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

Robotics and Automation Technology (VROBO)

CIP Code 150403

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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 Robotics and Automation Technology Safety Health and Skills

2.A.01 Obtain OSHA 10 Hour General Certification.

- 2.A.01.01 Implement safety knowledge obtained on a continuous basis.
- 2.A.01.02 Identify safety hazards in the shop, remove hazards and develop continuous improvement solutions.
- 2.A.01.03 Implement a tag-out and lock-out shop procedure.

2.A.01 Performance Example:

- Student will obtain an OSHA 10-hour general industry certificate.

2.A.02 Read and implement shop safety manual.

- 2.A.02.01 Demonstrate safety procedure(s) for maintaining machinery and equipment.
- 2.A.02.02 Demonstrate safety procedure(s) for operating machinery and equipment.

2.B Tools & Instrumentation

2.B.01 Demonstrate the use of tools, fasteners, and equipment.

- 2.B.01.01 Demonstrate and explain the use of threaded fasteners.
- 2.B.01.02 Demonstrate and explain the use of non-threaded fasteners.
- 2.B.01.03 Demonstrate and explain the use and types of anchors.
- 2.B.01.04 Install fasteners and anchors.
- 2.B.01.05 Demonstrate operation of power and power actuated tools according to current industry and OSHA standards and manufacturers' specifications.

2.B.01 Performance Example:

- Drill and tap at least 3 different size holes into a material and tap the holes using appropriate size tap. Use common size holes. (8-32, 10-32, ¼-20)

2.B.02 Use electrical test equipment.

- 2.B.02.01 Perform measurement of current using the ammeter / clamp-on.
- 2.B.02.02 Perform measurement of voltage using the voltmeter.
- 2.B.02.03 Perform measurement of resistance using the ohmmeter.
- 2.B.02.04 Measure circuit properties using the volt-ohm-multimeter (VOM).

2.B.02 Performance Example:

- Design a simple electrical circuit and measure ohms, volts and amperage using DVM.

2.B.03 Use electronic hand tools and equipment.

- 2.B.03.01 Identify and apply standard methods of attaching and making electrical connections; i.e. soldering, crimping, wire nuts and lugs.
- 2.B.03.02 Solder and de-solder electronic components.
- 2.B.03.03 Select and use basic hand tools and equipment used for electronic circuits including needle nose pliers, nut drivers, screwdrivers, wire cutters, wire strippers, and torque drivers.
- 2.B.03.04 Use advanced hand tools and equipment for assembling electronics circuits such as a Greenlee punch, taps and dies, hand drills, drill presses, and tools and riveters.

2.B.03 Performance Example:

- Design and build a simple electrical circuit consisting of stripped wires and soldered connections. Solder and de-solder and use all hand tools as needed.

2.B.04 Use measurement devices.

- 2.B.04.01 Identify and utilize both English and International (SI) measurement systems.
- 2.B.04.02 Define attributes, units, and systems of measurement used in Mechanical Engineering Technology (MET) fields.
- 2.B.04.03 Apply a variety of techniques, tools and formulas for determining measurements.
- 2.B.04.04 Identify appropriate electronic device/gauge for specific tasks.
- 2.B.04.05 Calibrate and use electronic devices and/or gauges accurately.

2.B.04 Performance Example:

- Measure a part using a 6 inch scale, micrometer and verniers.

2.C Engineering Design Process

2.C.01 Explain and demonstrate knowledge of the design process.

- 2.C.01.01 Identify the components of the design process.
- 2.C.01.02 Articulate the steps of the design process.
- 2.C.01.03 Use the design process to identify the problem(s) to be solved and evaluate the solutions to be tried.

2.C.01 Performance Example:

- Research different layout designs for the Design Process and explain the similarities and differences between them.
- Discuss and develop preliminary criteria that relate to the problem.

2.C.02 Create The Problem Statement.

- 2.C.02.01 Identify and define the problem in a written format.
- 2.C.02.02 Identify potential solutions through brainstorming.

2.C.02 Performance Example:

- Discuss and document as much as you can prior to doing research into a given problem.
- Write a Problem Statement to match the problem.

2.C.03 Research the related areas.

- 2.C.03.01 Identify the major areas to be researched.
- 2.C.03.02 Do background research into the problem.
- 2.C.03.03 Identify resources needed (supplies, personnel, equipment).

2.C.03 Performance Example:

- Determine the research needed, the process to be used, and then document the process and the finding from the research work done.
- Read and fully cite the relevant information that pertains to the problem.
- Present to peers a Problem Statement Review with background research represented and document the groups questions as additional research needed, i.e.: reiterative process.

2.C.04 Build and test a prototype; document the solution.

- 2.C.04.01 Develop solutions using a structured problem solving process.
- 2.C.04.02 Identify the components and process of the system.
- 2.C.04.03 Build a prototype or model.
- 2.C.04.04 Test product to verify that it meets customer specifications, regulations, etc.
- 2.C.04.05 Use appropriate testing equipment and tools for diagnosing the problem.
- 2.C.04.06 Document the solution; write a report.

2.C.04 Performance Example:
- Present a Design Review with all solutions represented to peers and document the group's questions for further consideration, i.e.: reiterative process.
- Develop and use a Decision Matrix based on relevant criteria to choose a final design solution.
- Present a Final Design Review with all background research represented and documented testing procedures and data to peers.

2.D Technical Communications

2.D.01 Develop working knowledge of various types of written technical communications.

2.D.01.01 Read and interpret technical reports, trade journals, machine manuals, Safety Protocols (SDS) and web sources.

2.D.01.02 Generate a technical report.

2.D.01 Performance Example:
- Write an abstract based on a technical document.
- Present a technical review based on a technical document.
- Participate in an on-line chat or a Blog site about a technical topic. Summarize your findings.

2.D.02 Demonstrate visual communications within the Electrical and Electronics fields.

2.D.02.01 Identify, read, and interpret electrical schematics and block diagrams.

2.D.02.02 Identify the schematic symbols and wiring diagrams for the major international standards: IEEE, International Organization for Standardization (ISO), American National Standards Institute (ANSI), etc.

2.D.02 Performance Example:
- Look-up and review different type of electrical & electronic schematics symbols and match them to the actual component.
- Research the different International Organizations that have different electrical and electronic symbols.

2.D.03 Demonstrate visual communications within the process control systems and/or programming.

2.D.03.01 Identify and interpret the standard flow charts symbols for the major international standards: IEEE, International Organization for Standardization (ISO), American National Standards Institute (ANSI), etc.

2.D.03.02 Read and interpret process control flow charts.

2.D.03.03 Identify and use appropriate symbols to develop a process diagram of a given process.

2.D.03 Performance Example:
- Research and report on the different International Organizations that have different flow chart symbols.
- Identify and follow a process using a flow chart for a given system.
- Develop a flow for an Automated Work Cell and use it to explain the job function(s).

2.D.04 Hand sketch drawings.

2.D.04.01 Define, and describe orthographic projections.

2.D.04.02 Produce fully annotated orthographic projections of a part.

2.D.04.03 Produce a free hand drawing of a mechanical component.

2.D.04.04 Produce sketches by integrating sketching techniques and styles.

2.D.04.05 Select and produce the appropriate pictorial style to best communicate solutions in the design process.

2.D.04 Performance Example:
- Generate orthographic hand sketches of different 3D object and fully denote all relevant dimensions
- Generate pictorial hand sketches of different 3D object to show part orientation.

2.D.05 Demonstrate basic use of a CAD system.

2.D.05.01 Create 2D-Orthographical drawings and pictorial drawings from CAD software.

2.D.05.02 Read and interpret detail blue prints or technical processes.

2.D.05.03 Define various geometric shapes and relationships and use appropriate geometry tools to draw basic shapes.

2.D.05.04 Distinguish among and define geometric constraints.

2.D.05.05 Identify and use the following geometric constraints in given three-dimensional models: horizontal, vertical, parallel, perpendicular, tangent, concentric, collinear, coincident, and equal.

2.D.05.06 Use the appropriate form of the Cartesian coordinate system to measure and plot a model.

2.D.05 Performance Example:
- Using a CAD design package, generate fully annotated orthographic drawing of different 3D object and show all relevant dimensions
- Using a CAD design package, generate pictorial drawing of different 3D object.
- Generate shop drawing to be used to produce the part.

2.E Mechanical Concepts

2.E.01 Design and build a mechanical transfer system.

2.E.01.01 Identify and describe all six simple machines (SM).

2.E.01.02 Develop working knowledge for the terms: Ideal Mechanical Advantage (IMA), Actual Mechanical Advantage (AMA), Power & Power Transfer, Efficiency, Compound Machine, Work In-put and Work Out-put.

2.E.01.03 Define each of the SM and give examples of their uses.

2.E.01.04 Build and demonstrate a SM.

2.E.01.05 Calculate the IMA & AMA for the different SM.

2.E.01.06 Design, build and operate a Compound Machine.

2.E.01.07 Identify the role that friction plays in SM operation.

2.E.01 Performance Example:
- Build a simple machine that turns rotary motion into linear motion.

2.E.02 Design and build a hydraulic system.

2.E.02.01 Identify and apply all safety protocols for hydraulic systems.

2.E.02.02 Identify the parts of a typical hydraulic cylinder and their designated uses.

2.E.02.03 Identify the various types of hydraulic pumps and their designated uses.

2.E.02.04 Identify the various types of hydraulic accumulators and their designated uses.

2.E.02.05 Identify the various types of actuators and their designated uses.

2.E.02.06 Identify the various types of hydraulic motors and their designated uses.

2.E.02.07 Identify the schematic symbol for each part of a hydraulic system.

2.E.02.08 Identify the operation of relief valves, pressure compensated flow control valves, check valves, directional control valves and servo control valves as used in a hydraulic system.

2.E.02.09 Design and build (or simulate) and operate a hydraulic system.

2.E.02 Performance Example:
- Design a simple hydraulic diagram for the operation of a dump truck bed.

2.E.03 Design and build a pneumatic system.
- 2.E.03.01 Identify and apply all safety protocols for pneumatic systems.
- 2.E.03.02 Identify the most commonly used components (including gases) used in a pneumatic system.
- 2.E.03.03 Identify the various types of compressors and their designated uses/operations.
- 2.E.03.04 Identify and describe the operation of desiccant dryers, receiver tanks, pressure switches and pressure regulators as used in a pneumatic system.
- 2.E.03.05 Identify the schematic symbols for compressors, safety release valves, single action spring return cylinders, after coolers, receivers, dryers, pilot regulators, slave regulators, exhaust center directional control valves, pressure center directional control valves, lubricators, filters and blocked center directional control valves as used in a pneumatic system.

2.E.03 Performance Example:
- Design and build a pneumatic system that can clamp a part using a single actuator controlled by a manual valve.

2.E.04 Identify and describe basic machine operations.
- 2.E.04.01 Identify and describe the use of a vertical mill.
- 2.E.04.02 Identify and describe the use of a lathe.
- 2.E.04.03 Identify and describe the use of power tools.

2.E.04 Performance Example:
- Explain how a machined part for a piece of equipment is made, show examples for milling and turning, and cutting.

2.F Electrical Concepts

2.F.01 Describe electrical current and electron theory.
- 2.F.01.01 Label the parts of an atom.
- 2.F.01.02 Explain the differences between an insulator and conductor.
- 2.F.01.03 Explain the difference between “Conventional Current Flow” and “Electron Flow” theories.
- 2.F.01.04 Describe the difference between direct and alternating current.
- 2.F.01.05 Describe the difference between analog and digital signals.

2.F.01 Performance Example:
- Explain the difference between
  - “Conventional and Electron “ Current Flow
  - AC and DC Electricity
  - Analog and Digital signals

2.F.02 Demonstrate knowledge of basic electronic components.
- 2.F.02.01 Identify switches and explain their functions (NO, NC, SPST, SPDT, DPST, DPDT, Multi-selector).
- 2.F.02.02 Identify and explain the function of resistors and potentiometers.
- 2.F.02.03 Identify resistors using the color code.
- 2.F.02.04 Identify and explain the function of capacitors.

2.F.02.05 Identify and explain the function of inductors and transformers.
2.F.02.06 Identify and explain the function of diodes.
2.F.02.07 Identify and explain the function of transistors (BJTs and FETs).
2.F.02.08 Identify and explain the function of LEDs and lamps.

2.F.02 Performance Example:
- Given a set of electronic components, identify each and briefly describe their function and application

2.F.03 Build, simulate and test basic electric circuits.
- 2.F.03.01 Construct a series circuit and investigate Ohm's Law.
- 2.F.03.02 In a series circuit, measure voltage and current at various points in the circuit.
- 2.F.03.03 In a series circuit, investigate Kirchoff's Voltage Law by measuring voltages.
- 2.F.03.04 Construct a parallel circuit and describe its relation to Ohm's Law.
- 2.F.03.05 In a parallel circuit, measure voltage and current at various points in the circuit.
- 2.F.03.06 In a parallel circuit, investigate Kirchoff's Current Law by measuring currents.
- 2.F.03.07 Construct a series-parallel circuit and describe its relation to Ohm's Law.
- 2.F.03.08 In a series-parallel circuit, measure voltage and current at various points in the circuit.
- 2.F.03.09 Calculate power dissipated using Watt's Law.
- 2.F.03.10 Identify and interpret relay wiring diagrams.
- 2.F.03.11 Identify and interpret ladder logic diagrams.

2.F.03 Performance Example:
- Given and electric circuit and measuring devices, determine voltage, current, resistance and power consumption at various points in the circuit

2.F.04 Test, use, and calculate magnetic devices.
- 2.F.04.01 Identify and explain magnetic principles and theorems.
- 2.F.04.02 Determine the effect of turns on an electromagnet.
- 2.F.04.03 Determine the effect of wire diameter on an electromagnet.
- 2.F.04.04 Determine the effect of current on an electromagnet.
- 2.F.04.05 Test and use a relay.
- 2.F.04.06 Describe, calculate, simulate and measure transformer characteristics including turns ratio, voltage, current, power and efficiency.

2.F.04 Performance Example:
- Explain the operation of and use a transformer in a circuit.

2.F.05 Explain the scientific principles of and use AC circuits.
- 2.F.05.01 Calculate RMS, Peak, Peak to Peak, and average values of a periodic waveform.
- 2.F.05.02 Calculate frequency, period and duty cycle of a periodic waveform.

2.F.05 Performance Example:
- Measure the period, peak value and peak to peak value of a sine wave with an oscilloscope.

2.F.06 Design, build and test electronic circuits using diodes and transistors.
- 2.F.06.01 Explain how a PN junction works.

2.F.06.02 Design, simulate, build, and test a half wave rectifier.
2.F.06.03 Design, simulate, build, and test a full wave rectifier.
2.F.06.04 Design, simulate, build and test a transistor as a switch.
2.F.06.05 Explain transistor bias point and how it relates to cutoff and saturation.

2.F.06 Performance Example:
- Design, build and test a full wave rectifier.

2.F.07 Explain the principles and characteristics of different types of electric motors.
- 2.F.07.01 Name and explain the function of the main parts of a DC motor – field, armature, brushes, commutator.
- 2.F.07.02 Explain the operation of DC motors, both self-excited and separately excited.
- 2.F.07.03 Explain the performance characteristics of series wound, shunt wound, and compound wound of DC motors.
- 2.F.07.04 Name and explain the function of the main parts of an AC motor, both rotor and stator (squirrel cage).
- 2.F.07.05 Differentiate between both induction and synchronous AC motors.
- 2.F.07.06 Explain the concept of three phase motors.

2.F.07 Performance Example:
- Disassemble and explain the parts of an electric motor.

2.F.08 Explain the basics of electric power transmission and distribution.
- 2.F.08.01 Explain the basics of power generation.
- 2.F.08.02 Explain the basics of three phase power.
- 2.F.08.03 Explain the basics of power transmission.
- 2.F.08.04 Explain the various high voltage values used in transmission.
- 2.F.08.05 Explain the various voltage values used in local distribution.
- 2.F.08.06 Explain the local distribution of power.

2.F.08 Performance Example:
- Explain the generation and distribution of electrical power.

2.F.09 Explain, design, simulate, and build combinational digital logic circuits.
- 2.F.09.01 Find and read specification sheets for various ICs.
- 2.F.09.02 Explain the basic gates AND, OR, INVERT, NAND, NOR, XOR.
- 2.F.09.03 State and use truth tables for the basic gates.
- 2.F.09.04 Create a truth table from a given word problem.
- 2.F.09.05 Create Sum of Products (SOP) Boolean expressions from a given truth table.
- 2.F.09.06 Simulate the logic diagram.
- 2.F.09.07 Build and test the logic diagram.
- 2.F.09.08 Troubleshoot the circuit.
- 2.F.09.09 Convert the SOP circuit to NAND gates.
- 2.F.09.10 Convert the SOP circuit to NOR gates.
- 2.F.09.11 Use DeMorgan's Laws to convert and build an alternative implementation of a circuit.
- 2.F.09.12 Design circuits using reprogrammable logic devices.

2.F.09 Performance Example:
- Design, build, test, troubleshoot and analyze a Combinational Logic Circuit.

2.F.10 Explain, design, simulate, and build sequential digital logic circuits.
- 2.F.10.01 Create timing diagrams and truth tables for D flip-flops and JK flip-flops.

2.F.10.02 Design, simulate and build up/down asynchronous and synchronous counters using D/JK flip-flops.
2.F.10.03 Build similar circuits using MSI circuits.

2.F.10 Performance Example:
- Design, build, test, troubleshoot and analyze a Sequential Logic Circuit.

2.F.11 Use and convert integers within the given number systems.
2.F.11.01 Perform conversions from decimal to binary and from binary to decimal.
2.F.11.02 Perform conversions from decimal to hex and from hex to decimal.
2.F.11.03 Perform conversions from binary to hex and from hex to binary.

2.F.11 Performance Example:
- Convert numbers between the three number systems and explain where each would be used.

2.G Fundamentals of Sensor Technologies

2.G.01 Explain the characteristics and operation of position sensors.
2.G.01.01 Describe the operation and use of a potentiometer to measure mechanical movement in a control system.
2.G.01.02 Design and build a circuit used to demonstrate the use of a potentiometer to measure mechanical movement in a control system.
2.G.01.03 Describe the operation and use of absolute and incremental optical rotary encoders.
2.G.01.04 Design and build a circuit using absolute and incremental optical rotary encoders.

2.G.01 Performance Example:
- Students will draw schematic symbols of potentiometers, describe their operation, and give examples of their use in mechanical systems used to measure mechanical movement. Students will also describe the use of incremental and absolute encoders used to measure mechanical movement.

2.G.02 Explain the characteristics and operation of velocity sensors.
2.G.02.01 Describe the operation and use of optical tachometers.
2.G.02.02 Design and build a circuit used to demonstrate the operation of optical tachometers.
2.G.02.03 Describe the operation and use of direct current transformers.
2.G.02.04 Design and build a circuit used to demonstrate the operation of direct current tachometers.

2.G.02 Performance Example:
- Students will design, build, and test a circuit using a velocity sensor.

2.G.03 Explain the characteristics and operation of proximity sensors.
2.G.03.01 Describe the operation and use of a mechanical limit switch in a control system.
2.G.03.02 Describe the operation, use of, and modes of operations for optical proximity sensors, including photo resistors, photodiodes, phototransistors and photovoltaic cells.
2.G.03.03 Describe the operation and use of ultrasonic proximity sensors in a control system.
2.G.03.04 Describe the operation and use of inductive and capacitive proximity sensors.
2.G.03.05 Describe the operation and use of hall-effect proximity sensors.

2.G.03.06 Design and build a circuit using one or more of the above proximity sensors.

2.G.03 Performance Example:
- Students will design, build and test a circuit using any type of proximity sensor.

2.G.04 Explain the characteristics and operation of load and force sensors.
- 2.G.04.01 Describe the operation and the use of strain gauges in a control system.
- 2.G.04.02 Design and build a circuit used to demonstrate the use of a strain gauge in a control system.

2.G.04 Performance Example:
- Students will design, build and test a circuit using a strain gauge.

2.G.05 Explain the characteristics and operation of pressure sensors.
- 2.G.05.01 Describe the operation and use of a pressure sensor in a control system.
- 2.G.05.02 Design and build a circuit used to demonstrate the use of a pressure sensor in a control system.

2.G.05 Performance Example:
- Students will design, build and test a circuit using a pressure sensor.

2.G.06 Explain the characteristics and operation of temperature sensors.
- 2.G.06.01 Describe the operation and use of a RTD in a temperature control system.
- 2.G.06.02 Design and build a circuit used to demonstrate the operation and use of a RTD (Resistor Temperature Device) in a temperature control system.
- 2.G.06.03 Describe the operation and use of a thermistor in a temperature control system.
- 2.G.06.04 Design and build a circuit used to demonstrate the operation and use of a thermistor in a temperature control system.
- 2.G.06.05 Describe the operation and use of a thermocouple in a temperature control system.
- 2.G.06.06 Design and build a circuit used to demonstrate the operation and use of a thermocouple in a temperature control system.
- 2.G.06.07 Describe the operation and use of an integrated-circuit temperature sensor in a temperature control system.
- 2.G.06.08 Design and build a circuit used to demonstrate the operation and use of an integrated-circuit sensor in a temperature control system.

2.G.06 Performance Example:
- Students will design, build and test a circuit using a temperature sensor.

2.H Programmable Logic Controller Foundations and Programming Concepts

2.H.01 Name and explain the basic building blocks of a programmable logic controller (PLC).
- 2.H.01.01 Identify the major advantages in the use of PLCs in automation.
- 2.H.01.02 Identify the major components of a PLC.
- 2.H.01.03 Define fixed and modular PLCs and give advantages of both types.
- 2.H.01.04 Identify the various programming devices used to program a PLC.
- 2.H.01.05 Explain the various modes of operations of a PLC.
- 2.H.01.06 Identify the criteria used in categorizing PLCs including functionality, number of inputs and outputs, cost, and physical size.

2.H.01 Performance Example:
- Students will develop a schematic diagram of a typical PLC system and identify all components and describe their function.

2.H.02 Identify and explain PLC hardware components.

2.H.02.01 Identify the input/output (I/O) section of a PLC and field device connections.
2.H.02.02 Describe PLC I/O addressing formats.
2.H.02.03 Describe the specifications, use and operation of Discrete I/O modules.
2.H.02.04 Describe the specifications, use and operation of Analog I/O modules.
2.H.02.05 Describe the specifications, use and operation of Specialty I/O modules.
2.H.02.06 Identify the Central Processing Unit (CPU) of a PLC.
2.H.02.07 Identify the power supply of a PLC and its specifications.
2.H.02.08 Identify PLC memory types and designs.
2.H.02.09 Describe the various Terminal Programming Devices used to program PLCs.
2.H.02.10 Explain Human Machine Interfaces (HMI's) and their applications.

2.H.02 Performance Example:
- Students will develop a schematic diagram of typical Input and Output configurations and correctly address using the specific manufacture's addressing formats.

2.H.03 Demonstrate an understanding of the fundamentals of PLC Logic.

2.H.03.01 Explain the Binary Concept and its use in PLC applications.
2.H.03.02 Explain the basic digital gate functions, AND, OR, INVERTER, and their applications in PLC logic.
2.H.03.03 Identify the role of Boolean algebra and its application in PLC logic simplification.
2.H.03.04 Develop equivalent PLC logic from Logic Gate Circuits derived from Boolean Expressions.
2.H.03.05 Develop equivalent PLC logic from Boolean Expressions derived from Logic Gate Circuits.

2.H.03 Performance Example:
- Students will develop simple PLC logic programs to replicate digital gate functions, i.e. AND, OR, and INVERTER functions. Students will further develop PLC logic programs derived from Boolean Expressions and Logic Gate Circuits.

2.H.04 Demonstrate an understanding of the fundamentals of PLC programs and PLC wiring diagrams.

2.H.04.01 Explain the role of electromagnetic relays and their role in PLC programming and PLC wiring diagrams.
2.H.04.02 Explain the NO and NC contacts and develop equivalent PLC programming and PLC wiring diagrams.
2.H.04.03 Develop PLC programming and PLC wiring diagrams using motor starters and contactors.
2.H.04.04 Develop PLC programming and PLC wiring diagrams using manually operated switches.
2.H.04.05 Develop PLC programming and PLC wiring diagrams using various sensors.
2.H.04.06 Develop PLC programming and PLC wiring diagrams from electromagnetic relay logic.
2.H.04.07 Develop PLC programming and PLC wiring diagrams directly from a narrative description.

2.H.04.08 Develop PLC programs using various delay and retentive timers.
2.H.04.09 Develop various PLC programs using various counters.
2.H.04.10 Develop PLC programs using Program Control Instructions, Master Control Reset, Jump, and Subroutines.
2.H.04.11 Develop PLC programs using Data Manipulation and Data Compare Instructions.
2.H.04.12 Develop PLC programs using basic Math Functions.
2.H.04.13 Develop PLC programs using Sequencer and Shift Register Instructions.
2.H.04.14 Develop PLC programs using programming blocks for analog inputs and outputs and PID (Proportional Integral Derivative) control.
2.H.04.15 Develop HMI (Human Machine Interface) programs to allow the user to view the PLC operation in real time, change timer or counter values and replace hardwired input and output devices.

2.H.04 Performance Example:
- Students will wire Inputs and Output devices to a PLC system. Students will develop PLC logic programs from a narrative description using timer, counter and advanced ladder programming instructions to automate a system. System may include the use of a Human Machine Interface HMI) device to complete the given task.

2.I Robotics Technology

2.I.01 Name and explain the basic building blocks and critical specifications of an industrial robot.
2.I.01.01 Identify classification by arm geometry.
2.I.01.02 Define the following robot terms: degrees of freedom, position axes, orientation axes, work envelope, tool center point.
2.I.01.03 Define and give an example of the following specifications for industrial robots: payload, repeatability, memory capacity, and environmental requirements.
2.I.01.04 Identify the various actuators used by a typical industrial robotic arm.
2.I.01.05 Identify the various drive mechanisms used by a typical industrial robotic arm.
2.I.01.06 Identify the various controllers used by a typical industrial robot.
2.I.01.07 Identify the various power sources used by a typical industrial robot.
2.I.01.08 Describe various end-of-arm tooling used by an industrial robot.
2.I.01.09 Identify various teaching and programming devices used to accurately program an industrial robot.
2.I.01.10 Describe various data storage devices used by a typical industrial robot.

2.I.01 Performance Example:
- Students will draw and label the basic building blocks of an industrial robot using the appropriate robotic terminology. Drawings will include examples of degrees of freedom, work envelope, position axes, actuators, drive mechanisms, controllers, power sources, and end of arm tooling.

2.I.02 Explain industrial robot characteristics and classifications.
2.I.02.01 Describe open-loop and close-loop control systems.
2.I.02.02 Identify an industrial robot's classification.
2.I.02.03 Describe the various arm geometries employed in industrial robots.
2.I.02.04 Describe the various power sources used by industrial robots.
2.I.02.05 Explain the various path control techniques used by industrial robots.

2.I.02 Performance Example:
- Students will draw and label electrical diagrams showing open-loop and close-loop industrial robot systems.

2.I.03 Explain the use of industrial robot work-cell sensors.
- 2.I.03.01 Describe the operation and use of simple contact sensors.
- 2.I.03.02 Describe the operation and use of simple noncontact sensors.
- 2.I.03.03 Describe the operation and use of process control sensors.

2.I.03 Performance Example:
- Students will develop and test simple industrial robot programs designed to show the operation of contact and noncontact sensors used with industrial robots.

2.I.04 Explain various end-of-arm tooling with industrial robots.
- 2.I.04.01 Define given tooling terms.
- 2.I.04.02 Identify various tooling power sources.
- 2.I.04.03 Identify various grippers: standard, servo, nonservo, vacuum, and magnetic.

2.I.04 Performance Example:
- Students will develop and test simple industrial robot programs designed to show the use of various end-of-arm tooling used with industrial robots.

2.I.05 Explain robot teaching and programming techniques.
- 2.I.05.01 Identify the complexities of work-cell programming.
- 2.I.05.02 Identify the functions of the controller used.
- 2.I.05.03 Explain on-line programming, methods used to and how it is accomplished.
- 2.I.05.04 Explain off-line programming, methods used to and how it is accomplished.

2.I.05 Performance Example:
- Students will develop and test a fully automated industrial robot program designed to operate a close-loop industrial robot system derived from a narrative description or system design specifications.

2.I.06 Build and program a mobile robot.
- 2.I.06.01 Assemble and build a mobile robot.
- 2.I.06.02 Create and load code to operate the mobile robot.
- 2.I.06.03 Control the robot using a remote control unit.
- 2.I.06.04 Control the robot; move forward, backward, turn and use different power levels in autonomous mode.
- 2.I.06.05 Use sensors to detect external conditions and to control the robot's operation.
- 2.I.06.06 Use loops and conditional statements in the program.

2.I.06 Performance Example:
- Students will design, build, program and test a mobile robotic system.

2.J Automated Systems

2.J.01 Design, simulate, build, or research at least two of the following industrial systems.
- 2.J.01.01 Motor Control application.
- 2.J.01.02 Punch press application.
- 2.J.01.03 Clamp and drill routine.
- 2.J.01.04 Injection molding machine.
- 2.J.01.05 Robot gripper and control routine.
- 2.J.01.06 Palletizing routine.

2.J.01.07 Batch Process routine.
2.J.01.08 Sorting process.
2.J.01.09 Mobile robot application.
2.J.01.10 Robotic work station.

2.J.01 Performance Example:
- Research and design a power point presentation to explain at least (2) of automation systems given.

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.C.02.01	W.2 Grade 9 - 12 (a, d, e) L.1 Grade 9 – 12 L.2 Grade 9 - 12	Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content • Introduce the topic; organize complex ideas, concepts, and information to make important connections and distinctions • Use precise language and domain-specific vocabulary to manage the complexity of the topic • Establish and maintain a formal style and objective tone while attend to the norms and conventions of the discipline in which they are writing Demonstrate command of the conventions of standard English grammar and usage when writing Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing
Performance Example: • Write a report that defines the design problem.		
2.C.04.06	W.1 Grade 9 – 12 (a, c, d, e) L.1 Grade 9 – 12 L.2 Grade 9 - 12	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant sand sufficient evidence. Introduce precise claims Use words, phrases and clauses to link major sections of the text Establish and maintain a formal style and objective tone Provide a concluding statement or section that follows from and supports the argument presented Demonstrate command of the conventions of standard English grammar and usage when writing Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing
Performance Example: • Write a report that documents the solution(s) to the design problem.		
2.D.01.02	W.7 Grade 9 – 12 W.2 Grade 9 – 12 (a, b,d,e) L.1 Grade 9 – 12 L.2 Grade 9 - 12	Conduct short as well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. Write informative/explanatory texts to examine and convey complex ideas, concepts and information clearly and accurately through the effective selection, organization, and analysis of content. Introduce the topic; organize complex ideas, concepts, and information to make important connections and distinctions Develop the topic with well-chosen, relevant, and specific facts,

		extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences' knowledge of the topic Use precise language and domain-specific vocabulary to manage the complexity of the topic Establish and maintain a formal style and objective tone while attend to the norms and conventions of the discipline in which they are writing. Demonstrate command of the conventions of standard English grammar and usage when writing Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing
Performance Example: • Write a technical report that synthesizes information found in different sources (magazines, web, manuals, reports) on the same subject as it relates to Technical Communications.		
2.D.01.01	RI.1 Grade 9 - 12 RI. 2 Grade 9 - 12 RI.4 Grade 9 - 12	Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from text. Determine the central idea of a text and analyze its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text. Determine the meaning of words and phrases as they are used in a text including technical meaning.
Performance Example: • Read various types of written technical communications including, but not limited to, technical reports, trade journals and magazines, machine manuals, safety protocols and web sources.		
2.D.01.02	R1.2 Grade 9 - 12 RI. 3 Grade 9 - 12 RI. 4 Grade 9 - 12	Determine the central idea of a text and analyze its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text. Analyze how the author unfolds and analysis or series of ideas or events, including the order in which the points are made, how they are introduced and developed, and the connections that are drawn between them. Determine the meaning of words and phrases as they are used in a text including technical meaning
Performance Example: • Read a flow chart and interpret the process.		
2.F.09.01	R1.2 Grade 9 - 12 RI. 4 Grade 9 - 12	Determine the central idea of a text and analyze its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text. Determine the meaning of words and phrases as they are used in a text including technical meaning
Performance Example: • Read a spec sheet for an IC found in your design.		

2.I.01.02	L.4	Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade [9 – 10 or 11 – 12] reading and content, choosing flexibly from a range of strategies.
Performance Example: • Write down the definition of the following robotic terms: degrees of freedom, position axes, orientation axes, work envelope, tool center point		
2.J.01	W.7 Grade 9 – 12 W.8 Grade 9 – 12 W.5 Grade 9 - 12 L.1 Grade 9 – 12 L.2 Grade 9 - 12	Conduct short as well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. Demonstrate command of the conventions of standard English grammar and usage when writing
Performance Example: • Write a 5 page research report on motor control application.		

Embedded Mathematics

CVTE Learning Standard Number	Math Content Conceptual Category and Domain Code Learning Standard Number	Text of Mathematics Learning Standard
2.B.04.01	4.MD-1	Know relative sizes of measurement units within one system of units, including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. *For example, know that 1 ft is 12 times as long as 1 in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs* (*1, 12*), (*2, 24*), (*3, 36*).
Performance Example: • Take measurements of a physical object in order to include them on a drawing.		
2.D.05.05	4.G-1	Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures.
Performance Example: • Draw perpendicular and parallel lines in a CAD drawing.		
2.F.03.04 2.F.03.07	5.NF-1 5.NF-2	1 .Add and subtract fractions with unlike denominators (including mixed numbers) by replacing given fractions with equivalent fractions in such a way as to produce an equivalent sum or difference

		of fractions with like denominators. 2. Solve word problems involving addition and subtraction of fractions referring to the same whole, including cases of unlike denominators, e.g., by using visual fraction models or equations to represent the problem. Use benchmark fractions and number sense of fractions to estimate mentally and assess the reasonableness of answers.
Performance Example: • Solve for equivalent resistance for parallel and series-parallel resistor networks.		
2.F.04.03	6.G-1 – MA.1.a 6.G-1- MA.1.b 7.G-4	6.G-1-MA.1.a.Use the relationships among radius, diameter, and center of a circle to find its circumference and area. 6.G-1-MA.1.b. Solve real-world and mathematical problems involving the measurements of circles. 7.G-4 Know the formulas for the area and circumference of a circle and solve problems; give an informal derivation of the relationship between the circumference and area of a circle.
Performance Example: • Calculate the cross sectional area of copper wire.		
2.E.01.05	6.RP-1 6.RP-2	6.RP-1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities 6.RP-2. Understand the concept of a unit rate $\boldsymbol{a/b}$ associated with a ratio $a:b$ with $b \neq 0$, and use rate language in the context of a ratio relationship.
Performance Example: • Calculate the mechanical advantage of a simple machine as a ratio or fraction.		
2.F.05.01	6.SP-5c	Summarize numerical data sets in relation to their context, such as by: Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.
Performance Example: • Calculate an average.		
2.F.05.02	4.NF-5 4.NF-6	5. Express a fraction with denominator 10 as an equivalent fraction with denominator 100, and use this technique to add two fractions with respective denominators 10 and 100. 6. Use decimal notation for fractions with denominators 10 or 100.
Performance Example: • Convert the period of a waveform to a period by taking the reciprocal value.		
2.F.11.01 2.F.11.02 2.F.11.03	5.NBT-1	Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and $\mathbf{1/10}$ of what it represents in the place to its left.
Performance Example: • Use the place value concept learned in decimal arithmetic to calculate the value of binary and hexadecimal numbers.		

Embedded Science and Technology/Engineering

Physical Science (Chemistry)

CVTE Learning Standard Number	Subject Area, Topic Heading and Learning Standard Number	Text of Chemistry Learning Standard
2.F.1	2. Atomic Structure and Nuclear Chemistry	2.1 Recognize discoveries from Dalton (atomic theory), Thomson (the electron), Rutherford (the nucleus), and Bohr (planetary model of atom), and understand how each discovery leads to modern theory.
Performance Example: • Students will be able to identify the parts of an atom through an understanding of the scientific process that has resulted in our modern theory of the atom.		

Physical Science (Physics)

CVTE Learning Standard Number	Subject Area, Topic Heading and Learning Standard Number	Text of Physics Learning Standard
2.D.2 2.F.2 2.F.3	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.
Performance Example: • Students will be given a diagram of a simple 2 battery LED flashlight and will be able to identify the basic electronic components and predict the effects each component will have on the flow of electricity through a circuit. Students will predict the effect connecting batteries in series and parallel has on the voltage of the flashlight. Students will also be expected to build and test their predictions with measurement tools.		
2.F.1.2	5. Electromagnetism	5.1 Recognize that an electric charge tends to be static on insulators and can move on and in conductors. Explain that energy can produce a separation of charges.
Performance Example: • Students will be able to identify the properties of insulators and conductors and identify examples of each. Students will be able to explain the behavior static electricity on insulators and conductors and apply that knowledge to the flow of electricity in electrical current.		
2.F.4 2.F.7 2.F.8.1	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 be able to understand how electric current creates a magnetic field and how this is used in technologies such as electromagnets, solenoid relays, transformers and electric motor/generators.		
2.F.5	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: • When given a periodic waveform, students will be able to determine the basic characteristics of the wave through measurement and calculation.		
2.F.8	5. Electromagnetism	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 understand why different voltage values are used in power transmission and how these values help to minimize the loss of energy in high voltage transmission lines.		

Technology/Engineering

CVTE Learning Standard Number	Subject Area, Topic Heading and Learning Standard Number	Text of Technology/Engineering Learning Standard
2.A.2.2 2.B.1	1. Materials, Tools, and Machines	1.2 Identify and explain appropriate measuring tools, hand tools, and power tools used to hold, lift, carry, fasten, and separate, and explain their safe and proper use. 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 apply knowledge of materials, tools, and equipment to safely perform tasks related to robotics and engineering technology.		
2.C.1 2.C.2 2.C.4	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. 2.2 Demonstrate methods of representing solutions to a design problem, e.g., sketches, orthographic projections, multiview drawings. 2.3 Describe and explain the purpose of a given prototype. 2.4 Identify appropriate materials, tools, and machines needed to construct a prototype of a given engineering design. 2.5 Explain how such design features as size, shape, weight, function, and cost limitations would affect the construction of a given prototype.
Performance Example: • Students will be able to use the engineering design process to analyze a problem, consider possible solutions, and create a design solution. The students will determine the best materials for the design considering factors such as cost, availability, reliability, and ease of operation/manufacture. Students will create a list of parts necessary to create the design and determine overall cost. Students will also maintain a journal documenting the steps of their process.		
2.D.4	2. Engineering Design	2.2 Demonstrate methods of representing solutions to a design problem, e.g., sketches, orthographic projections, multiview drawings.
Performance Example: • Students will be able to communicate the solution of a design problem by accurately drawing their solution using a variety of formats.		

2.B.1 2.B.3 2.E.1 2.E.2 2.E.3	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 apply knowledge of materials, tools, and equipment to safely perform tasks related to robotics and engineering technology.		
2.B.2	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 capable of using a multimeter to safely determine the characteristics of the components of a electrical circuits.		
2.C.1 2.C.2 2.C.3	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.
Performance Example: • Students will be able to use the engineering design process to analyze a problem, consider possible solutions, and create a design solution. The students will determine the best materials for the design considering factors such as cost, availability, reliability, and ease of operation/manufacture. Students will create a list of parts necessary to create the design and determine overall cost. Students will also maintain a journal documenting the steps of their process.		
2.C.4	1. Engineering Design	1.5 Interpret plans, diagrams, and working drawings in the construction of prototypes or models.
Performance Example: • Given the drawing of a prototype solution, students will be able to work in a group to build individual parts, conduct final assembly, and test the prototype while documenting their progress.		
2.C.4	1. Engineering Design	1.3 Produce and analyze multi-view drawings (orthographic projections) and pictorial drawings (isometric, oblique, perspective), using various techniques. 1.4 Interpret and apply scale and proportion to orthographic projections and pictorial drawings (e.g., ¼" = 1'0", 1 cm = 1 m).
Performance Example: • Students will be able to produce accurate scale drawings of a mechanical component using a variety of formats including hand sketching and CAD.		
2.E.2	3. Energy and Power Technologies—Fluid Systems	3.2 Explain the differences and similarities between hydraulic and pneumatic systems, and explain how each relates to manufacturing and transportation systems. 3.3 Calculate and describe the ability of a hydraulic system to multiply distance, multiply force, and effect directional change.
Performance Example: • Students will be tasked with designing a hand lift for a small automobile considering hydraulic and pneumatic solutions. Students will be able to determine the amount of force multiplication necessary, determine the necessary parts and create a design solution.		
2.E.2	7. Manufacturing	7.2 Identify the criteria necessary to select safe tools and

2.E.3	Technologies	procedures for a manufacturing process (e.g., properties of materials, required tolerances, end-uses). 7.3 Describe the advantages of using robotics in the automation of manufacturing processes (e.g., increased production, improved quality, safety).
Performance Example: • Students will observe the use of assembly line automation in the various industries and then design and build (or simulate) an assembly line process for the automotive industry that operates a pneumatic and hydraulic system.		
2.F.1.4	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 explain the reason AC is needed in power transmission and observe the prevalence of DC electronics in the home. Students will observe AC and DC current on an oscilloscope to demonstrate the differences in waveform		
2.F.2	5. Energy and Power Technologies—Electrical Systems	5.2 Identify and explain the components of a circuit, including sources, conductors, circuit breakers, fuses, controllers, and loads. Examples of some controllers are switches, relays, diodes, and variable resistors.
Performance Example: • Students will be able to interpret an electrical wiring diagram of a car and be able to identify the major electrical components.		
2.F.3	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. 5.2 Identify and explain the components of a circuit, including sources, conductors, circuit breakers, fuses, controllers, and loads. Examples of some controllers are switches, relays, diodes, and variable resistors. 5.3 Explain the relationships among voltage, current, and resistance in a simple circuit, using Ohm's law.
Performance Example: • Students will be given a diagram of a simple 2 battery LED flashlight and will be able to identify the basic electronic components and predict the effects each component will have on the flow of electricity through a circuit. Students will predict the effect connecting batteries in series and parallel has on the voltage of the flashlight. Students will also be expected to build and test their predictions with measurement tools.		
2.F.1.5	6. Communication Technologies	6.2 Differentiate between digital and analog signals. Describe how communication devices employ digital and analog technologies (e.g., computers, cell phones).
Performance Example: • Students will list and explain the benefits and drawbacks to switching from analog to digital communications. Students will apply this to explain why the 2008 regulatory decision by the FCC to switch from analog to digital cellular signals in the US.		

DESE Statewide Articulation Agreements

No Statewide Articulation Agreements at this time.

Industry Recognized Credentials (Licenses and Certifications/Specialty Programs)

1. OSHA 10 Hour Card
2. Autodesk Inventor 2012 Certified Associate
3. Autodesk Revit 2012 Certified Associate
4. Certified SolidWorks Associate (CSWA)
5. Certified SolidWorks Professional (CSWP)

Other

Reference Materials

- "Programmable Control Products – VersaMax PLC User's Manual" by GE Fanuc Automation, GFK1503C, Published 2001
- "Digital / Analog Trainer" – Model XK-700 by Elenco Electronics, Published 2007
- "Digital / Analog Trainer" – Model XK-550 by Elenco Electronics, Published 2010
- "Robocell User Manual" – Catalog 100346-F by Intelitek Inc. , Published 2005
- "Scorbase User Manual" – Catalog 100342 Rev. G by Intelitek Inc. , Published 2006
- "Controller USB User Manual" – Catalog 100341 Rev. G by Intelitek Inc. , Published 2007
- "Scorbit-ER 4u User Manual" – Catalog 100343Rev B by Intleitek Inc. , Published 2001
- "Laboratory Manual – Robotics – Theory and Industrial Application", by Ross, Ferdo, Sgro, Masterson & Towers, 2nd Edition, Copyright 2011, Published by Goodheart-Willcox
- "Laboratory Manual – Fluid Power – Hydraulics and Pneumatics" by Daines, Copyright 2009, Published by Goodheart-Willcox
- "Study Guide with Laboratory Activities, Electricity & Electronics" 10th Edition, by Gerrish, Dugger, Roberts , Copyright 2009, Published by Goodheart-Willcox
- "Instructors Manual – Programmable Logic Controllers – Hardware and Software" , 2nd Edition by Rabiee, Copyright 2009, Published by Goodheart-Willcox
- "National Instruments – Multisim Lab Manual – Electricity & Electronics" by Roberts, Copyright 2009, Published by Goodheart-Willcox
- "Instructors Manual- Electricity & Electronics" 10th Edition, by Gerrish, Dugger, Roberts, Copyright 2009, Published by Goodheart- Willcox
- "Modern Control Technology Components and Systems" by Christopher T Kilian, 3rd edition, Copyright 2006, Published by Delmar
- "Programmable Logic Controllers", by Frank D. Petruzella, 4th edition, Published by McGraw Hill
- "Principles of Electric Circuits, Conventional Current Version" by Thomas L. Floyd, Published by Prentice Hall, Copyright 2010
- "Introduction to Robotics" by Doug Keaton, James A Rehg and Clifford J Salmons, Published by Schoolcraft, Copyright 2009
- "Digital Fundamentals", by Thomas L. Floyd, Tenth Edition, Published by Person Prentice Hall, Copyright 2009
- Software
- National Instruments Multisim - http://www.ni.com/multisim/
- Festo-Didactic FluidSIM Hydraulics – http://www.festo-didactic.com
- Festo-Didactic FluidSIM Pneumatics- http://www.festo-didactic.com
- LogixPro - http://www.thelearningpit.com/
- "Electricity & Electronics" by Gerrish, Dugger, & Roberts, 10th Edition, Copyright 2009, Published by Goodheart-Willcox
- "Robotics, Theory and Industrial Applications" by Ross, Fardo, Masterson & Towers, 2nd Edition, Copyright 2011, Published by Goodheart-Willcox
- "Programmable Logic Controllers: Hardware and Programming" by Rabiee, 2nd Edition, Copyright 2009, Published by Goodheart-Willcox
- "Fluid Power: Hydraulics and Pneumatics" by Daines, 1st Edition, Copyright 2009, Published by Goodheart-Willcox

- "Instrumentation and Process Control" by Bartelt, 1st Edition, Copyright 2007, Published by Thompson Delmar Learning
- "Instrumentation" by Kirk & Rimbo, 3rd Edition, Copyright 1975, Published by American Technical Publishers
- "DC/AC Foundations of Electronics" by Phagan, Copyright 1997, Published by Goodheart-Willcox
- Lab Manual for "Programmable Logic Controllers", by Frank D. Petruzella, 4th edition, Published by McGraw Hill
- Activities Manual for "Programmable Logic Controllers", by Frank D. Petruzella, 4th edition, Published by McGraw Hill
- "Experiments in Digital Fundamentals", by Thomas L. Floyd, Tenth Edition, Published by Person Prentice Hall, Copyright 2009
- "Simatic S& S7-1200 Jump Start Study Guide", Siemens Industry, Inc. MID 10876 Release October 2009

Related National, Regional, and State Professional Organizations

- VEX Robotics, VEX and VEX Robotics are trademarks or service marks of Innovation First International, Inc.
- Institute of Electrical and Electronic Engineers (IEEE) - http://www.ieee.org
- American Society of Mechanical Engineers (ASME) – http://www.asme.org

Student Organizations

- Skills USA www.maskillsusa.org

Selected Websites

- VEX Robotics - http://www.vexrobotics.com/
- The Robotics Institute – Carnegie Mellon - http://www.ri.cmu.edu/
- The Learning Pit - http://www.thelearningpit.com/
- University of Wisconsin Online Learning Objects - http://www.wisc-online.com/ListObjects.aspx
- Rockwell Automation - http://ab.rockwellautomation.com/
- Siemens Corporation -