



*Vocational Technical Education Framework*



Construction Occupational Cluster

*Heating, Ventilation, Air Conditioning & Refrigeration (HVAC)*

CIP Code 470201

June 2014

**Massachusetts Department of Elementary and Secondary Education**

**Office for Career/Vocational Technical Education**

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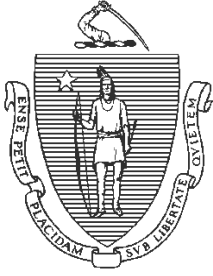
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## Commissioner's Letter

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# **Massachusetts Department of Elementary and Secondary Education**

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Mitchell D. Chester, Ed.D.  
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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

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## 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; Strand 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<sup>1</sup>

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<sup>2</sup> 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.

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<sup>1</sup> *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.*

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## 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.



## Construction Occupational Cluster

### Heating, Ventilation, Air Conditioning & Refrigeration Framework (HVAC)

#### Strand 1: Safety and Health Knowledge and Skills

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##### 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](http://www.doe.mass.edu/bullying)
- Centers for Disease Control and Prevention: [www.cdc.gov](http://www.cdc.gov)
- Environmental Protection Agency : [www.epa.gov](http://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](http://www.doe.mass.edu/cte)
- Massachusetts Department of Elementary and Secondary Education: [www.doe.mass.edu](http://www.doe.mass.edu)
- Massachusetts Emergency Management Agency: [www.mass.gov/eopss/agencies/mema](http://www.mass.gov/eopss/agencies/mema)
- Massachusetts General Law: [www.malegislature.gov](http://www.malegislature.gov)
- Massachusetts Health and Human Services: [www.mass.gov/dph](http://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](http://www.sdsonline.com)
- National Fire Protection Association: [www.nfpa.org](http://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](http://www.osha.gov)
- Readiness and Emergency Management for Schools: [www.rems.ed.gov](http://www.rems.ed.gov)
- Safe and Healthy Learning Environments: [www.doe.mass.edu/ssce/safety.html](http://www.doe.mass.edu/ssce/safety.html)

## Strand 2: Technical Knowledge and Skills

### 2.A Shop Safety & Refrigerant Regulations

- 2.A.01 Use tools and handle materials safely, in accordance with industry regulations and established shop procedures.
- 2.A.01.01 Describe and demonstrate the safe use of hand and power tools.
  - 2.A.01.02 Describe and demonstrate methods of handling refrigerants safely.
  - 2.A.01.03 Describe and demonstrate ladder safety procedures.
  - 2.A.01.04 List and comply with regulations for working in confined spaces.
  - 2.A.01.05 List and comply with fire prevention regulations.

2.A.01 Performance Examples:

- Student will participate in daily /weekly “Toolbox Safety Talks”.
- Student will pass a written and performance test for all shop tools and equipment before using them.

- 2.A.02 Demonstrate safety in refrigerant handling following Environment Protection Agency (EPA) regulations.
- 2.A.02.01 Successfully complete the EPA Section 608 course.
  - 2.A.02.02 Successfully complete the R-410a Safety Course.

2.A.02 Performance Examples:

- Students will take the 608 EPA Certification Exam including: Core information, Type 1 Certification (Small Appliances) Type 2 Certification (High-Pressure) Type 3 Certification (Low-Pressure).
- Students will complete a410a Safety Course and pass the certification exam.

- 2.A.03 Demonstrate and use refrigeration tools according to industry standards.
- 2.A.03.01 Demonstrate techniques in the use of manifold gauges.
  - 2.A.03.02 Demonstrate techniques in the use of electrical meters.
  - 2.A.03.02 Demonstrate techniques in swedging and flaring tubing.
  - 2.A.03.03 Demonstrate techniques on setting-up and operating a variety of gas torches and regulators.

2.A.03 Performance Example:

- Student will set-up and demonstrate the use of acetylene/oxygen/nitrogen gas equipment.

### 2.B Reading Technical Drawings and Blueprints

- 2.B.01 Read and interpret prints.
- 2.B.01.01 Explain the basic layout of a set of prints as well as the importance of the accompanying job specifications document.
  - 2.B.01.02 Recognize and identify basic print terms, abbreviations, line types, symbols and notes.
  - 2.B.01.03 Interpret and follow drawing dimensions.
  - 2.B.01.04 Determine true measurements from a print using an architect’s scale.
  - 2.B.01.05 Read and interpret floor plans, elevations, sections, details, ceiling plans, and finish schedules.

- 2.B.01.06 Discuss and implement estimating methods for pricing jobs using drawings/prints.
- 2.B.01.07 Identify, develop, and complete material quantity takeoff sheets.

- 2.B.01 Performance Examples:
- Student will perform shop work /job site projects/ from appropriate sets of prints/drawings.
  - Student will develop a material quantity takeoff for given project/job.
  - Student will develop a cost estimate from material quantity takeoff for given project/job.
  - Student will prepare an application for an appropriate mechanical permit.

## 2.C HVAC&R Fundamentals and Refrigeration Principles

- 2.C.01 Describe HVAC&R principles, regulations and career opportunities.
  - 2.C.01.01 Explain the importance of HVAC&R in modern society.
  - 2.C.01.02 Explain the basic principles of heating, ventilating, and air conditioning & refrigeration systems.
  - 2.C.01.03 Define heat energy and explain how it is transferred: convection, conduction, and radiation.
  - 2.C.01.04 Recognize and apply alternative and renewable technology in the HVAC&R industry.
  - 2.C.01.05 Identify career opportunities available in the HVAC&R industry.
  - 2.C.01.06 List and describe the types of regulatory codes & licensing in the HVAC&R industry.

- 2.C.01 Performance Example:
- Student will create a written composition based on the historical development and the importance of HVAC&R in modern society.

## 2.D Pipe Joining Techniques

- 2.D.01 Demonstrate piping practices.
  - 2.D.01.01 Identify, describe the use of, and install various types and sizes of steel pipe and copper tubing.
  - 2.D.01.02 Identify and install brass, steel, and copper fittings.
  - 2.D.01.03 Measure, cut, ream, thread, and connect steel pipe.
  - 2.D.01.04 Measure, cut, and bend copper tubing.
  - 2.D.01.05 Connect copper tubing using fittings, flares, and swedges.
  - 2.D.01.06 Identify and install different types of pipe hangers and supports.
  - 2.D.01.07 Demonstrate brazing and soldering techniques.
  - 2.D.01.08 Demonstrate brazing techniques using inert gas to prevent oxidation.
  - 2.D.01.09 Describe and demonstrate safety requirements for pressure testing a refrigeration system.

- 2.D.01 Performance Examples:
- Student will perform; measuring, cutting, bending, flaring, swedging, soldering/brazing copper tubing following the specifications on given project.

## 2.E Electrical Components and Wiring

- 2.E.01 Demonstrate wiring HVAC&R controls, motors, and circuits.

- 2.E.01.01 Describe the characteristics of controls, and install components into electrical circuits – low & high voltage.
- 2.E.01.02 Test and troubleshoot electrical circuits and devices using electrical meters.
- 2.E.01.03 Describe and apply properties of electrical conductors and insulators.
- 2.E.01.04 Describe and wire series, parallel and series/parallel circuits.
- 2.E.01.05 Explain concepts relating to direct current (DC) and alternating current (AC), Ohm’s law, Watts’s law and how they pertain to volts, amperes, ohms, impedances, and watts.
- 2.E.01.06 Explain concepts relating to resistive, capacitive, and inductive loads.
- 2.E.01.07 Determine voltage and current ratings of electrical devices.
- 2.E.01.08 Explain and apply principles of electrical circuit protection.
- 2.E.01.09 Explain and apply principles of electrical grounding.
- 2.E.01.10 Describe and demonstrate the application of various types of electric motors.
- 2.E.01.11 Describe, develop, and interpret schematics and other wiring diagrams.
- 2.E.01.12 Identify and describe factory and field wiring, high and low voltage, details, and legends on wiring diagrams.
- 2.E.01.13 Demonstrate the use of wire isolation and line transformers, relays, contactors, timers, sequencers and switches.
- 2.E.01.14 Explain and demonstrate the use of overloads, capacitors, pressure switches, solenoids, and thermostats.
- 2.E.01.15 Demonstrate troubleshooting techniques with electrical motors.
- 2.E.01.16 Describe and install solid-state devices.
- 2.E.01.17 Describe the structure of the Massachusetts Electrical Code (MEC).

2.E.01 Performance Example:

- Student will demonstrate their knowledge of basic electrical theory, by troubleshooting, and analyzing, HVAC&R equipment/components with electrical issues.

**2.F Refrigeration Components and Systems**

- 2.F.01 Troubleshoot and install refrigeration components.
  - 2.F.01.01 Describe and illustrate the mechanical refrigeration cycle.
  - 2.F.01.02 List refrigerant properties and accurately perform superheat, delta T, and sub-cooling calculations.
  - 2.F.01.03 Analyze and describe the operating conditions of mechanical compressors.
  - 2.F.01.04 Describe and install system evacuation and dehydration/degassing.
  - 2.F.01.05 Identify and use refrigeration leak detection methods and procedures according to industry standards.
  - 2.F.01.06 Describe classifications, properties, and different applications of refrigerants and use Temperature/Pressure and enthalpy charts.
  - 2.F.01.07 List and describe the characteristics of compressors.
  - 2.F.01.08 List and describe the characteristics of condensers.
  - 2.F.01.09 List and describe the characteristics of metering devices.
  - 2.F.01.10 List and describe the characteristics of evaporators.
  - 2.F.01.11 List and describe various types of liquid line components.

- 2.F.01.12 Install and describe various types of suction line components.
- 2.F.01.13 Install and describe the operation of refrigerant service valves.
- 2.F.01.14 Describe and use various types of refrigerant oils and lubricants.

- 2.F.01 Performance Examples:
- Student will create a basic refrigeration system by installing & connecting multiple refrigerant components into an operating system.
  - Student will demonstrate their knowledge of heat transfer principles by indicating temperature and pressure readings from given project.

## 2.G Installation and Service of Heating & Cooling Equipment

- 2.G.01 Install and troubleshoot air conditioning & heat pump equipment.
  - 2.G.01.01 Describe, install, and service condensate drain systems.
  - 2.G.01.02 Demonstrate refrigerant charging techniques of air conditioning and pump systems using manufacturers' recommended procedures.
  - 2.G.01.03 Identify and discuss applications of the different heat pump classifications such as air-source, grounds-source and water source.
  - 2.G.01.04 Install and service heat pumps.
  - 2.G.01.05 Install and service electric resistance heating systems.
  - 2.G.01.06 Describe and install heat pump with electric heating elements.
  - 2.G.01.07 List and describe the uses of heat pump operation in all modes.
  - 2.G.01.08 List and describe the characteristics of and test heat pump reversing valves.
  - 2.G.01.09 Define, calculate and troubleshoot supplementary heat.

- 2.G.01 Performance Example:
- Using the manufacturers' installation manuals and specifications the student will install a central air-conditioner unit and/or a heat pump system.

## 2.H Installation and Service of Oil Heating Equipment

- 2.H.01 Install and troubleshoot oil heating equipment.
  - 2.H.01.01 Describe and follow oil heat safety.
  - 2.H.01.02 Describe and perform an oil burner efficiency test and adjust according to manufacturer's specifications.
  - 2.H.01.03 Field-test furnace/boiler operation with industry approved instruments.
  - 2.H.01.04 Perform a delta T reading for purposes of troubleshooting and installation according to industry standards.
  - 2.H.01.05 Test and replace boiler/furnace operating and safety controls.
  - 2.H.01.06 Describe steam heating systems, components and safety controls.
  - 2.H.01.07 Describe, maintain and service hydronic components, pumps and circulators.
  - 2.H.01.08 Install and service oil-fired boilers & furnaces.
  - 2.H.01.09 Demonstrate maintenance, troubleshooting procedures, and repair of oil supply systems.
  - 2.H.01.10 Define and demonstrate the operations of starting an oil burner according to manufacturers' specifications and current industry standards.
  - 2.H.01.11 Describe and demonstrate methods of preparing fuel for combustion.
  - 2.H.01.12 Identify and define parts and operation of an oil burner.



- 2.H.01.13 Describe the characteristics of primary and safety controls.
- 2.H.01.14 List and describe characteristics of and install venting systems for oil appliances.

2.H.01 Performance Examples:

- Student will install and service an oil burner/boiler – service should include performing a combustion efficiency test - Bacharach Combustion Testing Kits recommended.
- Student will define the major components of an oil system, and describe the function of each component.

**2.I Installation and Service of Natural and Liquefied Petroleum Gas Equipment**

- 2.I.01 Install and troubleshoot gas heating equipment.
  - 2.I.01.01 Describe and follow gas heat safety.
  - 2.I.01.02 Discuss and measure liquefied petroleum (L.P.) and natural gas supply and manifold pressures.
  - 2.I.01.03 List characteristics of, test, and operate standing pilot ignition systems.
  - 2.I.01.04 List characteristics of, test, and operate hot surface and electronic ignition systems.
  - 2.I.01.05 List characteristics of and test combustion fan motor operation.
  - 2.I.01.06 Perform delta T reading for purposes of troubleshooting and installation according to industry standards.
  - 2.I.01.07 List and describe properties of, test, and adjust combustion on a gas appliance.
  - 2.I.01.08 List and describe characteristics of, test, replace, and adjust gas valves (positive & negatives).
  - 2.I.01.09 Describe potential problems with, test, adjust, and replace operating and safety controls.
  - 2.I.01.10 Describe characteristics of and troubleshoot 80% and 90% plus efficiency gas furnaces.
  - 2.I.01.11 Install LP/Natural gas conversion kits.
  - 2.I.01.12 Describe characteristics of, and maintain and service hydronic components, (e.g., pumps and circulators).
  - 2.I.01.13 Install and service gas boilers and furnaces to manufacturers' specifications.
  - 2.I.01.14 Describe characteristics of venting systems for gas appliances.

2.I.01 Performance Examples:

- Student will install and service a gas fired furnace/boiler –service should include checking safety devices and maintaining appropriate temperatures from delta-T readings.
- Student will identify the major components of gas fired equipment, and describe the function of each component.

**2.J Air Distribution and Indoor Air Quality**

- 2.J.01 Describe and demonstrate ventilation applications and forced-air duct systems.
  - 2.J.01.01 Calculate heat loss/ gain for a structure.
  - 2.J.01.02 Perform duct calculations for air distribution.
  - 2.J.01.03 Design and draw basic forced-air duct system.
  - 2.J.01.04 Explain and use concepts of the physical properties of air.



- 2.J.01.05 Define and apply the principles of air distribution systems, (e.g., stratification of air, drafts, etc.) following industry standards.
- 2.J.01.06 Describe and demonstrate the application of dampers, diffusers, grills, and registers.
- 2.J.01.07 Demonstrate processes and procedures used to troubleshoot and adjust humidification accessories.
- 2.J.01.08 Describe and use the different standards/codes of measuring indoor air quality (IAQ) such as air-filtration systems, ventilation systems, air-contaminants (pollutants particulates), Ozone, and measuring instruments.
- 2.J.01.09 Describe and demonstrate duct construction, including assembling, duct sealing, and insulating according to industry standards.

2.J.01 Performance Examples:

- Student will perform a Manual J calculation from given print/drawing.
- Student will perform a Manual D calculation from given print/drawing.
- Using calculation from previous task the student will design a forced-air duct system – project may include generating a takeoff list of ductwork and accessories.

**2.K Technical Plans and Prints**

- 2.K.01 Describe the basic layout of a set of construction documents.
  - 2.K.01.01 Identify and interpret a site plan from a basic set of construction plans.
  - 2.K.01.02 Identify and describe details from a basic set of construction plans.

## Strand 3: Embedded Academics

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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

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### 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](http://www.bpa.org)

### *Selected Websites*

- 5 Ways to Ace a Job Interview: [http://kidshealth.org/teen/school\\_jobs/jobs/tips\\_interview.html](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](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](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](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](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

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### 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](http://www.nfib.com)
- National Foundation for Teaching Entrepreneurship (NFTE): [www.nfte.com](http://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](http://www.sba.gov)

### *Glossary*

<b>Term</b>	<b>Definition</b>
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**

Chain of Command and Organizational Structure

**Definition**

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

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### 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

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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
Performance Example: <ul style="list-style-type: none"> <li>Research and present on a power point the various jobs in Health care that are specifically involved in providing immediate first aid to an injured person. Explain the role of the providers.</li> </ul>		
2.C.01.05	WHST.6-12.5-8 Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach. Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation. Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism
Performance Example: <ul style="list-style-type: none"> <li>Student will create a research paper about HVAC&amp;R career opportunities through the internet and other resources.</li> </ul>		
2.C.01.06	RI.6.3 Reading Standards for Informational Text	Analyze in detail how a key individual, event, or idea is introduced, illustrated, and elaborated in a text
Performance Example: <ul style="list-style-type: none"> <li>Student will recognize the types of regulatory codes &amp; licensing in the field of HVACR.</li> </ul>		
2.F.01.02	SL.9-12.1-3 Speaking and Listening Standards	Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–12 topics, texts, and issues, building on others’ ideas and expressing their own clearly and persuasively. Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data. Evaluate a speaker’s point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used.
Performance Example: <ul style="list-style-type: none"> <li>Student will perform a class presentation about the procedures of changing the superheat by adjusting the thermostatic valve.</li> </ul>		
2.E.01.12	SL.9-12.4-6 Speaking and Listening Standards	Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.

		<p>Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.</p> <p>Adapt speech to a variety of contexts and tasks, demonstrating a command of formal English when indicated or appropriate.</p>
<p>Performance Example:</p> <ul style="list-style-type: none"> <li>Student will present to the class how to identify the difference between line voltage and control wiring from a wiring diagram.</li> </ul>		
2.E.01.17	L.6-12.4(c-d) Language Standards	<p>Consult general and specialized reference materials (e.g., dictionaries, glossaries, thesauruses), both print and digital, to find the pronunciation of a word or determine or clarify its precise meaning, its part of speech, its etymology, or its standard usage. Verify the preliminary determination of the meaning of a word or phrase (e.g., by checking the inferred meaning in context or in a dictionary).</p>
<p>Performance Example:</p> <ul style="list-style-type: none"> <li>Student will reference applicable MA. Code relevant to electrical wiring to determine code language.</li> </ul>		
2.A.01.05	WHST.6-12.8 Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects	<p>Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.</p>
<p>Performance Example:</p> <ul style="list-style-type: none"> <li>Student will develop and implement a fire prevention project " for their peers from resources obtained from OSHA and NIOSH</li> </ul>		
2.C.01.01	WHST.6-12.2(a-f),4 Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects	<p>Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts. Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).</p> <p>Produce clear and coherent writing in which the development,</p>



		organization, and style are appropriate to task, purpose, and audience.
Performance Example: <ul style="list-style-type: none"> <li>Student will successfully complete a written exam based on the historical development and the importance of refrigeration in society.</li> </ul>		

## Embedded Mathematics

CVTE Learning Standard Number	Math Content Conceptual Category and Domain Code Learning Standard Number	Text of Mathematics Learning Standard
2.J.01.03	7.G.2 Geometry/ Draw, construct, and describe geometrical figures and describe the relationships between them	Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions. Focus on constructing triangles from three measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle. (MA 2011 specifies constructing triangles given measures of angles.)
Performance Example: <ul style="list-style-type: none"> <li>Student will design and draw a forced-air duct system using different geometric shapes.</li> </ul>		
2.D.01.05	8.EE.7 Expressions and Equations/ Analyze and solve linear equations and pairs of simultaneous linear equations.  8.EE.7a Expressions and Equations/ Analyze and solve linear equations and pairs of simultaneous linear equations.  8.EE.7b Expressions and Equations/ Analyze and solve linear equations and pairs of simultaneous linear equations.  7.RP.2 Ratios and Proportional Relationships/ Analyze proportional relationships and use them to solve real-world and mathematical problems.	8.EE.7 - Solve linear equations in one variable.  8.EE.7a - Give examples of linear equations in one variable with one solution, infinitely many solutions, or no solutions. Show which of these possibilities is the case by successively transforming the given equation into simpler forms, until an equivalent equation of the form $x = a$ , $a = a$ , or $a = b$ results (where $a$ and $b$ are different numbers).  8.EE.7b - Solve linear equations with rational number coefficients, including equations whose solutions require expanding expressions using the distributive property and collecting like terms.  7.RP.2 Recognize and represent proportional relationships between quantities.
Performance Example: <ul style="list-style-type: none"> <li>Student will solve a linear equation to identify missing dimension on copper project drawing.</li> </ul>		

2.F.01.06	<p>6.NS.6 The Number System/ Apply and extend previous understandings of numbers to the system of rational numbers.</p> <p>6.NS.6c The Number System/ Apply and extend previous understandings of numbers to the system of rational numbers.</p>	<p>6.NS.6 - Understand a rational number as a point on the number line. Extend number line diagrams and coordinate axes familiar from previous grades to represent points on the line and in the plane with negative number coordinates.</p> <p>6.NS.6c. Find and position integers and other rational numbers on a horizontal or vertical number line diagram; find and position pairs of integers and other rational numbers on a coordinate plane.</p>
<p>Performance Example:</p> <ul style="list-style-type: none"> <li>Student will identify refrigerant properties using refrigerant charts.</li> </ul>		
2.B.01.06	<p>7.EE.3 Expressions and Equations/ Solve real-life and mathematical problems using numerical and algebraic expressions and equations.</p>	<p>Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. <i>For example: If a woman making \$25 an hour gets a 10% raise, she will make an additional <math>\frac{1}{10}</math> of her salary an hour, or \$2.50, for a new salary of \$27.50. If you want to place a towel bar <math>9\frac{3}{4}</math> inches long in the center of a door that is <math>27\frac{1}{2}</math> inches wide, you will need to place the bar about 9 inches from each edge; this estimate can be used as a check on the exact computation.</i></p>
<p>Performance Example:</p> <ul style="list-style-type: none"> <li>Student will estimate the material take-off and the cost of an installation from a given print /drawing.</li> </ul>		
<p>2.E.01.05 2.G.01.09</p>	<p>9-12.A.SSE.1 Algebra/Seeing Structure in Expressions/ Interpret the structure of expressions.</p> <p>9-12.A.CED.4 Algebra/ Creating Equations/ Create equations that describe numbers or relationships.</p>	<p>9-12.ASSE.1 Interpret expressions that represent a quantity in terms of its context.* <input type="checkbox"/></p> <p>9-12.ACED.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. <i>For example, rearrange Ohm's law <math>V = IR</math> to highlight resistance <math>R</math>.*</i></p>
<p>Performance Example:</p> <ul style="list-style-type: none"> <li>Student will define concepts relating to Ohm's law, Watts law and how they pertain to volts, amperes, ohms, impedances, and watts.</li> </ul>		
2.H.01.02	<p>9-12.A.CED.3 Algebra/Creating Equations/ Create equations that describe numbers or relationships</p> <p>8.EE.8 Expressions and</p>	<p>9-12.A.CED.3 Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or non-viable options in a modeling context. <i>For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.</i></p> <p>8.EE.8 Analyze and solve pairs of simultaneous linear</p>

	Equations/ Solve real-life and mathematical problems using numerical and algebraic expressions and equations.	equations.
Performance Examples: <ul style="list-style-type: none"> <li>• Student will perform an oil burner efficiency test before and after adjustments are made to manufacturer's specifications.</li> <li>• Student will complete a cost analysis using the linear data from the efficiency tests.</li> </ul>		
2.B.01.04	MA.9-12.G.MG.4 Geometry/Modeling with Geometry/ Apply geometric concepts in modeling situations  9-12.A-SSE.1 Algebra/Seeing Structure in Expressions/ Interpret the structure of expressions.	MA.9-12.G.MG.4 - Use dimensional analysis for unit conversions to confirm that expressions and equations make sense.*  9-12.A-SSE.1 Interpret expressions that represent a quantity in terms of its context.*
Performance Example: <ul style="list-style-type: none"> <li>• Student will convert architectural scale on mechanical or layout drawing for actual sizes.</li> </ul>		

## 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.01.6	States of Matter 6.3	6.3 Using the kinetic molecular theory, describe and contrast the properties of gases, liquids, and solids. Explain, at the molecular level, the behavior of matter as it undergoes phase transitions.
Performance Example: <ul style="list-style-type: none"> <li>• Student will identify the application of the heat transfer process and determine the type of refrigerant best suited for the application.</li> </ul>		
2.F.01.07 2.F.01.08 2.F.01.09 2.F.01.10	States of Matter 6.1	6.1 Using the kinetic molecular theory, explain the behavior of gases and the relationship between pressure and volume (Boyle's law), volume and temperature (Charles's law), pressure and temperature (Gay-Lussac's law), and the number of particles in a gas sample (Avogadro's hypothesis). Use the combined gas law to determine changes in pressure, volume, and temperature.
Performance Example: <ul style="list-style-type: none"> <li>• Student will research and discuss with the class the behaviors of gases and the relationship between temperatures and pressures, Boyle's law, Charles's law, Gay-Lussac's law and the combined gas law.</li> </ul>		
2.F.01.14	Properties of Matter 1.1	1.1 Identify and explain physical properties (e.g., density,

		melting point, boiling point, conductivity, malleability) and chemical properties (e.g., the ability to form new substances). Distinguish between chemical and physical changes.
Performance Example:		
<ul style="list-style-type: none"> <li>Student will research the different types of refrigerant's oils and lubricants available and discuss the applications of refrigerant's oils and lubricants.</li> </ul>		
2.A.03.01	States of Matter 6.1 & 6.2	6.1 Using the kinetic molecular theory, explain the behavior of gases and the relationship between pressure and volume (Boyle's law), volume and temperature (Charles's law), pressure and temperature (Gay-Lussac's law), and the number of particles in a gas sample (Avogadro's hypothesis). Use the combined gas law to determine changes in pressure, volume, and temperature. 6.2 Perform calculations using the ideal gas law. Understand the molar volume at 273 K and 1.
Performance Example:		
<ul style="list-style-type: none"> <li>Student will convert refrigerant pressure to temperature using manifold gauge set</li> </ul>		
2.F.01.06	Properties of Matter 1.1	1.1 Identify and explain physical properties (e.g., density, melting point, boiling point, conductivity, malleability) and chemical properties (e.g., the ability to form new substances). Distinguish between chemical and physical changes.
Performance Examples:		
<ul style="list-style-type: none"> <li>Student will identify the physical properties of common refrigerants –e.g.,: molecular weight, boiling, freezing and critical points.</li> <li>Student will define and apply refrigerant composition, by identifying the refrigerants that need to be in a liquid state when charging a refrigeration system.</li> </ul>		

### *Physical Science (Physics)*

<b>CVTE Learning Standard Number</b>	<b>Subject Area, Topic Heading and Learning Standard Number</b>	<b>Text of Physics Learning Standard</b>
2.E.01.03	Electromagnetism 5.1	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:		
<ul style="list-style-type: none"> <li>Student will demonstrate their knowledge of electrical conductors when troubleshooting HVAC&amp;R equipment.</li> </ul>		
2.E.01.04	Electromagnetism 5.3	5.3 Using the kinetic molecular theory, explain the behavior of gases and the relationship between pressure and volume (Boyle's law), volume and temperature (Charles's law), pressure and temperature (Gay-Lussac's law), and the number of particles in a gas sample (Avogadro's hypothesis). Use the combined gas law to determine changes in pressure, volume, and temperature.
Performance Example:		
<ul style="list-style-type: none"> <li>Student will create schematic diagrams to include electrical components in series and parallel circuits.</li> </ul>		
2.E.01.06	Electromagnetism 5.2	5.2 Develop qualitative and quantitative understandings of current, voltage, resistance, and the connections among them (Ohm's law).

Performance Example: <ul style="list-style-type: none"> <li>Students will demonstrate their ability to quantitatively determine voltage, current, and resistance while troubleshooting various shop refrigeration equipment.</li> </ul>		
2.E.01.08	Electromagnetism 5.3	5.3 Using the kinetic molecular theory, explain the behavior of gases and the relationship between pressure and volume (Boyle's law), volume and temperature (Charles's law), pressure and temperature (Gay-Lussac's law), and the number of particles in a gas sample (Avogadro's hypothesis). Use the combined gas law to determine changes in pressure, volume, and temperature.
Performance Example: <ul style="list-style-type: none"> <li>Students will demonstrate their ability to identify voltage and current rating on electrical devices using various HVAC&amp;R equipment.</li> </ul>		
2.C.01.03	Heat and Heat Transfer 3.1 and 3.3	3.1 Explain how heat energy is transferred by convection, conduction, and radiation. 3.3 Describe the relationship between average molecular kinetic energy and temperature. Recognize that energy is absorbed when a substance changes from a solid to a liquid to a gas, and that energy is released when a substance changes from a gas to a liquid to a solid. Explain the relationships among evaporation, condensation, cooling, and warming.
Performance Example: <ul style="list-style-type: none"> <li>Student will define the differences between radiant, conduction, and convection heat energy.</li> </ul>		

### *Technology/Engineering*

CVTE Learning Standard Number	Subject Area, Topic Heading and Learning Standard Number	Text of Technology/Engineering Learning Standard
2.A.01.01	2.5 Materials, Tools, and Machines	2.5 Identify and demonstrate the safe and proper use of common hand tools, power tools, and measurement devices used in construction.
Performance Example: <ul style="list-style-type: none"> <li>Student will demonstrate how to safely use and maintain designated power &amp; hand tools.</li> </ul>		
2.G.01.07	Fluid Systems 3.1 and 3.4 & Thermal Systems 4.1 and 4.2	3.1 Explain the basic differences between open fluid systems (e.g., irrigation, forced hot air system, air compressors) and closed fluid systems (e.g., forced hot water system, hydraulic brakes). 3.4 Recognize that the velocity of a liquid moving in a pipe varies inversely with changes in the cross-sectional area of the pipe. 4.1 Differentiate among conduction, convection, and radiation in a thermal system (e.g., heating and cooling a house, cooking). 4.2 Give examples of how conduction, convection, and radiation are considered in the selection of materials for buildings and in the design of a heating system. 4.1 Differences among conduction, convection, and radiation in a thermal system.

Performance Example: <ul style="list-style-type: none"> <li>Student will draw a refrigeration system of a heat pump, identify the components, and indicate temperatures and pressures for different conditions in cooling &amp; heating modes.</li> </ul>		
2.E.01.01	Electrical Systems 5.2 , 5.3, and 5.4	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. 5.4 Recognize that resistance is affected by external factors (e.g., temperature).
Performance Example: <ul style="list-style-type: none"> <li>Student will wire an electrical circuit that includes switches, fuses, controls and loads.</li> </ul>		
2.E.01.05	Electrical Systems 5.5	5.5 Compare and contrast alternating current (AC) and direct current (DC), and give examples of each.
Performance Example: <ul style="list-style-type: none"> <li>Student will measure an electrical device that operates from AC current and DC current.</li> </ul>		
2.A.01.02	Electrical Systems 5.1	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: <ul style="list-style-type: none"> <li>Student will define and measure: voltage, current, and resistance using a multi-meter.</li> </ul>		

## DESE Statewide Articulation Agreements

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No Statewide Articulation Agreements at this time.

## Industry Recognized Credentials (Licenses and Certifications/Specialty Programs)

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Environmental Protection Agency (EPA) Refrigerant Recovery and Recycling - 608 - 609 - R410 Refrigeration Certifications

Occupational Safety and Health Administration (OSHA) 10 Hour Card – Construction

Hours credit toward Massachusetts Refrigeration Technician License requirements.

A student who successfully completes a CHAPTER 74 HVAC/R program approved by the Bureau of Pipefitters, Sprinkler Fitters and Refrigeration Technicians may be granted credit for a maximum of 700 shop hours, 100 hours of refrigeration theory and 100 hours of related Massachusetts electrical code training toward their refrigeration technician license. With this credit, a graduate will only need to document 2000 hours of work as an apprentice or trainee to sit for the exam (6000 hours of work required for those without this level of credit).

Hours credit toward Massachusetts Sheet Metal License requirements.

A student who successfully completes a CHAPTER 74 HVAC/R program approved by the Board of State Examiners of Sheet Metal Workers may be granted a maximum of 150 hours of educational theory credit and 1,600 hours of experience credit from that program towards their journeyman license.



## Other

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### Reference Materials

- NATE Reference manual; A guide to NATE certification of Residential & light commercial HVAC service technician
- ACCA Manual J® materials: Residential heating & cooling load calculation
- ACCA Manual D® materials: Residential equipment and duct design calculations
- NCCER PowerPoint Transparencies & NCCER PowerPoint Slides
- NCCER HVAC/R trainee guides Wheels of Learning Levels 1 – 2 – 3 – 4 & Core
- ASHRAE Journals / Articles
- Copeland Educational Manuals
- RSCS Journals / Articles John Tomczyk
- Sporlan Service Bulletins
- Electricity for Refrigeration, Heating and Air Conditioning 7<sup>th</sup> edition - Russell E. Smith - Thomson Delmar Learning 2007 Clifton Park NY
- NFPA 70®: National Electrical Code® (NEC®) 2011 Edition
- 2004 ARI Refrigeration and Air Conditioning 4th edition - Larry Jeffus Pearson Patience Hall
- Refrigeration & Air conditioning Technology 5th edition William C. Whitman –William M. Johnson – John A. Tomczyk - Clifton Park NY 2005 Delmar Cengage Learning

### Related National, Regional, and State Professional Organizations

- Air Conditioning Contractors of America (ACCA)
- Air-Conditioning and Refrigeration Institute (ARI)
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- (RSES) Refrigeration Service Engineers Society
- Sheet Metal & Air Conditioning Contractors' National Association (SMACNA)
- The Partnership for Air-Conditioning, Heating, Refrigeration Accreditation (PAHRA)
- Air Conditioning, Heating & Refrigeration Institute (AHRI)
- The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)  
ASHRAE advances technology to serve humanity and promote a sustainable world. Membership is open to any person associated with the field.
- North American Technician Excellence (NATE)  
NATE is an independent, third-party non-profit certification body for HVAC and HVAC/R technicians. Some of the study materials for NATE tests are available in the ACC library.
- Refrigeration Service Engineers Society (RSES)  
Since 1933, RSES has been a leader in training and education for professional HVACR technicians and contractors. The ACC HART Department is a member of RSES.

### Student Organizations

- Skills USA [www.maskillsusa.org](http://www.maskillsusa.org)

## Selected Websites

<a href="http://www.ari.org">http://www.ari.org</a>	Air-Conditioning and Refrigeration Institute (ARI)
<a href="http://www.ashrae.org/">http://www.ashrae.org/</a>	American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
<a href="http://www.rses.org/">http://www.rses.org/</a>	Refrigeration Service Engineers Society (RSES)
<a href="http://www.smacna.org/">http://www.smacna.org/</a>	Sheet Metal & Air Conditioning Contractors Association of Massachusetts
<a href="http://www.natex.org">www.natex.org</a>	North American Technician Excellence (NATE)
<a href="http://www.pahrahvacr.org">www.pahrahvacr.org</a>	The Partnership for Air-Conditioning, Heating, Refrigeration Accreditation (PAHRA)
<a href="http://www.achrnews.com">www.achrnews.com</a>	Air Conditioning, Heating & Refrigeration News   Weekly
<a href="http://www.phccma.org">www.phccma.org</a>	Plumbing, Heating & Cooling Contractors (PHCC)