

Massachusetts Department of Elementary & Secondary Education

Office for Career/Vocational Technical Education



Vocational Technical Education Framework



Manufacturing, Engineering & Technology Services Occupational Cluster

Engineering Technology (VENGR)

CIP Code 150000

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Commissioner's Letter



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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

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.

Appendix¹

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 Appendix² contains:

- Embedded Academic crosswalks for English Language Arts, Mathematics, and Science & Technology/Engineering.
- Statewide Articulations: Current statewide Articulation Agreements and/or Apprenticeship Programs available to the specific vocational program are listed on this page. The development of new statewide articulations continues, and therefore these pages will be revised as new agreements are finalized.
- Industry-Recognized Credentials: Technical Teacher Teams generated lists of credentials for the vocational programs. Program Advisory Committees throughout the state reviewed and provided recommendations through the validation process. *The credential list has been provided as a resource only and districts are not obligated to provide all of the specified credentials for students.*
- Other: These pages provide lists of reference materials, government agencies, professional and student organizations, and useful websites created by each framework team. These are intended as helpful resources for technical teachers, identified by peers. These are not recommended or required by the Department of Elementary & Secondary Education.

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

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

Organization of the Frameworks – Strand Two

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

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

2.A Automotive Technology Specific Safety Practices

- 2.A.01 Identify and describe safety procedures when dealing with different types of automotive lifts according to current industry standards.
- 2.A.01.01 Demonstrate procedures for safe lift operations.
- 2.A.01.02 Demonstrate safe use, placement and storage of floor jacks and jack stands.

2.A.01 Performance Example:

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

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

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

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

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

2.A.02 Performance Example:

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

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

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

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

2.A.03 Performance Example:

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

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

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

Advanced / Supplemental Standards (Not Required)

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

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

Advanced Automotive Technology Technical Knowledge and Skills

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

2.CC Demonstrate appropriate engine repair techniques.

2.CC.01 Perform appropriate cylinder Head Repair.

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

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

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

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

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

2.B.04 Performance Examples:

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

Manufacturing, Engineering & Technology Services Occupational Cluster

Engineering Technology Framework (VENGR)

Strand 1: Safety and Health Knowledge and Skills

1.A Fundamentals of Health and Safety

- 1.A.01 Describe and apply health and safety regulations.
- 1.A.01.01 Identify, describe and apply health and safety regulations that apply to specific tasks and jobs. Students must complete a safety credential program, e.g., Occupational Safety and Health Administration 10, CareerSafe and ServSafe.
 - 1.A.01.02 Identify, describe and apply Environmental Protection Agency (EPA) and other environmental protection regulations that apply to specific tasks and jobs in the specific occupational area.
 - 1.A.01.03 Identify, describe and apply Right-To-Know (Hazard Communication Policy) and other communicative regulations that apply to specific tasks and jobs in the specific occupational area.
 - 1.A.01.04 Explain procedures for documenting and reporting hazards to appropriate authorities.
 - 1.A.01.05 Identify and describe potential consequences for non-compliance with appropriate health and safety regulations.
 - 1.A.01.06 Identify and list contact information for appropriate health and safety agencies and resources.

1. A.01 Performance Examples:

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

- 1.A.02 Demonstrate appropriate health and safety practices based on the specific occupational area.
- 1.A.02.01 Identify, describe and demonstrate the effective use of Safety Data Sheets (SDS).
 - 1.A.02.02 Read and interpret chemical, product and equipment labels to determine appropriate health and safety considerations.
 - 1.A.02.03 Identify, describe and demonstrate personal, shop and job site safety practices and procedures.
 - 1.A.02.04 Demonstrate safe dress and use of relevant safety gear, personal protective equipment (PPE) and ergonomics, e.g., wrist rests, adjustable workspaces, equipment, gloves, proper footwear, earplugs, eye protection and breathing apparatus.
 - 1.A.02.05 Demonstrate appropriate safe body mechanics, including appropriate lifting techniques and ergonomics.
 - 1.A.02.06 Locate emergency equipment, first aid kit, SDS information directories and emergency action/response plan/escape routes in your lab, shop and

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

- 1.A.02.07 Demonstrate the safe use, storage, and maintenance of every piece of equipment in the lab, shop and classroom, e.g., the OSHA Lockout/Tagout Program (LOTO).
- 1.A.02.08 Describe safety practices and procedures to be followed when working with and around electricity, e.g., ground fault circuit interrupter (GFCI) and frayed wiring.
- 1.A.02.09 Handle, store, dispose of and recycle hazardous, flammable and combustible materials, according to EPA, OSHA and product specifications.
- 1.A.02.10 Demonstrate appropriate workspace cleaning, sanitation, disinfection and sterilization procedures required in specific occupational areas, e.g., Workplace Housekeeping OSHA Regulations.

1. A.02 Performance Examples:

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

- 1.A.03 Demonstrate appropriate responses to situations that may threaten health and safety.
 - 1.A.03.01 Describe First Aid procedures for potential injuries and other health concerns in the specific occupational area.
 - 1.A.03.02 Describe the importance of emergency preparedness and an emergency action/response plan.
 - 1.A.03.03 Describe procedures used to handle emergency situations, defensive measures and accidents, including identification, reporting, response, evacuation plans and follow-up procedures.
 - 1.A.03.04 Identify, describe and demonstrate safety practices in specific occupational areas used to avoid accidents.
 - 1.A.03.05 Identify and describe fire protection, protection, precautions and response procedures.
 - 1.A.03.06 Discuss the role of the individual and the company/organization in ensuring workplace safety including transportation to and from school, school activities and the workplace.
 - 1.A.03.07 Discuss ways to identify, prevent and report school and workplace violence, discrimination, harassment and bullying.
 - 1.A.03.08 Demonstrate positive and appropriate behavior that contributes to a safe and healthy environment in school and the workplace.

1. A.03 Performance Example:

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

Selected Websites

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

Strand 2: Technical Knowledge and Skills

2.A Engineering Safety Health and Skills

- 2.A.01 Obtain OSHA 10 Hour General Certification.
 - 2.A.01.01 Implement safety knowledge obtained on a continuous basis.
 - 2.A.01.02 Identify safety hazards in the shop, remove hazards, and develop continuous improvement solutions.
 - 2.A.01.03 Implement a tag-out and lock-out shop procedure.

2.A.01 Performance Example:

- Student will satisfy the requirements for an OSHA 10-hour general industry certification, based on school policy.

- 2.A.02 Read, explain and implement shop safety manual and procedures according to current industry and OSHA standards.
 - 2.A.02.01 Demonstrate safety procedure(s) for maintaining machinery and equipment.
 - 2.A.02.02 Demonstrate safety procedure(s) for operating machinery and equipment.

2.B Engineering – Introductory Knowledge and Skills

- 2.B.01 Demonstrate and apply the design process.
 - 2.B.01.01 Identify a problem to be solved based on identifying customer needs.
 - 2.B.01.02 Brainstorm ideas; develop and evaluate solutions; create documentation; build and test prototype; and present design.
 - 2.B.01.03 Create new designs by working in teams using brainstorming techniques.
 - 2.B.01.04 Maintain an engineering journal to document design solutions.
 - 2.B.01.05 Conduct market surveys, research patents, search internet sources, contact companies, and develop justification for at least three solutions of given engineering problems/customer needs..
 - 2.B.01.06 Develop best solution, sketch and model idea, survey market and customers, produce a timeline, develop industry support, report results periodically, re-evaluate solution, develop criteria and limitations and produce initial drawings.
 - 2.B.01.07 Describe the role of drawings and CAD models as vital documentation components in the engineering process.
 - 2.B.01.08 Fabricate a prototype using hand tools, manual machine tools, CNC devices, joining processes, measuring and cutting techniques.
 - 2.B.01.09 Develop testing protocol, test and evaluate prototype, assess performance and function, and modify design based upon results.
 - 2.B.01.10 Produce final drawing documentation, develop presentation, present results; patent, market, and sell idea.

- 2.B.01 Performance Examples:
- Select an invention or technological process that interests you and relates to your field of study (shop). Answer the following questions by applying the “Product Development lifecycle” (hand-out with model that has been distributed by your instructor), to this invention or process. What was the need at the time for this product/process? Were any alternate solutions proposed? Please explain. Were any new products/processes developed as a result of this invention? Please explain. List some different prototypes that were developed for the product/process, and identify any relevant documentation. Please include appropriate pictures, diagrams, drawings, etc. Identify the different design development cycles for this invention (product/process).
 - Student identifies a problem with the seats in a vehicle. Following the engineering process, they create, test and present a solution to the problem.
 - Student sees a need for a new product. Following the engineering process, the student creates, tests and presents the product, identifying the strengths and usefulness of the product.
 - Student can apply principles of total quality management techniques when carrying out their work. This will include development of benchmarks by teaming methods, use of documentation, graphing in measurement of outcomes, and understanding the need for change in processes when outcomes require it.

- 2.B.02 Demonstrate skills in problem solving, diagnostics, and troubleshooting.
- 2.B.02.01 Identify the components and process of the system (equipment).
 - 2.B.02.02 Identify the problem or source of the problem.
 - 2.B.02.03 Develop solutions using a structured problem solving process.
 - 2.B.02.04 Use appropriate testing equipment and tools for diagnosing the problem.
 - 2.B.02.05 Implement the appropriate strategies to remedy the problem.

- 2.B.02 Performance Example:
- Students use appropriate software to produce a flow chart of the design or workflow process. Student teams then use problem solving approaches, including brainstorming techniques, to identify possible solutions to a problem (or set of problems). Working individually, students produce a report that would diagnose the actual problem, suggest solutions and corrections, and propose strategies to prevent reoccurring problems.

- 2.B.03 Define and describe types of engineering.
- 2.B.03.01 Describe different pathways towards a variety of engineering careers.
 - 2.B.03.02 Explain how engineers impact society, the environment, economy, and daily life through their work.
 - 2.B.03.03 Identify the unique components and considerations of the different engineering fields (e.g., civil/structural, transportation, electrical, computer, software, manufacturing, mechanical, and biological/environmental/chemical).
 - 2.B.03.04 List the attributes of design in a variety of technical fields (e.g., biotechnology, manufacturing, environmental, power and energy, transportation, etc.).
 - 2.B.03.05 Describe one major engineering category or sub-discipline and describe core tasks, working conditions, salary, education and training, skills and abilities required.

- 2.B.03 Performance Example:
- Select a product or process (communication for example) and develop a historical time line noting the key inventions, adaptations, and impact that occurred over a centennial time period.

- 2.B.04 Document and communicate engineering concepts.
- 2.B.04.01 Write a technical design report.
 - 2.B.04.02 Maintain engineering logs/notebooks/journals and portfolios for projects.
 - 2.B.04.03 Utilize a variety of media formats to convey designs and processes (animation, presentation software, web page, etc.).

- 2.B.05 Develop project or product objectives and criteria.
 - 2.B.05.01 Define requirements for a project or product.
 - 2.B.05.02 Create specifications (or follow if given) for a project or product.
 - 2.B.05.03 Establish milestones for a project or product.
 - 2.B.05.04 Develop a time line for a project or product.
 - 2.B.05.05 Identify critical path components.
 - 2.B.05.06 Implement a schedule for a project or product.
- 2.B.06 Develop methods and plan of production.
 - 2.B.06.01 Determine method to be used to create a product (molding, machining, etc.).
 - 2.B.06.02 Define efficient order of fabrication operation.
 - 2.B.06.03 Identify parts and materials for product.
 - 2.B.06.04 Make custom parts (those not readily available that meet specifications).
 - 2.B.06.05 Assemble a product.
- 2.B.07 Explain, demonstrate and apply manufacturing process management techniques according to current industry and OSHA standards.
 - 2.B.07.01 Identify internal and external customer needs.
 - 2.B.07.02 Identify resources needed (supplies, personnel, equipment).
 - 2.B.07.03 Identify/create/provide needed standard operational procedures (SOPs).
 - 2.B.07.04 Monitor process using process control data.
 - 2.B.07.05 Explain inventory control and the implications to production and performance.
 - 2.B.07.06 Test product to verify that it meets customer specifications, regulations, etc.
 - 2.B.07.07 Demonstrate process used to document and ensure compliance.
 - 2.B.07.08 Insure timely delivery of product to customer.

2.B.07 Performance Example:

- Identify and develop a process for project development and apply it to the completion of a product/drawing/etc.

- 2.B.08 Apply principles of 'world class' operations (i.e., industry quality standard operation).
 - 2.B.08.01 Explain quality control techniques as applied to manufacturing/engineering and technical processes.
 - 2.B.08.02 Identify and apply the concepts of total quality management (TQM) appropriate to the field.
 - 2.B.08.03 Assess a plan for continuous improvement.
- 2.B.09 Apply industrial design and packaging.
 - 2.B.09.01 Explain the different elements of industrial design including branding, usability, ergonomics, sustainability, maintainability, aesthetics, etc.
 - 2.B.09.02 Design a packaging solution for a product (such as food, hair care, a tool, etc.). Explain the purposes, goals, and the risks and benefits of your design choices.
- 2.B.10 Explain introductory engineering concepts.
 - 2.B.10.01 Define and use engineering notations and prefixes: tera, giga, mega, kilo, milli, micro, nano, pico.
 - 2.B.10.02 Explain Prior Technologies in several common engineering areas.
 - 2.B.10.03 Complete a reverse engineering process for a design or device.
 - 2.B.10.04 Use both metric and English systems of measurements.

2.B.10 Performance Example:

- Using appropriate English and metric measurement tools (including both linear and angular), student reads and recognizes scaling and applies mathematical skills to obtain the measurements. The student will also demonstrate the use and application of basic formulas to prove accuracy of an assigned project. Students can select and use mechanical measuring tools such as micrometers and dial verniers, and electronic measuring devices including set up manipulation and operation of these devices as they apply to their technical field (calibrate equipment, understand working range, limits, and problems of devices used in the field). Students will use measurement skills to measure worn components for loss of functionality.

2.C Electrical Engineering Demonstration, Design, and Implementation

2.C.01 Demonstrate introductory electrical engineering knowledge and skills.

- 2.C.01.01 Identify appropriate test devices for specific tasks (e.g., oscilloscope or multimeter).
- 2.C.01.02 Calibrate and use test devices accurately (e.g., oscilloscope or multimeter).
- 2.C.01.03 Read and interpret schematics.

2.C.01 Performance Example:

- Students measure a sine wave and provide the following information to their instructor: the peak to peak voltage, the peak voltage, the RMS voltage, the average voltage, the wave's time (period) and the wave's frequency.

2.C.02 Explain and apply electrical engineering principles, and techniques and use design tools and materials according to current industry and OSHA standards..

- 2.C.02.01 Label and describe the parts of an atom.
- 2.C.02.02 Explain what classifies a material as an insulator, conductor, or semiconductor.
- 2.C.02.03 Describe resistance and what its function is in circuit design.
- 2.C.02.04 Identify resistors using color code.
- 2.C.02.05 Measure resistance using multimeters.
- 2.C.02.06 Identify basic circuit components (source, load, control, and conductors).
- 2.C.02.07 Describe different types and functions of switches.
- 2.C.02.08 Calculate voltage, current and resistance in circuits using Ohm's law.
- 2.C.02.09 Calculate current and voltage using Kirchhoff's law.
- 2.C.02.10 Measure voltage, current, and resistance in both series and parallel circuits.
- 2.C.02.11 Describe the differences among series, parallel, and series-parallel circuits.
- 2.C.02.12 Measure the value of capacitors using instrumentation.
- 2.C.02.13 Identify different types of capacitors, their values, and their voltage polarity requirements.
- 2.C.02.14 Differentiate between direct and alternating currents.
- 2.C.02.15 Draw and label waveforms (e.g., square, sawtooth, and sine).
- 2.C.02.16 Determine rise time, fall time, frequency, and amplitude using an oscilloscope.
- 2.C.02.17 Demonstrate the operation of diodes and describe their function.
- 2.C.02.18 Demonstrate the operation of transistors and describe their function.
- 2.C.02.19 Describe the differences among display devices: LED (light emitting diodes), seven segment display and LCD (liquid crystal display).
- 2.C.02.20 Locate logic families in a reference catalog.
- 2.C.02.21 Read specification sheets on an individual IC to determine suitability for use in a given circuit.
- 2.C.02.22 Perform conversions between binary and decimal, hexadecimal and binary, and hexadecimal and decimal.

- 2.C.02.23 Use schematics and symbolic algebra to represent digital gates as part of a solution to a design problem (logic symbols: AND, OR, NOT, NAND, NOR, X-OR and X-NOR gates).
- 2.C.02.24 Create Boolean expressions and truth tables.
- 2.C.02.25 Select min-term and max-term expressions (sum of product: SOP, product of sum: POS).
- 2.C.02.26 Use DeMorgan's theorem to convert a SOP to a POS in order to save resources in the production of circuits.
- 2.C.02.27 Formulate and use a Karnaugh Map and/or Boolean algebra to reduce logic equation.
- 2.C.02.28 Describe duality of logic functions.
- 2.C.02.29 Simplify, solve, construct, and demonstrate a circuit from a digital word problem.
- 2.C.02.30 Design circuits using reprogrammable logic devices.

2.C.02 Performance Example:

- Student will design and build an alarm circuit that utilizes two different alarm signals (light and sound, two different sounds, etc.)

2.C.03 Build and implement electrical engineering circuits.

- 2.C.03.01 Simulate a circuit.
- 2.C.03.02 Construct a circuit.
- 2.C.03.03 Troubleshoot problems with a circuit.
- 2.C.03.04 Create PLD (Programmable Logic Devices) logic files.
- 2.C.03.05 Construct and test simple latches and flip-flops from discrete gates.
- 2.C.03.06 Interpret, design, draw, and evaluate circuits using logic symbols (triggers, latches, flip-flops).
- 2.C.03.07 Create timing diagrams and truth tables for J-K flip-flop.
- 2.C.03.08 Analyze timing diagrams.
- 2.C.03.09 Explain timing requirements of ICs.

2.C.03 Performance Example:

- Student will create a circuit that will display a message (time, temp., etc.).

2.D Mechanical Engineering Demonstration, Design, and Implementation

2.D.01 Demonstrate introductory mechanical engineering knowledge and skills.

- 2.D.01.01 Identify the various industry-wide prototyping methods in use.
- 2.D.01.02 Describe common engineering plastics, processing, additives, fillers, colorants, modifiers, and their effects on properties.
- 2.D.01.03 Select suitable materials for a given application.
- 2.D.01.04 Use the measurement units of mass, length, angles and time and their extensions (e.g., velocity, density)
- 2.D.01.05 Identify and use devices and gauges (i.e. rulers, scales, timers, calipers, radius gauges, protractors) to accurately measure units of mass, length, angles, and time and their extensions.
- 2.D.01.06 Calibrate mechanical measurement devices and gauges.
- 2.D.01.07 Interpret detail and assembly drawings, technical processes, procedures, and instructions.
- 2.D.01.08 Extract and analyze properties of mass (i.e. volume, density, moment of inertia, etc.).

- 2.D.01.09 Evaluate the function and operation of assembly (motion, interference, etc.) of a mechanical design.
- 2.D.01.10 Demonstrate ethical challenges facing engineers in the design, redesign, repair and implementation of products.
- 2.D.01.11 Demonstrate various classes and subclasses of common engineering materials (e.g., organics, metals, polymers, ceramics, and composites) and their properties (solid, liquid, and plasma gas) from macrostructure to microstructure.
- 2.D.01.12 Demonstrate the use and application of the various classes and subclasses of materials.
- 2.D.01.13 Demonstrate property changing treatments (i.e. heat, chemical, additives, etc) in a variety of materials.
- 2.D.01.14 Describe and define the process of casting and molding as it relates to the engineering process and fabrication.
- 2.D.01.15 Trace the production of engineering materials from raw material to finished product as well as disposal, recycling, and describe the environmental impact of each process.
- 2.D.01.16 Demonstrate how the properties of materials and their use influences the reliability of a mechanical design (i.e. Mean Time Between Failure: MTBF, etc.)
- 2.D.01.17 Describe how design choices will affect the likelihood of safety and liability issues arising within the end use of a designed product.
- 2.D.01.18 Explain and demonstrate where material removal or addition would be the appropriate process to use in production (e.g., turning, milling, grinding, and plating).
- 2.D.01.19 Describe the process of forming (e.g., bending, forging, cutting, etc).
- 2.D.01.20 Explain how design choices will affect the ease and efficiency of manufacturing the designed product.

2.D.01 Performance Examples:

- Student will create a 3-D model of a part or assembly, analyze its mass properties, dynamic function, and perform finite element analysis.
- Student will describe the process for creating metals, plastics, ceramics or composites, conventional processing techniques, machining, forming and joining methods and common applications by creating a poster-board display.
- Student will create a case study and debate the liability, reliability, and safety issues for the design of a toy listed as a 'dangerous toy' by consumer groups.

- 2.D.02 Explain and apply mechanical engineering principles and techniques, and use design tools and materials according to current industry and OSHA standards.
 - 2.D.02.01 Define geometric shapes, line types, tools, and describe constraints used in sketching.
 - 2.D.02.02 Prepare clear and accurate hand sketches using orthographic and perspective views.
 - 2.D.02.03 Prepare clear and accurate hand sketches using annotative labels including materials, processes, functions and dimensions.
 - 2.D.02.04 Apply scale, dimensioning, and tolerance standards to drawings.
 - 2.D.02.05 Define and implement Geometric Dimensioning and Tolerancing (GD&T) for production drawings.

- 2.D.02.06 Create and edit a solid model using a 3-D modeling program, based upon design sketches. Utilize appropriate materials, measurements, fits, appearances, processes and functions.
- 2.D.02.07 Combine model parts into working assembly, manipulate and animate assembly using a 3-D modeling program.
- 2.D.02.08 Analyze parts and assemblies with respect to safety, handling, end user, production, cost, packaging, and environmental impact.
- 2.D.02.09 Create detail and assembly drawings based upon 3-D models.
- 2.D.02.10 Annotate detail drawings with dimensions, materials, processes and appropriate views.
- 2.D.02.11 Create section, detail, broken-out, break, and auxiliary views.
- 2.D.02.12 Create an assembly drawing with: balloons, a parts list containing items, quantities, descriptions and part numbers, appropriate assembly notes; and a titleblock based upon 3-D models.
- 2.D.02.13 Create a numbering system for each drawing set.
- 2.D.02.14 Identify, describe and prescribe ferrous and non-ferrous metals, plastics, ceramics and composites, based upon their micro and macro structures, relationship between micro structure and properties, common property changing procedures and treatments.
- 2.D.02.15 Design items using common engineering plastics based upon their processing, additives, fillers, colorants, modifiers and the effects on properties.
- 2.D.02.16 Analyze, describe, and test the concepts of simple machines: gears, pulleys, lever, wheel and axle, wedge and screw, and determine their mechanical advantages.
- 2.D.02.17 Analyze, describe, and test fluid systems based upon flow, pressure, density, temperature, elevation, and friction.
- 2.D.02.18 Analyze, describe, and test heat flow systems based upon conduction, convection, and radiation, and perform heat loss calculations.
- 2.D.02.19 Analyze, describe and test basic beam deflection relationships; stress, strain, tension, compression, torsion, moments for common cross-sectional shapes and materials using such techniques as finite element analysis (FEA).
- 2.D.02.20 Construct free body diagrams, resolve forces into vector components, solve static equations and calculate stress, strain, deflection, moment of inertia, linear and angular velocity and acceleration.

2.D.02.21 Identify where material joining would be the appropriate process to use in production (gluing, welding, etc.)

2.D.02 Performance Example:

Students will:

- For a complex assembly (guitar, bicycle, hair dryer, arbor press, gearbox, and hydraulic jack), create: 3D models of all parts; a 3-D assembly model; a 2-D assembly drawing with a parts list, balloons, and assembly notes and all detail drawings with dimensions, material notes, and a completed titleblock.
- Draw the atomic (cubic), micro (crystalline) and macro (grain) structures for steel. Describe how steel becomes hardened with the addition of carbon to the cubic structure, closing of interstitial spacing in crystalline structures and the formation of carbides at the grain boundaries. Describe tempering, annealing, stress-relieving, and quenching processes as they relate to the properties of steel. Create a poster board titled: "Steel, its Structures, Treatments, and Properties."
- Design and build a device or number of devices that use all six simple machines (lever, wheel and axle, pulley, inclined plane, wedge and screw) to transfer energy from one device to another.
- Design and build a hydraulic system to lift a known weight a defined distance in a specified time. Calculate the required input and output force, work and power for the system.
- Perform a heat loss study for a device. Consider convective, conductive, and radiation heat loss. For convective heat loss $q = h_c * A * \Delta T$. For conductive heat loss $q = k * A * \Delta T / s$. For radiation heat loss $q = \sigma * T^4 * A$.
- Create a tensile test specimen and test to failure. Record the force and elongation of sample at multiple points during testing; calculate the stress and strain; and plot a graph of stress versus strain. Determine the elastic range, proportional limit, yield point, resilience, plastic deformation, and the modulus of elasticity from the data. Compare to known values for the material.
- Design a structure utilizing trusses to support a known weight such as a crane. Solve the static equations necessary to determine maximum stress, strain, and deflection for the structure.
- Design a device to transmit linear motion into rotational motion. Determine the input linear velocity and calculate the output angular velocity and acceleration. Examples are: rack and pinion steering, a piston and crankshaft, a pulley and cord. Determine the output force based upon the input force or weight and the angular acceleration.

2.D.03 Build and implement mechanical engineering designs.

2.D.03.01 Use industry-wide prototyping methods including rapid-prototyping.

2.D.03.02 Build a prototype model from a drawing database.

2.D.03.03 Set up and operate a basic manufacturing assembly process, resulting in a finished product.

2.D.03.04 Build mechanical parts utilizing techniques such as turning, milling, cutting, bending, etc.

2.D.03 Performance Example:

- Students create parts for a mechanical assembly utilizing techniques such as turning, milling, cutting, bending, forming and 3-D printing. Students assemble parts and test for proper functioning.

2.E Automated Systems Engineering Demonstration, Design, and Implementation

2.E.01 Demonstrate automated systems engineering introductory knowledge and skills.

2.E.01.01 Define an automated system and a robot.

2.E.01.02 Evaluate the impact robots have on manufacturing and society.

2.E.01.03 Classify different types of robots.

2.E.01.04 Identify specifications for the work envelope of a robot.

- 2.E.01.05 Identify and sketch the components of a robot.
- 2.E.01.06 Describe servo, stepper and DC motors and possible uses.
- 2.E.01.07 Describe the components of robot controllers.
- 2.E.01.08 Select, size, and implement interface device(s) to control a motor(s).
- 2.E.01.09 Describe ways an end effector is specific to a process.
- 2.E.01.10 Explain the need for end of arm tooling and how it affects the robot's operation.
- 2.E.01.11 Describe various applications of a programmable logic controller (PLC) as related to its use in a computer integrated manufacturing (CIM) system.
- 2.E.01.12 Describe the difference between a PLC and a computer with interface.
- 2.E.01.13 Identify individual components used in CIM systems.
- 2.E.01.14 Explain the significance of teamwork and communication when combining the designs of the individual groups into a complete model of Flexible Manufacturing Systems (FMS).
- 2.E.01.15 Differentiate between open and closed loop control.
- 2.E.01.16 Design and create a program to evaluate data and make decisions using external digital and analog sensors.
- 2.E.01.17 Formulate a flow chart to correctly apply basic programming concepts.
- 2.E.01.18 Describe the function of sensors in electronic circuitry (temp., optical, etc.).
- 2.E.01.19 Explain the principles of control techniques and computer simulations.
- 2.E.01.20 Compare and contrast the benefits and drawbacks of the three categories of CIM manufacturing systems.
- 2.E.01.21 Describe the working relationship between the CNC mill and the robot.
- 2.E.01.22 Analyze and select CIM system components for a specific industrial application.

2.E.01 Performance Example:

- Students will compare and contrast a servo, a stepper motor, and a DC motor and describe how they are utilized in an automated system.

- 2.E.02 Explain and apply automated systems engineering principles and techniques, and use design tools and materials according to current industry and OSHA standards.
 - 2.E.02.01 Design an end effector.
 - 2.E.02.02 Design a working model of a robot or automated system.
 - 2.E.02.03 Program a robot or automated system to perform several tasks.
 - 2.E.02.04 Program a robot or automated system to solve a materials handling problem.
 - 2.E.02.05 Design an automated feed system with sensors.
 - 2.E.02.06 Design an interface that inspects, evaluates, and manages program parameters during the operation of the program.

2.E.02 Performance Example:

- Students will design an automated control system (door opener, automatic window shade, lighting control, etc.)

- 2.E.03 Build and implement automated systems engineering designs.
 - 2.E.03.01 Develop an end effector.
 - 2.E.03.02 Build a working model of a robot or automated system.
 - 2.E.03.03 Build drive systems used in robotics or automated system.
 - 2.E.03.04 Operate a CIM system utilizing appropriate safety precautions.
 - 2.E.03.05 Demonstrate how individual components work together to form a complete CIM system.

- 2.E.03.06 Assemble and test individual component designs by integrating them into a complete model FMS.
- 2.E.03.07 Run, test, evaluate, and redesign system operation.
- 2.E.03.08 Build an automated feed system with sensors.

2.E.03 Performance Examples:

- Using industry standard devices and controls, students will build and program a fully functioning robotic device that will perform a multi stepped task (travel to a location; pick up an object; move to another position; and place the object in a specific receptacle, etc.)
- Students will build an automated control system (door opener, automatic window shade, lighting control, etc.)

2.F Civil Engineering/Architecture Demonstration, Design, and Implementation

2.F.01 Demonstrate civil engineering/architecture introductory knowledge.

- 2.F.01.01 Describe the importance of architecture and civil engineering and their evolution over time.
- 2.F.01.02 Compare and contrast various architectural styles.
- 2.F.01.03 Describe the components of and coordination required of an entire construction document set including: mechanical, electrical, plumbing, civil, structural and architectural drawings.
- 2.F.01.04 Use an architectural or engineering scale to measure drawings.
- 2.F.01.05 Identify various structural systems (i.e. steel frame, concrete frame, etc.) including foundation types.
- 2.F.01.06 Explain surveying strategies and equipment use.
- 2.F.01.07 Describe the importance of sustainable design.
- 2.F.01.08 Identify and differentiate among the responsibilities of various members of a project team including the design (architect, engineers, etc.) and construction team (general contractor, subcontractors, etc.) members.
- 2.F.01.09 Solve statics problems using computerized packages (e.g., MD Solids).
- 2.F.01.10 Calculate stress and strain in simple parts.
- 2.F.01.11 Plot a stress/strain diagram.
- 2.F.01.12 Describe the parts of a stress/strain diagram.
- 2.F.01.13 Perform moment of inertia calculations.
- 2.F.01.14 Solve for stress, strain, and deflection in common beam shapes.
- 2.F.01.15 Analyze, describe, and test basic beam deflection relationships: stress, strain, tension, compression, torsion, moments for common cross-sectional shapes and materials, using such techniques as finite element analysis (FEA).
- 2.F.01.16 Construct free body diagrams; resolve forces into vector components; solve static equations; and calculate stress, strain, deflection, moment of inertia, linear and angular velocity and acceleration.

2.F.01 Performance Examples:

- Students will research and present a chosen architectural style.
- Students will conduct a tensile test using a structural analyzer and use the results to create a stress/strain diagram.

2.F.02 Explain and apply civil engineering/architectural principles and techniques, and use design tools and materials according to current industry and OSHA standards.

- 2.F.02.01 Create a site survey.
- 2.F.02.02 Conduct soil testing and analyze the results.
- 2.F.02.03 Analyze a site and determine the drainage requirements.
- 2.F.02.04 Design site grading including cut and fill volume calculations.

- 2.F.02.05 Create a commercial site design including parking, roads, and landscaping.
- 2.F.02.06 Apply building codes, regulations, and standards to a construction project.
- 2.F.02.07 Calculate dead, live, and environmental (snow, wind) loads on a structure.
- 2.F.02.08 Trace gravity loads through a structure from their point of application to the building's foundation.
- 2.F.02.09 Determine the tributary area of a particular structural element.
- 2.F.02.10 Design a simply supported beam including an analysis of shear, bending moment and deflection requirements.
- 2.F.02.11 Create a cost estimate for a construction project.
- 2.F.02.12 Perform heat loss calculations.
- 2.F.02.13 Apply sustainable design to a project.

2.F.02 Performance Example:

- Students will design a simply supported beam, column, and foundation of a one-story commercial building.

- 2.F.03 Build and implement civil engineering/architecture designs.
 - 2.F.03.01 Create a 3D computer model of both residential and commercial buildings.
 - 2.F.03.02 Build a scale model of a building with a particular architectural style.
 - 2.F.03.03 Build, test, and redesign a scale model of an engineering structure (e.g., building, bridge, etc.).
 - 2.F.03.04 Create an as-built drawing set including plans, sections, and details.

2.F.03 Performance Examples:

- Students will use computer modeling software to create rendered drawings and a walk-through of a building.
- Students will create a balsa wood bridge and perform destructive testing.

Third Year Engineering Integrated Areas and Engineering Maintenance

Below are listed additional Categories of Learning, Standards and Objectives beyond the scope of the two year DESE requirement. They are placed in the Appendices as reference and can be used in the third year of an Engineering Technology program.

2.G* Third Year Engineering Integrated Area Research Design, Implementation and Maintenance

- 2.G.01* Demonstrate integrated area research introductory knowledge.
 - 2.G.01.01* Identify and explain additional engineering areas such as, but not limited to: Manufacturing, Aerospace, Environmental, Nuclear, Mining, Green/Sustainable Technologies, Geological, Agricultural, Marine and Ocean.
 - 2.G.01.02* Identify an emerging or other engineering area for student research.
 - 2.G.01.03* Present an emerging or other engineering area's design for a business plan.

2.G.01 Performance Examples:

Student will:

- Research an engineering topic of interest. Use expanding knowledge to develop a project/presentation. Reflect on use of prior core knowledge and project possibilities/uses in the selected engineering focus.
- Develop a work improvement plan for a current co-op job experience relating to how a company operates in manufacturing.

- 2.G.02* Explain and apply integrated area research principles and techniques, and use design tools and materials according to current industry and OSHA standards.
- 2.G.02.01* Develop a working design of a system used in an emerging or other selected engineering area.
- 2.G.02.02* Identify components of design for the selected emerging or other engineering area.
- 2.G.02.03* Identify how a component or subsystem of a design relates to core engineering learning area(s).

2.G.02 Performance Example:

- Student will design and develop a system to process used cooking oil for use in low powered diesel engines.

2.G.03* Build and implement integrated area research designs.

- 2.G.03.01* Build a model of a system for a selected emerging or other engineering area based on a business plan and working design.

2.G.03 Performance Example:

- Student will build a system for converting solar energy into electrical energy for use in the home. Student will develop a business plan and marketing strategy aimed at potential investors.

2.H* **Third Year Elective Engineering Area Design Template**

2.H.01* Demonstrate elective engineering area introductory knowledge and skills.

Note: This section provides a framework to help an Engineering Technology student pursue a personally interesting, self-selected domain of engineering for study.

This choice is in addition to the required standard sections, namely, Electrical, Mechanical, Automated Systems and Civil Engineering. This option may serve as a third year study elective, perhaps the basis for a senior year project or an advanced practice opportunity in the engineering design process.

Choices are as limitless, as are the many areas of engineering. A small example of engineering areas of focus would be: Environmental, Medical Device, Aeronautical, Computer Firmware, High Power Electrical, Municipal Systems, Chemical Manufacturing, Automotive Embedded Systems, Ceramics, Optical Sensor, Nuclear Power, Agricultural, etc.

- 2.H.01.01* Identify an elective engineering area (EEA) of interest.
- 2.H.01.02* Present initial research and rationale of the feasibility for further engineering study and activities within the EEA of choice.
- 2.H.01.03* Determine and demonstrate knowledge of essential scientific discoveries for the EEA.
- 2.H.01.04* Determine and demonstrate knowledge of the mathematics required for success in engineering within the EEA.
- 2.H.01.05* Describe the engineering history within the EEA.
- 2.H.01.06* Explain the evolution and the state of the art of the technology (both devices and processes) within the EEA.
- 2.H.01.07* Identify and demonstrate *knowledge* of the design tools, design techniques and materials utilized in the EEA.
- 2.H.01.08* Identify and demonstrate *knowledge* of implementing and building a design within the EEA.
- 2.H.01.09* Identify and demonstrate *knowledge* of the tools, techniques, skills and materials utilized in the maintenance of the system for the EEA.
- 2.H.01.10* Comprehensively review and document your introductory EEA findings.
Note: this is to strengthen your understanding of the feasibility of

continuing your EEA efforts to include engineering design, implementation and maintenance within this domain.

2.H.01 Performance Example:

- Student presents their introductory findings on their elective engineering area to an audience of instructor(s) and peers for review. They declare their plans for an actual design or redesign, implementation and maintenance of their EEA subsystem.

2.H.02* Explain and apply elective engineering area principles, and techniques and use design tools and materials according to current industry and OSHA standards.

- 2.H.02.01* Analyze or reverse engineer a design of a system, subsystem or component, typical of your EEA.
- 2.H.02.02* Demonstrate a working knowledge of the design techniques typical of your EEA industry.
- 2.H.02.03* Create or recreate an *initial* EEA design (i.e. schematics, drawing, flowcharts, psuedocode, etc.) using elementary design tools typical to the chosen engineering domain.
- 2.H.02.04* Specify materials and/or components for your EEA design.
- 2.H.02.05* Determine a maintenance strategy for your EEA design.
- 2.H.02.06* After review and update of the initial design, create or recreate a working design (if possible, using computer aided design (CAD) tools) typical of your EEA industry.
- 2.H.02.07* Follow the engineering design process through all stages of your EEA design or emulated design.

2.H.02 Performance Example:

- Student profiles their reverse engineering project, in words and photos, for inclusion in their vocational portfolio.

2.H.03* Build and implement elective engineering area designs.

Note: Dependant on the domain of the chosen EEA, the implementation or building specified in this section, may be physical or in some other form such as software.

- 2.H.03.01* Build a model or working prototype of your EEA design or redesign. Or, alternatively, fashion a model of an emulated commercial EEA design.
- 2.H.03.02* Specify and document processes that will ensure efficiency in the commercial manufacturing of an EEA design (either yours or an existing one).

2.H.03 Performance Example:

- Student builds, and utilizes, a jig or fixture which demonstrates increased efficiency in some element of the manufacturing of a component within an EEA design.

2.H.04* Maintain elective engineering area designs.

- 2.H.04.01* Identify skills required for personnel who will perform maintenance and repair of design(s) typical of your EEA.
- 2.H.04.02* Identify the tools and processes for maintenance and repair of your design or of design(s) typical for your EEA.
- 2.H.04.03* Practice providing maintenance and/or repair of design(s) typical of your EEA, while keeping a repair log.

2.H.04 Performance Example:

- Student performs a maintenance test on their EEA implementation based on its design. They inset a fault or bug into their prototype and then allow a fellow student to determine the fault, while tracking the time and ease of diagnosis.

2.I*

Engineering Maintenance

2.I.01* Maintain electrical engineering equipment.

- 2.I.01.01* Identify skills for appropriate person(s) for maintenance and repair of electrical equipment.
- 2.I.01.02* Identify the tools and processes for appropriate person(s) for maintenance and repair of electrical equipment.
- 2.I.01.03* Research and provide preventative maintenance on an electrical system (such as a 3D printer), keeping a log for documentation. Provide corrective maintenance on an electrical system.
- 2.I.01.04* Monitor equipment operational indicators to insure that equipment is performing according to manufacturer's specifications .

2.I.01 Performance Example:

- Student will create a preventative maintenance schedule on an electrical system (such as an oscilloscope), keeping a log for documentation.

2.I.02* Maintain mechanical engineering equipment.

- 2.I.02.01* Identify required skills for maintenance and repair of mechanically designed equipment.
- 2.I.02.02* Identify the tools and processes required for maintenance and repair of mechanically designed equipment.
- 2.I.02.03* Research and provide preventative maintenance on a mechanical system (such as a bicycle, lathe, or automobile), keeping a log for documentation. Provide corrective maintenance on a mechanical system.
- 2.I.02.04* Monitor equipment operational indicators to insure that equipment is performing according to current industry and OSHA standards,
- 2.I.02.05* Maintain, inventory, and organize tools and equipment.
- 2.I.02.06* Develop and maintain a written log for service and repair of tools and equipment.
- 2.I.02.07* Maintain electronic and mechanical devices and gauges as specified by manufacturer, including cleaning, storage and calibration.
- 2.I.02.08* Store, retrieve, copy, and output drawing files depending upon system setup.

2.I.03* Maintain automated systems engineering equipment.

- 2.I.03.01* Identify skills required for maintenance and repair of an automated system.
- 2.I.03.02* Identify the tools and processes required for maintenance and repair of an automated system.
- 2.I.03.03* Research and provide preventative maintenance on an automated system (such as a robot), keeping a log for documentation. Provide corrective maintenance on an automated system.
- 2.I.03.04* Monitor operational indicators to insure that the automated system is performing according to current industry and OSHA standards.

2.I.03 Performance Example:
▪ Student will prepare a schedule to monitor operational indicators to insure that the automated system is performing according to current industry and OSHA standards (such as small CIM system).

- 2.I.04* Maintain civil engineering/architecture equipment.
- 2.I.04.01* Identify skills required for maintenance and repair of a structure.
 - 2.I.04.02* Identify the tools and processes required for maintenance and repair of a structure.
 - 2.I.04.03* Research and describe preventative maintenance on a system (such as a bridge), keeping a log for documentation. Provide corrective maintenance on a system.
 - 2.I.04.04* Monitor structural operational indicators to insure that the system is performing according to current industry and OSHA standards.

2.I.04 Performance Example:
▪ Student will use sensors to observe the performance of a built structure.

- 2.I.05* Maintain integrated area research equipment.
- 2.I.05.01* Identify skills required for maintenance and repair of integrated areas equipment.
 - 2.I.05.02* Identify the tools and processes required for maintenance and repair of integrated areas equipment.
 - 2.I.05.03* Research and provide preventative maintenance on integrated areas system, keeping a log for documentation. Provide corrective maintenance on another engineering areas system.

Strand 3: Embedded Academics

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

Academic Crosswalks

[Appendix A:](#) [English Language Arts](#)

[Appendix B:](#) [Mathematics](#)

[Appendix C:](#) [Science and Technology/Engineering](#)

Earth and Space Science

Life Science (Biology)

Physical Science (Chemistry and Physics)

Technology/Engineering

Strand 4: Employability and Career Readiness

4.A Career Exploration and Navigation

- 4.A.01 Develop a career plan and portfolio.
 - 4.A.01.01 Develop and revise career plan annually based on workplace awareness and skill attainment.
 - 4.A.01.02 Assess personal strengths and interest areas to determine potential careers, career pathways and career ladders.
 - 4.A.01.03 Examine potential career field(s)/discipline(s) and identify criteria to select, secure and keep employment in chosen field(s).
 - 4.A.01.04 Research and evaluate a variety of careers utilizing multiple sources of information and resources to determine potential career(s) and alternatives.
 - 4.A.01.05 Identify training and education requirements that lead to employment in chosen field(s) and demonstrate skills related to evaluating employment opportunities.
 - 4.A.01.06 Explore and evaluate postsecondary educational opportunities including degrees and certifications available, traditional and nontraditional postsecondary pathways, technical school and apprenticeships, cost of education, financing methods including scholarships and loans and the cost of loan repayment.
 - 4.A.01.07 Create a portfolio showcasing academic and career growth including a career plan, safety credential, resume and a competency profile demonstrating the acquisition of the knowledge and skills associated with at least two years of full-time study in the Chapter 74 program.

- 4.A.02 Demonstrate job search skills.
 - 4.A.02.01 Conduct a job search and complete written and electronic job applications, resumes, cover letters and related correspondence for a chosen career path.
 - 4.A.02.02 Explore and evaluate postsecondary job opportunities and career pathways specific to career technical areas.
 - 4.A.02.03 Identify role and use of social media and networking for staying current with career and employment trends as well as networking, job seeking and career development opportunities.
 - 4.A.02.04 Demonstrate ability to use social media and networking to develop useful occupational contacts, job seeking and career development opportunities.

- 4.A.03 Demonstrate all phases of the job interview process.
 - 4.A.03.01 Gather relevant information about potential employer(s) from multiple print and digital sources, assessing the credibility and accuracy of each source.
 - 4.A.03.02 Identify employment eligibility criteria, such as drug/alcohol free status, clean driving record, etc.

- 4.A.03.03 Practice effective interviewing skills: appearance, inquiry and dialogue with interviewer, positive attitude and evidence of work ethic and skills.
- 4.A.03.04 Explore and evaluate employment benefit packages including wages, vacation, health care, union dues, cafeteria plans, tuition reimbursement, retirement and 401K.

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

4.B Communication in the Workplace

- 4.B.01 Demonstrate appropriate oral and written communication skills in the workplace.
 - 4.B.01.01 Communicate effectively using the language and vocabulary appropriate to a variety of audiences within the workplace including coworkers, supervisors and customers.
 - 4.B.01.02 Read technical and work-related documents and demonstrate understanding in oral discussion and written exercise.
 - 4.B.01.03 Demonstrate professional writing skills in work-related materials and communications (e.g., letters, memoranda, instructions and directions, reports, summaries, notes and/or outlines).
 - 4.B.01.04 Use a variety of writing/publishing/presentation applications to create and present information in the workplace.
 - 4.B.01.05 Identify, locate, evaluate and use print and electronic resources to resolve issues or problems in the workplace.
 - 4.B.01.06 Use a variety of financial and data analysis tools to analyze and interpret information in the workplace.
 - 4.B.01.07 Orally present technical and work-related information to a variety of audiences.
 - 4.B.01.08 Identify and demonstrate professional non-verbal communication.
- 4.B.02 Demonstrate active listening skills.
 - 4.B.02.01 Listen attentively and respectfully to others.
 - 4.B.02.02 Focus attentively, make eye contact or other affirming gestures, confirm understanding and follow directions.
 - 4.B.02.03 Show initiative in improving communication skills by asking follow-up questions of speaker in order to confirm understanding.

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

4.C Work Ethic and Professionalism

- 4.C.01 Demonstrate attendance and punctuality.
- 4.C.01.01 Identify and practice professional time-management and attendance behaviors including punctuality, reliability, planning and flexibility.
- 4.C.02 Demonstrate proper workplace appearance.
- 4.C.02.01 Identify and practice professional appearance specific to the workplace.
- 4.C.02.02 Identify and practice personal hygiene appropriate for duties specific to the workplace.
- 4.C.02.03 Identify and wear required safety gear specific to the workplace.
- 4.C.03 Accepts direction and constructive criticism.
- 4.C.03.01 Demonstrate ability (both verbally and non-verbally) to accept direction and constructive criticism and to implement solutions to change behaviors.
- 4.C.03.02 Ask appropriate questions to clarify understanding of feedback.
- 4.C.03.03 Analyze own learning style and seek instructions in a preferred format that works best for their understanding (such as oral, written or visual instruction).
- 4.C.04 Demonstrate motivation and initiative.
- 4.C.04.01 Evaluate assigned tasks for time to completion and prioritization.
- 4.C.04.02 Demonstrate motivation through enthusiasm, engagement, accurate completion of tasks and activities.
- 4.C.04.03 Demonstrate initiative by requesting new assignments and challenges.
- 4.C.04.04 Explain proposed solutions to challenges observed in the workplace.
- 4.C.04.05 Demonstrate the ability to evaluate multiple solutions to problems and challenges using critical reasoning and workplace/industry knowledge and select the best solution to the problem.
- 4.C.04.06 Implement solution(s) to challenges and/or problem(s) observed in the workplace.
- 4.C.04.07 See projects through completion and check work for quality and accuracy.
- 4.C.05 Demonstrate awareness of workplace culture and policy.

- 4.C.05.01 Display ethical behavior in use of time, resources, computers and information.
- 4.C.05.02 Identify the mission of the organization and/or department.
- 4.C.05.03 Explain the benefits of a diverse workplace.
- 4.C.05.04 Demonstrate a respect for diversity and its benefit to the workplace.
- 4.C.06 Interact appropriately with coworkers.
 - 4.C.06.01 Work productively with individuals and in teams.
 - 4.C.06.02 Develop positive mentoring and collaborative relationships within work environment.
 - 4.C.06.03 Show respect and collegiality, both formally and informally.
 - 4.C.06.04 Explain and follow workplace policy on the use of cell phones and other forms of social media.
 - 4.C.06.05 Maintain focus on tasks and avoid negative topics or excessive personal conversations in the workplace.
 - 4.C.06.06 Negotiate solutions to interpersonal and workplace conflicts.

4. C Performance Examples:

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

Student Organizations

Business Professionals of America

www.bpa.org

Selected Websites

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

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

Strand 5: Management and Entrepreneurship Knowledge and Skills

5.A Starting a Business

- 5.A.01 Demonstrate an understanding of the practices required to start a business.
 - 5.A.01.01 Define entrepreneurship and be able to recognize and describe the characteristics of an entrepreneur.
 - 5.A.01.02 Compare and contrast types of business ownership (i.e., sole proprietorships, franchises, partnerships, corporations).
 - 5.A.01.03 Identify and explain the purpose and contents of a business plan.
 - 5.A.01.04 Demonstrate an understanding of the principles and concepts of a business's supply chain (i.e., suppliers, producers and consumers).

5. A Performance Examples:

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

5.B Managing a Business

- 5.B.01 Demonstrate an understanding of managing a business.
 - 5.B.01.01 Formulate short- and long-term business goals.
 - 5.B.01.02 Demonstrate effective verbal, written and visual communication skills.
 - 5.B.01.03 Utilize a decision-making process to make effective business decisions.
 - 5.B.01.04 Identify a business's chain of command and define its organizational structure.
 - 5.B.01.05 Identify and apply effective customer service skills and practices.
 - 5.B.01.06 Identify, interpret and develop written operating procedures and policies.
 - 5.B.01.07 Track inventory, productivity and labor cost.
 - 5.B.01.08 Demonstrate business meeting skills.
 - 5.B.01.09 Identify professional organizations and explore their benefits.

5. B Performance Examples:

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

5.C Marketing a Business

- 5.C.01 Demonstrate an understanding of marketing and promoting a business.
 - 5.C.01.01 Explain the role of business in the economy.
 - 5.C.01.02 Describe the relationship between business and community.
 - 5.C.01.03 Describe methods of market research and identifying target markets.

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

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

5.D Financial Concepts and Applications in Business

- 5.D.01 Demonstrate an understanding of financial concepts and applications.
 - 5.D.01.01 Identify essential financial reports and understand their purpose (i.e., budget, balance sheet and income statement).
 - 5.D.01.02 Describe payroll practices (i.e., deductions – federal, FICA and state taxes and insurances).
 - 5.D.01.03 Identify the importance of maintaining accurate records.
 - 5.D.01.04 Apply practices related to pricing, purchasing and billing.
 - 5.D.01.05 Maintain and reconcile a checking account.
 - 5.D.01.06 Identify the options for funding a business.

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

5.E Legal/Ethical/Social Responsibilities

- 5.E.01 Demonstrate an understanding of legal, ethical and social responsibility for businesses.
 - 5.E.01.01 Identify state and federal laws and regulations related to managing a business.
 - 5.E.01.02 Describe and identify ethical business practices.
 - 5.E.01.03 Demonstrate an understanding of business contracts.
 - 5.E.01.04 Explain the role of diversity in the workplace.
 - 5.E.01.05 Explain the role of labor organizations.
 - 5.E.01.06 Identify practices that support clean energy technologies and encourage environmental sustainability.
 - 5.E.01.07 Demonstrate an understanding of how technology advancements impact business practices.

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

Selected Websites

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

Glossary

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

Term

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

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

- 6.A.01 Demonstrate proficiency in the use of computers and applications, as well as an understanding of the concepts underlying hardware, software, and connectivity.
 - 6.A.01.01 Use online help and other support to learn about features of hardware and software, as well as to assess and resolve problems.
 - 6.A.01.02 Install and uninstall software; compress and expand files (if the district allows it).
 - 6.A.01.03 Explain effective backup and recovery strategies.
 - 6.A.01.04 Apply advanced formatting and page layout features when appropriate (e.g., columns, templates, and styles) to improve the appearance of documents and materials.
 - 6.A.01.05 Use editing features appropriately (e.g., track changes, insert comments).
 - 6.A.01.06 Identify the use of word processing and desktop publishing skills in various careers.
 - 6.A.01.07 Identify the use of database skills in various careers.
 - 6.A.01.08 Define and use functions of a spreadsheet application (e.g., sort, filter, find).
 - 6.A.01.09 Explain how various formatting options are used to convey information in charts or graphs.
 - 6.A.01.10 Identify the use of spreadsheet skills in various careers.
 - 6.A.01.11 Use search engines and online directories.
 - 6.A.01.12 Explain the differences among various search engines and how they rank results.
 - 6.A.01.13 Explain and demonstrate effective search strategies for locating and retrieving electronic information (e.g., using syntax and Boolean logic operators).
 - 6.A.01.14 Describe good practices for password protection and authentication.
- 6.A.02 Demonstrate the responsible use of technology and an understanding of ethics and safety issues in using electronic media at home, in school, and in society.
 - 6.A.02.01 Demonstrate compliance with the school's Acceptable Use Policy.
 - 6.A.02.02 Explain issues related to the responsible use of technology (e.g., privacy, security).
 - 6.A.02.03 Explain laws restricting the use of copyrighted materials.
 - 6.A.02.04 Identify examples of plagiarism, and discuss the possible consequences of plagiarizing the work of others.
- 6.A.03 Design and implement a personal learning plan that includes the use of technology to support lifelong learning goals.
 - 6.A.03.01 Evaluate the authenticity, accuracy, appropriateness, and bias of electronic resources, including Web sites.
 - 6.A.03.02 Analyze the values and points of view that are presented in media messages.
 - 6.A.03.03 Describe devices, applications, and operating system features that offer accessibility for people with disabilities.

- 6.A.03.04 Evaluate school and work environments in terms of ergonomic practices.
- 6.A.03.05 Describe and use safe and appropriate practices when participating in online communities (e.g., discussion groups, blogs, social networking sites).
- 6.A.03.06 Explain and use practices to protect one's personal safety online (e.g., not sharing personal information with strangers, being alert for online predators, reporting suspicious activities).
- 6.A.03.07 Explain ways individuals can protect their technology systems and information from unethical users.
- 6.A.04 Demonstrate the ability to use technology for research, critical thinking, problem solving, decision making, communication, collaboration, creativity, and innovation.
 - 6.A.04.01 Devise and demonstrate strategies for efficiently collecting and organizing information from electronic sources.
 - 6.A.04.02 Compare, evaluate, and select appropriate electronic resources to locate specific information.
 - 6.A.04.03 Select the most appropriate search engines and directories for specific research tasks.
 - 6.A.04.04 Use a variety of media to present information for specific purposes (e.g., reports, research papers, presentations, newsletters, Web sites, podcasts, blogs), citing sources.
 - 6.A.04.05 Demonstrate how the use of various techniques and effects (e.g., editing, music, color, rhetorical devices) can be used to convey meaning in media.
 - 6.A.04.06 Use online communication tools to collaborate with peers, community members, and field experts as appropriate (e.g., bulletin boards, discussion forums, listservs, Web conferencing).
 - 6.A.04.07 Plan and implement a collaborative project with students in other classrooms and schools using telecommunications tools (e.g., e-mail, discussion forums, groupware, interactive Web sites, video conferencing).

Appendices

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

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

Embedded Academic Crosswalks

Embedded English Language Arts and Literacy

CVTE Learning Standard Number	Strand Coding Designation Grades ELAs Learning Standard Number	Text of English Language Arts Learning Standard
2.A.01 – 2.A.02 2B.01 – 2.B.10 2.C.01- 2.C.20	WHST. Grades 6-12.10	Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences
<p>Performance Example: Students will create and maintain over a period of time, logs and/or journals that reflect understanding of a variety of professional skills and professional vocabulary. Students will use domain specific vocabulary and demonstrate standard English grammar and usage.</p>		
2.A.02.01 2.A.02.02	RST. grades 9-10.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions
<p>Performance Example: Students will read technical texts and supporting articles and summarize the precise details of shop safety procedures in 2 column notes.</p>		
2.B.01.02 2.B.01.03	SL. Grades 8-1a-d SL. Grades 9 -10.1a-d SL. Grades 11-12.1a-d	<p>8. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others’ ideas and expressing their own clearly.</p> <p>a. Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.</p> <p>b. Follow rules for collegial discussions and decision-making, track progress toward specific goals and deadlines, and define individual roles as needed.</p> <p>c. Pose questions that connect the ideas of several speakers and respond to others’ questions and comments with relevant evidence, observations, and ideas.</p> <p>d. Acknowledge new information expressed by others, and, when warranted, qualify or justify their own views in light of the evidence presented</p> <p>9-10 Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–10 topics, texts, and issues, building on others’ ideas and expressing their own clearly and persuasively.</p> <p>a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or</p>

		<p>issue to stimulate a thoughtful, well-reasoned exchange of ideas.</p> <p>b. Work with peers to set rules for collegial discussions and decision-making (e.g., informal consensus, taking votes on key issues, presentation of alternate views), clear goals and deadlines, and individual roles as needed.</p> <p>c. Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions.</p> <p>d. Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented</p> <p>11-12</p> <p>Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 11–12 topics, texts, and issues, building on others’ ideas and expressing their own clearly and persuasively.</p> <p>a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.</p> <p>b. Work with peers to promote civil, democratic discussions and decision-making, set clear goals and deadlines, and establish individual roles as needed.</p> <p>c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives.</p> <p>d. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task.</p>
<p>Performance Example:</p> <p>Students will participate effectively in collaborative efforts to brainstorm ideas and develop and evaluate solutions. Students will practice listening and engaging in diplomatic responses using professional language and sound reasoning.</p>		
<p>2.b.01- 2.B.10 2.C.01- 2.C.20</p>	<p>RST. grades 9-10.3 RST. Grades 11-12.3</p>	<p>9-10</p> <p>Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text</p> <p>11-12</p> <p>Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.</p>
<p>Performance Example:</p> <p>1. Students will read technical texts, such as but not limited to, service manuals or manufacturers’ recommendations, then follow a variety of complex multistep procedures to successfully complete the task.</p> <p>2. Students will read technical texts, such as but limited to, manuals or manufacturers’ recommendations, then record using two column notes or any appropriate graphic organizer domain specific words and phrases relevant to the technical procedures performed..</p>		
<p>2.B.01- 2.B.10</p>	<p>L. grades 9 – 12.6</p>	<p>Acquire and use accurately general academic and domain-specific</p>

2.C.01- 2.C.20		words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression
<p>Performance Example: Students will use domain specific words and phrases when performing technical tasks/procedures in the career area and related settings when working with the instructor, classmates or clients.</p>		
2.B.03.02 2.B.01.10 2.B.07.05 2.B.09.02 2.C.05.13 2.C.05.17 2.C.07.01 2.C.07.23 2.C.07.30 2.C.07.34 2.C.07.36 2.C.11.08	SL. Grades 8.4 SL. Grades 9 – 10.4 SL. Grades 11-12.4	<p>8. Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation</p> <p>9-10 Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.</p> <p>11-12 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>
<p>Performance Example: Students will orally present to the instructor/class demonstrations and/or role plays on content specific technical techniques using domain specific vocabulary. Students will accurately and concisely describe the technical processes, techniques and tools.</p>		
2.C.02.14 2.C.02.19 2.C.05.18 2.C.06.01 2.C.11.04 2C.12.03 2.C.13.03	RST. Grades 6-12.4 RST.6-10.9	<p>Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–12 texts and topics</p> <p>6-8 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.</p> <p>9-10 Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts</p>
<p>Performance Example: Using graphic organizers such as top-down webs, Venn diagrams, T sheets and others, students will compare and contrast technical information such as, but not limited to, engineering designs, architecture and tools.</p>		
2.B.01.05 2.B.01.06 2.B.10.01 2.B.03.02 2.B.03.05 2.C.04.03	W. grades 9-12.7	<p>7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.</p>

<p>2.C.05.17 2.C.05.22 2.C.07.36 2.C.08.03 2.C.08.03 2.C.09.02 2.C.12.03 2.C.13.02 2.C.16.03 2.C.17.01 2.C.17.02 2.C.19.01 2.C.20.03</p>	<p>W. grades 9-10.8</p> <p>RST. Grades 9-10.10 RST. Grades 11-12.10</p>	<p>8</p> <p>Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation</p> <p>Grades 9-10.10 By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.</p> <p>Grades 11-12.10 By the end of grade 12, read and comprehend science/technical texts in the grades 11–CCR text complexity band independently and proficiently</p>
<p>Performance Example: Using technology, texts, manuals and other resources, students will research and write a paper on a content specific topic demonstrating knowledge of subject. Students will document the research using works cited pages, bibliographies and/or in-text citations. Students will demonstrate command of the conventions of standard English grammar and usage. Students will research a content specific topic and present a multimedia PowerPoint which will demonstrate understanding and organization of the topic while using the standards of the English language appropriately. <u>Students will credit the appropriate sources.</u></p>		
<p>2.B.01.03 2.B.03.03 2.B.04.01 2.C.01.03 2.C.02.15 2.C.02.20 2.C.02.21 2.C.02.23 2.C.03.06 2.C.05.06 2.C.06.02 2.C.06.03 2.C.06.05 2.C.05.16 2.C.06.10 2.C.13.15</p>	<p>WHST. Grades 6-12.4</p> <p>RST. Grades 6-12.4</p>	<p>Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience</p> <p>Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–12 texts and topics.</p>
<p>Performance Example: Students will read and interpret either orally or in writing technical schematics, drawings, and/or specification sheets and other content specific informative texts for appropriate topic assignments.</p>		
<p>2.B.01.05</p>	<p>SL.6-12.6</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: In a professional tone and manner, Students will conduct market surveys and contact companies displaying articulated speech appropriate to the task.</p>		

Embedded Mathematics

CVTE Learning Standard Number	Math Content Conceptual Category and Domain Code Learning Standard Number	Text of Mathematics Learning Standard
2.B.01	* Modeling	See the asterisks in the Math Framework document for more detail information on the used standards assigned as these will be project dependant.
<p>Performance Example:</p> <p>* Modeling</p> <p>The basic modeling cycle is summarized in the diagram below. It involves (1) identifying variables in the situation and selecting those that represent essential features, (2) formulating a model by creating and selecting geometric, graphical, tabular, algebraic, or statistical representations that describe relationships between the variables, (3) analyzing and performing operations on these relationships to draw conclusions, (4) interpreting the results of the mathematics in terms of the original situation, (5) validating the conclusions by comparing them with the situation, and then either improving the model or, if it is acceptable, (6) reporting on the conclusions and the reasoning behind them. Choices, assumptions, and approximations are present throughout this cycle.</p> <div> <pre> graph LR Problem([Problem]) --> Formulate([Formulate]) Formulate --> Compute([Compute]) Compute --> Interpret([Interpret]) Interpret --> Validate{Validate} Validate --> Formulate Validate --> Report([Report]) </pre> </div> <p>In descriptive modeling, a model simply describes the phenomena or summarizes them in a compact form. Graphs of observations are a familiar descriptive model—for example, build, test and redesign a scale model of a balsa wood bridge.</p>		
2.B.08.01 2.B.08.02	S-ID,	<p>Summarize, represent, and interpret data on a single count or measurement variable.</p> <ol style="list-style-type: none"> 1. Represent data with plots on the real number line (dot plots, histograms, and box plots). 2. Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets. 4. Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.

	S-MD	<p>Make inferences and justify conclusions from sample surveys, experiments, and observational studies.</p> <p>3. Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.</p>
<p>Performance Example: Describe a set of numbers and then make accurate inferences about your group of data based on incomplete information. (i.e. a bag of multiple colored candies - M&M or Skittles)</p>		
2.B.09.02	G-GMD, G-GG	<p>Explain volume formulas and use them to solve problems.</p> <p>1. Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone.</p> <p>3. Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems</p> <p>Apply geometric concepts in modeling situations.</p> <p>1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).</p> <p>2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot)</p> <p>3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).</p>
<p>Performance Example: Design a package to house a rubik's cube. A pattern layout or development will be created on graph paper and transferred to paperboard. Graphics will then be applied to paperboard panels and flaps.</p>		
2.B.10.01 2.B.10.04	4.MD	<p>Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.</p> <p>1. Know relative sizes of measurement units within one system of units, including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit.</p>
<p>Performance Example: The United States is the only country that uses the English system. It is because of this global marketplace that the sizes of engineered objects must often be communicated in both English and metric units. Converting linear measurements to provide dual dimensioning saves the manufacturer time, which keeps product costs down.</p>		
2.C.02.04 2.C.02.05 2.C.02.08 2.C.02.09 2.C.02.15 2.C.02.16 2.C.02.22 2.C.02.23 2.C.02.24 2.C.02.27	A-CED F-IF	<p>Create equations that describe numbers or relationships.</p> <p>1. Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.</p> <p>2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.</p> <p>4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.</p> <p>Analyze functions using different representations.</p> <p>7. Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.</p>

		relationship, or two input-output pairs (include reading these from a table). 3. Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function.
Performance Example: Experimentally determine the density of several blocks. Then, calculate various blocks' density and compare the experimental results with published densities of the blocks.		
2.D.02.01 2.D.02.04 2.D.02.05 2.D.02.18 2.D.02.19 2.D.02.20	A-CED	Create equations that describe numbers or relationships. 1. Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions. 4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
	5.MD	Geometric measurement: Understand concepts of volume and relate volume to multiplication and to addition. 3. Recognize volume as an attribute of solid figures and understand concepts of volume measurement. a. A cube with side length 1 unit, called a "unit cube," is said to have "one cubic unit" of volume, and can be used to measure volume. b. A solid figure which can be packed without gaps or overlaps using n unit cubes is said to have a volume of n cubic units. 4. Measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft, and improvised units. 5. Relate volume to the operations of multiplication and addition and solve real-world and mathematical problems involving volume. a. Find the volume of a right rectangular prism with whole-number side lengths by packing it with unit cubes, and show that the volume is the same as would be found by multiplying the edge lengths, equivalently by multiplying the height by the area of the base. Represent threefold whole-number products as volumes, e.g., to represent the associative property of multiplication. b. Apply the formulas $V = l \times w \times h$ and $V = b \times h$ for rectangular prisms to find volumes of right rectangular prisms with whole-number edge lengths in the context of solving real-world and mathematical problems. c. Recognize volume as additive. Find volumes of solid figures composed of two non-overlapping right rectangular prisms by adding the volumes of the non-overlapping parts, applying this technique to solve real-world problems.
	7.EE	Solve real-life and mathematical problems using numerical and algebraic expressions and equations. 3. 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. 4. Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and

<p>Performance Example: Students will identify the similarities between the temperature management of building systems and the climate mechanisms that manage temperature on earth.</p>		
2.C.14	3. Earth Processes and Cycles	<p>3.4 Explain how water flows into and through a watershed. Explain the roles of aquifers, wells, porosity, permeability, water table, and runoff.</p> <p>3.5 Describe the processes of the hydrologic cycle, including evaporation, condensation, precipitation, surface runoff and groundwater percolation, infiltration, and transpiration.</p>
<p>Performance Example: Student will understand how a site's location within a watershed effects the infiltration, drainage, and runoff. Students will be able to use USGS topographical maps to determine the overland flow routes and estimated groundwater depth and flow direction for a site.</p>		
2.C.06.18 2.C.14.12 2.C.14.13	1. Matter and Energy in the Earth System	1.3 Explain how the transfer of energy through radiation, conduction, and convection contributes to global atmospheric processes, such as storms, winds, and currents.
<p>Performance Example: Students will identify the similarities between the temperature management of building systems and the climate mechanisms that manage temperature on earth.</p>		
2.C.14.13 2.C.13.07	2. Energy Resources in the Earth System	<p>2.1 Recognize, describe, and compare renewable energy resources (e.g., solar, wind, water, biomass) and nonrenewable energy resources (e.g., fossil fuels, nuclear energy).</p> <p>2.2 Describe the effects on the environment and on the carbon cycle of using both renewable and nonrenewable sources of energy.</p>
<p>Performance Example: Students will use an understanding of how site location can provide renewable energy as well as reduce the need for climate control for a building to minimize the ecological footprint of a new development.</p>		

Physical Science (Chemistry)

CVTE Learning Standard Number	Subject Area, Topic Heading and Learning Standard Number	Text of Chemistry Learning Standard
2.C.02.01	2. Atomic Structure and Nuclear Chemistry	2.1 Recognize discoveries from Dalton (atomic theory), Thomson (the electron), Rutherford (the nucleus), and Bohr (planetary model of atom), and understand how each discovery leads to modern theory.
<p>Performance Example: Students will be able to identify the parts of an atom through an understanding of the scientific process that has resulted in our modern theory of the atom.</p>		

Physical Science (Physics)

CVTE Learning Standard Number	Subject Area, Topic Heading and Learning Standard Number	Text of Physics Learning Standard
2.C.05.05	Properties of Matter	Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object. 3. Recognize that the measurement of volume and mass requires understanding of the sensitivity of measurement tools (e.g., rulers, graduated cylinders, balances) and knowledge and appropriate use of significant digits.
<p>Performance Example: Students will be able to select measurement devices with an appropriate level of accuracy for the task involved. Students can demonstrate the use of measurement devices by determining the density of a very small and very large piece of metal forcing students to use different measurement tools to obtain an accurate measurement at different size scales.</p>		
2.C.14.12	Heat Energy	14. Recognize that heat is a form of energy and that temperature change results from adding or taking away heat from a system. 16. Give examples of how heat moves in predictable ways, moving from warmer objects to cooler ones until they reach equilibrium.
<p>Performance Example: Students will be able to calculate the rate of heating and cooling of a material and understand how specific heat capacity influences the rate at which a substance will gain or lose heat.</p>		
2.C.13.16	1. Motion and Forces	1.1 Compare and contrast vector quantities (e.g., displacement, velocity, acceleration force, linear momentum) and scalar quantities (e.g., distance, speed, energy, mass, work). 1.2 Distinguish between displacement, distance, velocity, speed, and acceleration. Solve problems involving displacement, distance, velocity, speed, and constant acceleration. 1.5 Use a free-body force diagram to show forces acting on a system consisting of a pair of interacting objects. For a diagram with only co-linear forces, determine the net force acting on a system and between the objects.
<p>Performance Example: Students will be able to analyze situations with multiple forces acting on an object and determine the net force acting on the object to determine its acceleration and velocity vectors.</p>		
2.C.02	5. Electromagnetism	5.2 Develop qualitative and quantitative understandings of current, voltage, resistance, and the connections among them (Ohm's law). 5.3 Analyze simple arrangements of electrical components in both series and parallel circuits. Recognize symbols and understand the functions of common circuit elements (battery, connecting wire, switch, fuse, resistance) in a schematic diagram.
<p>Performance Example: Students will be given a simple 2 battery LED flashlight and will be able to identify the basic electronic components and predict the effects each component will have on the flow of electricity through the circuit. Students will predict the effect connecting batteries in series and parallel has on the voltage of the flashlight. Students will also be expected test their predictions with measurement tools.</p>		

2.C.06.18	3. Heat and Heat Transfer	3.1 Explain how heat energy is transferred by convection, conduction, and radiation. 3.2 Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached.
Performance Example: Students will understand why electrical components generate heat and how to properly select and apply devices (i.e. heat sinks and fans) to transfer heat energy away from sensitive electronics.		
2.C.06.16 2.C.06.17	2. Conservation of Energy and Momentum	2.2 Interpret and provide examples of how energy can be converted from gravitational potential energy to kinetic energy and vice versa. 2.3 Describe both qualitatively and quantitatively how work can be expressed as a change in mechanical energy.
Performance Example: Students will be able to understand the mechanics behind the force multiplication of simple machines and explain why simple machines can be used to allow the user to do more work with less input force.		
2.C.06.16 2.C.06.17	1. Motion and Forces	1.6 Distinguish qualitatively between static and kinetic friction, and describe their effects on the motion of objects.
Performance Example: Students will be able to understand that simple machines require the user to do more work in order to overcome the effects of friction which are present in all mechanical systems.		
2.C.02.02	5. Electromagnetism	5.1 Recognize that an electric charge tends to be static on insulators and can move on and in conductors. Explain that energy can produce a separation of charges.
Performance Example: Students will be able to identify the properties of insulators and conductors and identify examples of each. Students will be able to explain the behavior static electricity on insulators and conductors and apply that knowledge to the flow of electricity in electrical current.		

Technology/Engineering

CVTE Learning Standard Number	Subject Area, Topic Heading and Learning Standard Number	Text of Technology/Engineering Learning Standard
2.A.2	1. Materials, Tools, and Machines	1.3 Identify and explain the safe and proper use of measuring tools, hand tools, and machines (e.g., band saw, drill press, sander, hammer, screwdriver, pliers, tape measure, screws, nails, and other mechanical fasteners) needed to construct a prototype of an engineering design.
Performance Example: Students will be able to safely operate machinery and equipment related to engineering construction.		
2.B.01	2. Engineering Design	2.1 Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s),

		<p>construct a prototype, test and evaluate, communicate the solution(s), and redesign.</p> <p>2.2 Demonstrate methods of representing solutions to a design problem, e.g., sketches, orthographic projections, multiview drawings.</p> <p>2.4 Identify appropriate materials, tools, and machines needed to construct a prototype of a given engineering design.</p> <p>2.5 Explain how such design features as size, shape, weight, function, and cost limitations would affect the construction of a given prototype.</p>
<p>Performance Example: Students will be able to use the engineering design process to analyze a problem, consider possible solutions, and create a design solution. The students will determine the best materials for the design considering factors such as cost, availability, reliability, and ease of operation/manufacture. Students will create a list of parts necessary to create the design and determine overall cost. Students will also maintain a journal documenting the steps of their process.</p>		
2.C.05	1. Materials, Tools, and Machines	<p>1.1 Given a design task, identify appropriate materials (e.g., wood, paper, plastic, aggregates, ceramics, metals, solvents, adhesives) based on specific properties and characteristics (e.g., strength, hardness, and flexibility).</p> <p>1.2 Identify and explain appropriate measuring tools, hand tools, and power tools used to hold, lift, carry, fasten, and separate, and explain their safe and proper use.</p>
<p>Performance Example: Students will be asked to select a material for an insulating cup holder. The student will be able to research and understand the properties of common engineering materials used today and select a safe and cost effective material.</p>		
2.C.05 2.C.07	2. Engineering Design	2.4 Identify appropriate materials, tools, and machines needed to construct a prototype of a given engineering design.
<p>Performance Example: Students will be given a design to create a prototype of. The student research different possible materials and current prototyping methods and analyze their associated costs and benefits.</p>		
2.C.13	5. Construction Technologies	<p>Describe and explain parts of a structure, e.g., foundation, flooring, decking, wall, roofing systems.</p> <p>5.3 Explain how the forces of tension, compression, torsion, bending, and shear affect the performance of bridges.</p> <p>5.4 Describe and explain the effects of loads and structural shapes on bridges.</p>
<p>Performance Example: Student will be able to understand the various ways architectural styles incorporate the safe support of loads. Students will demonstrate knowledge by designing and building (or using simulation) a bridge and determining the weight it can support and point of failure of the design.</p>		
2.B.08	2. Engineering Design	2.6 Identify the five elements of a universal systems model: goal, inputs, processes, outputs, and feedback.
<p>Performance Example: Students will survey users and industry in order to obtain feedback on a design solution or prototype in order to improve design.</p>		
2.A.02	2. Construction Technologies	2.5 Identify and demonstrate the safe and proper use of

2.C.08 2.C.12		common hand tools, power tools, and measurement devices used in construction.
Performance Example: Students will be able to safely operate machinery and equipment related to engineering and construction.		
2.B.01 2.C.06	1. Engineering Design	<p>1.1 Identify and explain the steps of the engineering design process: identify the problem, research the problem, develop possible solutions, select the best possible solution(s), construct prototypes and/or models, test and evaluate, communicate the solutions, and redesign.</p> <p>1.2 Understand that the engineering design process is used in the solution of problems and the advancement of society. Identify examples of technologies, objects, and processes that have been modified to advance society, and explain why and how they were modified.</p> <p>1.3 Produce and analyze multi-view drawings (orthographic projections) and pictorial drawings (isometric, oblique, perspective), using various techniques.</p>
Performance Example: Students will be able to apply the engineering design process to a problem selected by the instructor and be able to communicate a design solution through drawings.		
2.B.01 2.C.06 2.C.13		<p>1.4 Interpret and apply scale and proportion to orthographic projections and pictorial drawings (e.g., $\frac{1}{4}'' = 1'0''$, 1 cm = 1 m).</p> <p>1.5 Interpret plans, diagrams, and working drawings in the construction of prototypes or models.</p>
Performance Example: Students will be able to apply the engineering design process to a problem and produce documentation and designs with enough detail to allow construction of a prototype and which demonstrate a thorough analysis of many possible solutions.		
2.B.06 2.C.05	7. Manufacturing Technologies	<p>7.1 Describe the manufacturing processes of casting and molding, forming, separating, conditioning, assembling, and finishing.</p> <p>7.2 Identify the criteria necessary to select safe tools and procedures for a manufacturing process (e.g., properties of materials, required tolerances, end-uses).</p>
Performance Example: When given a manufacturing problem students will be able to select appropriate manufacturing methods and materials to safely and efficiently create a product.		
2.C.01	5. Energy and Power Technologies—Electrical Systems	5.1 Explain how to measure and calculate voltage, current, resistance, and power consumption in a series circuit and in a parallel circuit. Identify the instruments used to measure voltage, current, power consumption, and resistance.
Performance Example: Students will be able to use a multimeter to test and troubleshoot electrical equipment.		
2.C.02 2.C.03	5. Energy and Power Technologies—Electrical Systems	5.1 Explain how to measure and calculate voltage, current, resistance, and power consumption in a series circuit and in a parallel circuit. Identify the instruments used to measure voltage, current, power consumption, and resistance.

		<p>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.</p> <p>5.3 Explain the relationships among voltage, current, and resistance in a simple circuit, using Ohm's law.</p> <p>5.5 Compare and contrast alternating current (AC) and direct current (DC), and give examples of each.</p>
<p>Performance Example: When given a diagram of a simple 2 battery LED flashlight students will be able to identify the basic electronic components and predict the effects each component will have on the flow of electricity through a circuit. Students will predict the effect connecting batteries in series and parallel has on the voltage of the flashlight. Students will also predict the effect an alternating current would have on the LED. Students will also be expected to build and test their predictions with measurement tools.</p>		
2.C.05	2. Construction Technologies	2.1 Identify and explain the engineering properties of materials used in structures (e.g., elasticity, plasticity, R value, density, strength).
2.C.05 2.C.14.06	2. Construction Technologies	2.6 Recognize the purposes of zoning laws and building codes in the design and use of structures.
<p>Performance Example: Students will understand how the selection of building location and building materials effects the safety and reliability of a mechanical structure and recognize the science and engineering rational for building codes</p>		
2.C.06	3. Energy and Power Technologies—Fluid Systems	<p>3.3 Calculate and describe the ability of a hydraulic system to multiply distance, multiply force, and effect directional change.</p> <p>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.</p> <p>3.5 Identify and explain sources of resistance (e.g., 45° elbow, 90° elbow, changes in diameter) for water moving through a pipe.</p>
<p>Performance Example: Students will be tasked with designing a hand lift for a small automobile considering hydraulic and pneumatic solutions. Students will be able to determine the amount of force multiplication necessary, determine the necessary parts and create a design solution.</p>		
2.C.06 2.C.13 2.C.14	4. Energy and Power Technologies—Thermal Systems	<p>4.1 Differentiate among conduction, convection, and radiation in a thermal system (e.g., heating and cooling a house, cooking).</p> <p>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.</p> <p>4.3 Explain how environmental conditions such as wind, solar angle, and temperature influence the design of buildings.</p>
<p>Performance Example: Students will be able to calculate the rate of heating and cooling of a material and understand how specific heat capacity influences the rate at which a substance will gain or lose heat. Students will be able to apply this knowledge to sustainable building design.</p>		
2.C.06	2. Construction Technologies	2.2 Distinguish among tension, compression, shear, and torsion,

2.C.13		and explain how they relate to the selection of materials in structures. 2.4 Calculate the resultant force(s) for a combination of live loads and dead loads.
<p>Performance Example: Student will be able to understand the various ways architectural styles incorporate the safe support of loads. Students will demonstrate knowledge by designing and building (or using simulation) a bridge and determining the weight it can support and point of failure of the design.</p>		
2.C.09	7. Manufacturing Technologies	7.3 Describe the advantages of using robotics in the automation of manufacturing processes (e.g., increased production, improved quality, safety).
<p>Performance Example: Students will observe the use of assembly line automation in the various industries and explain the benefits and limitations when compared to manual assembly.</p>		
2.C.09	6. Communication Technologies	6.3 Explain how the various components (source, encoder, transmitter, receiver, decoder, destination, storage, and retrieval) and processes of a communication system function.
<p>Performance Example: Students will be able to operate and program a communication system to have a robot perform an assembly line task.</p>		

DESE Statewide Articulation Agreements

ARTICULATION AGREEMENT

Between

Massachusetts Community Colleges

And

Massachusetts Chapter 74-Approved Secondary
Career/Vocational Technical Engineering Technology Programs

Effective Date: December 5, 2012

for more information, click

<http://www.masscc.org/partnerships-initiatives/voc-schools-articulation-agreements>

Industry Recognized Credentials (Licenses and Certifications/Specialty Programs)

- | | |
|---------------------------------------|--|
| 1. Lego "Mindstorm" | Provider: Carnegie Mellon University |
| 2. VEX (RobotC) | Provider: Carnegie Mellon University |
| 3. AutoDesk Inventor | Provider: Authorized AutoDesk instruction facility |
| 4. Solidworks | Provider: Authorized Solidworks instructional facility |
| 5. Project Lead the Way (PLTW) | Provider: Associated college that accept course credit |
| 6. American Radio Relay League (ARRL) | Provider: FCC HAM license Preparation |
| 7. Basic Electronics Test | Provider:
http://www.expertrating.com/certifications/Electronics-test.asp |
| 8. LabView - | Provider: National Instruments
(optional PLTW software package) |

Other

Reference Materials

- Floyd, T. L. (2009). Digital Fundamentals. Pearson: Prentice Hall.
- Tokheim, R. (2010). Digital Electronics: Principles and Applications. McGraw Hill
- Holtzapple, M. T. (2004). Foundations of Engineering. McGraw Hill
- Lindeburg, M. R. (2008). Civil engineering reference manual for the pe exam. (Eleventh Edition ed.). Professional Publications, Inc.
- Matteson, D., Kennedy, D., Baur, S., & Kultermann, E. (2011). Civil engineering and architecture. Cengage Learning.
- Aubin, P. F. (2012). Revit Architecture. Cengage Learning
- Madsen D., Folkestad J., Schertz K., Shumaker T., Stark C., Turpin J. L. (2004). Engineering Drawing and Design. (Third Edition.) Delmar: Thomson Learning.
- Karsnitz J. R., O'Brien S., Hutchinson K. (2013). Engineering Design: An Introduction (Second Edition.) Delmar: Cengage Learning.
- Handley B. A., Marshall D. M., Coon C. (2012) Principles of Engineering. Delmar: Cengage Learning

Related National, Regional, and State Professional Organizations

- Project Lead The Way, Indianapolis, IN
- Museum Of Science, Boston, MA
- American Association of Engineering Societies <http://www.aes.org/>
- American Society for Engineering Education <http://www.asee.org/>
- Accreditation Board for Engineering and Technology <http://www.abet.org/>
- The Minerals, Metals, & Materials Society <http://www.tms.org/>
- American Society of Mechanical Engineering <http://www.asme.org>
- IEEE Industry Standards and Technology Organization <http://www.ieee-isto.org/>
- Institute of Electrical and Electronics Engineers <http://www.ieee.org>
- American Society of Civil Engineers (ASCE) <http://www.asce.org/>
- Association of Engineering Geologists <http://aegweb.org/>
- Association for Women Geoscientists (Civil Engineering-related Society) <http://www.awg.org/>
- Society of Manufacturing Engineers <http://www.sme.org>
- Institute of Industrial Engineers <http://www.iienet.org/>
- ASTM International Standards <http://www.astm.org/>
- International Council on Systems Engineering <http://www.incose.org/>
- American Society of Safety Engineers (ASSE) <http://www.asse.org/>
- American Society for Testing and Materials (ASTM) <http://www.astm.org/>
- The American Institute of Architects <http://www.aia.org/>

Student Organizations

- Skills USA www.maskillsusa.org
- National Technical Honor Society: www.nths.org/
- First Robotics: www.usfirst.org
- Vex Robotics: www.vexrobotics.com

- Junior Engineering Technical Society: www.tsaweb.org
- American Society of Mechanical Engineers: www.asme.org
- Society of Automotive Engineers: www.SAE.org
- Project Lead the Way: www.pltw.org
- Museum of Science: www.mos.org
- The Engineering Honor Society: à Tau Beta Pi www.tbp.org

Selected Websites

- www.pltw.org
- www.mos.org
- www.rit.edu
- www.wit.edu
- www.bu.edu
- www.tufts.edu
- www.wpi.edu
- www.northeastern.edu
- www.robotc.net/
- www.battlebots.com/
- www.marinetech.org/rov_competition