in the Appendices.

Strand Four:

Employability (and Career Readiness) Knowledge and Skills focused on providing students with general knowledge and skills to be college and career ready. The Strand Four Team worked collaboratively with staff from the Department of Elementary and Secondary Education and the Advisors of the Career and Technical Student Organizations to crosswalk standards to national CTSO Curricula, as applicable.

- Language and wording were clarified.
- Additions included a focus on providing students with skills for employability/career readiness.
- Modifications included Career Exploration & Navigation, Communication in the Workplace, and Work Ethic & Professionalism.
- New Performance Examples have been included.
- Within each strand, standards and objectives were grouped under Topic Headings, which are displayed in bold. Each standard is followed by a performance example. See the section below titled: "Organization of the Frameworks – Strand Two". All strands were organized in that manner, with the exception of the former Strand Three.

Strand Five:

Strand Five contains Management and Entrepreneurship Knowledge and Skills that are general for all students. The Strand Five Team worked collaboratively with staff from the Department of Elementary and Secondary Education and the Advisors of the Massachusetts Career and Technical Student Organizations to crosswalk standards to national Career & Technical Student Organizations Curricula, as applicable.

- Language and wording were clarified and organized into a logical format.
- The Strand Five Team felt that the 2007 curriculum remained valid.
- Additions included a focus on providing students with skills for management and entrepreneurship applicable to all vocational programs.
- Modifications included Starting and Managing a Business, Marketing, and Financial Concepts & Applications in Business, and Legal/Ethical/Social Responsibilities.
- New Performance Examples have been included.
- Within each strand, standards and objectives were grouped under Topic Headings, which are displayed in bold. Each standard is followed by a performance example. See the section below titled: "Organization of the Frameworks – Strand Two". All strands were organized in that manner, with the exception of the former Strand Three.

Strand Six

Strand Six Technology Literacy Knowledge and Skills has been replaced with the 2008 Massachusetts Technology Literacy Standards and Expectations Framework.

Appendix[1]

Each framework contains an "Appendix" section which includes an Embedded Academic Crosswalk, Industry Recognized Credentials, Statewide Articulation Agreements, Professional, Governmental, and Student Organizations, Resources, and relevant websites.

The Appendix[2] contains:

- Embedded Academic crosswalks for English Language Arts, Mathematics, and Science & Technology/Engineering.
- Statewide Articulations: Current statewide Articulation Agreements and/or Apprenticeship Programs available to the specific vocational program are listed on this page. The development of new statewide articulations continues, and therefore these pages will be revised as new agreements are finalized.

- Industry-Recognized Credentials: Technical Teacher Teams generated lists of credentials for the vocational programs. Program Advisory Committees throughout the state reviewed and provided recommendations through the validation process. *The credential list has been provided as a resource only and districts are not obligated to provide all of the specified credentials for students.*

- Other: These pages provide lists of reference materials, government agencies, professional and student organizations, and useful websites created by each framework team. These are intended as helpful resources for technical teachers, identified by peers. These are not recommended or required by the Department of Elementary & Secondary Education.

[1] *Note:* Although most Framework Teams provided information for the "Appendix", not all teams did. *Therefore, sub-headings within the "Appendix" without information have been deleted.*

Disclaimer: Reference in the Appendices Section to any specific commercial products, processes, or services, or the use of any trade, firm or corporation name is for the information and convenience of the public, and does not constitute endorsement or recommendation by the Massachusetts Department of Elementary and Secondary Education.

Organization of the Frameworks – Strand Two

The Vocational Technical Education Frameworks contain knowledge and skills covering all aspects of industry, reflected in six strands: Safety and Health, Technical, Embedded Academics, Employability, Management and Entrepreneurship, and Technological.

Within each strand, standards and objectives were grouped under topic headings, which are displayed in bold. Each standard is followed by a performance example. In the excerpt below, 2.A is the topic; 2.A.01 is the first standard and 2.A.01.01 and 2.A.01.02 are the objectives under that standard.

2.A Automotive Technology Specific Safety Practices

2.A.01 Identify and describe safety procedures when dealing with different types of automotive lifts according to current industry standards.

2.A.01.01 Demonstrate procedures for safe lift operations.

2.A.01.02 Demonstrate safe use, placement and storage of floor jacks and jack stands.

2.A.01 Performance Example:

- Student will set up lift using manufacturer's suggested lift points.

2.A.02 Demonstrate and describe safety procedures when dealing with high pressure systems including necessary ventilation according to current industry standards.

2.A.02.01 Describe and demonstrate the importance of safety procedures to be used when servicing high pressurized systems (fuel systems, brakes, air conditioning, suspension, hydraulic systems, etc.).

2.A.02.02 Describe and demonstrate safe use of oxygen/acetylene torches and electric welding equipment.

2.A.02.03 Demonstrate ventilation procedures to be followed when working in the lab/shop area.

2.A.02 Performance Example:

- Student will relieve fuel system pressure to perform necessary repairs.

2.A.03 Identify and describe safety procedures when dealing with electrical circuits according to current industry standards.

2.A.03.01 Describe safety procedures to be followed when servicing supplemental restraint systems.

2.A.03.02 Demonstrate safety awareness of high voltage circuits of electric or hybrid electric vehicles and related safety precautions.

2.A.03 Performance Example:

- Safely disable Supplemental Restraint System (SRS) air bag for repair using manufacturer's recommendations.

There are additional changes to some of the Frameworks Strand Two (Technical Knowledge and Skills). Specifically, Strand Two of the Frameworks for Animal Science, Environmental Science and Technology and Horticulture begin with core standards required for all participants in the programs, followed by a series of standards organized in concentrations. For example, Strand Two of the Horticulture Framework begins with the core standards required of all Horticulture students (Topics 2.A through 2.I). These standards are followed by the three concentrations: Arboriculture

(Topics 2.J through 2.L), Greenhouse Management and Floriculture (Topics 2.J. through 2.L) and Landscape and Turf Management (Topics 2.M through 2.Q).

Advanced / Supplemental Standards (Not Required)

Another variation that is new to the revised Strand Two Frameworks is the addition of advanced or supplemental standards which are noted with the use of an asterisk (*). *These standards are not required, but are provided as suggestions that districts may choose to use to increase the depth of a particular topic, or add additional topics, particularly for advanced students or for those seniors who do not participate in cooperative education.*

The following is an example from Automotive Technology, where entire topics were added:

Advanced Automotive Technology Technical Knowledge and Skills

Note: The following competencies are optional, supplementary competencies suitable for advanced students. These are not required.

2.CC Demonstrate appropriate engine repair techniques.

2.CC.01 Perform appropriate cylinder Head Repair.

2.CC.01.01* Diagnose, remove and replace cylinder head(s).

2.CC.01.02* Clean and visually inspect a cylinder head for cracks; check gasket surface areas for warpage and surface finish; check passage condition; determine necessary action.

The following is an example from the Strand Two Radio and Television Broadcasting Framework that shows the addition of an advanced objective, 2.B.04.08*:

2.B.04 Explain concepts fundamental to shooting in cinema and video.

2.B.04.01 Compare and contrast a single-camera and a multiple-camera production.
2.B.04.02 Explain the importance of shooting for the edit (i.e., match on action, sequencing, coverage).
2.B.04.03 Explain the importance of continuity.
2.B.04.04 Explain the 180° Rule line, and its application in various cinema scenarios.
2.B.04.05 Identify and establish a specific point-of-view when shooting from a script.
2.B.04.06 Analyze the methods in which specific shots can evoke emotion from an audience.
2.B.04.07 Define drop frame and non-drop frame code shooting and explain how to account for both when preparing for an edit.
2.B.04.08* Describe various cinematographic methods necessary when shooting scenes that incorporate post-production visual effect

2.B.04 Performance Examples:

- Students will list similarities and differences of single-camera and multiple-camera shoots.
- Students will describe multiple shooting considerations that are useful in streamlining the editing process.

Strand 1: Safety and Health Knowledge and Skills

1.A Fundamentals of Health and Safety

1.A.01 Describe and apply health and safety regulations.

- 1.A.01.01 Identify, describe and apply health and safety regulations that apply to specific tasks and jobs. Students must complete a safety credential program, e.g., Occupational Safety and Health Administration 10, CareerSafe and ServSafe.
- 1.A.01.02 Identify, describe and apply Environmental Protection Agency (EPA) and other environmental protection regulations that apply to specific tasks and jobs in the specific occupational area.
- 1.A.01.03 Identify, describe and apply Right-To-Know (Hazard Communication Policy) and other communicative regulations that apply to specific tasks and jobs in the specific occupational area.
- 1.A.01.04 Explain procedures for documenting and reporting hazards to appropriate authorities.
- 1.A.01.05 Identify and describe potential consequences for non-compliance with appropriate health and safety regulations.
- 1.A.01.06 Identify and list contact information for appropriate health and safety agencies and resources.

1. A.01 Performance Examples:

- List and define OSHA Health and Safety Regulations, EPA and other environmental protection regulations to occupational area.
- List and define Right-to-Know regulations and reporting of hazards and contact information for appropriate health and safety agencies.
- List the laws and rules of regulatory agencies governing sanitation and safety.
- Utilize OSHA as well as health and safety websites for purposes of research.

1.A.02 Demonstrate appropriate health and safety practices based on the specific occupational area.

- 1.A.02.01 Identify, describe and demonstrate the effective use of Safety Data Sheets (SDS).
- 1.A.02.02 Read and interpret chemical, product and equipment labels to determine appropriate health and safety considerations.
- 1.A.02.03 Identify, describe and demonstrate personal, shop and job site safety practices and procedures.
- 1.A.02.04 Demonstrate safe dress and use of relevant safety gear, personal protective equipment (PPE) and ergonomics, e.g., wrist rests, adjustable workspaces, equipment, gloves, proper footwear, earplugs, eye protection and breathing apparatus.
- 1.A.02.05 Demonstrate appropriate safe body mechanics, including appropriate lifting techniques and ergonomics.
- 1.A.02.06 Locate emergency equipment, first aid kit, SDS information directories and emergency action/response plan/escape routes in your lab, shop and

classroom, including labels and signage that follow OSHA Hazard Communication Program (HAZCOM), eyewash stations, shower facilities, sinks, fire extinguishers, fire blankets, telephone, master power switches and emergency exits.

1.A.02.07 Demonstrate the safe use, storage, and maintenance of every piece of equipment in the lab, shop and classroom, e.g., the OSHA Lockout/Tagout Program (LOTO).

1.A.02.08 Describe safety practices and procedures to be followed when working with and around electricity, e.g., ground fault circuit interrupter (GFCI) and frayed wiring.

1.A.02.09 Handle, store, dispose of and recycle hazardous, flammable and combustible materials, according to EPA, OSHA and product specifications.

1.A.02.10 Demonstrate appropriate workspace cleaning, sanitation, disinfection and sterilization procedures required in specific occupational areas, e.g., Workplace Housekeeping OSHA Regulations.

1. A.02 Performance Examples:

- Identify, describe and demonstrate the use of SDS.
- List and demonstrate shop dress code, safety procedures and location of emergency equipment in labor classroom.
- Define and demonstrate safe storage and maintenance of equipment and proper disposal or recycling of hazardous, flammable and combustible materials.
- Identify, describe and demonstrate the Universal Precautions set of guidelines.

1.A.03 Demonstrate appropriate responses to situations that may threaten health and safety.

1.A.03.01 Describe First Aid procedures for potential injuries and other health concerns in the specific occupational area.

1.A.03.02 Describe the importance of emergency preparedness and an emergency action/response plan.

1.A.03.03 Describe procedures used to handle emergency situations, defensive measures and accidents, including identification, reporting, response, evacuation plans and follow-up procedures.

1.A.03.04 Identify, describe and demonstrate safety practices in specific occupational areas used to avoid accidents.

1.A.03.05 Identify and describe fire protection, protection, precautions and response procedures.

1.A.03.06 Discuss the role of the individual and the company/organization in ensuring workplace safety including transportation to and from school, school activities and the workplace.

1.A.03.07 Discuss ways to identify, prevent and report school and workplace violence, discrimination, harassment and bullying.

1.A.03.08 Demonstrate positive and appropriate behavior that contributes to a safe and healthy environment in school and the workplace.

1. A.03 Performance Example:
- Define first aid procedures and protocols used to handle emergency situations and practices used to avoid accidents.
- View safety videos and discuss the role of workplace safety.
- Attend or participate in a human rights alliance organization presentation.
- Observe and/or demonstrate the appropriate use of a fire extinguisher using the (PASS) technique: Pull, Aim, Squeeze, Sweep.
- Review and discuss specific policies, procedures and protocols regarding discrimination, harassment and bullying.
- Discuss and/or role-play proper and respectful behavior that contributes to a positive climate.
- Discuss and/or demonstrate behavior that contributes to a collaborative/teamwork environment.

Selected Websites

- Bullying Prevention and Intervention Resources : www.doe.mass.edu/bullying
- Centers for Disease Control and Prevention: www.cdc.gov
- Environmental Protection Agency : www.epa.gov
- "Lost Youth – Four Stories of Injured Young Workers"– WorkSafeBC: http://www2.worksafebc.com/Publications/Multimedia/Videos.asp?reportid=34291
- Massachusetts Department of Elementary and Secondary Education. (2011). Career/Vocational Technical Education Safety Guide: www.doe.mass.edu/cte
- Massachusetts Department of Elementary and Secondary Education: www.doe.mass.edu
- Massachusetts Emergency Management Agency: www.mass.gov/eopss/agencies/mema
- Massachusetts General Law: www.malegislature.gov
- Massachusetts Health and Human Services: www.mass.gov/dph
- Massachusetts Right to Know Law Summary: http://www.mass.gov/lwd/docs/dos/mwshp/hib397.pdf
- Safety Data Sheet: www. sdsonline.com
- National Fire Protection Association: www.nfpa.org
- Protection of Student Rights: Massachusetts General Law: https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXII/Chapter76/Section5
- Occupational Safety and Health Administration: www.osha.gov
- Readiness and Emergency Management for Schools: www.rems.ed.gov
- Safe and Healthy Learning Environments: www.doe.mass.edu/ssce/safety.html

Strand 2: Technical Knowledge and Skills

2.A Safety in the Electronics Laboratory

2.A.01 Demonstrate safe practices within the electronics laboratory following OSHA regulations, industry standards and established shop safety procedures.

- 2.A.01.01 Complete the requirements of OSHA 10-hour certification course and receive a course completion card.
- 2.A.01.02 Follow safety and emergency procedures, as defined in the shop safety manual.
- 2.A.01.03 Practice work habits that provide personal safety, safety for others, and protect the safety and security of the external environment.
- 2.A.01.04 Select and use appropriate personal protective equipment at all times.
- 2.A.01.05 Maintain a sanitary and clutter-free work environment.
- 2.A.01.06 Monitor, use, store, and dispose of materials according to established OSHA procedures.
- 2.A.01.07 Follow standard Electrostatic Discharge (ESD) procedures.

2.A.01 Performance Example:

- Student will complete the General Industry OSHA 10 hour training course.
- The student will prepare a shop Health and Safety plan describing safety procedures and work habits.

2.B Fundamentals of Electronic Circuit Assembly

2.B.01 Identify electronic schematic symbols.

- 2.B.01.01 Identify passive component symbols.
- 2.B.01.02 Identify active component symbols.
- 2.B.01.03 Identify and list variable component symbols.

2.B.01 Performance Example:

- Given a schematic of a variable output power supply; the student will identify resistors, capacitors, transformers, diodes, regulator ICs, potentiometers etc.

2.B.02 Draw a schematic diagram.

- 2.B.02.01 Sketch a basic circuit by hand.
- 2.B.02.02 Create a basic circuit using schematic software.

2.B.02 Performance Example:

- Using an electronic symbol template; the student will draw the schematic of a variable output power supply.

2.B.03 Produce a parts list.

- 2.B.03.01 List parts from a schematic.
- 2.B.03.02 Locate vendors for electronic parts.
- 2.B.03.03 Calculate total parts list cost.

2.B.03 Performance Example:

- Given a schematic of a variable output power supply; the student will generate a parts list including vendor and cost analysis.

2.B.04 Construct an electronic circuit prototype according to current industry and OSHA standards.

- 2.B.04.01 Describe the connections on a solder-less breadboard.
- 2.B.04.02 Arrange components on a solder-less breadboard.

2.B.04 Performance Example:
- Given a solder-less breadboard; the student will draw a line diagram showing which points are connected to each other.
- Given a solder-less breadboard, schematic, and all required parts; the student will build a functional variable output power supply prototype.

2.B.05 Assemble an electronic circuit on a printed circuit board.

2.B.05.01 Use solder to connect leaded components on a printed circuit board.
2.B.05.02 Use solder to connect surface mount components on a printed circuit board.
2.B.05.03 Differentiate polarity markings on components.

2.B.05 Performance Example:
- Given an unpopulated printed circuit board and all required parts; the student will assemble a variable output power supply.

2.C Theory and Application of DC

2.C.01 Apply electronic circuit laws.

2.C.01.01 Use Ohm's Law to calculate voltage.
2.C.01.02 Use Ohm's Law to calculate current.
2.C.01.03 Use Ohm's Law to calculate resistance.
2.C.01.04 Use Watt's law to calculate power.
2.C.01.05 Use Kirchhoff's law to verify total voltage and total current.
2.C.01.06 Describe basic magnetism laws and principles.

2.C.01 Performance Example:
- Given a series-parallel resistive network schematic; the student will calculate total current, individual voltage drops, parallel current legs, and power values.
- Given two separate coils of wire; the student will demonstrate how the coils are repelled or attracted to each other when power is applied and polarity is reversed.

2.C.02 Apply electronic circuit theorems.

2.C.02.01 Use Norton's theorem to analyze DC circuits.
2.C.02.02 Use Thevenin's theorem to analyze DC circuits.
2.C.02.03 Use Superposition to analyze DC circuits.

2.C.02 Performance Example:
- Given a series-parallel resistive network schematic; the student will calculate the Thevenin's voltage and resistance values.

2.C.03 Construct and test DC circuits.

2.C.03.01 Construct a circuit and verify Thevenin's Theorem.
2.C.03.02 Construct a circuit and verify Norton's Theorem.

2.C.03 Performance Example:
- Given a series-parallel resistive network schematic; the student will measure total current, individual voltage drops and parallel current leg values.
- Given a series-parallel resistive network schematic; the student will measure the Thevenin's voltage and resistance values.

2.D Theory and Application of AC

2.D.01 Perform calculations in AC circuits.

- 2.D.01.01 Calculate RMS, peak, peak-to-peak, and average values of a sine wave.
- 2.D.01.02 Calculate frequency, time and duty cycle of a periodic waveform.
- 2.D.01.03 Calculate phase shift.
- 2.D.01.04 Calculate reactance.
- 2.D.01.05 Calculate impedance.
- 2.D.01.06 Calculate apparent, true, reactive, power factor.
- 2.D.01.07 Calculate transformer characteristics.
- 2.D.01.08 Calculate filter circuits parameters.

2.D.01 Performance Example:

- Given a resistor-capacitor network schematic; the student will calculate capacitive reactance, impedance, and phase angle at three different input frequency values.

2.D.02 Perform measurements in AC circuits.

- 2.D.02.01 Measure peak and peak-to-peak values of a sine wave.
- 2.D.02.02 Measure frequency, time and duty cycle of a periodic waveform.
- 2.D.02.03 Measure phase shift.
- 2.D.02.04 Graphically plot reactance versus frequency.
- 2.D.02.05 Graphically plot impedance versus frequency.

2.D.02 Performance Example:

- Using an oscilloscope; the student will analyze a resistor-capacitor network including measuring AC input values (frequency, peak voltage etc) as well as component voltage drops, and phase shifts at three different input frequency values.
- Using a function generator and oscilloscope; the student will display a sine wave with a period of 13 microseconds.

2.E Theory and Application of Analog Electronics

2.E.01 Analyze semiconductors.

- 2.E.01.01 Explain manufacturers' specifications of semiconductor devices.
- 2.E.01.02 Explain characteristics of discrete semiconductors.
- 2.E.01.03 Explain biasing of discrete semiconductor devices.
- 2.E.01.04 Describe thermal management of discrete semiconductor devices.
- 2.E.01.05 Identify transistor configurations.
- 2.E.01.06 Identify and list types of transistor biasing configurations.
- 2.E.01.07 Identify rectifier diode circuits.
- 2.E.01.08 Identify regulator diode circuits.
- 2.E.01.09 Analyze power supply circuits.
- 2.E.01.10 Analyze a thyristor circuit.

2.E.01 Performance Example:

- Given selected diode and transistor circuit schematics; the student will calculate diode currents, BJT and FET transistor current and voltage values, and plot results on graph paper.
- Given a schematic of a power supply with a crowbar protection circuit; the student will specify the function and purpose of all semi-conductor devices.
- Given the required components; the student will demonstrate use of a BJT as a switch in saturation and cutoff.

2.E.02 Test semiconductors.

- 2.E.02.01 Test diodes with multimeters.
- 2.E.02.02 Test transistors.

2.E.02.03 Test thyristors.

2.E.02 Performance Example:
- Using a multi-meter; the student will measure and record forward and reverse bias resistance values of various diodes, BJT and FET transistors, and an SCR.

2.E.03 Construct and test semiconductor circuits.
- 2.E.03.01 Measure and explain current and voltage characteristics of diode types.
- 2.E.03.02 Measure and explain current and voltage characteristics of transistor types.
- 2.E.03.03 Measure and explain current voltage characteristics of thyristor types.
- 2.E.03.04 Analyze transistor amplifiers circuits.
- 2.E.03.05 Analyze oscillator circuits.

2.E.03 Performance Example:
- Given selected diode and transistor DC circuit schematics, solder-less breadboard, and required components; the student will measure diode currents, BJT and FET transistor current and voltage values, and prepare laboratory reports on the collected data.
- Given selected transistor amplifier circuit schematics, solder-less breadboard, and required components; the student will measure BJT and FET transistor voltage gain values, phase relationships, and prepare laboratory reports on the collected data.
- Given the required parts; the student will build a 30 kHz oscillator using a 555 timer.

2.E.04 Evaluate operational amplifier circuits.
- 2.E.04.01 Describe operational amplifier IC characteristics.
- 2.E.04.02 Design operational amplifier circuits.

2.E.04 Performance Example:
- Given various operational amplifier circuit schematics; the student will calculate input-output current and voltage values, and prepare laboratory reports on the collected data.
- Given various operational amplifier circuit schematics, solder-less breadboard, and required components; the student will measure input-output current and voltage values, and prepare laboratory reports on the collected data.

2.F Theory and Application of Digital Electronics

2.F.01 Perform calculations in digital circuits.
- 2.F.01.01 Use the two's complement number system for math operations.
- 2.F.01.02 Convert between binary, decimal and hexadecimal numbers.
- 2.F.01.03 Identify and use alternate digital codes.
- 2.F.01.04 Draw logic diagrams from Boolean expressions.
- 2.F.01.05 Write truth table from a Boolean expression or logic circuit.
- 2.F.01.06 Use reduction theorems to simplify digital electronic circuits.
- 2.F.01.07 Analyze waveforms for latches/flip-flops.
- 2.F.01.08 Analyze counter circuits waveforms.

2.F.01 Performance Example:
- Given appropriate worksheets; the student will convert between binary, octal, decimal, and hexadecimal numbering systems.
- Using K-Mapping and Boolean algebra; the student will simplify SOP expressions.
- Given appropriate worksheets; the student will convert between Boolean expressions, truth tables and logic diagrams.

2.F.02 Identify and apply digital principles.
- 2.F.02.01 Differentiate between high, low and tri-state characteristics of a digital signal.

2.F.02.02 Identify basic TTL gates of the 7400 series and describe IO characteristics.
2.F.02.03 Specify pin numbers and manufacturer markings on digital ICs.
2.F.02.04 Compare and contrast the differences between TTL and CMOS logic families.
2.F.02.05 Identify and calculate parity bits for error control.
2.F.02.06 Describe the universal properties of NAND and NOR gates.
2.F.02.07 Illustrate alternate schematic forms of basic logic gates.
2.F.02.08 Identify various combinational and sequential logic circuits.
2.F.02.09 List reduction theorems used to simplify digital Electronic circuits.
2.F.02.10 Identify the basic architecture of a microprocessor or microcontroller.
2.F.02.11 Describe a digital oscillator circuit.
2.F.02.12 Describe circuits that perform A/D and D/A conversions.

2.F.02 Performance Example:
- Given circuit schematic, solder-less breadboard, and required components; the student will use a counter IC to drive a 3 to 8 decoder.
- Given circuit schematic, solder-less breadboard, and required components; the student will build a 2 bit Adder circuit using NAND gates.

2.F.03 Identify and describe characteristics of digital components.
2.F.03.01 Define and describe PLDs (Programmable Logic Devices).
2.F.03.02 Describe line driver characteristics and their applications.

2.F.03 Performance Example:
- Given circuit schematic, solder-less breadboard, and required components; the student will connect multiple tri-state line driver devices (such as 74244 or equivalent) to a common bus and use the tri-state controls to determine which device drives the bus.

2.F.04 Construct and test digital circuits.
2.F.04.01 Wire, test and explain combinational logic circuits.
2.F.04.02 Wire and test various flip-flops to verify truth tables.
2.F.04.03 Wire and test various latches to verify truth tables.
2.F.04.04 Measure waveforms for counter circuits and analyze behaviors and characteristics.
2.F.04.05 Construct, simulate and explain encode and decode circuits.
2.F.04.06 Construct, simulate and explain shift registers.
2.F.04.07 Construct, simulate and explain comparators.
2.F.04.08 Construct, simulate and explain adder circuits.
2.F.04.09 Construct, simulate and explain multiplexer ICs.

2.F.04 Performance Example:
- Given circuit schematic, solder-less breadboard, and required components; the student will use a flip-flop and combinatorial logic to turn on an LED when an 8 bit counter reaches a specified value.

2.G Applied Engineering

2.G.01 Utilize engineering concepts.
2.G.01.01 List and apply the steps of the design process to designated electronics projects.
2.G.01.02 Utilize the steps of the design process to solve given problems.
2.G.01.03 Work in teams using brainstorming techniques to create new designs.
2.G.01.04 Use engineering notations and prefixes.
2.G.01.05 Describe and use the steps for troubleshooting a given problem.

2.G.01 Performance Example:
- The student will develop both analog and digital versions of a collision detection and drive control system. Compare the positive and negative features of the two approaches.
- Given appropriate worksheets; the student will convert between kilo, mega, milli, micro, nano, and pico numeric representations..

2.G.02 Develop engineering documents.
- 2.G.02.01 Write a technical design report.
- 2.G.02.02 Maintain engineering logs/journals for projects.
- 2.G.02.03 Utilize a variety of media formats to convey designs and processes.

2.G.02 Performance Example:
- The student will save a schematic from a schematic capture system and convert the file so it can be imported to an MS-Word document.

2.G.03 Examine motors.
- 2.G.03.01 Identify the various types of electric motors and demonstrate their proper use/operation.
- 2.G.03.02 Identify various types of stepper motors.
- 2.G.03.03 Utilize stepper motor circuitry.
- 2.G.03.04 Design, build and operate a simple electric motor.

2.G.03 Performance Example:
- Given circuit schematic, solder-less breadboard, and required components; the student will examine the relationships between voltage level and polarity and a DC motor speed and rotation direction.
- Use a stepper motor control system to steer a vehicle in a prescribed path.
- Build a simple DC motor using a coil of wire, a magnet, and a power source.

2.G.04 Design an autonomous robotics system.
- 2.G.04.01 Utilize sensors to interface in a robotic control system.
- 2.G.04.02 Design, build, and operate an autonomous robot.

2.G.04 Performance Example:
- Given the required components; the student will program a robot to maneuver through an obstacle course.
- Design and build an autonomous vehicle that drives toward the brightest light in a room.
- Design a controller that turns 8 devices on and off in sequence for various prescribed time periods.

2.H Software Applications

2.H.01 Utilize programming.
- 2.H.01.01 Write a simple control program using a programming language.
- 2.H.01.02 Simulate a circuit using a software simulation program.

2.H.01 Performance Example:
- Write a software program to turn one of eight LEDs on in repeating sequential order.

2.H.02 Design circuit layouts.
- 2.H.02.01 Use PCB software to develop a basic circuit design.
- 2.H.02.02 Describe or use a process for PCB fabrication.

2.H.02 Performance Example:
- Simulate the performance of a modulo 9 digital counter circuit in your schematic capture software system.
- Using printed circuit board software; the student will generate a milling file for an electronic circuit board.

2.I Applied Electronic Devices in a Manufacturing Environment

2.I.01 Utilize electronic equipment for measuring.
- 2.I.01.01 Identify DC functions and ranges on measuring devices.
- 2.I.01.02 Use a multimeter to measure DC circuit values.
- 2.I.01.03 Identify AC functions and ranges on measuring devices.
- 2.I.01.04 Use a multimeter to measure AC circuit values.
- 2.I.01.05 Demonstrate the use of an oscilloscope.
- 2.I.01.06 Demonstrate the use of a function generator.
- 2.I.01.07 Identify various waveforms.

2.I.01 Performance Example:
- Given the required components; the student will demonstrate how to use a meter to measure DC and AC voltage.
- Given the required components; the student will demonstrate how to use an oscilloscope to measure DC and AC voltage.

2.I.02 Utilize tools to build electronic projects.
- 2.I.02.01 Solder and crimp connectors and lugs.
- 2.I.02.02 Solder and de-solder electronic components, including surface mount components.
- 2.I.02.03 Select and use basic hand tools and equipment used for electronic circuits.
- 2.I.02.04 Describe and use advanced hand tools and equipment designed for manufacturing of electronic devices.

2.I.02 Performance Example:
- Given an electronic circuit kit: the student will construct a working electronic device from a kit.

2.J Advanced Standards (ETA Sourced)

2.J.01* Demonstrate knowledge and skills relevant to computer electronics.
- 2.J.01.01* Describe the major sections of a computer.
- 2.J.01.02* Demonstrate how the computer block diagram and flow charts are utilized.
- 2.J.01.03* Describe different types of computer memory and how storage is accomplished.
- 2.J.01.04* Explain the importance of an Arithmetic Logic Unit (ALU).
- 2.J.01.05* Define ROM, RAM, PROM, EPROM, EEPROM and EAPROM.
- 2.J.01.06* Explain the importance of data-buses and their associated bandwidth.
- 2.J.01.07* Explain the reasons for different computer languages and their relationships.
- 2.J.01.08* Define the words ‘peripheral device’ and list various types.
- 2.J.01.09* Explain the reasons for using interface devices/chips/cards and name common types.

2.J.02* Demonstrate knowledge and skills relevant to optical electronics.
- 2.J.02.01* List common electronics display devices.
- 2.J.02.02* Explain how LCD displays operate, comparing their advantages and disadvantages.
- 2.J.02.03* Describe how LED remote hand units work.
- 2.J.02.04* Explain why and list some locations of circuits in which opto-isolators are used.
- 2.J.02.05* List uses of light activated controls and explain how photo devices are incorporated.

2.J.03* Demonstrate knowledge and skills relevant to audio and video Systems.
- 2.J.03.01* Explain the major components of the most common home entertainment products.
- 2.J.03.02* Describe microphone technology and usage.
- 2.J.03.03* Explain speaker construction and precautions.
- 2.J.03.04* Compare the differences between good quality and distorted sound and describe the electronic/acoustical reasons for each.
- 2.J.03.05* Explain how signals may conflict and the symptoms the conflict may produce.
- 2.J.03.06* Explain how to isolate troubles between discrete equipment units.

2.J.04* Demonstrate knowledge and skills relevant to communications electronics.
- 2.J.04.01* Describe major types of two-way radio communications (e.g., avionics, land mobile and maritime).

Strand 3: Embedded Academics

Strand 3: Embedded Academics, a critical piece of a Vocational Technical Education Framework, are presented as Crosswalks between the Massachusetts Vocational Technical Education Frameworks and the Massachusetts Curriculum Frameworks. These Crosswalks are located in the Appendix of this Framework.

Academic Crosswalks

Appendix A: English Language Arts
Appendix B: Mathematics
Appendix C: Science and Technology/Engineering
Earth and Space Science
Life Science (Biology)
Physical Science (Chemistry and Physics)
Technology/Engineering

Strand 4: Employability and Career Readiness

4.A Career Exploration and Navigation

4.A.01 Develop a career plan and portfolio.

- 4.A.01.01 Develop and revise career plan annually based on workplace awareness and skill attainment.
- 4.A.01.02 Assess personal strengths and interest areas to determine potential careers, career pathways and career ladders.
- 4.A.01.03 Examine potential career field(s)/discipline(s) and identify criteria to select, secure and keep employment in chosen field(s).
- 4.A.01.04 Research and evaluate a variety of careers utilizing multiple sources of information and resources to determine potential career(s) and alternatives.
- 4.A.01.05 Identify training and education requirements that lead to employment in chosen field(s) and demonstrate skills related to evaluating employment opportunities.
- 4.A.01.06 Explore and evaluate postsecondary educational opportunities including degrees and certifications available, traditional and nontraditional postsecondary pathways, technical school and apprenticeships, cost of education, financing methods including scholarships and loans and the cost of loan repayment.
- 4.A.01.07 Create a portfolio showcasing academic and career growth including a career plan, safety credential, resume and a competency profile demonstrating the acquisition of the knowledge and skills associated with at least two years of full-time study in the Chapter 74 program.

4.A.02 Demonstrate job search skills.

- 4.A.02.01 Conduct a job search and complete written and electronic job applications, resumes, cover letters and related correspondence for a chosen career path.
- 4.A.02.02 Explore and evaluate postsecondary job opportunities and career pathways specific to career technical areas.
- 4.A.02.03 Identify role and use of social media and networking for staying current with career and employment trends as well as networking, job seeking and career development opportunities.
- 4.A.02.04 Demonstrate ability to use social media and networking to develop useful occupational contacts, job seeking and career development opportunities.

4.A.03 Demonstrate all phases of the job interview process.

- 4.A.03.01 Gather relevant information about potential employer(s) from multiple print and digital sources, assessing the credibility and accuracy of each source.
- 4.A.03.02 Identify employment eligibility criteria, such as drug/alcohol free status, clean driving record, etc.

4.A.03.03 Practice effective interviewing skills: appearance, inquiry and dialogue with interviewer, positive attitude and evidence of work ethic and skills.

4.A.03.04 Explore and evaluate employment benefit packages including wages, vacation, health care, union dues, cafeteria plans, tuition reimbursement, retirement and 401K.

4. A Performance Examples:

- Conduct research to analyze and present on specific careers within a cluster.
- Conduct web-based job search using sites such as Monster.com, CareerBuilder.com, Indeed.com, Snagajob.com, Simplyhired.com and others.
- Create profile on social media/networking site such as LinkedIn and/or LinkedIn University for postsecondary research and employment opportunities.
- Complete online job application.
- Conduct and videotape practice interviews for instructor and student analysis.
- Provide students with sample employment and benefit packages for evaluation.

4.B Communication in the Workplace

4.B.01 Demonstrate appropriate oral and written communication skills in the workplace.

4.B.01.01 Communicate effectively using the language and vocabulary appropriate to a variety of audiences within the workplace including coworkers, supervisors and customers.

4.B.01.02 Read technical and work-related documents and demonstrate understanding in oral discussion and written exercise.

4.B.01.03 Demonstrate professional writing skills in work-related materials and communications (e.g., letters, memoranda, instructions and directions, reports, summaries, notes and/or outlines).

4.B.01.04 Use a variety of writing/publishing/presentation applications to create and present information in the workplace.

4.B.01.05 Identify, locate, evaluate and use print and electronic resources to resolve issues or problems in the workplace.

4.B.01.06 Use a variety of financial and data analysis tools to analyze and interpret information in the workplace.

4.B.01.07 Orally present technical and work-related information to a variety of audiences.

4.B.01.08 Identify and demonstrate professional non-verbal communication.

4.B.02 Demonstrate active listening skills.

4.B.02.01 Listen attentively and respectfully to others.

4.B.02.02 Focus attentively, make eye contact or other affirming gestures, confirm understanding and follow directions.

4.B.02.03 Show initiative in improving communication skills by asking follow-up questions of speaker in order to confirm understanding.

4. B Performance Examples:

- Read and analyze technical instructions to learn what makes them effective.
- Read and analyze technical instructions to follow directions and/or solve a problem.
- Examine a technical document and use it to write a set of instructions for another student to follow and evaluate.
- Analyze websites for effective technical writing and design.
- Create brochures and presentations using software and/or Web 2.0 tools to convey technical information.
- Conduct research using the Internet, print documents, observations and interviews to create a technical guide.

4.C Work Ethic and Professionalism

4.C.01 Demonstrate attendance and punctuality.

- 4.C.01.01 Identify and practice professional time-management and attendance behaviors including punctuality, reliability, planning and flexibility.

4.C.02 Demonstrate proper workplace appearance.

- 4.C.02.01 Identify and practice professional appearance specific to the workplace.
- 4.C.02.02 Identify and practice personal hygiene appropriate for duties specific to the workplace.
- 4.C.02.03 Identify and wear required safety gear specific to the workplace.

4.C.03 Accepts direction and constructive criticism.

- 4.C.03.01 Demonstrate ability (both verbally and non-verbally) to accept direction and constructive criticism and to implement solutions to change behaviors.
- 4.C.03.02 Ask appropriate questions to clarify understanding of feedback.
- 4.C.03.03 Analyze own learning style and seek instructions in a preferred format that works best for their understanding (such as oral, written or visual instruction).

4.C.04 Demonstrate motivation and initiative.

- 4.C.04.01 Evaluate assigned tasks for time to completion and prioritization.
- 4.C.04.02 Demonstrate motivation through enthusiasm, engagement, accurate completion of tasks and activities.
- 4.C.04.03 Demonstrate initiative by requesting new assignments and challenges.
- 4.C.04.04 Explain proposed solutions to challenges observed in the workplace.
- 4.C.04.05 Demonstrate the ability to evaluate multiple solutions to problems and challenges using critical reasoning and workplace/industry knowledge and select the best solution to the problem.
- 4.C.04.06 Implement solution(s) to challenges and/or problem(s) observed in the workplace.
- 4.C.04.07 See projects through completion and check work for quality and accuracy.

4.C.05 Demonstrate awareness of workplace culture and policy.

4.C.05.01 Display ethical behavior in use of time, resources, computers and information.
4.C.05.02 Identify the mission of the organization and/or department.
4.C.05.03 Explain the benefits of a diverse workplace.
4.C.05.04 Demonstrate a respect for diversity and its benefit to the workplace.

4.C.06 Interact appropriately with coworkers.
4.C.06.01 Work productively with individuals and in teams.
4.C.06.02 Develop positive mentoring and collaborative relationships within work environment.
4.C.06.03 Show respect and collegiality, both formally and informally.
4.C.06.04 Explain and follow workplace policy on the use of cell phones and other forms of social media.
4.C.06.05 Maintain focus on tasks and avoid negative topics or excessive personal conversations in the workplace.
4.C.06.06 Negotiate solutions to interpersonal and workplace conflicts.

4. C Performance Examples:
- Complete a learning style analysis tool.
- Develop a rubric to assess work ethic and professionalism as detailed in the standards above.

Student Organizations

Business Professionals of America www.bpa.org

Selected Websites

- 5 Ways to Ace a Job Interview: http://kidshealth.org/teen/school_jobs/jobs/tips_interview.html
- America's Career Resource Network: http://acrn.ovae.org/teachers/careerexpclassrm.htm
- Career Cruiser – Florida Department of Education: http://www.fldoe.org/workforce/pdf/cruiser.pdf
- Career Development Guide and Glossary: http://www.doe.mass.edu/connect/cde.html
- Career One Stop: http://www.careeronestop.org/
- Career Plan: http://www.doe.mass.edu/cd/plan/intro.html
- Career Plan Model: http://www.doe.mass.edu/ccr/epp/samples/cpmodel_11x17.pdf
- Checklist: http://www.doe.mass.edu/cd/plan/checklist.pdf
- Career Tech: http://www.okcareertech.org/cac/Pages/resources_products/ethics_web_sites.htm
- Ethics Resource Center: http://www.ethics.org/
- Interaction in the Workplace: http://hrweb.berkeley.edu/guides/managing-hr/interaction/communication
- Individual Learning Plans: How-to Guide: "Promoting Quality Individualized Learning Plans: A How to Guide on the High School Years" http://www.ncwd-youth.info/ilp/how-to-guide

- ILP Fact Sheet: http://www.ncwd-youth.info/fact-sheet/individualized-learning-plan
- ILP Policy Brief: http://www.ncwd-youth.info/ilp/produce-college-and-career-ready-high-school-graduates
- ILP Resources Home Page: http://www.ncwd-youth.info/ilp
- Interview Skills Lesson Plans: http://www.amphi.com/media/1220281/interview%20skills%20lesson%20plan.doc
- Labor and Workforce Development: http://www.mass.gov/lwd/employment-services/preparing-for-your-job-search/
- Maine Community College System – Center for Career Development: http://www.ccd.me.edu/careerprep/CareerPrepCurriculum_LP-6.pdf
- Massachusetts Work-Based Learning: http://skillspages.com/masswbl
- North Dakota Association of Agriculture Educators: http://www.ndaae.org/attachments/File/Preparing_students_for_a_Job_Interview.pptx
- NY CTE Learning Standards—Career Development and Occupational Studies (CDOS) Resource Guide with Core Curriculum : http://www.p12.nysed.gov/cte/cdlearn/cdosresourceguide.html
- Occupational Outlook Handbook: http://www.bls.gov/ooh/
- Purdue OWL Job Search Resources (for writing resumes, applications, and letters): https://owl.english.purdue.edu/engagement/34/
- Soft Skills to Pay the Bills — Mastering Soft Skills for Workplace Success: http://www.dol.gov/odep/topics/youth/softskills/
- US Department of Labor: http://www.dol.gov/dol/audience/aud-unemployed.htm
- Workplace Communication: http://www.regionalskillstraining.com/sites/default/files/content/WC%20Book%201.pdf
- Your Plan For the Future: http://www.yourplanforthefuture.org

Strand 5: Management and Entrepreneurship Knowledge and Skills

5.A Starting a Business

5.A.01 Demonstrate an understanding of the practices required to start a business.

- 5.A.01.01 Define entrepreneurship and be able to recognize and describe the characteristics of an entrepreneur.
- 5.A.01.02 Compare and contrast types of business ownership (i.e., sole proprietorships, franchises, partnerships, corporations).
- 5.A.01.03 Identify and explain the purpose and contents of a business plan.
- 5.A.01.04 Demonstrate an understanding of the principles and concepts of a business's supply chain (i.e., suppliers, producers and consumers.

5. A Performance Examples:

- Develop a presentation pertaining to an entrepreneur and their business.
- Communicate with a business owner and discuss the pros and cons of starting and owning a business. Summarize the main points of the discussion.
- Choose a product or service and describe the process leading to distribution.
- Write a business plan for a business in your community.

5.B Managing a Business

5.B.01 Demonstrate an understanding of managing a business.

- 5.B.01.01 Formulate short- and long-term business goals.
- 5.B.01.02 Demonstrate effective verbal, written and visual communication skills.
- 5.B.01.03 Utilize a decision-making process to make effective business decisions.
- 5.B.01.04 Identify a business's chain of command and define its organizational structure.
- 5.B.01.05 Identify and apply effective customer service skills and practices.
- 5.B.01.06 Identify, interpret and develop written operating procedures and policies.
- 5.B.01.07 Track inventory, productivity and labor cost.
- 5.B.01.08 Demonstrate business meeting skills.
- 5.B.01.09 Identify professional organizations and explore their benefits.

5. B Performance Examples:

- Working as a team, role-play situations that an entrepreneur might face in dealing with customers or employees.
- Contact a relevant professional organization and request information about its benefits, membership requirements and costs.
- Plan and conduct a business meeting.
- Identify companies that are known for customer service and list the practices that help differentiate themselves from all others in their industry.

5.C Marketing a Business

5.C.01 Demonstrate an understanding of marketing and promoting a business.

- 5.C.01.01 Explain the role of business in the economy.
- 5.C.01.02 Describe the relationship between business and community.
- 5.C.01.03 Describe methods of market research and identifying target markets.

5.C.01.04 Describe and apply the concepts of a marketing mix (the 4Ps of marketing: product, price, place and promotion).
5.C.01.05 Compare and contrast the promotional tools and techniques used to sell products, services, images and ideas.
5.C.01.06 Describe the impact of supply and demand on a product or business.
5.C.01.07 Identify direct and indirect competition on a business.
5.C.01.08 Identify and use sales techniques to meet client needs and wants.
5.C.01.09 Discuss strategies to acquire and retain a customer base.

5. C Performance Examples:
- Research reliable sources to identify marketing and industry data related to a business.
- Conduct market research by developing a survey and presenting the results.
- Create a promotional campaign using a variety of media.
- Write a marketing plan for a product.

5.D Financial Concepts and Applications in Business

5.D.01 Demonstrate an understanding of financial concepts and applications.

5.D.01.01 Identify essential financial reports and understand their purpose (i.e., budget, balance sheet and income statement).
5.D.01.02 Describe payroll practices (i.e., deductions – federal, FICA and state taxes and insurances).
5.D.01.03 Identify the importance of maintaining accurate records.
5.D.01.04 Apply practices related to pricing, purchasing and billing.
5.D.01.05 Maintain and reconcile a checking account.
5.D.01.06 Identify the options for funding a business.

5. D Performance Examples:
- Given an employee time card and rate of pay, calculate gross pay, taxes, deductions and net pay.
- Develop a budget for a simulated business or project.
- Analyze and discuss financial documents from a company.
- Research various methods of funding a business.

5.E Legal/Ethical/Social Responsibilities

5.E.01 Demonstrate an understanding of legal, ethical and social responsibility for businesses.

5.E.01.01 Identify state and federal laws and regulations related to managing a business.
5.E.01.02 Describe and identify ethical business practices.
5.E.01.03 Demonstrate an understanding of business contracts.
5.E.01.04 Explain the role of diversity in the workplace.
5.E.01.05 Explain the role of labor organizations.
5.E.01.06 Identify practices that support clean energy technologies and encourage environmental sustainability.
5.E.01.07 Demonstrate an understanding of how technology advancements impact business practices.

5.E Performance Example:
- Read and interpret a contract.
- Complete an application for a license, permit or certificate.
- Research federal, state and local regulations and laws required for a business.
- Participate in and summarize a discussion with a member of a labor or civil rights organization.

Selected Websites

- CVTE Strand 1, 4, and 5 Resources: https://sites.google.com/a/mccanntech.org/cvte-strands-1-4-and-5-resources/
- Entrepreneur: http://www.entrepreneur.com
- Inc. Magazine: http://www.inc.com/
- Junior Achievement "Be Entrepreneurial Program": https://www.juniorachievement.org/web/ja-usa/home
- Kahn Academy Interviews with Entrepreneurs: https://www.khanacademy.org/economics-finance-domain/entrepreneurship2/interviews-entrepreneurs
- Kauffman Founders School: http://www.entrepreneurship.org/en/founders-school.aspx
- National Federation of Independent Business: www.nfib.com
- National Foundation for Teaching Entrepreneurship (NFTE): www.nfte.com
- SBA Loans: http://www.sba.gov
- SkillsUSA Professional Development Program Competency List: http://www.skillsusa.org/downloads/PDF/lessons/professional/PDPPreview.pdf
- Small Business Administration: www.sba.gov

Glossary

Term	**Definition**
Balance sheet	A statement of the assets, liabilities and capital of a business at a particular point in time.
Budget	An estimate of income and expenditure for a set period of time.
Business Ownership	Types of business ownership refer to the legal structure of an organization. Legal structures include: Sole Proprietorship, Partnerships, Corporations and Limited Liability Companies.
Business Plan	A written document that describes in detail your business goals and how you are going to achieve them from a marketing, operational and financial point of view.

Term	Definition
Chain of Command and Organizational Structure 	Refers to the management structure of an organization. It identifies lines of authority, lines of communication, and reporting relationships. Organizational structure determines how the roles, power and responsibilities are assigned and coordinated and how information flows between the different levels of management. (A visual representation of this structure is called an org chart).
FICA	Federal Insurance Contributions Act requires taxes deducted from pay for supporting Social Security.
Income Statement	A financial statement providing operating results for a specific time period showing a business's revenues, expenses and profit or loss.
Market Research	• Primary: Surveys, Focus Groups, Observation • Secondary: Websites, Internet
Marketing Mix	A set of controlled variables that formulate the strategic position of a product or service in the marketplace. These variables are known as the 4 P's of marketing and include product, place, price and promotion.
Methods to Track Inventory, Productivity and Labor Cost	Refers to the processes a business uses to account for: 1) the inflows and outflows of inventory and materials related to inventory; 2) the efficiency of operations and 3) the cost of labor including salary and benefits.
Promotional Tools and Techniques	The six elements of a promotional mix are: advertising, visual merchandising, public relations, publicity, personal selling and sales promotion.
Supply Chain	The supply chain, or channel of distribution, describes how the product is handled and/or distributed from suppliers with materials, to the manufacturer, wholesaler or retailer and finally to the consumer.
Target Market	Those who are most likely to buy your product or service.

Strand 6: Technology Literacy Knowledge and Skills

6.A Technology Literacy Knowledge and Skills (Grades 9 through 12)

6.A.01 Demonstrate proficiency in the use of computers and applications, as well as an understanding of the concepts underlying hardware, software, and connectivity.

- 6.A.01.01 Use online help and other support to learn about features of hardware and software, as well as to assess and resolve problems.
- 6.A.01.02 Install and uninstall software; compress and expand files (if the district allows it).
- 6.A.01.03 Explain effective backup and recovery strategies.
- 6.A.01.04 Apply advanced formatting and page layout features when appropriate (e.g., columns, templates, and styles) to improve the appearance of documents and materials.
- 6.A.01.05 Use editing features appropriately (e.g., track changes, insert comments).
- 6.A.01.06 Identify the use of word processing and desktop publishing skills in various careers.
- 6.A.01.07 Identify the use of database skills in various careers.
- 6.A.01.08 Define and use functions of a spreadsheet application (e.g., sort, filter, find).
- 6.A.01.09 Explain how various formatting options are used to convey information in charts or graphs.
- 6.A.01.10 Identify the use of spreadsheet skills in various careers.
- 6.A.01.11 Use search engines and online directories.
- 6.A.01.12 Explain the differences among various search engines and how they rank results.
- 6.A.01.13 Explain and demonstrate effective search strategies for locating and retrieving electronic information (e.g., using syntax and Boolean logic operators).
- 6.A.01.14 Describe good practices for password protection and authentication.

6.A.02 Demonstrate the responsible use of technology and an understanding of ethics and safety issues in using electronic media at home, in school, and in society.

- 6.A.02.01 Demonstrate compliance with the school's Acceptable Use Policy.
- 6.A.02.02 Explain issues related to the responsible use of technology (e.g., privacy, security).
- 6.A.02.03 Explain laws restricting the use of copyrighted materials.
- 6.A.02.04 Identify examples of plagiarism, and discuss the possible consequences of plagiarizing the work of others.

6.A.03 Design and implement a personal learning plan that includes the use of technology to support lifelong learning goals.

- 6.A.03.01 Evaluate the authenticity, accuracy, appropriateness, and bias of electronic resources, including Web sites.
- 6.A.03.02 Analyze the values and points of view that are presented in media messages.
- 6.A.03.03 Describe devices, applications, and operating system features that offer accessibility for people with disabilities.

6.A.03.04 Evaluate school and work environments in terms of ergonomic practices.

6.A.03.05 Describe and use safe and appropriate practices when participating in online communities (e.g., discussion groups, blogs, social networking sites).

6.A.03.06 Explain and use practices to protect one's personal safety online (e.g., not sharing personal information with strangers, being alert for online predators, reporting suspicious activities).

6.A.03.07 Explain ways individuals can protect their technology systems and information from unethical users.

6.A.04 Demonstrate the ability to use technology for research, critical thinking, problem solving, decision making, communication, collaboration, creativity, and innovation.

6.A.04.01 Devise and demonstrate strategies for efficiently collecting and organizing information from electronic sources.

6.A.04.02 Compare, evaluate, and select appropriate electronic resources to locate specific information.

6.A.04.03 Select the most appropriate search engines and directories for specific research tasks.

6.A.04.04 Use a variety of media to present information for specific purposes (e.g., reports, research papers, presentations, newsletters, Web sites, podcasts, blogs), citing sources.

6.A.04.05 Demonstrate how the use of various techniques and effects (e.g., editing, music, color, rhetorical devices) can be used to convey meaning in media.

6.A.04.06 Use online communication tools to collaborate with peers, community members, and field experts as appropriate (e.g., bulletin boards, discussion forums, listservs, Web conferencing).

6.A.04.07 Plan and implement a collaborative project with students in other classrooms and schools using telecommunications tools (e.g., e-mail, discussion forums, groupware, interactive Web sites, video conferencing).

Appendices

The framework teams created an "Appendix" listing potential industry recognized credentials attainable by secondary students; lists of professional, student, and relevant government organizations; and useful resources and websites. **** It is important to note that although most Framework Teams provided information for the "Appendix", not all teams did. Therefore, sub-headings within the "Appendix" without information have been deleted.***

Disclaimer: Reference in the Appendices Section to any specific commercial products, processes, or services, or the use of any trade, firm or corporation name is for the information and convenience of the public, and does not constitute endorsement or recommendation by the Massachusetts Department of Elementary and Secondary Education.

Embedded Academic Crosswalks

Embedded English Language Arts and Literacy

CVTE Learning Standard Number	Strand Coding Designation Grades ELAs Learning Standard Number	Text of English Language Arts Learning Standard
2.B 2.B.01.01 2.B.01.02 2.B.03.01 2.B.04.01 2.F 2.F.02.04 2.F.02.09 2.F.02.01	RST. 9-12.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 9–12 texts and topics*.
Performance Example: Students will maintain a journal defining and connecting words and symbols of domain-specific vocabulary while reading electronic schematics.		
2.B. 2.B.03.01 2.G. 2.G.01.01 2.G.01-04 2.G.02.01	WHST. 6-12.4	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
Performance Example: Utilizing content specific formatting, students will produce a written 2+ page technical report using domain-specific vocabulary using engineering notations.		

2.F 2.F.03.01 2.F.03.02 2.F.03.03 2.F.04.05 2.F.04.06 2.F.04.07 2.F.04.08 2.F.04.09 2.E. 2.E.01.01 2.E.0102 2.E.01.03	SL.8-10.4	9-10. Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task. 8.Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.
Performance Example: In a group or individually, students will orally cite to the teacher and/or the class, specifications, characteristics, and biasing of semiconductors and any other content specific knowledge.		
2.E 2.E.04.01 2.E.04.02 2.F 2.F.02.12 2.F.02.09	WHST.6-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes
Performance Example: • Given a schematic of semiconductors, studies will write a short (1-3 pages) analysis of circuits, using domain specific vocabulary with organization and style appropriate to the purpose. • Students will prepare lab reports on collected data using a standard format with accurate calculations and conclusions. • Students will write a 10% summary of text material using domain-specific vocabulary with a clear, concise, organized focus.		

2.G 2.G.02.02 2.G.02.03	WHST.6-12.10 WHST.9-10.6	Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
Performance Example: Students will maintain an engineering log for all projects, utilizing updated technological resources to produce designs/processes.		
2.I 2.I.02.04	SL.9-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest
Performance Example: Individually or in groups, students will demonstrate understanding of advanced hand tools and equipment by producing a multimedia presentation utilizing domain-specific vocabulary.		

Embedded Mathematics

CVTE Learning Standard Number	Math Content Conceptual Category and Domain Code Learning Standard Number	Text of Mathematics Learning Standard
2.B.03.03	7.RP	Analyze proportional relationships and use them to solve real-world and mathematical problems. 7.RP.b. Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships..
Performance Example: Calculate total parts list cost.		
2.C.01.01	A-CED-1, A-CED.4, A-REI.3	Create equations that describe numbers or relationships A-CED-1. Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic* *functions, and simple rational and exponential functions.(Note: This standard is included because given current and resistance students can write and use OHM's Law to solve for voltage).* A-CED.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm's law V = IR to highlight resistance R.* Solve equations and inequalities in one variable A-REI.3. Solve linear equations and inequalities in one variable,

		including equations with coefficients represented by letters. (see note for A-CED-1)
Performance Example: Using OHM's Law I=V/R calculate voltage when given current and resistance.		
2.C.01.02	A-CED-1, A-CED.4, A-REI.3	Create equations that describe numbers or relationships 1. Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions.(Note: This standard is included because given voltage and resistance students can write and use OHM's Law to solve for current).* A-CED.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm's law V = IR to highlight resistance R.* Solve equations and inequalities in one variable A-REI.3. Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. (see note for A-CED-1)
Performance Example: Using OHM's Law I=V/R calculate current when given voltage and resistance.		
2.C.01.03	A-CED-1, A-CED.4, A-REI.3	Create equations that describe numbers or relationships 1. Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions.(Note: This standard is included because given voltage and current students can write and use OHM's Law to solve for resistance).* A-CED.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm's law V = IR to highlight resistance R.* Solve equations and inequalities in one variable A-REI.3. Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. (see note for A-CED-1)
Performance Example: Using OHM's Law I=V/R calculate resistance when given current and voltage.		
2.C.01.04	A-CED-1, A-CED.4, A-REI.3	Create equations that describe numbers or relationships 1. Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions.(Note: This standard is included because given voltage and current students can write and use Watt's Law to solve for power).* A-CED.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm's law V = IR to highlight resistance R.* Solve equations and inequalities in one variable A-REI.3. Solve linear equations and inequalities in one variable,

		including equations with coefficients represented by letters. (see note for A-CED-1)
Performance Example: Using Watt's Law P=V X I, calculate power when given voltage and current.		
2.C.01.05	7.NS	Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers. 7.NS.1. Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. a. Describe situations in which opposite quantities combine to make 0. *For example, a hydrogen atom has 0 charge because its two constituents are oppositely charged.* b. Understand $p + q$ as the number located a distance $\|q\|$ from p, in the positive or negative direction depending on whether q is positive or negative. Show that a number and its opposite have a sum of 0 (are additive inverses). Interpret sums of rational numbers by describing real-world contexts. c. Understand subtraction of rational numbers as adding the additive inverse, $p - q = p + (-q)$. Show that the distance between two rational numbers on the number line is the absolute value of their difference, and apply this principle in real-world contexts.
Performance Example: Using Kirchhoff's Law $V_T=V_1+V_2+V_3$, calculate total voltage when given individual voltage drops.		
2.D.01.01	F-TF.2,F-TF.5, F.TF.7	Extend the domain of trigonometric functions using the unit circle F-TF.2. Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle. Model periodic phenomena with trigonometric functions F-TF.5. Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline. F-TF.7. (+) Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology, and interpret them in terms of the context.
Performance Example: Calculate RMS, peak, peak-to-peak, and average values of sine wave.		
2.D.01.03	F-TF.2,F-TF.5, F.TF.7	Extend the domain of trigonometric functions using the unit circle F-TF.2. Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle. Model periodic phenomena with trigonometric functions F-TF.5. Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline. F-TF.7. (+) Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology, and interpret them in terms of the context.
Performance Example: Calculate phase shift.		
2.D.01.04	F-TF.2,F-TF.5, F.TF.7	Extend the domain of trigonometric functions using the unit circle F-TF.2. Explain how the unit circle in the coordinate plane enables

		the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle. Model periodic phenomena with trigonometric functions F-TF.5. Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline. F-TF.7. (+) Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology, and interpret them in terms of the context.
Performance Example: Calculate reactance.		
2.D.01.05	F-TF.2,F-TF.5, F.TF.7	Extend the domain of trigonometric functions using the unit circle F-TF.2. Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle. Model periodic phenomena with trigonometric functions F-TF.5. Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline. F-TF.7. (+) Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology, and interpret them in terms of the context.
Performance Example: Calculate impedance.		
2.D.01.06	F-TF.2,F-TF.5, F.TF.7	Extend the domain of trigonometric functions using the unit circle F-TF.2. Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle. Model periodic phenomena with trigonometric functions F-TF.5. Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline. F-TF.7. (+) Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology, and interpret them in terms of the context.
Performance Example: Calculate apparent, true, reactive, power factor.		
2.E.03.01	5.G.1,5.G.2,.5.G.3,.5.G.4, 6.NS.8, N-Q.1, A-REI.10, A-REI.11	Graph points on the coordinate plane to solve real-world and mathematical problems. 5.G.1. Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., *x*-axis and *x*-coordinate, *y*-axis and *y*-coordinate). 5.G.2. Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. Classify two-dimensional figures into categories based on their properties.

		5.G.3. Understand that attributes belonging to a category of two dimensional figures also belong to all subcategories of that category. *For example, all rectangles have four right angles and squares are rectangles, so all squares have four right angles.* 5.G.4. Classify two-dimensional figures in a hierarchy based on properties. Apply and extend previous understandings of numbers to the system of rational numbers. 6.NS.8. Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate. Reason quantitatively and use units to solve problems. N-Q.1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. Represent and solve equations and inequalities graphically A-REI.10. Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line). A-REI.11. Explain why the x-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect are the solutions of the equation $f(x) = g(x)$; find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where $f(x)$ and/or $g(x)$ are linear, polynomial, rational, absolute value, exponential, and logarithmic functions. Interpret functions that arise in applications in terms of the context F-IF.4. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.*
Performance Example: Produce a graph relating voltage and current through a semi-conductor device.		
2.E.03.02	5.G.1,5.G.2,.5.G.3,.5.G.4, 6.NS.8, N-Q.1, A-REI.10, A-REI.11	Graph points on the coordinate plane to solve real-world and mathematical problems. 5.G.1. Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate). 5.G.2. Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. Classify two-dimensional figures into categories based on their properties. 5.G.3. Understand that attributes belonging to a category of two

		dimensional figures also belong to all subcategories of that category. *For example, all rectangles have four right angles and squares are rectangles, so all squares have four right angles.* 5.G.4. Classify two-dimensional figures in a hierarchy based on properties. Apply and extend previous understandings of numbers to the system of rational numbers. 6.NS.8. Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate. Reason quantitatively and use units to solve problems. N-Q.1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. Represent and solve equations and inequalities graphically A-REI.10. Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line). A-REI.11. Explain why the x-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect are the solutions of the equation $f(x) = g(x)$; find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where $f(x)$ and/or $g(x)$ are linear, polynomial, rational, absolute value, exponential, and logarithmic functions. Interpret functions that arise in applications in terms of the context F-IF.4. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.*
Performance Example: Produce a graph relating voltage and current through a semi-conductor device.		
2.E.03.03	5.G.1,5.G.2,.5.G.3,.5.G.4, 6.NS.8, N-Q.1, A-REI.10, A-REI.11	Graph points on the coordinate plane to solve real-world and mathematical problems. 5.G.1. Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate). 5.G.2. Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. Classify two-dimensional figures into categories based on their properties. 5.G.3. Understand that attributes belonging to a category of two dimensional figures also belong to all subcategories of that category.

		For example, all rectangles have four right angles and squares are rectangles, so all squares have four right angles. 5.G.4. Classify two-dimensional figures in a hierarchy based on properties. Apply and extend previous understandings of numbers to the system of rational numbers. 6.NS.8. Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate. Reason quantitatively and use units to solve problems. N-Q.1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. Represent and solve equations and inequalities graphically. A-REI.10. Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line). A-REI.11. Explain why the *x*-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect are the solutions of the equation $f(x) = g(x)$; find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where $f(x)$ and/or $g(x)$ are linear, polynomial, rational, absolute value, exponential, and logarithmic functions. Interpret functions that arise in applications in terms of the context. F-IF.4. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.*
Performance Example: Produce a graph relating voltage and current through a semi-conductor device.		
2.G.01.04	8.EE.1, 8.EE.2, 8.EE.3, 8.EE.4	Work with radicals and integer exponents. 8.EE.1. Know and apply the properties of integer exponents to generate equivalent numerical expressions. *For example, 32 × 3–5 = 3–3 = 1/33 = 1/27.* 8.EE.2. Use square root and cube root symbols to represent solutions to equations of the form $x2 = p$ and $x3 = p$, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that $\sqrt{2}$ is irrational. 8.EE.3. Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. *For example, estimate the population of the United States as 3 × 108 and the population of the world as 7 × 109, and determine that the world population is more than 20 times larger.* 8.EE.4. Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g., use millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology.

Performance Example: Given whole unit values, convert to various metric prefixes and write in both scientific and engineering notation formats.		
2.I.01.05	7.RP.1, 7.RP.2.a, 7.RP.2.b	Analyze proportional relationships and use them to solve real-world and mathematical problems. 1. Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units. *For example, if a person walks 1/2 mile in each 1/4 hour, compute the unit rate as the complex fraction 1/2/1/4 miles per hour, equivalently 2 miles per hour.* 2. Recognize and represent proportional relationships between quantities. a. Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin. b. Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.
Performance Example: Using an oscilloscope, determine the amplitude and frequency as a function of vertical and horizontal calibration settings for each box/gradicule.		
2.I.01.06	7.RP.1, 7.RP.2.a, 7.RP.2.b	Analyze proportional relationships and use them to solve real-world and mathematical problems. 1. Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units. *For example, if a person walks 1/2 mile in each 1/4 hour, compute the unit rate as the complex fraction 1/2/1/4 miles per hour, equivalently 2 miles per hour.* 2. Recognize and represent proportional relationships between quantities. a. Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin. b. Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.
Performance Example: Using a signal generator, set the controls and multiplier switches to produce specific frequencies and amplitudes.		

Embedded Science and Technology/Engineering

Physical Science (Physics)

CVTE Learning Standard Number	Subject Area, Topic Heading and Learning Standard Number	Text of Physics Learning Standard

CVTE Learning Standard Number	Subject Area, Topic Heading and Learning Standard Number	Text of Physics Learning Standard
2.B.01	5. Electromagnetism	5.3 Analyze simple arrangements of electrical components in both series and parallel circuits. Recognize symbols and understand the functions of common circuit elements (battery, connecting wire, switch, fuse, resistance) in a schematic diagram.
Performance Example: Students will be able to understand a schematic representation of a circuit and be able to analyze the circuit based on the symbolic representations.		
2.C.01 2.C.02	5. Electromagnetism	5.2 Develop qualitative and quantitative understandings of current, voltage, resistance, and the connections among them (Ohm's law). 5.3 Analyze simple arrangements of electrical components in both series and parallel circuits. Recognize symbols and understand the functions of common circuit elements (battery, connecting wire, switch, fuse, resistance) in a schematic diagram. 5.5 Explain how electric current is a flow of charge caused by a potential difference (voltage), and how power is equal to current multiplied by voltage.
Performance Example: Students will be able to analyze DC circuits and calculate values for voltage, current, and resistance using Ohm's law. Students will also be able to understand the way current and voltage combine to calculate power.		
2.D.01.01 2.D.01.02 2.D.02.01 2.D.02.02	4. Waves	4.1 Describe the measurable properties of waves (velocity, frequency, wavelength, amplitude, period) and explain the relationships among them. Recognize examples of simple harmonic motion.
Performance Example: Students will be tasked with determining the basic properties of a periodic waveform such as a pendulum or simple sound wave through both measurement and calculation.		

2.G.03	5. Electromagnetism	5.6 Recognize that moving electric charges produce magnetic forces and moving magnets produce electric forces. Recognize that the interplay of electric and magnetic forces is the basis for electric motors, generators, and other technologies.
Performance Example: Students will construct a simple motor and be able to explain the role that electric current has in producing the magnetic field and the hazards involved with motor heating. Students will operate a stepper motor and be able to compare the design of a simple electric motor with a stepper motor.		

Technology/Engineering

CVTE Learning Standard Number	**Subject Area, Topic Heading and Learning Standard Number**	**Text of Technology/Engineering Learning Standard**
CVTE Learning Standard Number	Subject Area, Topic Heading and Learning Standard Number	Text of Technology/Engineering Learning Standard
2.B.02.01	2. Engineering Design	2.2 Demonstrate methods of representing solutions to a design problem, e.g., sketches, orthographic projections, multi-view drawings.
Performance Example: Students will be tasked with creating a phone charger for the car which converts 12V DC to 5V DC,; the student will be able to represent their solution using a schematic diagram of the circuit.		
2.B.03	2. Engineering Design	2.4 Identify appropriate materials, tools, and machines needed to construct a prototype of a given engineering design.
Performance Example: When a student is given a schematic diagram of a circuit, the student will be able to determine the best materials for the circuit considering factors such as cost, availability, component reliability, and ease of operation/manufacture. Students will create a list of parts necessary to create the circuit.		
2.G.01 2.G.02	2. Engineering Design	2.1 Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign
Performance Example: Students will be able to use the engineering design process to analyze a problem, consider possible solutions, and create a design solution. Students will also maintain a journal documenting the steps of their process.		
2.B.05.02 2.I.02.03	1. Materials, Tools, and Machines	1.3 Identify and explain the safe and proper use of measuring tools, hand tools, and machines (e.g., band saw, drill press, sander, hammer, screwdriver, pliers, tape measure, screws, nails, and other mechanical fasteners) needed to construct a prototype of an engineering design.
Performance Example: Students will be able to safely operate the tools needed to create and test simple electronic circuits that occur in creating prototypes of devices, such as soldering electrical connections on LEDs.		

2.B.02 2.B.03	1. Engineering Design	1.1 Identify and explain the steps of the engineering design process: identify the problem, research the problem, develop possible solutions, select the best possible solution(s), construct prototypes and/or models, test and evaluate, communicate the solutions, and redesign. 1.5 Interpret plans, diagrams, and working drawings in the construction of prototypes or models.
Performance Example: When a student is tasked with designing a power supply or amplifier circuit, the student will be able to create an optimal design after considering many possible solutions. The students will determine the best materials for the circuit considering factors such as cost, availability, component reliability, and ease of operation/manufacture. Students will create a list of parts necessary to create the circuit and determine overall cost.		
2.C.01 2.I.01	5. Energy and Power Technologies—Electrical Systems	5.1 Explain how to measure and calculate voltage, current, resistance, and power consumption in a series circuit and in a parallel circuit. Identify the instruments used to measure voltage, current, power consumption, and resistance. 5.3 Explain the relationships among voltage, current, and resistance in a simple circuit, using Ohm's law.
Performance Example: When given a multimeter and a simple light bulb and battery circuit, students will be able to determine the power consumption of the light bulb by measuring the light bulb and battery's characteristics.		
2.C 2.D	5. Energy and Power Technologies—Electrical Systems	5.5 Compare and contrast alternating current (AC) and direct current (DC), and give examples of each.
Performance Example: Students will operate the same light bulb with AC and DC current and be able to describe and give an explanation of the difference in illumination.		
2.D.02	5. Energy and Power Technologies—Electrical Systems	5.1 Explain how to measure and calculate voltage, current, resistance, and power consumption in a series circuit and in a parallel circuit. Identify the instruments used to measure voltage, current, power consumption, and resistance.
Performance Example: Students will be able to observe an AC wave on an oscilloscope and be able to perform measurements to describe the wave.		
2.G	1. Engineering Design	1.1 Identify and explain the steps of the engineering design process: identify the problem, research the problem, develop possible solutions, select the best possible solution(s), construct prototypes and/or models, test and evaluate, communicate the solutions, and redesign. 1.2 Understand that the engineering design process is used in the solution of problems and the advancement of society. Identify examples of technologies, objects, and processes that have been modified to advance society, and explain why and how they were modified. 1.3 Produce and analyze multi-view drawings (orthographic projections) and pictorial drawings (isometric, oblique, perspective), using various techniques.

Performance Example: Students will be tasked with creating a phone charger for the car which converts 12V DC to 5V DC. Students will use the engineering design process to consider possible solutions, create schematic drawings of the solutions, and select the optimal design. Students will thoroughly document their process using engineering logs/journals.		
2.I.02.03	2. Construction Technologies	2.5 Identify and demonstrate the safe and proper use of common hand tools, power tools, and measurement devices used in construction
Performance Example: Students will be able to identify and safely operate the tools needed to create and test simple electronic circuits that occur in creating prototypes of devices, such as soldering electrical connections on LEDs.		

DESE Statewide Articulation Agreements

No Statewide Articulation Agreements at this time.

Industry Recognized Credentials (Licenses and Certifications/Specialty Programs)

ETA (Electronic Technicians Association)
- Student Electronics Technician
- Associate Level Technician

ISCET (International Society of Certified Electronic Technicians)
- Associate Certified Electronics Technician

Other

Reference Materials

Introductory DC/AC Electronics, 6th Edition; by Nigel P. Cook

Digital Electronics a Practical Approach, 8th Edition; by William Kleitz

Electronics Principles and Applications, 7th Edition; by Charles Schuler

Electric Circuit Fundamentals, 7th Edition; by Thomas Floyd

Digital Fundamentals, 10th Edition; by Thomas Floyd

Electronic Principles, 7th Edition; by Albert Malvino

ETA-I competency lists

Related National, Regional, and State Professional Organizations

- ETA
- ISCET
- Institute of Electrical and Electronic Engineers

Student Organizations

- Skills USA www.maskillsusa.org

Selected Websites

- www.ieee.org
- www.iscet.org
- www.eta-i.org