



Vocational Technical Education Framework



Agriculture and Natural Resources Occupational Cluster

Horticulture (VHORT)

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Massachusetts Department of Elementary and Secondary Education

Office for Career/Vocational Technical Education

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Commissioner's Letter



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Mitchell D. Chester, Ed.D.
Commissioner

July 2014

Dear Colleagues,

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

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

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

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

Sincerely,

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

Introduction

Overview & Organization and Key Changes

Overview

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

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

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

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

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

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

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

The Phase I Process was completed on an accelerated timetable and resulted in all Vocational Technical Education Frameworks; 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.*

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Organization of the Frameworks – Strand Two

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

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

2.A Automotive Technology Specific Safety Practices

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

2.A.01 Performance Example:

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

- 2.A.02 Demonstrate and describe safety procedures when dealing with high pressure systems including necessary ventilation according to current industry standards.
- 2.A.02.01 Describe and demonstrate the importance of safety procedures to be used when servicing high pressurized systems (fuel systems, brakes, air conditioning, suspension, hydraulic systems, etc.).
- 2.A.02.02 Describe and demonstrate safe use of oxygen/acetylene torches and electric welding equipment.
- 2.A.02.03 Demonstrate ventilation procedures to be followed when working in the lab/shop area.

2.A.02 Performance Example:

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

- 2.A.03 Identify and describe safety procedures when dealing with electrical circuits according to current industry standards.
- 2.A.03.01 Describe safety procedures to be followed when servicing supplemental restraint systems.
- 2.A.03.02 Demonstrate safety awareness of high voltage circuits of electric or hybrid electric vehicles and related safety precautions.

2.A.03 Performance Example:

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

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

(Topics 2.A through 2.I). These standards are followed by the three concentrations: Arboriculture (Topics 2.J through 2.L), Greenhouse Management and Floriculture (Topics 2.J. through 2.L) and Landscape and Turf Management (Topics 2.M through 2.Q).

Advanced / Supplemental Standards (Not Required)

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

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

Advanced Automotive Technology Technical Knowledge and Skills

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

2.CC Demonstrate appropriate engine repair techniques.

2.CC.01 Perform appropriate cylinder Head Repair.

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

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

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

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

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

2.B.04 Performance Examples:

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

Agriculture and Natural Resources Occupational Cluster

Horticulture Framework (VHORT)

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 Horticulture Safety and Health Knowledge and Skills

- 2.A.01 Apply and practice OSHA and other health and safety regulations and precautions that apply specifically to the horticulture industry.
- 2.A.01.01 Demonstrate the use of appropriate safety gear and Personal Protective Equipment (PPE) needed in horticulture such as proper dress for weather conditions, heat and cold stress, and tool specific PPE (e.g., dust mask when mixing soil or cutting stone, and working with vermiculite).
- 2.A.01.02 Use tools and equipment safely and to industry specifications. Use body mechanics including proper lifting and ergonomic techniques such as the correct use of a tree dolly or wheelbarrow.

2.A.01 Performance Example:

- Cut pavers on a wet saw for a walkway outdoors while dressed appropriately for the weather and wearing work boots and appropriate Personal Protective Equipment.

- 2.A.02 Be prepared to pass the Massachusetts Pesticide Applicators CORE License exam.
- 2.A.02.01 Evaluate and explain a pesticide label and determine contents.
- 2.A.02.02 Identify and explain the signal word(s) on label including Caution, Warning, and Danger.
- 2.A.02.03 Identify and describe chemical points of entry including dermal, oral, and inhalation.
- 2.A.02.04 Utilize proper handling and mixing techniques according to current industry standards,
- 2.A.02.05 Demonstrate proper storage and record keeping as required by regulation and industry standards.
- 2.A.02.06 Identify state and federal regulations as related to pesticide application.
- 2.A.02.07 Define and explain the EPA Worker Protection Standard for agricultural pesticide safety.

2.A.02 Performance Examples:

- Record in classroom log book SDS, storage location, and copy of label.
- Mix a simulation product in accordance with the label measurements and directions.
- Read a label and describe the dangers associated with product.
- Locate the EPA Registration number and look up the SDS using the internet.

2.B Botany

- 2.B.01 Use plant classification principles to identify a wide variety of plants.
- 2.B.01.01 Categorize and identify plants by hierarchy systems.
- 2.B.01.02 Identify plants using a dichotomous key.
- 2.B.01.03 Classify plants using nomenclature.
- 2.B.01.04 Identify how common plant parts are used in classification.
- 2.B.01.05 Compare and contrast angiosperms, gymnosperms and ferns.
- 2.B.01.06 Classify plants according to their lifecycle (e.g., annual, perennial and biennial).

2.B.01 Performance Example:

- Create a hierarchy chart of a chosen plant species investigating the origin and relatives of each.

- 2.B.02 Demonstrate an understanding of plant cell biology.
- 2.B.02.01 Identify the differences between prokaryotic cells and eukaryotic cells.
 - 2.B.02.02 Distinguish between the roles of organelles in the cell.
 - 2.B.02.03 Describe plant inheritance principles, including the role of DNA.
 - 2.B.02.04 Compare and contrast mitosis and meiosis and relate where both occur in the plant.

2.B.02 Performance Example:

- View and identify cell organelles using a microscope. Discuss and analyze the roles of organelles while making real-life analogies to each.

- 2.B.03 Demonstrate an understanding of plant anatomy.
- 2.B.03.01 Explain the major structural differences of monocots and dicots.
 - 2.B.03.02 Identify the forms, functions, and tissues associated with root systems.
 - 2.B.03.03 Outline and describe the pathways water and nutrients take into the plant.
 - 2.B.03.04 Describe the functions of plant stems.
 - 2.B.03.05 Compare the composition of herbaceous and woody stems.
 - 2.B.03.06 Identify internal and external leaf components and their functions (e.g., light absorption, transpiration).
 - 2.B.03.07 Compare and contrast leaf arrangements and types.
 - 2.B.03.08 Identify the components and functions of a flower.
 - 2.B.03.09 Identify the different forms of flowers and how they affect reproduction.
 - 2.B.03.10 Explain the major types, functions, and dispersal methods of fruits.
 - 2.B.03.11 Classify the major categories and parts of seeds.

2.B.03 Performance Examples:

- Student groups build the xylem tissue of a plant using everyday objects. The objects should have the same characteristics of cells that compose a xylem. For example: various forms of pasta can be glued together to form the vessels, tracheids, and chlorenchyma cells that compose the xylem. The systems can be tested against each other for strength, water transport, etc.
- Students are provided with several different environmental scenarios. The temperature, wind, humidity, rain, light, inhabitants and soil are all varied. The student is asked to design a flower and fruit that would be effective in each of those environments. The student must take into consideration flower composition, pollination, fruit development, dispersal and seed growth.

- 2.B.04 Apply principles of plant physiology and metabolism to plant growth.
- 2.B.04.01 Identify factors that impact plant growth (e.g., water, nutrients, light, air, and temperature).
 - 2.B.04.02 Describe the process of transpiration and how environmental factors affect rate.
 - 2.B.04.03 Explain the process of photosynthesis (light dependent and independent reactions).
 - 2.B.04.04 Explain how the availability of water, carbon dioxide, and light affect photosynthesis.
 - 2.B.04.05 Explain the process of cellular respiration and the factors that affect the rate.
 - 2.B.04.06 List the macro and micro nutrients necessary for healthy plant growth.
 - 2.B.04.07 Identify plant tropisms and the factors that are associated with them.
 - 2.B.04.08 Utilize plant hormones to affect plant growth including auxin, cytokinin, gibberellins, and abscisic acid.

2.B.04.09 Describe the role and movement of water and nutrients in plants (e.g., cohesion – tension theory, pressure flow hypothesis).

2.B.04 Performance Example:

- Observe plants that are exposed to the various types of tropisms. Students document the change in the plant from day to day. Determine if the tropism is a positive or negative response and determine what caused the change in growth.

2.B.05 Distinguish between sexual and asexual reproduction of plants.

2.B.05.01 Identify the different forms of sexual and asexual plant reproduction and debate the advantage of each.

2.B.05.02 Explain the process of fertilization and pollination.

2.B.05.03 Propagate plants both sexually and asexually using various techniques (e.g., budding, grafting, cuttings, and seeds).

2.B.05 Performance Example:

- Perform multiple types of asexual and sexual propagation and journal the growth of each. Students will determine the advantages and disadvantages of each method.

2.C Plant Health Care

2.C.01 Demonstrate an understanding of principles of entomology.

2.C.01.01 Identify the characteristics and life cycles of insects.

2.C.01.02 Identify insect damage including piercing-sucking, chewing, skeletonizing, and disease transmission.

2.C.01.03 Apply appropriate strategies for insect control.

2.C.01.04 Describe invasive insects and their effects on the environment.

2.C.01.05 Compare and contrast the benefits and potential hazards associated with introducing an invasive insect.

2.C.01.06 Explain insect population dynamics with regard to threshold.

2.C.01 Performance Example:

- Scout for and identify insect feeding damage on a plant and recommend industry recognized strategies of controls that will not harm beneficial insects. Also, determine if it is on the invasive species list and if so report it to the local EPA office.

2.C.02 Demonstrate an understanding of principles of plant pathology.

2.C.02.01 Identify the characteristics and life cycles of pathogens (e.g., bacteria, viruses, fungus).

2.C.02.02 Identify pathogen damage (blight, necrosis, blotches, and scorch).

2.C.02.03 Apply strategies for control of pathogens (e.g., preventative, systemic, and contact).

2.C.02.04 Describe invasive pathogens and their effects on the environment.

2.C.02 Performance Example:

- Scout for and identify diseases on plant material, identify the pathogen which is causing the diseases and recommend industry recognized controls for the disease.

2.C.03 Demonstrate an understanding of principles of plant physiology.

2.C.03.01 Identify common nutrient disorders (e.g., NPK, Fe, Mg, pH imbalance).

2.C.03.02 Identify and explain signs of water stress.

2.C.03.03 Analyze the effects of nutrient deficient soil on plant growth.

2.C.03.04 Compare and contrast nutrient deficiency and phytotoxicity.

2.C.03.05 Determine if the lacking nutrient is mobile or immobile.

- 2.C.03 Performance Examples:
- Identify common nutrient disorders based on observation.
 - Identify the difference between a nutrient disorder and phytotoxicity.
 - Create a power point presentation of common nutrient disorders including pictures and descriptions of the disorders.
 - With evidence provided from a specific soil testing analysis, evaluate plants located in the nutrient deficient site with those found in a healthy site.

- 2.C.04 Describe the components and benefits of a quality plant health care plan.
- 2.C.04.01 Describe and apply rationale for using cultural, biological, and chemical strategies in an Integrated Pest Management Plan/Plant Health Care Plan.
- 2.C.04.02 Describe the benefits of utilizing native and introduced plants in the landscape.
- 2.C.04.03 Explain the negative impact of using invasive plants.
- 2.C.04.04 Prescribe ways to promote beneficial insects.
- 2.C.04.05 Create soil conditions to promote beneficial soil organisms.
- 2.C.04.06 Distinguish between organic and inorganic fertilizers.

- 2.C.04 Performance Examples:
- Identify invasive species and their impacts on plants and animals.
 - Incorporate soil amendments that increase soil diversity.
 - Select a native or introduced plant that is best for a specified location.
 - Describe the cultural, biological, and chemical strategies used for a landscape or other managed area.

2.D Soils

- 2.D.01 Demonstrate an understanding of concepts of soil origin and development.
- 2.D.01.01 List soil formation factors and describe the effect parent material has on soil development.
- 2.D.01.02 Compare and contrast chemical and physical weathering.
- 2.D.01.03 List and explain forces which move soil.
- 2.D.01.04 Define the horizons within a soil profile.

- 2.D.01 Performance Examples:
- Dig a test pit to examine the different horizons within the soil profile. Students will identify the factors which led to the development of the soil.
 - Choose an item from the student's everyday lives and explain how the item would be chemically and physically weathered; showing the difference between the two types of weathering.

- 2.D.02 Evaluate physical properties of soil in relation to soil characteristics.
- 2.D.02.01 Define the three soil separates and different textural classes including loam.
- 2.D.02.02 Determine soil texture and perform a ribbon test to determine the textural class of a soil.
- 2.D.02.03 Define macro/micro pores and explain causes and effects of soil compaction.
- 2.D.02.04 Explain how percolation, permeability, and infiltration relate to the density of an ideal growth medium.
- 2.D.02.05 Relate soil aggregates to soil texture.
- 2.D.02.06 Define and identify sources of soil organic matter.

- 2.D.02.07 Explain the process of composting and the decay process whereby humus is produced.
- 2.D.02.08 Compare the positive and negative aspects of organic matter.
- 2.D.02.09 Explain matric potential.
- 2.D.02.10 Define soil water potential as it relates to water holding capacity and the importance to plant health.
- 2.D.02.11 Define and explain capillary rise and osmosis.

2.D.02 Performance Example:

- Students are to bring a soil sample from home and examine it. Within their own sample, students are to identify organic matter, pore space and other identifying characteristics of their soil. Once paired, the students will coach their partner as to how to perform a Ribbon Test to determine the textural class for their soil sample.

2.D.03 Analyze relationships of soil life to plant health.

- 2.D.03.01 Explain the dependence of food chains on soil and the role of decomposers.
- 2.D.03.02 Classify soil life.
- 2.D.03.03 Explain immobilization and mineralization as they pertain to the nitrogen and carbon cycles.
- 2.D.03.04 Define and explain the importance of mycorrhizae to plant roots.
- 2.D.03.05 Explain and demonstrate how to promote soil health while controlling harmful soil organisms.

2.D.03 Performance Example:

- Prepare a presentation about soil life and plant health. Describe different food chains in relation to soil life. Choose three ways in which a grower can promote soils health and choose three ways a grower can control harmful organisms.

2.D.04 Relate soil fertility to appropriateness of a growing medium.

- 2.D.04.01 Define/explain cation exchange capacity.
- 2.D.04.02 List factors and inhibitors of nutrient uptake by plants including pH.
- 2.D.04.03 Explain how root interception, mass flow, and diffusion lead to nutrient uptake.
- 2.D.04.04 Determine factors contributing to soil pH and buffering capacity.
- 2.D.04.05 Adjust soil pH.
- 2.D.04.06 List and explain causes of soil salinity and methods of managing saline soils.

2.D.04 Performance Example:

- Prepare a presentation about factors which contribute to the fertility of a soil, including; pH, cation exchange capacity, buffering capacity, and saline issues.

2.D.05 Apply soil testing processes and techniques to determine soil health.

- 2.D.05.01 List reasons to perform and explain methods of soil testing.
- 2.D.05.02 Perform basic soil tests for pH and N-P-K content.
- 2.D.05.03 Prepare a soil sample for testing in a commercial laboratory and interpret results of a commercial soil test.
- 2.D.05.04 Determine N-P-K content of fertilizer.

2.D.05 Performance Examples:

- Determine the actual content of each nutrient in a given bag of fertilizer and determine the amount of filler. Prepare a chart displaying the amount of each nutrient and filler for a variety of weight bags.
- Perform a basic soil test to determine pH and N-P-K content.

Horticulture Concentration: Arboriculture

2.E Arboriculture Health and Safety Knowledge and Skills

- 2.E.01 Demonstrate equipment safety.
- 2.E.01.01 Follow the ANSI Z133 safety standards.
 - 2.E.01.02 Inspect all equipment for maintenance and safety considerations according to current industry and safety standards and manufacturer's specifications.
 - 2.E.01.03 Use modern safety features specific to each piece of equipment, such as chainsaws and chippers.

2.E.01 Performance Example:

- Assign each student group a different section of the Z133 standards to read and complete a related project. Students must present their projects to the class.

- 2.E.02 Explain the safe use of arboricultural pesticides and care for application equipment.
- 2.E.02.01 Wear appropriate personal protective equipment for pesticide application according to manufacturer's recommendations.
 - 2.E.02.02 Measure, mix, and apply a recommended chemical for control of a specific pest (using simulations where appropriate).
 - 2.E.02.03 Clean, inspect, and care for pesticide application tools following appropriate industry and manufacture guidelines.
 - 2.E.02.04 List and explain state pesticide regulations and protections.

2.E.02 Performance Example:

- Read a pesticide label and determine application rate and method. Put on all PPE, apply the pesticide (simulation), clean all equipment used, and prepare the remaining pesticide for storage.

- 2.E.03 Demonstrate safety and appropriate health precautions when working in adverse weather conditions.
- 2.E.03.01 Identify potential hazards related to sun exposure and Ultraviolet (UV) rays.
 - 2.E.03.02 Identify potential hazards related to summer heat conditions (e.g., heat stroke, heat exhaustion, dehydration).
 - 2.E.03.03 Identify potential hazards related to extreme cold (e.g., hypothermia, frost bite, dehydration).
 - 2.E.03.04 Identify potential hazards of storm weather (e.g., lightning, high winds, mixed precipitation, freezing surfaces).

2.E.03 Performance Example:

- Complete first aid training regarding symptoms of weather related injuries and their associated treatment.

- 2.E.04 Identify potential safety and health hazards encountered when working in outdoor environments.
- 2.E.04.01 Identify the hazards, precautions, and symptoms of insect carrying diseases (e.g., lyme disease, Eastern Equine Encephalitis (EEE), malaria).
 - 2.E.04.02 Identify the potential hazards of animals (rabies, biting hazard).
 - 2.E.04.03 Identify and recognize potential plants that may cause adverse reactions (e.g., poisonous plants, plant irritations, allergies).
 - 2.E.04.04 Explain how OSHA's 4 High Hazard areas are responsible for the majority of serious workplace injuries and fatalities (e.g., Falls, Electrocutions, Struck By, and Caught Between).

2.E.04 Performance Example:

- Complete a class presentation on an assigned environmental hazard associated with working in outdoor environments.

2.F Arboricultural Equipment

- 2.F.01 Operate a chainsaw safely and efficiently following manufacturer's guidelines and regulations.
- 2.F.01.01 Wear chaps, hard hat, eye protection, ear protection and appropriate attire (e.g., work boots, long pants etc.) every time a chainsaw is started.
 - 2.F.01.02 Select and properly fit all personal protective equipment.
 - 2.F.01.03 Explain how chaps work.
 - 2.F.01.04 Explain kickback and reactive forces.
 - 2.F.01.05 Label basic parts of a chainsaw.
 - 2.F.01.06 Demonstrate leglock and ground start procedure.
 - 2.F.01.07 Cut upwards and downward using a chainsaw following proper safety procedures.
 - 2.F.01.08 Mix fuel and oil for 2-cycle engine according to manufacturer's specifications.
 - 2.F.01.09 Perform basic maintenance on a chainsaw (e.g., clean, sharpen, care for bar and chain, etc.).
 - 2.F.01.10 Use proper ergonomics when using a chainsaw.

2.F.01 Performance Examples:

- Choose appropriate PPE required for operation of a chainsaw. Explain function of and describe proper fit of said PPE.
- Mix oil and fuel to achieve appropriate ratio determined by the owner's manual. Fill both the fuel and bar oil reservoirs. Use one of the approved methods to start the chainsaw. While maintaining proper positioning, cut pieces off of a log utilizing a variety of cuts. When done cutting prepare the saw for storage (clean, sharpen, maintain etc.).

- 2.F.02 Demonstrate use of a chipper according to current industry standards and manufacturer's specifications.
- 2.F.02.01 Distinguish between disc and drum chippers.
 - 2.F.02.02 List safety features and identify danger zones relating to chippers.
 - 2.F.02.03 Perform scheduled maintenance of a chipper.
 - 2.F.02.04 Demonstrate proper feeding and ergonomic body position when using a chipper.
 - 2.F.02.05 Use clean-up tools appropriately.
 - 2.F.02.06 Properly attach a chipper to a truck.
 - 2.F.02.07 Apply proper road safety precautions.

2.F.02 Performance Examples:

- Prepare a presentation for the class comparing and contrasting disc and drum chippers. Presentation should include safety features and danger zones of chippers.
- Select and wear appropriate PPE for operation of a brush chipper. Utilizing proper body mechanics, chip brush and use clean up tools (rakes shovels etc.) to clean a work site.

- 2.F.03* Describe or demonstrate the proper usage of aerial lifts.
- 2.F.03.01* Review the Massachusetts Hoisters License requirements for operating equipment and be prepared to take the test.
 - 2.F.03.02* Identify potentially energized conductors.
 - 2.F.03.03* Compare and contrast various types of aerial lifts and list the attributes of each.
 - 2.F.03.04* Perform a site inspection including identification and potential mitigation of site hazards (e.g., overhead/buried utilities, irrigation systems, structures etc.).

- 2.F.03.05* Describe or demonstrate set up and operation procedures for aerial lifts.
- 2.F.03.06* Compare and contrast various types of fall arrest harnesses and demonstrate their use.
- 2.F.03.07* Explain hazards associated with shock loading an aerial lift.
- 2.F.03.08* Analyze multiple methods for aerial rescue from an aerial lift.
- 2.F.03.09* Explain pre-travel preparations for aerial lifts (e.g., all booms stowed and locked if applicable).

2.F.03 Performance Examples:

- Prepare a presentation for the class comparing and contrasting a variety of aerial lifts. Presentation should include safety features of the lifts, licenses required, cost, electrical conductivity, PPE requirements and limitations.
- Perform a site inspection for accessibility of an aerial lift. Set up an aerial lift and utilize it to travel throughout a tree to a number of predetermined locations. Once complete prepare the lift for travel.

2.F.04 Demonstrate the use and care of ropes and lines.

- 2.F.04.01 Differentiate between 3, 12, 16, and 24 strand line.
- 2.F.04.02 Compare and contrast climbing lines with varying lengths and diameters.
- 2.F.04.03 Analyze the interaction of differing diameters of cordages (e.g., different diameter eye and eye tied on different diameter climbing lines.).
- 2.F.04.04 Compare and contrast bagging and coiling line.
- 2.F.04.05 Explain strength loss of knots and splices.
- 2.F.04.06 Inspect and care for ropes.
- 2.F.04.07 Compare and contrast whipping, taping, and dipping for treatment of rope ends.
- 2.F.04.08 Define tying, dressing, and setting knots and hitches.
- 2.F.04.09 Tie, dress, set, and demonstrate the appropriate use and limitations of the following knots and hitches: Bowline, Figure 8, Tautline, Prusik, Fisherman's, Blakes, Running Bowline, Timber, Clove, Half, Sheet Bend, Bowline and Bight, Scaffold, Anchor Bend, Buntline and Bullet.
- 2.F.04.10 Compare and contrast safe working load and tensile strength.
- 2.F.04.11 Differentiate between weight and force.

2.F.04 Performance Examples:

- Prepare a presentation for the class comparing and contrasting a variety of ropes; topics should include; suggested care, weight, elasticity, size, color, and strength.
- Play knot tying games where not only knot tying ability is tested but also knowledge of the knot is included.
- Compete in the Massachusetts FFA Arbor Skills CDE knot tying event.

2.F.05 Identify, select, and maintain basic arboricultural equipment.

- 2.F.05.01 Identify tools used in the maintenance of equipment.
- 2.F.05.02 Define equipment and maintenance terms.
- 2.F.05.03 Identify the basic components of small engines.
- 2.F.05.04 Differentiate between two- and four-cycle engines.
- 2.F.05.05 Differentiate between gas and diesel engines.
- 2.F.05.06 Identify maintenance procedures recommended for gas and diesel engines.
- 2.F.05.07 Conduct (daily) maintenance of arboriculture equipment according to owner's manual recommendations.
- 2.F.05.08 Use winches following industry approved techniques and guidelines and explain safety concerns associated with winches.

- 2.F.05 Performance Examples:
- Prepare a presentation for the class on a given piece of equipment; including uses, cost, longevity, and specifics about the equipment. Perform daily maintenance of given equipment.
 - Compete in the Mass FFA Arbor Skills CDE in the equipment ID event.

2.G Tree Climbing

- 2.G.01 Identify and describe tree climbing safety.
- 2.G.01.01 Perform a pre-climb inspection of the tree and surrounding area.
- 2.G.01.02 Explain the components of an electrical hazard awareness program.
- 2.G.01.03 Use appropriate verbal call and response communication system (e.g., “Stand clear.” “All clear.”).
- 2.G.01.04 Perform pre-climb gear inspection on all gear to be used.
- 2.G.01.05 Compare methods of rope installation.
- 2.G.01.06 Determine tie in location and acceptable diameters relative to species and task to be performed.
- 2.G.01.07 Describe and demonstrate how to use ladders according to current industry standards.
- 2.G.01.08 Compare a closed system and an open system.
- 2.G.01.09 Compare a variety of lanyard types and their uses.
- 2.G.01.10 Determine the appropriate climbing method to be employed for a given tree.
- 2.G.01.11 Explain the proper use and safety limitations of mechanical ascenders.
- 2.G.01.12 Explain the use of re-direct.
- 2.G.01.13 Explain double crotching.

- 2.G.01 Performance Examples:
- Perform a pre-climb inspection of a site; listing all site hazards as well as electrical hazards.
 - Prepare a presentation for the class comparing and contrasting a variety of climbing techniques and equipment available. Construct a “wish list” of gear and prioritize said list.

- 2.G.02 Demonstrate appropriate systems of safe and efficient tree climbing techniques according to current industry standards.
- 2.G.02.01 Install a climbing line.
- 2.G.02.02 Install a false-crotch/cambium saving device.
- 2.G.02.03 Use a lanyard safely to advance a rope.
- 2.G.02.04 Demonstrate the following climbing techniques; body thrusting, modified footlock, and secured footlock.
- 2.G.02.05 Describe and demonstrate single line techniques.
- 2.G.02.06 Use climbing spurs properly while on belay.
- 2.G.02.07 Demonstrate safe limb walking techniques.
- 2.G.02.08 Descend safely on a friction hitch/mechanical descender.
- 2.G.02.09 Demonstrate proper ground working skills.
- 2.G.02.10 Demonstrate proper ergonomic techniques associated with tree climbing.

- 2.G.02 Performance Examples:
- Climb a variety of trees utilizing a variety of climbing skills. Access multiple pre-determined points throughout the canopy and ring a pre-set bell.
 - Compete in the Mass FFA Arbor Skills CDE in the throw-line, work climb, and speed climb events.

2.H Tree Maintenance

- 2.H.01 Identify trees using multiple growth characteristics.
- 2.H.01.01 Define and explain tree anatomy used in identification of trees.
 - 2.H.01.02 Use common and scientific names to identify trees according to the Massachusetts FFA Arbor Skills Career Development Event (CDE).
 - 2.H.01.03 Use a key or reference guide to identify trees.
 - 2.H.01.04 Identify coniferous, deciduous, and deciduous-coniferous trees.

2.H.01 Performance Examples:

- Compile a specimen collection for the tree ID list.
- Compete in the Mass FFA Arbor Skills CDE in the Tree ID event.

- 2.H.02* Demonstrate and apply scientific principles of tree transplanting in accordance with the ANSI A300 standards.
- 2.H.02.01* Describe the standard techniques of digging a tree and preparing it for travel.
 - 2.H.02.02* Calculate the size of root ball required for a successful transplant (e.g., 9"-12" of root ball for every inch of trunk diameter).
 - 2.H.02.03* Evaluate a variety of methods for transplanting (e.g., balled and burlapped (B&B), Bare root, Containerized).
 - 2.H.02.04* Burlap and move a root ball, according to industry standards.
 - 2.H.02.05* Prepare a planting hole according to industry standards.
 - 2.H.02.06* Explain the importance of planting depth for transplanting success.
 - 2.H.02.07* Demonstrate techniques of removing all containers, burlap, wire baskets, and trunk wrap.
 - 2.H.02.08* Demonstrate and explain the importance for post transplanting care (e.g., watering, mulching, etc.) to avoid transplant stress.
 - 2.H.02.09* Compare and contrast different types of mulch, assessing the benefits of each and the proper techniques of application.
 - 2.H.02.10* Perform a support needs assessment and explain the techniques of staking/guying a newly transplanted tree when appropriate.
 - 2.H.02.11* Discuss causes of construction damage and recommend remediation of damage.

2.H.02 Performance Examples:

- Choose a tree and evaluate it for likelihood of transplant success. Determine and evaluate factors which contribute to transplant success including; the best method for transplanting, size of ball (if required).
- Transplant trees utilizing a variety of methods. Demonstrate appropriate pre and post transplanting care.

- 2.H.03 Demonstrate and explain current arboricultural pruning techniques in accordance with the ANSI A300 standards.
- 2.H.03.01 Prune following ANSI A300 standards.
 - 2.H.03.02 Identify common pruning tools, use safely and follow maintenance practices.
 - 2.H.03.03 Explain how a tree reacts to pruning and list reasons for pruning while applying knowledge of Compartmentalization of Decay in Trees (CODIT).
 - 2.H.03.04 Identify and locate the branch bark ridge, branch collar and explain the relation to callus tissue development.

- 2.H.03.05 Relate wound dressing to wound closure.
- 2.H.03.06 Explain tree structure in relation to pruning.
- 2.H.03.07 Describe the following varieties of pruning objectives; crown cleaning, crown thinning, crown raising, crown reduction, crown restoration, and utility pruning.
- 2.H.03.08 Perform pruning cuts on a variety of sizes of limbs.
- 2.H.03.09 Evaluate and explain specialty pruning methods.
- 2.H.03.10 Identify reasons not to top trees.
- 2.H.03.11 Prune following proper body mechanics and ergonomic principles.

2.H.03 Performance Examples:

- Locate an example of CODIT and explain the processes which led the tree to be in its current condition. Locate the branch bark ridge and branch collar.
- Demonstrate proper body mechanics while making pruning cuts on a variety of sizes of limbs to accomplish a variety of pruning objectives.

2.H.04* Identify and explain scientific principles pertaining to supplemental tree support and tree health in accordance with ISA standards.

- 2.H.04.01* Perform a tree health assessment to establish need for support.
- 2.H.04.02* Explain techniques for bracing, cabling, and guying trees, according to current industry and ANSI standards.
- 2.H.04.03* Discuss lightning protection.
- 2.H.04.04* Evaluate a variety of cabling systems.
- 2.H.04.05* Install a cabling system.
- 2.H.04.06* Describe and demonstrate multiple methods of fertilizing trees.
- 2.H.04.07* Perform basic scouting techniques consistent with a PHC program.

2.H.04 Performance Example:

- Perform a needs assessment for a tree with a structural defect. Determine which type of support will best fit the tree, the situation, and the client. Install the chosen supplemental support system.

2.I Tree Removal

- 2.I.01 Demonstrate limbing, felling, and bucking techniques according to current industry standards.
 - 2.I.01.01 Measure tree height using a variety of methods.
 - 2.I.01.02 Evaluate a felling site for obstacles.
 - 2.I.01.03 Demonstrate cuts, notches, hinges, and back-cuts and explain their function.
 - 2.I.01.04 Bore cut-to make a back-cut using proper technique.
 - 2.I.01.05 Formulate a felling plan which includes; hazards, lean in two planes, escape route, size of hinge, and plan of back cut.
 - 2.I.01.06 Describe the use of felling sights.
 - 2.I.01.07 Describe barber chairing.
 - 2.I.01.08 Explain the use of force as a component of a felling plan (e.g., felling wedges, lever, rope, machinery etc.).
 - 2.I.01.09 Limb and buck following safety methods.
 - 2.I.01.10 Evaluate and measure a tree for lumber and firewood.
 - 2.I.01.11 Explain different markets for green waste.

- 2.I.01 Performance Examples:
- Practice cutting notches and making backcuts behind them leaving uncut hinge fiber on scraps of wood.
 - Formulate a felling plan for a given tree including; hazards, lean in two planes, escape route, size of hinge, and plan of backcut. Use the felling sights to determine direction of fall. Measure the height of the tree and place a target where the top is supposed to land. Make felling cuts and apply force to ensure tree falls over. Measure the distance from the intended target and the actual landing spot and diagnose why there was a difference.
 - Evaluate a tree for lumber or firewood and limb and buck a felled tree using proper and safe methods.

- 2.I.02* Describe safe and efficient arboricultural rigging principles and practices in accordance with the ANSI Z133 and A300 standards.
- 2.I.02.01* Define arboricultural rigging.
- 2.I.02.02* Compare and contrast butt tying, tip tying, and balancing.
- 2.I.02.03* Explain and compare static and dynamic loads.
- 2.I.02.04* Compare natural crotch rigging and the use of several types of false crotches.
- 2.I.02.05* Explain the importance of and how to manage friction.
- 2.I.02.06* Explain cycles to failure of gear and tree parts.
- 2.I.02.07* Compare a variety of friction devices.
- 2.I.02.08* Discuss anchor point selection.
- 2.I.02.09* Select, inspect, and maintain rigging gear.
- 2.I.02.10* Safely rig and lower a limb.
- 2.I.02.11* Use a Green Log Weight Chart to determine the weight of a given log.
- 2.I.02.12* Explain principles of using a chainsaw in a tree.
- 2.I.02.13* Demonstrate ergonomic rigging principles (e.g., climber and ground worker).

- 2.I.02 Performance Examples:
- Evaluate a tree limb which is to be rigged out. Choose whether to tip tie, butt tie, or balance the limb. Determine how much friction is required to safely lower the limb and choose appropriate rigging gear to achieve desired outcome. While utilizing proper body mechanics rig the limb, cut it and lower it to the ground.
 - Compare and contrast static and dynamic loads while utilizing a Green Log Weight Chart to determine the weight of a log to be rigged.

NOTES:

* Indicates supplemental/advanced learning standards and objectives.

Horticulture Concentration: Greenhouse Management and Floriculture

2.J Floral Design & Interior Landscape

- 2.J.01 Explain how floral designs from different historical periods influence today's designs.
- 2.J.01.01 Compare and contrast different historical periods of floral design.
- 2.J.01.02 Identify major characteristics of each historical period and relate them to modern day design.

- 2.J.01 Performance Example:
- Create a presentation of the historical periods of floral design explaining how they impact current floral standards.

- 2.J.02 Identify and implement the mechanics and techniques used in floral design construction.
- 2.J.02.01 Select appropriate container taking into account the size, texture, shape and color.
- 2.J.02.02 Compare and contrast the various brands and types of floral foam, along with the specialty forms and devices.
- 2.J.02.03 Prepare floral foam for use in a particular design.

- 2.J.02.04 Distinguish between the types of adhesive products and their uses.
- 2.J.02.05 Select the appropriate cutting tool for the design work.
- 2.J.02.06 Identify the types of picks and describe their uses.
- 2.J.02.07 Identify varying gauges and forms of wire and demonstrate wiring and taping techniques.
- 2.J.02.08 Categorize size, materials and uses of ribbon and construct a bow using the various sizes and types.
- 2.J.02.09 Demonstrate different techniques, uses and types of decorative wire.

2.J.02 Performance Example:

- Prepare an inventory list of the necessary supplies needed for a corsage and specific style of arrangement.

- 2.J.03 Evaluate, design and demonstrate construction principles used to create floral designs.
 - 2.J.03.01 Apply the knowledge of balance, emphasis, focal point harmony, rhythm, proportion and scale in a design.
 - 2.J.03.02 Use elements of line, form, texture, and color in creating a design.
 - 2.J.03.03 Identify the twelve common floral design forms used in the floral industry (Oval, inverted-T, Vertical, Asymmetrical triangle, Horizontal, Hogarth's Curve, Right Angle, Round, Crescent, Diagonal, Equilateral Triangle, and Fan).
 - 2.J.03.04 Execute the four basic floral design forms (round, triangle, line, horizontal).
 - 2.J.03.05* Execute the advanced floral design shapes used in the floral industry, including contemporary and Ikebana designs.
 - 2.J.03.06 Analyze the color wheel, distinguish between color harmonies and analyze the use of color in designs.
 - 2.J.03.07 Select cut flowers and greens that are appropriate for use in a variety of designs.
 - 2.J.03.08 Identify the forms and shapes of flowers (e.g., mass, line, form, filler).
 - 2.J.03.09 Utilize techniques of flower placement to achieve the design principles and elements.
 - 2.J.03.10 Identify the most commonly used cut flowers and foliage in modern day design.
 - 2.J.03.11 Select appropriate flowers for and construct a single and multiple flower boutonniere and corsage using both the wiring and taping methods as well as adhesive glue.
 - 2.J.03.12 Select appropriate flowers for and design a single and multiple bloom bud vase.

2.J.03 Performance Examples:

- Prepare a portfolio of drawings illustrating the twelve floral design forms and prepare examples demonstrating the use of floral principles in floral arrangements.
- Design floral arrangements that exemplify the principles and elements of floral design.

- 2.J.04 Determine the appropriate floral selection and demonstrate post-harvest handling and methods of cut flowers.
 - 2.J.04.01 Use scientific names to identify the most common cut flowers including those on the National FFA Floriculture Career Development Event Plant List.
 - 2.J.04.02 Explain the vase life of flowers and how it affects selection for a design.
 - 2.J.04.03 Explain the availability and color selections of cut flowers and foliage.
 - 2.J.04.04 Identify standard industry packing quantities for cut flowers and foliage.

- 2.J.04.05 Identify steps and procedures for the handling of flowers from farm to market.
- 2.J.04.06 Identify the causes of premature flower senescence including fungus, bacteria, and ethylene gas.
- 2.J.04.07 Demonstrate the steps and methods of flower conditioning.
- 2.J.04.08 Identify the advantages of using floral preservatives and pre-hydrating solutions.
- 2.J.04.09 Analyze the importance of pH to water quality and how it affects the vase life of flowers.
- 2.J.04.10 Apply the knowledge of refrigeration and sanitation as it relates to flower life extension.
- 2.J.04.11 Perform specific floral conditioning techniques for distinctive & delicate flowers and foliage.
- 2.J.04.12 Identify storing requirements, such as temperature and humidity levels, for flowers and foliage.
- 2.J.04.13* Select suitable flowers and identify the methods used to dry and preserve them.

2.J.04 Performance Example:

- Perform experiments determining the benefits of various types of floral preservative and processing techniques.

2.J.05 Prepare and execute specific designs for holidays, special occasions and events.

- 2.J.05.01 Identify industry significant holidays and the appropriate arrangements that accompany them.
- 2.J.05.02 Construct wreaths using a variety of materials such as evergreens, dried and permanent materials and properly attach decorations.
- 2.J.05.03* Examine traditions of various cultures in regard to special occasions and holiday floral needs.
- 2.J.05.04* Describe the process of special event consultations and populate an order form.
- 2.J.05.05* Identify appropriate locations for floral design pieces for a given event.
- 2.J.05.06* Distinguish between the various forms of bridal bouquets and demonstrate the techniques of each, including the arm bouquet, clutch bouquet, hand-tied bouquet, and colonial bouquet (in a holder) and cascading bouquet (in a holder).
- 2.J.05.07* Identify the floral pieces that are used at a matrimonial ceremony (e.g., pews, altars, entries, vestibules) and receptions (e.g., guest tables, serving tables, cake tables).
- 2.J.05.08* Identify the types and significance of various sympathy arrangements and demonstrate the techniques used to create the following types: casket cover, standing sprays, baskets, set/picked pieces, wreaths, and other modern designs and plants.
- 2.J.05.09* Discuss permanent flowers and demonstrate the techniques used to create a permanent arrangement.

2.J.05 Performance Example:

- Plan, design, construct and determine costs for all plants, corsages, boutonnieres and decorations for a wedding order.

- 2.J.06 Apply the principles of interior landscape design.
- 2.J.06.01 Use scientific names to identify the most common indoor plants using the National FFA Floriculture Career Development Event Plant List.
- 2.J.06.02 Practice effective plant use in the interior landscape (e.g., light, water and temperature requirements and size).
- 2.J.06.03 Identify the functions of plants used in interior locations.
- 2.J.06.04 Plan and implement an interior plantscape while applying the principles of design.
- 2.J.06.05 Evaluate the elements of a design. (e.g., screens, living walls, accent pieces, etc.) and analyze their usage.
- 2.J.06.06 Identify the special care required for tropical & foliage plants.
- 2.J.06.07 Develop a maintenance schedule for interior plantscapes.
- 2.J.06.08 Select and decorate the appropriate indoor plant for a specific use and distinguish between permanent and temporary indoor plants.

- 2.J.06 Performance Example:
- Create a reference guide depicting light and water requirements for plants used in interior spaces.

2.K Greenhouse Management & Production

- 2.K.01 Describe the types of basic greenhouse structures & systems.
- 2.K.01.01 Compare and contrast the various types of greenhouse structures and their construction including Gothic arch, Quonset, ridge and furrow and uneven-span and identify the attributes of each.
- 2.K.01.02 Identify the construction materials used to build greenhouses and compare the various forms of greenhouse coverings (e.g., polyethylene, glass, etc.).
- 2.K.01.03 Identify the uses of coldframes, hotbeds, growing rooms and bulb cellars.
- 2.K.01.04 Compare shade materials and methods.
- 2.K.01.05 Calculate the heat requirements for a greenhouse and compare and contrast the commonly used heating systems.
- 2.K.01.06 Summarize the benefits of ventilation and cooling and identify methods of both.
- 2.K.01.07 Differentiate between the various types of greenhouse benches and arrangements.
- 2.K.01.08 Calculate the bench space required dependent on a variety of pot sizes, spacing and arrangements.

- 2.K.01 Performance Example:
- Design a greenhouse structure, determining the requirements for covering, heating, irrigation and bench arrangement.

- 2.K.02 Assess the use of different growing media's and fertilizers in greenhouse production.
- 2.K.02.01 Evaluate the makeup of varying types of growing media used in the greenhouse.
- 2.K.02.02 Identify the uses for artificial or soilless media.
- 2.K.02.03 Summarize fertilizer requirements of a variety of crops and how it changes throughout the life of the plant.
- 2.K.02.04 Identify the forms of fertilizers which can be applied (e.g., dry, liquid, control released) and describe the appropriate uses for each.
- 2.K.02.05 Monitor salt levels in media and identify the impacts of salt and poor drainage on a plant's health.

- 2.K.02.06 Calculate fertilizer application rates (direct injector proportions and traditional application methods).
- 2.K.02.07 Evaluate methods and chemicals needed to change water quality.
- 2.K.02.08 Calculate the amount media required to fill a variety of pot sizes for production.

2.K.02 Performance Example:

- Create a balanced fertilizer program for a greenhouse crop and calculate the amount of fertilizer necessary to complete the program.

- 2.K.03 Explain the role of water in greenhouse production.
 - 2.K.03.01 Identify the types of manual and automatic watering systems commonly found in greenhouses.
 - 2.K.03.02 Compare and contrast watering methods such as hose watering, intermittent mist system, overhead water, perimeter irrigation, soaker hose system and tube irrigation. Identify the advantages of each.
 - 2.K.03.03 Compare capillary mats and ebb and flood benches to other irrigation methods.

2.K.03 Performance Example:

- Create two irrigation systems for the school's greenhouse and identify the advantages and disadvantages of each.

- 2.K.04* Explain the role of hydroponics in the industry and apply production principles.
 - 2.K.04.01* Describe the history, importance and use of hydroponics in the industry.
 - 2.K.04.02* Evaluate and compare structures, growing media and methods used in hydroponic production facilities.
 - 2.K.04.03* Identify crops that could be grown hydroponically.
 - 2.K.04.04* Describe the nutritional requirements of hydroponic crops and how nutrients are obtained.
 - 2.K.04.05* Calculate nutrient rate and volume measurements for hydroponic systems and the role that water plays in production.
 - 2.K.04.06* Perform common tests on water for production.

2.K.04 Performance Example:

- Analyze root growth in different types of hydroponic growth medium.

- 2.K.05 Apply knowledge to the propagation and reproduction of plants.
 - 2.K.05.01 Explain the environmental requirements for seed germination. (e.g., water, oxygen, temperature and light).
 - 2.K.05.02 Describe the requirements of a germination media (e.g., components, texture, water capacity, and sterility).
 - 2.K.05.03 Identify and select seed sowing methods appropriate for size of seed and production method.
 - 2.K.05.04 Cite the requirements for transplanting seedlings (e.g., stage of growth and environmental requirements).
 - 2.K.05.05 Differentiate between the types of cutting for asexual propagation (e.g., including stem, leaf and leaf bud cuttings).
 - 2.K.05.06 Evaluate the environment required for cuttings (e.g., moisture, temperature, media, sterility, and fertilization).
 - 2.K.05.07 Perform the layering and division method of propagation.

- 2.K.05.08* Explain the importance of plant biotechnology (e.g., micro propagation/tissue culture) in the industry and society and how it affects production and yields.
- 2.K.05.09* Compare and contrast meristem and tissue culture.
- 2.K.05.10* Describe the techniques and environmental conditions necessary to undertake the process of tissue culture.
- 2.K.05.11* Demonstrate the process of tissue culture using the appropriate methods and techniques.

- 2.K.05 Performance Examples:
- Perform the multiple types of asexual propagation and compare the rate of plant production.
 - Chart the germination and development of seedlings.

- 2.K.06 Apply methods of controlling plant disease and pests in a greenhouse environment.
 - 2.K.06.01 Distinguish between biological, cultural, physical and chemical pest management practices.
 - 2.K.06.02 Identify the common insects found in greenhouse plants including aphids, mealybug, mites, thrip, and scale.
 - 2.K.06.03 Identify commonly found diseases in greenhouse such as Botrytis blight, downy mildew, powdery mildew, *Pythium*, *Phytophthora*, *Rhizoctonia*, *Xanthomonas*, and other bacteria and viruses.
 - 2.K.06.04 Describe a greenhouse environment that discourages disease growth.

- 2.K.06 Performance Example:
- Develop a quick reference guide for common greenhouse pests and diseases, include potential remedies and treatments.

- 2.K.07 Identify and explain the principles for producing greenhouse crops.
 - 2.K.07.01 Identify major greenhouse crops including, African violets, bedding plants, chrysanthemums, cineraria, cyclamen, Easter Lilies & other bulb plants, foliage plants, gloxinia, holiday cacti, kalanchoe, orchids, poinsettias and vegetables.
 - 2.K.07.02 Transplant plants in various stages of growth.
 - 2.K.07.03 Define photoperiodism and distinguish between short-day plants, long-day plant and day-neutral plants.
 - 2.K.07.04 Describe lighting requirements in a greenhouse including supplemental lighting.
 - 2.K.07.05 Analyze the impact of temperature on plant growth and development (e.g., DIF, thermoperiodism, etc.).
 - 2.K.07.06 Utilize plant regulators and retardants to alter plant hormones effectiveness.
 - 2.K.07.07 Compare and contrast methods of pinching and disbudding.
 - 2.K.07.08 Summarize factors to consider when selecting a greenhouse crop to produce.
 - 2.K.07.09 Explain the seasonal markets for greenhouse crops.

- 2.K.07 Performance Example:
- Prepare a planning production guide for a specific greenhouse crop taking into account, starting stock, lighting, temperature and desire target date.

2.L Floriculture Business Operations

- 2.L.01 Demonstrate the knowledge and skills required to operate a floriculture business.
 - 2.L.01.01 Describe the various types of floral businesses in the industry.

- 2.L.01.02 Describe the logistics and planning of floral deliveries including events and sympathy.
- 2.L.01.03 Explain the role of wholesalers in the marketing and distribution of crops.
- 2.L.01.04 Compute the unit cost of goods sold.
- 2.L.01.05 Calculate the retail cost of goods using the Standard Ratio Markup, Retail Cost of Goods plus Labor, Divisional Percentage Pricing and Leader Pricing.
- 2.L.01.06 Package plants and designs for distribution or delivery.
- 2.L.01.07 Identify methods used to sell or fill floral orders outside a delivery zone.

2.L.01 Performance Example:

- Create a flow chart identifying the route of a specific floral product, and what it takes to arrive at a flower shop (Flower chain).

2.L.02* Develop marketing strategies pertaining to the floral industry.

- 2.L.02.01* Identify methods to merchandize floral products and services.
- 2.L.02.02* Distinguish between merchandizing and visual displays.
- 2.L.02.03* Identify the purposes and categories of visual displays.
- 2.L.02.04* Develop and illustrate visual merchandizing strategies.

2.L.02 Performance Example:

- Create a display featuring a floral product and illustrate an advertisement to accompany it.

NOTES:

* Indicates supplemental/advanced learning standards and objectives.

Horticulture Concentration: Landscaping and Turf Management

2.M Safety and Health Knowledge and Skills

2.M.01 Demonstrate safety and appropriate health precautions when working in adverse weather conditions.

- 2.M.01.01 Identify potential hazards related to sun exposure and UV rays.
- 2.M.01.02 Identify potential hazards related to summer heat conditions (e.g., heat stroke, heat exhaustion, dehydration).
- 2.M.01.03 Identify potential hazards related to extreme cold (e.g., hypothermia, frost bite, dehydration).
- 2.M.01.04 Identify potential hazards of storm weather (e.g., lightning, high winds, mixed precipitation, freezing surfaces).

2.M.01 Performance Examples:

- Perform various horticulture tasks in adverse weather conditions such as rain, snow, cold and heat using appropriate PPE and clothing.

2.M.02 Identify safety and health hazards when working in outdoor environments and demonstrate safe practices.

- 2.M.02.01 Identify and recognize the hazards, precautions, and symptoms of insect carrying diseases (e.g., Lyme Disease, EEE, malaria).
- 2.M.02.02 Identify and describe the hazards of animals (rabies, biting hazard).
- 2.M.02.03 Identify plants that may cause adverse reactions (e.g., poisonous plants, plant irritations, allergies).
- 2.M.02.04 Explain how OSHA's 4 High Hazard areas are responsible for the majority of serious workplace injuries and fatalities (e.g., Falls, Electrocutions, Struck By, and Caught Between).

2.M.02 Performance Examples:

- While working in an area near high grass, dress appropriately to keep certain plants away from the body and use repellent to repel ticks and mosquitoes.

2.N Landscape Design and Estimating

2.N.01 Perform a site analysis and design a landscape plan.

- 2.N.01.01 Sketch site dimensions using basic survey equipment.
- 2.N.01.02 Calculate square area.
- 2.N.01.03 Convert site measurements to scale dimensions using an Architect's and Engineer's scale ruler.
- 2.N.01.04 Describe the effects of sun, wind, moisture, and sound on a landscape site.
- 2.N.01.05 Identify current and future site use.
- 2.N.01.06 Read and interpret a landscape plan.
- 2.N.01.07 Select appropriate plants for a landscape plan.
- 2.N.01.08 Determine measurements using an Architect's and Engineer's scale ruler.
- 2.N.01.09 Use lettering techniques and graphic symbols appropriate to landscape design.
- 2.N.01.10* Create a landscape design using appropriate drawing tools, including computerized software.

2.N.01 Performance Example:

- Create a landscape design plan by accurately measuring and calculating the dimensions of the site and properly using technical drawings tools and/or software. The plan should include: scale, orientation, title box, recognized symbols, appropriate plant selection for the site, and appropriate landscape materials for the site.

2.N.02* Develop a detailed estimate and proposal for both a typical landscape construction project and a regularly scheduled landscape maintenance job.

- 2.N.02.01* Identify the components of an estimate.
- 2.N.02.02* Calculate labor costs for a job.
- 2.N.02.03* Calculate equipment and rental costs for a job.
- 2.N.02.04* Calculate material costs for a job.
- 2.N.02.05* Calculate subcontractor expenses for a job.
- 2.N.02.06* Calculate disposal costs for a job.
- 2.N.02.07* Calculate overhead for a job.
- 2.N.02.08* Calculate markups for a job.
- 2.N.02.09* Create a full budget for a job.

2.N.02 Performance Example:

- Create an estimate for a landscape project which includes all costs, expenses and markups and is presented in a professional format.

2.0 Landscape Construction

2.0.01 Complete a site analysis and develop landscape construction recommendations.

- 2.0.01.01 Survey and measure property using construction measuring equipment (e.g., levels, transits, measuring wheels and tapes).
- 2.0.01.02 Estimate material and supplies needed for a job site.
- 2.0.01.03 Identify current utility locations and hazards.
- 2.0.01.04 Survey existing grades and recommend corrective options.

2.0.01 Performance Example:

- Create a landscape site analysis for a construction plan by surveying the site, locating utilities (DIGSAFE) and making recommendations for grade changes.

2.0.02 Demonstrate practices related to landscape construction operations.

- 2.0.02.01 Identify and describe different walkway materials and systems (e.g., pavers, blue stone, natural flat stones, concrete).
- 2.0.02.02 Demonstrate knowledge and skills required to install a walkway.
- 2.0.02.03 Identify and describe different retaining wall materials and systems (e.g., interlocking concrete, wet stone, dry stone).
- 2.0.02.04 Demonstrate knowledge and skills required to install a retaining wall.
- 2.0.02.05* Identify and describe various water features and systems for construction (e.g., ponds, fountains, waterfalls).
- 2.0.02.06* Demonstrate knowledge and skills required to install a water feature.

2.0.02 Performance Example:

- Complete a landscape constructing the project (paver, interlocking wall, water feature) using industry recognized (i.e. integrated concrete paver institute) or material manufacturer methods or standards.

- 2.0.03 Operate and maintain a skid steer loader and front end loader following safety standards and manufacturers' specifications.
 - 2.0.03.01 Review the Massachusetts Hoisting License requirements for operating landscape construction equipment and be prepared to take the test.
 - 2.0.03.02 Use a variety of make and model landscape construction equipment following OSHA training protocols.
 - 2.0.03.03 Perform basic engine maintenance (e.g., filters, fuels, grease points, and routine adjustments).
 - 2.0.03.04 Identify and explain the components of a skid steer loader and front end loader.
 - 2.0.03.05 Operate a skid steer loader and a front end loader safely.

2.0.03 Performance Example:

- Demonstrate the safe operation and manufacturers recommended maintenance of a skid steer loader and/or front end loader, and participate in the FFA equipment operation contest.

- 2.0.04 Identify the main features of an irrigation system.
 - 2.0.04.01 Define irrigation terms.
 - 2.0.04.02 Compare and contrast the types of landscape irrigation systems (e.g., drip, impact, rotary, temporary).
 - 2.0.04.03 Determine water requirements of a landscape.
 - 2.0.04.04 Hand irrigate plants using recommended procedures.
 - 2.0.04.05 Determine appropriate irrigation systems for landscape needs.
 - 2.0.04.06* Design a landscape irrigation system which utilizes water conservation techniques.
 - 2.0.04.07 Install an irrigation system and adjust heads for proper water distribution.
 - 2.0.04.08 Repair and adjust an irrigation system.
 - 2.0.04.09 Maintain an irrigation system including seasonal start up and shut down maintenance requirements.

2.0.04 Performance Example:

- Install and maintain an irrigation system by determining the water needs of the property and using the appropriate type of system and tools to deliver water in a safe and efficient manner.

2.P Landscape Maintenance and Installation

- 2.P.01 Identify plants commonly used in New England landscapes.
 - 2.P.01.01 Identify bulbs (e.g., daffodil, tulip, gladiola, Lily of the valley).
 - 2.P.01.02 Identify annuals (e.g., impatiens, geraniums, marigolds).

- 2.P.01.03 Identify perennials (Hemerocallis, Rudbeckia, Delphinium).
- 2.P.01.04 Identify deciduous shrubs (e.g., Forsythia, Viburnum, and Lilac).
- 2.P.01.05 Identify needled evergreen shrubs (e.g., Taxus, Juniper).
- 2.P.01.06 Identify coniferous trees (e.g., Pine, Spruce, and Fir).
- 2.P.01.07 Identify deciduous trees (e.g., Maple, Oak, and Birch).
- 2.P.01.08 Identify deciduous- coniferous trees (e.g., larch, dawn redwood, bald cypress).

- 2.P.01 Performance Example:
- Compete in the FFA Nursery Landscape CDE.

- 2.P.02 Plant and maintain trees, shrubs, and herbaceous plant material.
- 2.P.02.01 Prepare soils for planting.
 - 2.P.02.02 Install bedding plants and groundcovers (e.g., annuals, perennials).
 - 2.P.02.03 Install trees and shrubs.
 - 2.P.02.04 Evaluate a variety of methods for transplanting (e.g., B&B, Bare root, Containerized).
 - 2.P.02.05 Identify plant stress caused by transplanting, construction damage, and other cultural damage.
 - 2.P.02.06 Stake and guy trees using current industry approved techniques.
 - 2.P.02.07 Stake and tie flowering plants using proper technique.
 - 2.P.02.08 Maintain bedding plants.
 - 2.P.02.09 Apply winter protection techniques (e.g., mulching hardiness, anti-desiccant).
 - 2.P.02.10 Identify potential water runoffs and restrictions and their implications.

- 2.P.02 Performance Examples:
- Prepare a planting site for a tree and/or shrub installation.
 - Stake and guy a tree.

- 2.P.03 Prune trees, shrubs, and herbaceous perennials.
- 2.P.03.01 Identify reasons for pruning (e.g., dead wood, diseased, safety, and shape/aesthetics).
 - 2.P.03.02 Identify and use types of pruning tools (e.g., bypass pruners, anvil pruners, loppers, hand saw, pole saw, pole pruner).
 - 2.P.03.03 Describe and demonstrate thinning techniques.
 - 2.P.03.04 Describe and demonstrate restorative pruning.
 - 2.P.03.05 Describe and demonstrate corrective pruning.
 - 2.P.03.06 Describe and demonstrate basal pruning.
 - 2.P.03.07 Clean and maintain pruning tools.
 - 2.P.03.08 Identify various specialty pruning techniques (e.g., espalier, topiary, bonsai, pollard, heading back, trellising).

- 2.P.03 Performance Examples:
- Select the proper tool for cut.
 - Make cut using 1, 2, 3 cut principles.

- 2.P.04 Use and maintain a commercial mower.
- 2.P.04.01 Distinguish between different mower types (e.g., walk behind, riding, rotary, reel, and flail).
 - 2.P.04.02 Operate various types of commercial mowers according to current industry and OSHA standards.

- 2.P.04.03 Perform basic engine maintenance (e.g., filters, fuels, grease points, and routine adjustments).
- 2.P.04.04 Perform blade maintenance (e.g., inspection for wear and defects, changing, sharpening, and balance).
- 2.P.04.05 Identify damage to plants caused by improper use (e.g., bark damage).
- 2.P.04.06 Identify safety hazards from improper use.

2.P.04 Performance Examples:

- Operate a commercial mower in accordance with the owner's manual:
 - Wear proper PPE while starting, operating, and shutting down a commercial mower.
 - Before starting the commercial mower for a job check the following: filters, spark plug, grease points, blade, and safety components.
 - While operating the commercial mower, student should be conscious of plant material and should be keeping a safe distance to avoid plant damage.

2.P.05 Use and maintain a string line trimmer according to current industry and OSHA standards.

- 2.P.05.01 Operate various models of commercial string line trimmers.
- 2.P.05.02 Mix 2-cycle fuel mix as outlined in manual when applicable.
- 2.P.05.03 Perform basic maintenance of engine (e.g., filters, fuel, and adjustment).
- 2.P.05.04 Perform basic maintenance of power head (e.g., changing string, greasing).
- 2.P.05.05 Identify damage to plants caused by improper use (e.g., bark damage).
- 2.P.05.06 Identify safety hazards from improper use.

2.P.05 Performance Examples:

- Operate a string-line trimmer in accordance with the owner's manual:
 - Wear proper PPE while starting, operating, and shutting down string-line trimmer.
 - Before starting the string-line trimmer for a job check the following: filters, spark plug, grease points, blade, and safety components.
 - While operating the string-line trimmer, student should be conscious of plant material and should be keeping a safe distance to avoid plant damage.
 - Student should demonstrate proper handling of string-line trimmer to minimize stress on back.

2.P.06 Safely use and maintain a commercial backpack blower according to current industry and OSHA standards.

- 2.P.06.01 Operate a commercial backpack blower.
- 2.P.06.02 Perform basic maintenance of engine (e.g., filters, fuel, and adjustment).
- 2.P.06.03 Properly mix fuel as outlined in manual.
- 2.P.06.04 Identify safety hazards of improper use.

2.P.06 Performance Examples:

- Operate a Backpack Blower in accordance with the owner's manual:
 - Wear proper PPE while starting, operating, and shutting down backpack blower.
 - Before starting the blower for a job check the following: filters, spark plug, and safety components.
 - Demonstrate use during proper weather conditions.
 - While operating the backpack blower, student should be conscious of plant material and should be keeping a safe distance to avoid plant damage.

2.P.07 Operate and maintain a chainsaw according to current industry and OSHA standards.

- 2.P.07.01 Explain kickback and reactive forces.

- 2.P.07.02 Explain how chaps, hard hat, ear protection, and appropriate attire (e.g., long pants, boots, etc.) are necessary every time chainsaw is started.
- 2.P.07.03 Select and properly fit all PPE.
- 2.P.07.04 Label common parts of a chainsaw.
- 2.P.07.05 Demonstrate leg lock and ground start procedure.
- 2.P.07.06 Mix 2-cycle fuel.
- 2.P.07.07 Perform basic maintenance on a chainsaw (e.g., clean, sharpen, care for bar and chain, etc.).
- 2.P.07.08 Use a chainsaw following ergonomic principles.

2.P.07 Performance Examples:

- Operate a Chain Saw in accordance with the owner’s manual:
 - Wear proper PPE while starting, operating, and shutting down chainsaw.
 - Before starting the chainsaw for a job check the following: filters, spark plug, bar and chain, and safety components.
 - Student should demonstrate proper stance while starting and using chainsaw.
 - Students should demonstrate proper chain sharpening using proper size tools.

2.Q Turfgrass Management

- 2.Q.01 Identify and select cool season/temperate grasses.
 - 2.Q.01.01 Identify and describe the major parts of a typical turfgrass plant.
 - 2.Q.01.02 Describe the three growth habits of turf grasses.
 - 2.Q.01.03 List and describe the major factors affecting turfgrass growth.
 - 2.Q.01.04 Identify and describe cool-season and warm-season turf grasses.
 - 2.Q.01.05 Describe the characteristics of each of the cool-season turfgrasses.
 - 2.Q.01.06 List key factors influencing turfgrass quality.

2.Q.01 Performance Example:

- Compete in the FFA Turfgrass Career Development Event.
- Select proper grass seed depending on location, light, and water requirements.

- 2.Q.02 Renovate and maintain an established turfgrass area according to current industry standards.
 - 2.Q.02.01 Identify, select and utilize seeding techniques (e.g., hand seeding, slice seeding, hydro seeding, and over seeding).
 - 2.Q.02.02 Install sod following proper procedures and techniques.
 - 2.Q.02.03 Identify and explain uses for turf growth regulators and wetting agents.
 - 2.Q.02.04 Identify and explain the beneficial and negative effects of thatch.
 - 2.Q.02.05 Describe the watering requirements of newly planted turf.
 - 2.Q.02.06 Describe the watering requirements of established turf.
 - 2.Q.02.07 Determine the growing conditions which effect mowing requirements.
 - 2.Q.02.08* List the mowing height ranges for golf courses, athletic fields and residential properties.

2.Q.02 Performance Examples:

- Student will describe what a sodded lawn needs to survive.
- Student will point out thatch and determine if dethatching is necessary.
- Students will prepare a watering schedule for established lawn based on season and fertilizer schedule.

- 2.Q.03 Identify common turfgrass weeds, insects, and pathogens.
 - 2.Q.03.01 Identify common broadleaf turf weeds (e.g., Turf, FFA, CDE list).

- 2.Q.03.02 Identify common invasive grass weeds (Turf, FFA CDE).
- 2.Q.03.03 Identify common turf insects and their types of damage (e.g., Turf, FFA CDE).
- 2.Q.03.04 Identify common turf pathogens and their damage (e.g., Turf, FFA CDE).
- 2.Q.03.05 Describe types of pest controls (e.g., cultural, biological, and chemical).
- 2.Q.03.06 List stressful conditions affecting residential and specialty turf.
- 2.Q.03.07 Identify types of application equipment used in turf (e.g., spreaders, hand sprayers, boom sprayers, fertigator).

2.Q.03 Performance Examples:

- Create a presentation that includes the following:
 - Identify common weeds, their growth habits, and growing environments.
 - Identify turfgrass insects in NE, their life cycles, and their control methods.
 - Identify turfgrass pathogens, potential hosts, life cycles, and control methods.
- Compete in the FFA Turfgrass Career Development Event.

2.Q.04 Develop a turfgrass fertilization and pest control program.

- 2.Q.04.01 Explain how fertilizer requirements are determined.
- 2.Q.04.02 Identify fertilization programs for residential lawns.
- 2.Q.04.03* Identify fertilization programs for specialty turf areas (e.g., athletic fields, golf course greens, tees, and fairways).
- 2.Q.04.04 Use and calibrate sprayers and spreaders.

2.Q.04 Performance Example:

- Based on the turfgrass blend, use of turfgrass, and location, a schedule for each season should be created to maintain health and vigor of turf area.

2.Q.05 Describe the different requirements of specialty turf areas (e.g., golf course, athletic fields, parks, and lawns).

- 2.Q.05.01 Identify the main types of sport fields.
- 2.Q.05.02 Describe the major characteristics of each sports turf grass.
- 2.Q.05.03* Layout, survey, and cite dimensions of athletic fields (e.g., baseball, football, soccer, etc.).
- 2.Q.05.04* Describe the management requirements of putting greens, tees, and fairways.
- 2.Q.05.05* Describe the soil requirements for USGA putting greens.
- 2.Q.05.06* Describe the functions of roughs, bunkers, and hazards.
- 2.Q.05.07* Outline the major management practices used for roughs, bunkers, and hazards.

2.Q.05 Performance Example:

- Create a presentation comparing and contrasting uses of each field and possible stresses to the turfgrass.

NOTES:

- * Indicates supplemental/advanced learning standards and objectives.

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.
Chain of Command and Organizational Structure	Refers to the management structure of an organization. It identifies lines of authority, lines of communication, and reporting relationships. Organizational structure determines how the roles, power and responsibilities are assigned and coordinated and how information flows between the different levels of management. (A visual representation of this structure is called an org chart).
	
FICA	Federal Insurance Contributions Act requires taxes deducted from pay for supporting Social Security.
Income Statement	A financial statement providing operating results for a specific time period showing a business's revenues, expenses and profit or loss.
Market Research	<ul style="list-style-type: none">• 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.

Term**Definition**

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.02 (one example)	RI Grades 9-10 1.0	Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
	RST grades 9-12 #1.	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
	SL Grades 9-12 1.0	Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on <i>grades 11–12 topics, texts, and issues</i> , building on others' ideas and expressing their own clearly and persuasively.
<p>Performance Example:</p> <ul style="list-style-type: none"> Students read and review requirements for the Massachusetts Pesticide License along with related regulations and safety documents. In groups they identify key words and concepts explicit in the documents and resources. The students then prepare presentations on the different components of the licensing requirements and present to their peers in preparation for the exam. 		
All standards	RI Grades 11-12 4.0	Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze how an author uses and refines the meaning of a key term or terms over the course of a text (how Madison defines <i>faction</i> in <i>Federalist</i> No. 10).
	RST grades 9-12 #2	Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
	RST grades 9-12 #3	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.
	RST grades 11-12 #4.	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to <i>grades 11–12 # texts and topics</i> .
	RST grades 9-12 #5	Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
<p>Performance Example:</p> <ul style="list-style-type: none"> In each of the instructional units, students are engaged in reading trade literature and scientific documentation related to the primary standard/topic area. This foundation is the basis by which all lab/field work is conducted. The students are challenged to apply their understanding of the vocabulary, text meaning and key terms to the lab/field study. This is further supported through written and verbally presented material at the end of each cluster/unit. 		
2.B.04 (one example)	W Grades 11-12 1.0	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
	WHST Grades 11-12 #1 (a-e)	Write arguments focused on <i>discipline-specific content</i> .
	WHST 11-12 #6.0	Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

	RI Grades 11-12 7.0	Integrate and evaluate multiple sources of information presented in different media or formats (visually, quantitatively) as well as in words in order to address a question or solve a problem.
	RST grades 9-12 #7	Integrate and evaluate multiple sources of information presented in diverse formats and media quantitative data, video, multimedia) in order to address a question or solve a problem.
	SL Grades 9-12 2.0	Integrate multiple sources of information presented in diverse formats and media (visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.
<p>Performance Example:</p> <ul style="list-style-type: none"> Analyze plants that are exposed to the various types of tropisms. Students document the change in the plant from day to day, determine if it is a positive or negative response and determine what caused the change in growth. These findings are analyzed and students write a lab report including research on previous studies on types of tropisms. Information gathered from internet, written and presented materials is incorporated into the study. Final report includes the use of multiple formats (graphs, media, video, etc) to demonstrate their findings while citing supporting evidence. 		
2.C.04 (only one example)	W Grades 9-12 2.0	<u>Write informative/explanatory texts</u> to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.
	WHST Grades 11-12 #2.0 (a-e)	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
	W Grades 9-12 4.0	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)
	WHST Grades 11-12 #4.0	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
	WHST Grades 11-12 #5.0	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
	WHST 11-12 #6.0	Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
	W Grades 9-10 7.0	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.
	WHST Grades 11-12 #7.0	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.
	SL Grades 9-12 6.0	Adapt speech to a variety of contexts and tasks, demonstrating a command of formal English when indicated or appropriate.
<p>Performance Example:</p> <ul style="list-style-type: none"> Students conduct research on one of the factors that can influence landscape or area management (for example; invasive species and their impacts on nearby plants and animals or soil amendments that increase soil diversity). Using this information they create a strategy for a landscape or managed area considering location, native planting, introduced planting and cultural, biological and chemical strategies. 		

As they progress through the project, additional information is incorporated into their report/project proposal. The final proposal is presented (as if to a customer or parks association) including visual, written and animated media as appropriate.		
2.Q.01-05 (as one example)	W Grades 9-10 8.0	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.
	WHST Grades 11-12 #8.0	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
	W Grades 9-12 9.0	Draw evidence from literary or informational texts to support analysis, reflection, and research.
	WHST Grades 11-12 #9.0	Draw evidence from informational texts to support analysis, reflection, and research.
	RST grades 9-12 #8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
	SL Grades 9-12 4.0	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>Performance Example:</p> <ul style="list-style-type: none"> Students research in teams, common weeds and their causes, common turfgrass insects in NE and their control methods, turfgrass pathogens, their causes, and control methods. In groups they discuss different aspects of each which influence turf maintenance and how it impacts different environments (golf course, sports field, nature trail). Using multiple sources, students create a report for a specific customer (environment) with recommendations for turf management. Students include simulated models (either computer generated or physical model) to support their position. Written and visual/physical materials are presented to the class. Students prepare written and practical materials and compete in the FFA Turfgrass Career Development Event. 		
2.N.01-02	W Grades 9-12 10.0	Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.
	WHST Grades 11-12 #10.0	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.
	SL Grades 9-12 5.0	Make strategic use of digital media (textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.
<p>Performance Example:</p> <ul style="list-style-type: none"> Throughout the year, students gather information and research aspects that influence landscaping design (plants, turf, flowers, soil, locale, culture/social, paving/walkways etc). Over the course, students complete short documents related to each of the categorical areas. This cumulates in a major report including landscape design plan by accurately measuring and calculating the dimensions of the site and properly using technical drawings tools and/or software, the plan should include: scale, orientation, title box, 		

recognized symbols, proper plant selection for the site, and appropriate landscape materials for the site. As part of the extended project the student creates an estimate for a landscape project in which all costs, expenses and markups are presented in a professional format.

Embedded Mathematics

CVTE Learning Standard Number	Math Content Conceptual Category and Domain Code Learning Standard Number	Text of Mathematics Learning Standard
2.I.02.10	A-CED.4	Rearrange formulas to highlight a quantity of interest, using the same reason as in solving equations.
	G-MG.1	Use geometric shapes, their measures, and their properties to describe objects (modeling a tree trunk or human torso as a cylinder).
<p>Performance Example:</p> <ul style="list-style-type: none"> Instruct the class on how to determine the weight of a log using the Green Log Weight chart for various species of trees. Upon mastery of the chart usage, the class could be asked to determine the weight of a log where the diameter is not known. The class can be led in discussion about what measurements are available that would aid in determining the diameter (relations between circumference and diameter). The students would have to measure the circumference and manipulate the formula to solve for the diameter. Circumference = Pi * diameter. <p>Example: An arborist has a trunk section of an American Elm that is approximately 5 foot long with a circumference of 62 inches. Using the circumference formula the arborist would need to determine the approximate (to the nearest inch) diameter and use the Green Log Weight chart to determine the weight for safe removal.</p> <p>Circumference Formula $C = \pi \times \text{diameter}$ Rewrite the formula to solve for the diameter. $d = C / \pi$ $d = 62 / 3.14$ $d = 19.7$ (20 inches) Using the Green Log Weight chart a 20" log of American Elm weighs approximately 118 lbs/linear foot. $5 \text{ feet} \times (118 \text{ lbs/ft}) = 590 \text{ lbs.}$ The 5' log would weigh 590 lbs.</p>		
2.K.02.06	9-12.N-Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale the origin in graphs and data
<p>Performance Example:</p> <ul style="list-style-type: none"> Instruct class how to use a given fertilizer label to determine the rate of application. This can be used for either injector or standard fertilizer applications. Discuss how the use of ratios and conversions can obtain the same quantities found on the chart. Instruct the class to calculate the mixing rate of a fertilizer that does not provide a table to use. Emphasis should be made that multiple conversions need to be completed because fertilizers are weighed in ounces, mixed in gallons and applied in parts per million (ppm). <p>Example:</p> <p>Crop: Tomatoes in 1 gallon pots, in Metro-Mix Use Peters Excel All Purpose 21-5-20 fertilizer at 150 ppm nitrogen with every watering from a 20 gallon concentrate stock tank with a 1:200 injector (no label available). Calculate how many ounces of 21-5-20 fertilizer you will need per 1 gallon of irrigation water. Formula: ounces of fertilizer per gal irrigation water = $150 \text{ ppm} / (75 \times 100 \times 0.21)$ $= 150 / (1575)$ $= 0.0952$ ounces of fertilizer per gallon irrigation water</p>		

<p>Have the class take into account an injector ratio and stock tank size, and calculate how many ounces of 21-5-20 will be required for 20 gallon stock tank. First account for the 1:200 injector, then for the 20 gallon tank $0.095 \text{ ounces per gallon} \times 200 \text{ (injector proportion)} = 19 \text{ ounces per gallon stock concentrate}$ $19 \text{ ounces per gallon of stock} \times 20 \text{ gallon tank} = 380 \text{ ounces per 20 gallon stock tank}$</p>																				
2.K.02.08	9-12.G.GMD.3	Use volume formulas for cylinders, pyramids, cones, spheres to solve problems.																		
<p>Performance Example:</p> <ul style="list-style-type: none"> Determine which pot size requires the least soilless media to fill (approximate the uniform shape of the pot). <ol style="list-style-type: none"> 4.5" standard pot (4.5" diameter x 4" height cylinder). 6" bulb pan (6" diameter x 3.75" height cylinder). 4" square pot (4" width x 4" length x 3.5" height). To solve determine the volume for each pot, then compare values. <ol style="list-style-type: none"> volume for a cylinder $v = \pi \times \text{radius squared} \times \text{height}$ radius = diameter divide by 2 Use 3.14 for pi $v = 3.14 \times 2.25 \text{ in} \times 2.25 \text{ in} \times 4 \text{ in} = 63.585 \text{ in cubed}$ volume for a cylinder $v = \pi \times \text{radius squared} \times \text{height}$ Use 3.14 for pi $v = 3.14 \times 3 \text{ in} \times 3 \text{ in} \times 3.75 \text{ in} = 105.975 \text{ in cubed}$ volume for a cube or rectangle is side x side x side $4 \text{ in} \times 4 \text{ in} \times 3.5 \text{ in} = 56 \text{ in cubed}$ The 4" square pot would require the least amount of media fill. 																				
2.K.01.08	G.MG.2	Apply geometric concepts in modeling situations. Apply concepts of density based on area and volume in modeling situations (persons per square mile, BTUs per cubic foot). ★																		
	G.MG.MA.4	Use dimensional analysis for unit conversions to confirm that expressions and equations make sense. ★																		
	N-Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. ★																		
<p>Performance Example:</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th colspan="2" style="text-align: center;">Fertilizer 12-4-8 Guaranteed Analysis</th> </tr> </thead> <tbody> <tr> <td style="text-align: left;">Total Nitrogen</td> <td style="text-align: right;">12%</td> </tr> <tr> <td style="text-align: center;">6.50% Ammoniacal Nitrogen</td> <td></td> </tr> <tr> <td style="text-align: center;">1.00% Nitrate Nitrogen</td> <td></td> </tr> <tr> <td style="text-align: center;">0.90% Other Water Soluble Nitrogen</td> <td></td> </tr> <tr> <td style="text-align: center;">3.60% Water Insoluble Nitrogen</td> <td></td> </tr> <tr> <td style="text-align: left;">Available Phosphate Acid (P205)</td> <td style="text-align: right;">4%</td> </tr> <tr> <td style="text-align: left;">Soluble Potash (K₂O)</td> <td style="text-align: right;">8%</td> </tr> <tr> <td style="text-align: left;">Total Available Plant Food, Not Less than</td> <td style="text-align: right;">24%</td> </tr> </tbody> </table> <p>Proper fertilization of greenhouse crops is very important to their survival. The recommended broadcast application for a floriculture crop is: 1st application: Apply 5 pounds of 12-4-8 per 1000 square feet of bench space Additional application: Apply 3 pounds of 12-4-8 per 1000 square feet Question: For a 200' x 25' bench space of the floriculture crop how many total pounds of fertilizer would you need for 5 applications? Solution: Use the formula for the area of a rectangle to determine the square footage of the bench space. $A =$</p>			Fertilizer 12-4-8 Guaranteed Analysis		Total Nitrogen	12%	6.50% Ammoniacal Nitrogen		1.00% Nitrate Nitrogen		0.90% Other Water Soluble Nitrogen		3.60% Water Insoluble Nitrogen		Available Phosphate Acid (P205)	4%	Soluble Potash (K ₂ O)	8%	Total Available Plant Food, Not Less than	24%
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* indicates Modeling standard.

(+) indicates standard beyond College and Career Ready.

length x width (be sure unit dimensions are the same) (7.G.6)

1. $25 \times 200 = 5,000$ sq ft of Floriculture Crop Bench Area

2. Use proportional relationship (7.RP.2.c)

1st application: Apply 5 lbs of fertilizer per 1,000 sq ft

5 pounds = x pounds x = 25

1000 sq ft 5000 sq ft

= 25 lbs/5,000 sq ft

Addition applications:

Apply 3 lbs of fertilizer per 1,000 sq ft = 15 lbs/5,000 sq ft

3 pounds = x pounds x = 15

1000 sq ft 5000 sq ft

= 15 lbs/5,000 sq ft

15 lbs x 4 applications = 60 lbs/5,000 sq ft

3. 25 lbs + 60 lbs = 85 total pounds of fertilizer needed

2.K.01.05	G.MG.1	Apply geometric concepts in modeling situations. Use geometric shapes, their measures, and their properties to describe objects (modeling a tree trunk or a human torso as a cylinder). ★
	G.SRT.8	Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems. ★
	G-GMD.4	Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.

Performance Example:

HEATING YOUR GREENHOUSE

Calculating energy requirements

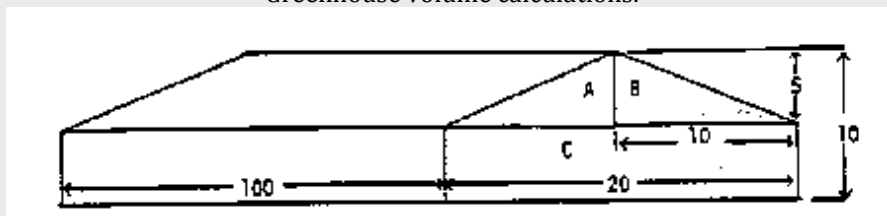
How do I calculate energy requirements for my greenhouse?

This method will give a fairly good estimate.

Calculating your energy requirements for greenhouse heating:

1. Figure out the exposed surface area of the greenhouse covering (i.e. poly, fiberglass, glass, etc.). (G.MG.1)

Greenhouse volume calculations.



Even Span Structure

Break the greenhouse into the various areas then add together to calculate total surface area. You may sketch a net for the figure. (6.G.4)

Short walls

Area A + B is a triangle so Area = $1/2 \times b \times h = .5 (20 \times 5) = 50$ sq ft

Area C = $b \times h = 20 \times 5 = 100$ sq ft

Total Area = $A + B + C = 100 + 50 = 150$ sq ft

There are two short walls so $2 \times 150 = 300$ sq ft

Long walls

Area of long wall $100 \times 5 = 500$ sq ft

There are two long walls so $2 \times 500 = 1000$ sq ft

Roof

Area one side $b \times h$ $b = 100$ feet to find height must use Pythagorean Theorem (8.G.7)

$a^2 + b^2 = c^2$ $10^2 + 5^2 = 125$

$c^2 = 125$

* Indicates Modeling standard.

(+) indicates standard beyond College and Career Ready.

Square root of $c^2 = c$

$c =$ square root of 125 is about 11.2 feet

Area one side of roof = $b \times h = 100 \times 11.2 = 1120$ sq ft

Area of both sides of the roof $2 \times 1120 = 2240$ sq ft

(For this example since the floor is not exposed directly to the outside, it is not being included in the exposed surface area.)

Total exposed surface area $300 + 1000 + 2240 = 3540$ sq ft (7.G.6)

2. Calculate the "temperature difference" – the difference between the desired minimum greenhouse temperature and the average lowest winter temperature in your area.

The ideal minimum greenhouse temperature for tomatoes in winter is 60 degrees Fahrenheit.

If the average coldest temperature in winter is 33.5 degrees Fahrenheit, then the difference between the two temperatures is 26.5 degrees F. (T. D.)

3. BTU'S (British Thermal Units) required for heating the greenhouse :

Use table 1 below to determine heat transfer coefficient based on the material used building the greenhouse.

Multiply the "total inside surface area" by the "temperature difference" by the "heat transfer coefficient."

(S. A.) \times (T. D.) \times (H.T.C.) = BTU'S (British Thermal Units) required

For our example to grow tomatoes in this greenhouse made of single layer glass:

$3540 \times 26.5 \times 1.13 = 106005.3$ BTU

Table 1 Heat Transfer Coefficient (H.T.C.) for Greenhouse Construction Materials

From (<http://aggie-horticulture.tamu.edu/GREENHOUSE/NURSERY/guides/ghhdbk/heattab.html>)

Material	BTU/sq ft - o F - hr
1. Glass, single layer	1.13
2. Glass, double layer, 1/4" space	0.65
3. PE film, single layer	1.15
4. PE film, double layer, separated	0.70
5. Fiberglass	1.00
6. Concrete block, 8"	0.51
7. Concrete block, 8" plus 1" foam urethane	0.13
8. Concrete block, 8" plus 1" foam polystyrene	0.18
9. Concrete poured, 6"	0.75
10. Cement asbestos board, 1/4"	1.10
11. Cement asbestos board, 1/4" plus 1" foam urethane	0.14
12. Cement asbestos board, 1/4" plus 1" foam poly styrene	0.21

(The smaller the heat transfer coefficient the lower the heat loss)

2.0.01.02	A-CED.1	Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.
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<p>Performance Example:</p> <ul style="list-style-type: none"> Instruct the class on the design and construction of stairs. Have them determine the measurements for potential scenarios that could be found in landscape construction. <p>Example: How many steps are required to connect two levels if the two levels are 96 inches apart and a 6-inch riser is desired?</p> <p>Set up as a linear equation: The number of steps equals the required distance divided by the height of the risers. Let n = # steps, d = distance to be connected and h = riser height. (be sure units are the same) $n = d/h$ $n = 96/6$ $n = 16$ 16 steps would be required.</p>		
2.0.01.02	G-MG.1-.3	<p>Use geometric shapes, their measures, and their properties to describe objects (modeling a tree trunk or a human torso as a cylinder). ★</p> <p>Apply concepts of density based on area and volume in modeling situations (persons per square mile, BTUs per cubic foot). ★</p> <p>Apply geometric methods to solve design problems (designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios). ★</p>
<p>Performance Example:</p> <ul style="list-style-type: none"> Discuss how to determine the amount of mulch required completing a landscape job and then determining the quantity through volume formulas. <p>Example: How many cubic yards of mulch are needed to cover an area 70 feet long and 10 feet wide with 3 inches of mulch?</p> <p>To solve you need to use the volume formula for a rectangular prism and convert all dimensions to yards. 1 yard = 3 feet 1 yard = 36 inches 70 feet x 1 yard/ 3 feet = 23 1/3 yards 10 feet x 1 yard/3 feet = 3 1/3 yards 3 inches x 1 yard/ 36 inches = 1/12 yards Volume = length x width x height $V = 23 \frac{1}{3} \times 3 \frac{1}{3} \times \frac{1}{12} = 175/27$ cubic yards or about 6.48 cubic yards</p>		
2.N.02	A-CED.1	Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.
<p>Performance Example:</p> <ul style="list-style-type: none"> Discuss the costs associated with determining the cost of job. Explain how the student would determine the cost using a mathematical formula. <p>Example: A landscaper's material, labor, and overhead costs are \$4,560. If the landscaper's profit is 40% of the cost of the project, what would be the total charge to complete the project? Total charge equals costs plus 40% of costs $T = \text{Total charge}$ $c = \text{landscaper's cost}$ $T = c + .4c$ $T = 4560 + .4(4560) = \\$6383$</p>		
2.K.02.08	N-Q.MA.3.a.	Describe the effects of approximate error in measurement and rounding on measurements and on computed values from measurements. Identify significant figures in recorded measures and computed values based on the context given and the precision of the tools used to measure. ★
<p>Performance Example:</p> <ul style="list-style-type: none"> Discuss with students the many types of greenhouse products and various size differences. In particular 		

<p>review the various sizes and shapes of the greenhouse pots and the multiple ways that soil can be delivered (truckload, bails, or bags). Discuss how a grower would determine how many units of soil would be needed to fill a determined number of pots.</p> <p>Example: You are responsible for ordering potting media which is sold in 3.5 cubic feet bags. It takes one cubic foot of potting media for 5 one gallon pots. How many bags of potting media would you need to pot 5,000 one gallon pots?</p> <p>To calculate number of bags you first have to determine the number of cubic feet needed for 5000 pots. $1 \text{ cubic foot} / 5 \text{ pots} = x \text{ cubic feet} / 5000 \text{ pots}$ $x = 1000 \text{ cubic feet}$. Then to determine the number of 3.5 cubic feet bags take the total cubic feet and divide by 3.5 cubic feet. $1000 \text{ cubic feet} / 3.5 \text{ cubic feet} = 285.71$ round up to 286 bags.</p>		
2.N.02.04	N-Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. *
<p>Performance Example:</p> <ul style="list-style-type: none"> Discuss with the class how to determine the quantity of goods required for a given landscape job using mathematical procedures. <p>Example: How many feet of plastic edging will be needed to edge five azalea beds that measure 25 1/2 feet x 50 1/4 feet each?</p> <p>Calculate the perimeter for one bed then multiply by 5. $P = \text{perimeter}$ $L = \text{length}$ $W = \text{width}$ $P = 2L + 2W$ Total equals $5 \times P$ or $T = 5(2L + 2W)$ $T = 5 (2 * 25.5 + 2 * 50.25)$ $= 5(51 + 100.5) = 757.5 \text{ feet}$</p>		
2.K.01.08	7.G.6	Solve real-world and mathematical problems involving area, volume, and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.
<p>Performance Example:</p> <ul style="list-style-type: none"> Review the space required for particular pots sizes/plants to grow. Explain how the space required for a crop is determined using mathematical procedures when provided particular values. <p>Example: A greenhouse has 20 benches that are 4 feet wide and 12 feet long. If the final spacing for 6-inch poinsettias are 18 x 18 inches, what is the maximum number of pots that could be placed in the greenhouse?</p> <p>The total bench area is number of benches x width x length $20 \times 4 \times 12 = 960 \text{ feet squared}$ Need to convert inches to feet so units are the same. $18 \text{ inches} \times (1 \text{ foot} / 12 \text{ inches}) = 1.5 \text{ feet}$ $1.5 \times 1.5 = 2.25 \text{ feet squared per pot}$ $960 \text{ feet squared} = 426 \text{ pots}$ $2.25 \text{ feet squared per pot}$</p>		
2.N.01.02	G.MG.3	Apply geometric methods to solve design problems (designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios). *
<p>Performance Example:</p> <ul style="list-style-type: none"> Discuss with the class how to determine the quantity goods needed for a given landscape job using mathematical procedures. <p>Example:</p>		

* indicates Modeling standard.

(+) indicates standard beyond College and Career Ready.

If a bale of pine straw will mulch an area of 50 square feet, how many bales are required to mulch a project with one area measuring 50' x 75' and a second area measuring 40' x 27.5'?

Calculate the total square area by adding the square of each area
 Area one + area two
 $50' \times 75' + 40' \times 27.5' = 4850 \text{ sq ft}$
 Total area divided by the area one bale will mulch is the number of bales needed for the project
 $4850 \text{ sq. ft.} = 97 \text{ bales needed for the project}$
 50 sq. ft.

Embedded Science and Technology/Engineering

Life Science (Biology)

CVTE Learning Standard Number	Subject Area, Topic Heading and Learning Standard Number	Text of Biology Learning Standard
2.B.01.01	5.2	Describe species as reproductively distinct groups of organisms. Recognize that species are further classified into a hierarchical taxonomic system (kingdom, phylum, class, order, family, genus, species) based on morphological, behavioral, and molecular similarities. Describe the role that geographic isolation can play in speciation.
<p>Performance Example:</p> <ul style="list-style-type: none"> • Provide the class with a field guide and show them a variety of plant specimens (leaf, flower, and stem) to identify. Instruct the students to classify common landscape plants and determine which traits are similar. Relate these traits to their ideal growing conditions and susceptibility to disease. • Upon mastery of this skill, take the class outdoors with their field guides to determine the classification of local plant specimens. Lead the class in a discussion about how scientists determine an organism's taxonomic classification. 		
2.B.01.02	5.2	Describe species as reproductively distinct groups of organisms. Recognize that species are further classified into a hierarchical taxonomic system (kingdom, phylum, class, order, family, genus, species) based on morphological, behavioral, and molecular similarities. Describe the role that geographic isolation can play in speciation.
<p>Performance Example:</p> <ul style="list-style-type: none"> • Review with the class how to use field guides to determine the genus and species of plant and determine common traits of that genus and species. • Provide the class with a set of unknown specimens. Ask them to develop a dichotomous key to identify each of the specimens by using visible characteristics described as sets of paired sentences. Each specimen should be able to be identified to a unique name. • Upon completion of their dichotomous keys, have students swap their key and samples with another student. They should attempt to identify the samples using the key just created. 		
2.B.02.01	2.2	Compare and contrast, at the cellular level, the general structures and degrees of complexity of prokaryotes and eukaryotes.
<p>Performance Example:</p> <ul style="list-style-type: none"> • Review the basic differences between prokaryotic and eukaryotic cells. Show pictures of each while pointing out the distinguishing characteristics. • Have students look at prepared slides of prokaryotes and eukaryotic plant cells. Have them draw and label identifying characteristics. • Assess mastery of cell type identification by creating a lab practical exam where students demonstrate 		

<p>knowledge by correctly labeling unknown prepared samples under a microscope as prokaryotes or eukaryotes.</p> <ul style="list-style-type: none"> • Online resources can be a substitute for prepared slides. 		
2.B.02.02	2.1	Relate cell parts/organelles (plasma membrane, nuclear envelope, nucleus, nucleolus, cytoplasm, mitochondrion, endoplasmic reticulum, Golgi apparatus, lysosome, ribosome, vacuole, cell wall, chloroplast, cytoskeleton, centriole, cilium, flagellum, pseudopod) to their functions. Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, facilitated diffusion, active transport).
<p>Performance Example:</p> <ul style="list-style-type: none"> • Review the key differences between prokaryotic and eukaryotic cells. Instruct students on the key differences between plant and animal cells, highlighting the presence of a chloroplast in a plant cell. • Research on the internet images of leaf cells and root cells. Compare the internal structures of each and identify their key characteristics and function. Construct a Venn diagram comparing and contrasting the two cell types. • Continue the comparison by examining healthy and chlorotic leaves and discussing their differences. Students will be able to identify the components that make up a functioning leaf cell. • Round out the learning experience by preparing wet mount slides from an actual leaf and root and compare them under a compound microscope. Staining the cells with methyl blue may help visualize some of the organelles. Lead the class in a discussion about the organelles found in cells and how they each contribute the cell's overall function to maintain homeostasis. 		
2.B.02.03	3.2	Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic code. Explain the basic processes of transcription and translation, and how they result in the expression of genes. Distinguish among the end products of replication, transcription and translation.
<p>Performance Example:</p> <ul style="list-style-type: none"> • Define the role of DNA in an organism and ensure students understand that DNA controls protein production. Proteins determine an organism's physical and chemical characteristics. • Discuss differences in plant characteristics such as leaf size, cuticle thickness, bark thickness, and rooting habit. Help students to conclude that these characteristics are determined by their DNA and adaptations for survival are influenced by their habitats. • Demonstrate these principles in the field by finding plants in their natural habitats or preferred growing environment (greenhouse and landscape material) and comparing their different structures. • Assess learning by presenting students with a plant and having them predict the optimal growing conditions for the specimen. 		
2.B.02.04	2.6/2.7	(2.6) Describe the cell cycle and the process of mitosis. Explain the role of mitosis in the formation of new cells, and its importance in maintaining chromosome number during asexual reproduction. (2.7) Describe how the process of meiosis results in the formation of haploid cells. Explain the importance of this process in sexual reproduction, and how gametes form diploid zygotes in the process of fertilization.
<p>Performance Example:</p> <ul style="list-style-type: none"> • Define the two different cell division processes: meiosis and mitosis. Explain that meiosis makes sex cells, pollen and egg, and mitosis makes all other plant cells. • Collect flower specimens and use dissecting tools and a dissecting scope to isolate the pollen and egg. Compare and contrast the different cells according to size and quantity. • Collect plant samples and identify the meristems and the three areas where cell division occurs in the plant. Take leaf, stem, and root cuttings which can be propagated to develop new plants through mitosis. • Observe injured trees and woody plant material and see the areas of callus formation. Discuss the cambium layer as a meristem and how the plant compartmentalizes the injury through mitosis. 		

<ul style="list-style-type: none"> View a prepared slide or make a wet mount of a plant root tip. Observe the cells dividing by mitosis and identify the different phases of division. Have students draw and label a cell in each phase. Assess mastery by designing a lab practical where microscopes are set up and students must identify the type of cell they are observing, determine the type of division that created it, and which phase the cell is currently undergoing. 		
2.B.04.01	2.4	Identify the reactants, products, and basic purposes of photosynthesis and cellular respiration. Explain the interrelated nature of photosynthesis and cellular respiration in the cells of photosynthetic organisms.
<p>Performance Example:</p> <ul style="list-style-type: none"> Discuss the photosynthesis equation and relate each of the chemical formulas to their more familiar common names. Have students identify the reactants and products of the reaction. Examine images of plants that are in poor health and hypothesize about the cause of their condition. Discuss how some plants require much more sunlight and/or water than others. Compare and contrast the plants that grow in dry, sunny slopes to plants that grow in low, shady wetlands focusing on leaf types and rooting habits. 		
2.B.04.03	2.4	Identify the reactants, products, and basic purposes of photosynthesis and cellular respiration. Explain the interrelated nature of photosynthesis and cellular respiration in the cells of photosynthetic organisms.
<p>Performance Example:</p> <ul style="list-style-type: none"> Students design an experiment to determine the effect of different light strengths on a common plant. Student groups should hypothesize how the plants will grow under the different light conditions and present their findings to the class. Upon mastery of this classroom task, students will apply their knowledge by observing similar plants growing in sunny versus shady conditions outdoors, noting differences in leaf size, leaf quantity, and overall plant health and growth. Students will relate these differences to the amount of photosynthesis occurring in each plant. 		
2.B.04.04	2.4	Identify the reactants, products, and basic purposes of photosynthesis and cellular respiration. Explain the interrelated nature of photosynthesis and cellular respiration in the cells of photosynthetic organisms.
<p>Performance Example:</p> <ul style="list-style-type: none"> Discuss the photosynthesis equation and relate each of the chemical formulas to their more familiar common names. Have students identify the reactants and products of the reaction. Illustrate the effect of the different photosynthesis reactants (light, water, and carbon dioxide) by setting up controlled experiments in the classroom or greenhouse to be followed for several weeks. Independent variables to be tested should include amount of water and access to sunlight. Students will record the growth (stem height and number of leaves) and health (color of leaves) of the plants under each condition. Conclusions can be drawn about the optimal growing conditions. Oxygen, a product of photosynthesis, can be measured when growing aquatic plants and measuring the number of oxygen bubbles emitted. 		
2.B.04.05	2.4	Identify the reactants, products, and basic purposes of photosynthesis and cellular respiration. Explain the interrelated nature of photosynthesis and cellular respiration in the cells of photosynthetic organisms.
<p>Performance Example:</p> <ul style="list-style-type: none"> Introduce the cellular respiration equation and help students to discover that cellular respiration and photosynthesis are opposite processes. Lead the class in a discussion about energy and how it changes forms during these two reactions. Remind students that plant cells have both chloroplasts and mitochondria by using magnified images of plant cells highlighting these organelles. Analyze the oxygen consumed by growing plants (germinating seeds) and non-growing plants (non- 		

germinating seeds). Data can be collected by using respirometers or students can analyze given data such as the table below.

Cumulative Oxygen Consumed (mL)

Time (minutes)	0	10	20	30	40
Dry Seeds (non-germinating) 22°C	0.0	0.2	0.1	0.0	0.1
Germinating seeds 22°C	0.0	8.8	16.0	23.7	32.0

Help students to conclude that germinating seeds are consuming more oxygen than non-germinating seeds. Therefore, growth requires oxygen which is a required reactant of the cellular respiration reaction.

Follow up by growing a plant in a bell jar and have students brainstorm reasons why the plant is able to survive without adding water, carbon dioxide, or oxygen. Students should conclude that the materials are being recycled and used repeatedly for both photosynthesis and cellular respiration reactions.

2.B.05.02	2.7	Describe how the process of meiosis results in the formation of haploid cells. Explain the importance of this process in sexual reproduction, and how gametes form diploid zygotes in the process of fertilization.
<p>Performance Example:</p> <ul style="list-style-type: none"> • Lead students in a discussion about the anatomy of a flower. Distribute pictures of different flowers and have students locate the anthers and ovaries of each. • Distribute flowers from greenhouse plants for students to examine. Have students determine the sexually reproductive parts of the flower. Students will dissect the flower to uncover the anther, stamen, and ovaries. Hypothesize about the function of each part. • Students should discover that the pollen develops a pollen tube within a pistil. The pollen travels through the pollen tube to fertilize the egg in the ovary producing a seed. • Observe the results of a fertilized egg by cross sectioning an apple and examining the swollen ovary and seed. 		
2.C.04.03	6.2	Analyze changes in population size and biodiversity (speciation and extinction) that result from the following: natural causes, changes in climate, human activity, and the introduction of, non-native species.
<p>Performance Example:</p> <ul style="list-style-type: none"> • Have students research invasive plant species found in Massachusetts using the United States Department of Agriculture National Agriculture Library. The National Invasive Species Information Center is available online. Students should present information on an invasive species to the class including samples, mode of introduction, and remediation efforts. • To summarize the lesson and ensure mastery of content, the instructor can construct a lab practical examination where students must identify different local invasive species by looking at samples or images. Answers should include a brief written explanation of the invasive species threatening characteristics. 		
2.D.02.11	2.1	Relate cell parts/organelles (plasma membrane, nuclear envelope, nucleus, nucleolus, cytoplasm, mitochondrion, endoplasmic reticulum, Golgi apparatus, lysosome, ribosome, vacuole, cell wall, chloroplast, cytoskeleton, centriole, cilium, flagellum, pseudopod) to their functions. Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, facilitated diffusion, active transport).

<p>Performance Example:</p> <ul style="list-style-type: none"> Remind students that osmosis is the diffusion of water that requires no energy. Review water's properties of cohesion and adhesion. Give examples of how water is attracted to a paper towel, which is why paper towels are so absorbent. Demonstrate adhesion by having students count how many water drops can fit on top of a penny. Students should notice that the water domes on top of the penny and appears to stick to the water that is already there. Review the anatomy of roots and stems and highlight the purpose of xylem for transporting water throughout the plant. Help students to connect the previous discussion about cohesion and adhesion to the anatomy of a plant. Explore how water travels through a plant by watching colored water travel up cut flowers and change the colors of the petals. Have students write about their observations using technical vocabulary. 		
2.D.03.01	6.3	Use a food web to identify and distinguish producers, consumers, and decomposers, and explain the transfer of energy through trophic levels. Describe how relationships among organisms (predation, parasitism, competition, commensalism, mutualism) add to the complexity of biological communities.
<p>Performance Example:</p> <ul style="list-style-type: none"> Show the students images of different decomposers found in soil. Have students dig test plots around the school campus and catalogue the amount of decomposition observed. Students should compare the O horizons in the soil from the different test plots. Extend student understanding of decomposers by examining populations of earthworms. Have small groups of students hypothesize how different independent variables, such as temperature and soil pH, can affect earthworm behavior. Set up the experiments using purchased worms and bins of soil. Conclude instruction by discussing how human impact can influence entire ecosystems due to the cause and effect relationships between organisms in a food web. 		
2.D.03.03	6.4	Explain how water, carbon, and nitrogen cycle between abiotic resources and organic matter in an ecosystem, and how oxygen cycles through photosynthesis and respiration.
<p>Performance Example</p> <ul style="list-style-type: none"> Introduce relevant terminology such as immobilization and mineralization of nitrogen in relation to the nitrogen cycle. Create an experiment with two test plants. One sample will be grown with nitrogen in an immobilized form and the other sample will be grown using ammonium nitrate, which is readily available to the plant. Students will observe over a period of time which plants respond better to the fertilization treatment. Extend student understanding of fertilization applications by applying a similar technique to landscape plants or lawn areas for a longer period of study. Students apply water soluble nitrogen and organic fertilizers to their test sites. Over time, students will make quantitative and qualitative recordings showing the health of the plants or lawn. Discuss how these different nitrogen sources are being used by the plants. Students should compare the length of time between the different fertilization methodologies. By examining the composition and chemistry of the fertilizer, conclusions can be drawn about the manufacturing and marketing techniques used by commercial companies. 		
2.D.03.04	6.4	Explain how water, carbon, and nitrogen cycle between abiotic resources and organic matter in an ecosystem, and how oxygen cycles through photosynthesis and respiration.

Performance Example:

- Review the nitrogen cycle highlighting the importance of bacteria fixation converting nitrogen to a usable form.
- Examine images of root nodules or excavate local woodland plants with attached root nodules. Have students compare and contrast different nodules. Study cross sections of nodules and record observations. Lead students in a discussion about how some root nodules have more effective bacterial colonies and lead to differences in appearance.
- Observe native hardwoods growing in an urban area where natural leaf litter or soil profiles are not available to the plant. Notice the growth habits and health of the trees. Students will conclude that the absence of organic material reduces the quantity of mycorrhizae in the soil and therefore makes nutrients less available to the plant.
- Present student with the following scenario and have them explain the situation using technical terminology
- A homeowner decides to establish a lawn abutting a flourishing beech tree. Within 10 years, the beech tree is showing signs of decline. It has several dying branches, blistering bark, and reduced foliage. Explain why the beech tree has changed from a healthy specimen to an unhealthy specimen after the lawn was established.

Physical Science (Chemistry)

CVTE Learning Standard Number	Subject Area, Topic Heading and Learning Standard Number	Text of Chemistry Learning Standard
2.A.02.04	I. Properties of Matter 1.2	Explain the difference between pure substances (elements and compounds) and mixtures. Differentiate between heterogeneous and homogeneous mixtures.
Performance Example: <ul style="list-style-type: none">• Provide samples of non-toxic materials that mix well with water (salt, sugar, tea, Kool-Aid) and samples of materials that do not mix well with water (cooking oil, flour, and corn starch would work well). The samples represent pesticides in various physical forms (liquid, powder, granular). Have the students attempt to mix a small amount of each material with water.• The students will observe homogeneous and heterogeneous mixtures. Ask the students how mixing and handling techniques may differ depending on a pesticide concentrate's ability to mix with water.		
2.A.02.04	II. Scientific Inquiry Skills Standards SIS2. Design and conduct scientific investigations.	Properly use instruments, equipment, and materials (scales, probe ware, meter sticks, microscopes, computers) including set-up, calibration (if required), technique, maintenance, and storage. Follow safety guidelines.
Performance Example: <ul style="list-style-type: none">• Provide samples of non-toxic materials to represent pesticide concentrates, measuring equipment (graduated cylinders, measuring spoons, balances), safety equipment (gloves, eye protection), and pesticide labels with mixing instructions. Instruct the students on proper use of measuring and safety equipment. Have the students wear safety gear and mix the "pesticides" according to the labels. Students should observe and record any spills, including those that contaminate the person.• Conclude with a discussion of how to measure pesticide concentrates for mixing and of the importance of safety equipment. Ask the students to describe where they were "contaminated" during the measuring and mixing process and what might have happened if they had not been wearing appropriate chemical personal protection equipment.		
2.B.03.02	I. Content Standards 4. Chemical Bonding 4.5	Identify how hydrogen bonding in water affects a variety of physical, chemical, and biological phenomena (surface tension, capillary action, density, boiling point).

<p>Performance Example:</p> <ul style="list-style-type: none"> Explain how hydrogen bonding creates water's surface tension and capillary action. Explain how roots take in water via capillary action, a phenomenon caused by the hydrogen bonding in water. Students may observe capillary action in the rising of a column of water in a very thin tube or straw, or by the soaking up of water by a paper towel, sponge, potting mix or soil. 		
2.B.03.04	I. Content Standards 4. Chemical Bonding 4.5	Identify how hydrogen bonding in water affects a variety of physical, chemical, and biological phenomena (surface tension, capillary action, density, boiling point).
<p>Performance Example:</p> <ul style="list-style-type: none"> Explain how hydrogen bonding creates water's surface tension and capillary action. Explain how water's surface tension and capillary action keep the water column intact as the transpiration process moves the water up the plant stem. Students may observe capillary action in the rising of a column of water in a very thin tube or straw, or by the soaking up of water by a paper towel, sponge, potting mix or soil. Demonstrate the adhesive and cohesive properties of water by placing a stalk of celery in a glass of water with some red food coloring. Capillary action aids in the water being drawn up through the xylem. Students will observe the colored water being moved upwards against gravity. 		
2.B.04.01	I. Content Standards 7. Solutions, Rates of Reaction, and Equilibrium 7.5	Identify the factors that affect the rate of a chemical reaction (temperature, mixing, concentration, particle size, surface area, catalyst).
<p>Performance Example:</p> <ul style="list-style-type: none"> Teach the students that plant growth is a result of many interrelated chemical reactions, and that the factors that affect the rates of chemical reactions are the same as those that impact plant growth. Students may consider anything the plant takes in (water, carbon dioxide, nutrients, light) to be "reactants". Students may consider the ultimate "product" of these chemical reactions to be healthy plant tissue (more product = bigger plants or better growth). Conduct an investigation with the students on the affects of several factors on plant growth in a greenhouse *. Students control for factors like the amount of light, amount of water, concentration of carbon dioxide, nutrient concentration, and temperature. Students' measure and record plant growth using indicators like plant height, mass, color, leaf surface area, and maturity. Students generate data and draw conclusions about the relationships between plant inputs ("reactants"), and plant growth (the "product"). Students present their findings in a report or presentation. *Note: Trials of corn seedlings or similar would work well as they germinate and grow quickly, respond noticeably to changes in growing conditions, are genetically similar, their growth is easily measured, and they can be grown in statistically significant quantities. 		
2.B.04.03	I. Content Standards 8. Acids and Bases and Oxidation-Reduction Reactions 8.4	Describe oxidation and reduction reactions and give some everyday examples, such as fuel burning and corrosion. Assign oxidation numbers in a reaction.
<p>Performance Example:</p> <ul style="list-style-type: none"> Any number of the reactions in the photosynthesis process may be described in terms of oxidation-reduction, or electron transfer. 		
2.B.04.04	I. Content Standards 7. Solutions, Rates of Reaction, and Equilibrium 7.5	Identify the factors that affect the rate of a chemical reaction (temperature, mixing, concentration, particle size, surface area, catalyst).
<p>Performance Example:</p> <ul style="list-style-type: none"> Study the effects of the availability of water, carbon dioxide, and light on photosynthesis by measuring plant growth in greenhouse trials. 		

2.B.04.05	I. Content Standards 8. Acids and Bases and Oxidation-Reduction Reactions 8.4	Describe oxidation and reduction reactions and give some everyday examples, such as fuel burning and corrosion. Assign oxidation numbers in a reaction.
Performance Example: <ul style="list-style-type: none"> Any number of the reactions in the cellular respiration process may be described in terms of oxidation-reduction, or electron transfer. 		
2.B.04.06	I. Content Standards 3. Periodicity 3.2	Use the periodic table to identify the three classes of elements: metals, nonmetals, and metalloids.
Performance Example: <ul style="list-style-type: none"> Use the periodic table of elements to classify plant nutrients as metals (K, Mg, Ca, Mn, Fe, Zn, Cu, Mo, Ni, Na), nonmetals (N, P, S, B, Cl, H, O, C), or metalloids (Si). 		
2.B.04.06	I. Content Standards 4. Chemical Bonding 4.6	Name and write the chemical formulas for simple ionic and molecular compounds, including those that contain the polyatomic ions: ammonium, carbonate, hydroxide, nitrate, phosphate, and sulfate.
Performance Example: <ul style="list-style-type: none"> Identify, name, and write the chemical formulas for the polyatomic ions that supply plant nutrients (ammonium, nitrate, phosphate, and sulfate). 		
2.B.04.09	I. Content Standards 4. Chemical Bonding 4.5	Identify how hydrogen bonding in water affects a variety of physical, chemical, and biological phenomena (surface tension, capillary action, density, boiling point).
Performance Example: <ul style="list-style-type: none"> Explain how hydrogen bonding creates water's surface tension and capillary action. Explain how water's surface tension and capillary action keep the water column intact as the transpiration process moves the water up the plant stem. Students may observe capillary action in the rising of a column of water in a very thin tube or straw, or by the soaking up of water by a paper towel, sponge, potting mix or soil. Demonstrate the adhesive and cohesive properties of water by placing a stalk of celery in a glass of water with some red food coloring. Capillary action aids in the water being drawn up through the xylem. Students will observe the colored water being moved upwards against gravity. 		
2.B.04.09	I. Content Standards 7. Solutions, Rates of Reaction, and Equilibrium 7.4	Compare and contrast qualitatively the properties of solutions and pure solvents (colligative properties such as boiling point and freezing point).
Performance Example: <ul style="list-style-type: none"> Define colligative properties of solutions and define osmosis. Describe the role of osmosis, a colligative property of solutions, in the pressure flow hypothesis. 		
2.D.02.09	I. Content Standards 4. Chemical Bonding 4.5	Identify how hydrogen bonding in water affects a variety of physical, chemical, and biological phenomena (surface tension, capillary action, density, boiling point).
Performance Example: <ul style="list-style-type: none"> Describe matric potential as the result of hydrogen bonding effects in water, including capillary action and surface tension. 		
2.D.02.10	I. Content Standards 4. Chemical Bonding 4.5	Identify how hydrogen bonding in water affects a variety of physical, chemical, and biological phenomena (surface tension, capillary action, density, boiling point).

<p>Performance Example:</p> <ul style="list-style-type: none"> Describe soil water potential as the result of hydrogen bonding effects in water, including capillary action and surface tension. 		
2.D.02.11	I. Content Standards 7. Solutions, Rates of Reaction, and Equilibrium 7.4	Compare and contrast qualitatively the properties of solutions and pure solvents (colligative properties such as boiling point and freezing point).
<p>Performance Example:</p> <ul style="list-style-type: none"> Define colligative properties of solutions and define osmosis. Describe the role of osmosis, a colligative property of solutions, in soils. 		
2.D.04.01	I. Content Standards 5. Chemical Reactions and Stoichiometry 5.2	Classify chemical reactions as synthesis (combination), decomposition, single displacement (replacement), double displacement, and combustion.
<p>Performance Example:</p> <ul style="list-style-type: none"> Characterize the cation exchange process in soils as replacement reactions (e.g., H⁺ replaces K⁺ on the CEC). 		
2.D.05.04	I. Content Standards 5. Chemical Reactions and Stoichiometry 5.4	Determine percent compositions, empirical formulas, and molecular formulas.
<p>Performance Example:</p> <ul style="list-style-type: none"> Determine percent composition of N-P-K in fertilizers given the chemical formulas of the nutrients and the molar masses of the elements present. Use the percent composition to determine the mass of N-P-K in a given amount of fertilizer. Example: One thousand kilograms of commercial fertilizer is 21% ammonium nitrate, NH₄NO₃, by mass. How many kilograms of nitrogen, N, are present? 		
2.E.02.02	I. Content Standards 1. Properties of Matter 1.2	Explain the difference between pure substances (elements and compounds) and mixtures. Differentiate between heterogeneous and homogeneous mixtures.
<p>Performance Example:</p> <ul style="list-style-type: none"> Provide samples of non-toxic materials that mix well with water (salt, sugar, tea, Kool-Aid) and samples of materials that do not mix well with water (cooking oil, flour, and corn starch would work well). The samples represent pesticides in various physical forms (liquid, powder, granular). Have the students attempt to mix a small amount of each material with water. The students will observe homogeneous and heterogeneous mixtures. Ask the students how mixing and handling techniques may differ depending on a pesticide concentrate's ability to mix with water. 		
2.E.02.02	II. Scientific Inquiry Skills Standards SIS2. Design and conduct scientific investigations.	Properly use instruments, equipment, and materials (scales, probeware, meter sticks, microscopes, computers) including set-up, calibration (if required), technique, maintenance, and storage. Follow safety guidelines.
<p>Performance Example:</p> <ul style="list-style-type: none"> Provide samples of non-toxic materials to represent pesticide concentrates, measuring equipment (graduated cylinders, measuring spoons, balances), safety equipment (gloves, eye protection), and pesticide labels with mixing instructions. Instruct the students on proper use of measuring and safety equipment. Have the students wear safety gear and mix the "pesticides" according to the labels. Students should observe and record any spills, including those that contaminate the person. Conclude with a discussion of how to measure pesticide concentrates for mixing and of the importance of safety equipment. Ask the students to describe where they were "contaminated" during the measuring and mixing process and what might have happened if they had not been wearing appropriate chemical personal protection equipment. 		

2.F.05.03	I. Content Standards 5. Chemical Reactions and Stoichiometry 5.2	Classify chemical reactions as synthesis (combination), decomposition, single displacement (replacement), double displacement, and combustion.
<p>Performance Example:</p> <ul style="list-style-type: none"> Identify the combustion of gasoline or diesel as the source of power for small engines. Discuss the need for oxygen combustions reaction and the role of carburetors in engines. 		
2.F.05.03	I. Content Standards 7. Solutions, Rates of Reaction, and Equilibrium 7.5	Identify the factors that affect the rate of a chemical reaction (temperature, mixing, concentration, particle size, surface area, catalyst).
<p>Performance Example:</p> <ul style="list-style-type: none"> Describe how small particle size, larger surface area, and mixing increase the rate of a reaction. Discuss how the carburetor in an engine works to mix small fuel droplets with oxygen for fast combustion reactions (explosions), as opposed to slower burning of the fuel. 		
2.K.03.03	I. Content Standards 4. Chemical Bonding 4.5	Identify how hydrogen bonding in water affects a variety of physical, chemical, and biological phenomena (surface tension, capillary action, density, boiling point).
<p>Performance Example:</p> <ul style="list-style-type: none"> Explain how hydrogen bonding creates water's surface tension and capillary action. Students may observe capillary action in the rising of a column of water in a very thin tube or straw, or by the soaking up of water by a paper towel, sponge, or capillary mat. 		

Physical Science (Physics)

CVTE Learning Standard Number	Subject Area, Topic Heading and Learning Standard Number	Text of Physics Learning Standard
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Botany-1 2.B.04.03	Introductory Physics, Electromagnetic Radiation 6.2	Describe the electromagnetic spectrum in terms of frequency and wavelengths, and identify the locations of radio waves, microwaves, infrared radiation, visible light (red, orange, yellow, green, blue, indigo, violet), ultraviolet rays, x-rays, and gamma rays on the spectrum.
<p>Performance Example:</p> <ul style="list-style-type: none"> Instruct the students that they will be performing an experiment on the light plants use to photosynthesize (before covering the details on the light and dark reactions of photosynthesis). The students will design an experiment using the scientific method; writing a question to investigate, forming a hypothesis, creating a procedure, making observations, and analyzing the data. <p>Example: Question – What color of light is most beneficial to plant growth? Hypothesis – A spider plant will experience more growth under red light than any other color of light. Procedure</p> <ol style="list-style-type: none"> The initial length of the leaves of 5 young spider plants (of similar size) will be determined. The leaves will be labeled A, B, and C to ensure the same leaves are measured every time. The label will consist of half an index card tied loosely around the base of the leaf. Chicken wire will be bent and secured into a cylinder around each spider plant. Each spider plant will have the chicken wire wrapped in plastic wrap of various colors. Plant 1 will be wrapped in clear plastic wrap, Plant 2 will be wrapped in red plastic wrap, Plant 3 		

will be wrapped in blue plastic wrap, Plant 4 will be wrapped in yellow plastic wrap, and Plant 5 will be wrapped in black construction paper. The plastic wrap must be sure to cover the top of the chicken wire as well (to ensure no direct sunlight reaches them).

- 5) The plants will be connected to a watering system to ensure an equal amount of water and nutrients reaches each plant.
- 6) Once a week students will measure the length of various spider plant leaves.
- 7) The plant (2, 3, or 4) experiencing the most growth over the course of one month will illustrate the color most beneficial to plants.

Data

Plant #	Color Filter	Time	Leaf "A"	Leaf "B"	Leaf "C"
1	Clear	Initial			
		Week 1			
		Week 2			
		Week 3			

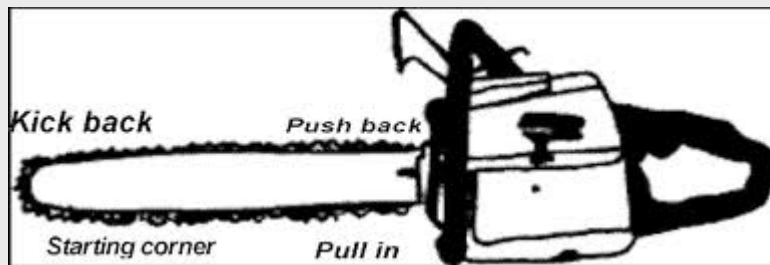
Plant #	Color Filter	Time	Leaf "A"	Leaf "B"	Leaf "C"
2	Red	Initial			
		Week 1			
		Week 2			
		Week 3			

- Students will summarize the data collected and relate it to the color and wavelengths of light absorbed by the plant.
- As the experiment progresses, students will have the opportunity to investigate the properties of light, identify the wavelength of light associated with each particular color, and discuss the light dependent reactions of photosynthesis.

Arbor - 1 2.F.01.04 2.F.01.07 2.P.07.01	Introductory Physics, Motion and Forces, 1.4	Interpret and apply Newton's three laws of motion.
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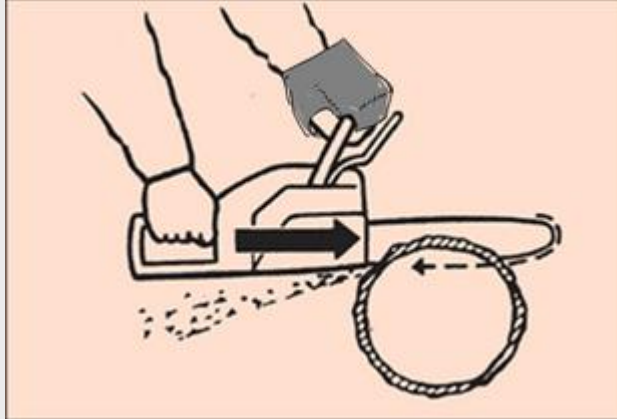
Performance Example:

- Students will learn about Newton's Third Law while learning the kickback and reactive forces of chainsaws.
- Instruct the class on the proper procedure for several different cuts including the uppercut, the undercut, and the bore cut and the purposes of each cut. These cuts produce different reactive forces on the chainsaw and the user. Understanding these forces will help students remain safe while using a chainsaw.
- Students will describe these forces in terms of Newton's Laws of Motion; the third of which states that for every action force on an object there is a reaction force equal in strength (magnitude), but opposite in direction.



- To illustrate the action and reaction forces, a chainsaw will have four quadrants drawn on the bar. Students will be asked the direction in which the chain goes around the bar. They will understand that the chain leaves the top of the bar, circles downward and back towards the user. An arrow can be drawn with a sharpie showing this force and as the chainsaw cuts into wood the chain is pushing in the direction of the arrow. Students will be reminded of Newton's Third Law which states that as the chainsaw pushes into the wood, there must be something pushing back. Students should be able to identify which direction

the force is applied (equal and opposite) and what is doing the pushing (the wood).

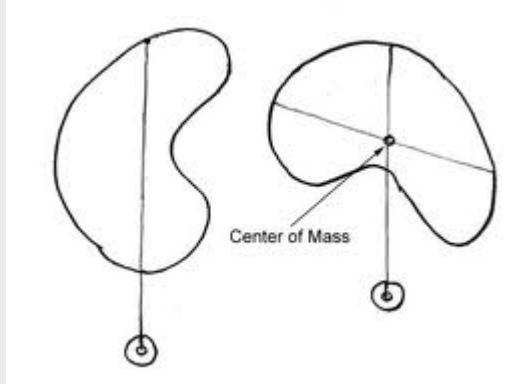


- For each of the four quadrants on the chainsaw bar, students will be able to identify the direction of chain movement, the direction of the force exerted by the bar and chain on the wood, and the direction of the force exerted by the wood on the chainsaw. Students should then be able to predict what the user will experience with each of the cuts. Students should be able to predict the outcome of various cuts, including the cause of the force that is responsible for kickback. The additional components of kickback can also be discussed at this time including the teeth on the chain cutting too deeply and binding the chain.
- Once students understand the various cuts, the forces and how they are generated, they will practice these cuts. Students will also have a chance to review the reactive forces using the quadrants on the blade.

Arbor - 2 2.I.02.02	Introductory Physics, Motion and Forces, 1.8	Describe conceptually the forces involved in circular motion.
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Performance Example:

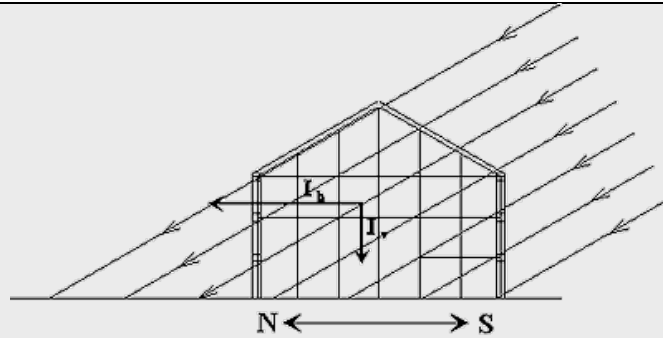
- Students will be able to compare and contrast butt tying, tip tying, and balancing as methods of tree limb removal. In efforts to understand the purpose of these methods, students must have an understanding of center of mass (or center of balance).
- Students will take a simple irregular, flat object provided by the teacher (e.g., hammer, wrench, etc.) and find the center of mass. While hanging the object from one end, allow a chalk line to hang down from the same attachment point. Mark where the chalk line hangs on the object. This will be repeated from two different points around the object. The point where the two lines cross is the center of mass.



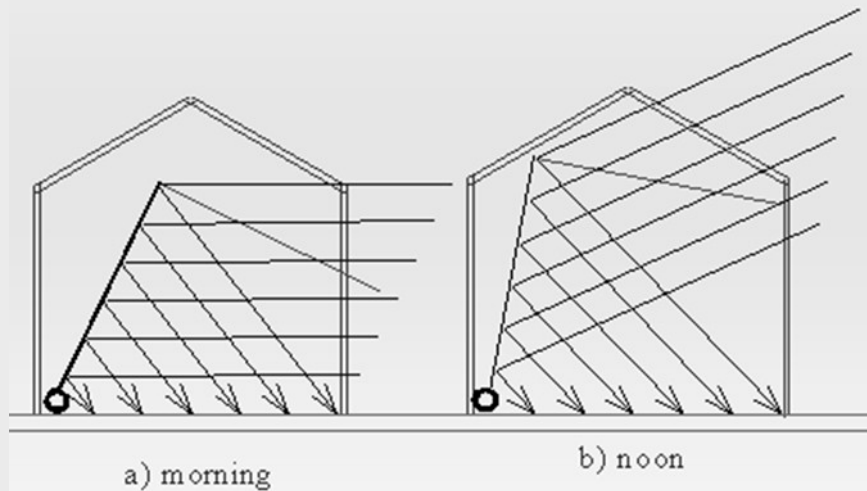
- Students will now relate the understanding of center of mass and apply it to tree limbs. Outside students will find a larger limb with branches and twigs intact. The limb should be able to be lifted and supported with a rope system. This will allow students to repeat the previous activity with the limb. Since students will be working with a three dimensional limb they may find the center of mass to be outside of the limb and branches. In this situation the students will be unable to mark the location of where the string hangs and a thin rigid wire can be used (the wire must maintain its position so that the intersection points/center of mass can be found).
- Now that students have found the center of mass they will be given a scenario to predict the outcome.

Example:

<p>A limb is to be removed from a tree. How will the motion of the falling tree limb change if the rope is tied at the branches center of mass? How will this change if it is tied below the center of mass? How will this change if it is tied above the center of mass?</p> <p>Summarize what you have learned about how the tie-off location affects the motion of the limb. Be sure to relate the concepts of butt tying, tip tying, and balancing to the three examples above. What are some situations in which each of these styles of tying-off a limb would be beneficial?</p>		
<p>Arbor - 3 2.I.02.03</p>	<p>Introductory Physics, Motion and Forces, 1.4 Introductory Physics, Conservation of Energy and Momentum 2.2</p>	<p>Interpret and apply Newton’s three laws of motion. Interpret and provide examples of how energy can be converted from gravitational potential energy to kinetic energy and vice versa.</p>
<p>Performance Example:</p> <ul style="list-style-type: none"> Define the difference between static and dynamic loads and the effects of the amount of force generated. Explain the factors contributing to force. Break students into groups. Give each group a weight, a dynamometer, and a tether to attach the two. Have students hang the weight from the dynamometer. Have the students predict the peak force the weight will produce with different length tethers. Have students hold the weight in one of four different locations at full length of the tether, drop the weight drop and then record the peak reading. Locations to start at are; at rest hanging below, above, and next to. Change the length of the tether and repeat. Compare the readings between the different tether lengths to what the students predicted. Extrapolate what would happen with different length tethers. Explain what could be done to minimize forces generated during different rigging activities. 		
<p>Flori-1 2.K.01.02</p>	<p>Introductory Physics, Heat and Heat Transfer, 3.1</p>	<p>Explain how heat energy is transferred by convection, conduction, and radiation.</p>
<p>Performance Example:</p> <ul style="list-style-type: none"> Students will design a model greenhouse that will regulate its own temperature. Students will research various building materials and understand the insulating ability (R) and heat loss (U) values used to describe these materials. Students will write a proposal for their design including an explanation of heat loss through conduction and radiation. After approval of their design students will build their model greenhouse. Upon completion of the project students will place their greenhouses outside during a typical day for the current season to measure the maximum and minimum internal and external temperatures. Once the greenhouses have been tested, students will compare the maximum and minimum internal temperatures and relate these numbers to a chart of “R” and “U” values. Students will write a summary based on the difference they observed in internal versus external temperatures. Students will explain heat loss in terms of conduction and radiation, and describe how they could improve upon their design. 		
<p>Flori-2 2.K.01.05</p>	<p>Physics, Waves, 4.4</p>	<p>Describe qualitatively the basic principles of reflection and refraction of waves.</p>
<p>Performance Example:</p> <ul style="list-style-type: none"> The students will design a greenhouse that will use the power of the sun to regulate temperatures during the winter in northern climates. At higher latitudes, the angle of the sun and length of sun exposure is much lower, therefore providing less heat for the green house. By using the Law of Reflection, students will build a model reflecting wall to generate heat in a green house. 		



Traditionally, much of the light energy that enters the greenhouse will also leave out the other side.



By adding a reflecting wall, the amount of solar energy absorbed by the greenhouse could be improved.

- Students will summarize the project by describing the effect the reflecting wall had on the ability of the greenhouse to retain solar energy in winter. Students will describe what will happen to the sunlight as the sun moves higher and lower in the horizon and link this idea to the Law of Reflection. Students will also explain the benefits and drawbacks of this method.

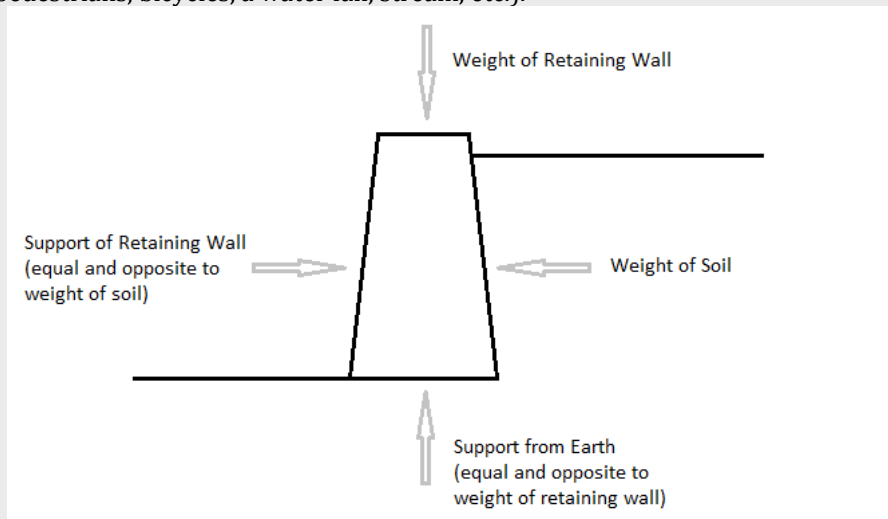
Land - 1 2.0.02.04	Physics, Motion and Forces, 1.4	Use a free-body force diagram to show forces acting on a system consisting of a pair of interacting objects. For a diagram with only co-linear forces, determine the net force acting on a system between the objects.
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Performance Example:

- Instruct the class on the knowledge and skills required to install a retaining wall.
- The instructor will put an illustration of several locations in which retaining walls are used. These can include riverfront barriers, stone walls along bike trails, free standing walls in front of office buildings, free standing aesthetic seat walls, gated free standing walls, planter walls, patios with steps, free standing walls with 90 degree corners, water features (e.g., waterfalls or ponds).



- Think: Students will spend several minutes thinking of the forces involved in some or all of these different locations. These examples could include the mass of the wall, the mass of soil and earth, the mass of water, the mass of pedestrians, and the mass of the gate.
- Pair: After students have a moment to write down their ideas, they will share these ideas with a neighbor. Students will have an opportunity to combine their knowledge and build upon their original ideas.
- Share: The instructor will have groups give examples of forces at play in various scenarios (i.e. the previous mentioned examples and pictures). After students have listed several forces involved, the instructor will show students how to draw a simple free-body diagram to show the forces acting on the retaining wall. The instructor should be sure to remind students that for every force, there is an equal and opposite force (e.g., as the mass of the bricks push down on the Earth, the Earth pushes up on the bricks).
- In small groups, students will take a specific scenario and draw a free-body diagram showing the forces (all forces should be shown with equal and opposite forces). The instructor will move around the room asking groups questions about their diagrams. These examples will include additional forces including (weight of pedestrians, bicycles, a water fall, stream, etc.).

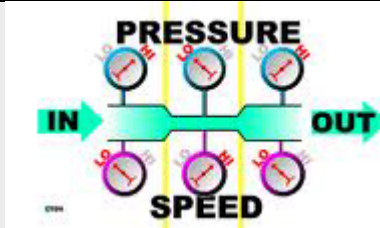


- Once students have finished they should be given time to share their free body diagrams. As closing remarks, the class can discuss what happens if certain forces change over time (e.g., additional rainfall increases the mass of the Earth behind the retaining wall). What would happen if the retaining wall could no longer resist the force exerted by the soil? The answer is there would be a failure in the retaining wall.

Land - 2 2.0.04.07	Introductory Physics, Motion and Forces, 1.1	Compare and contrast vector quantities and scalar quantities (pressure).
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Performance Example:

- Students will be able to describe what pressure is, how pressure is measured, and how pressure affects the function of irrigation systems.
- Students will perform an experiment to show what happens to pressure with a reduction in pipe diameter. The experiment will follow the scientific method; writing a question to investigate, forming a hypothesis, creating a procedure, making observations, and analyzing the data.
- PVC pipes are made available of various sizes along with the fittings, reducers, pressure gauges, and PVC cement.
- At the end of the experiment students should find that as diameter decreases, the pressure inside the tube or pipe decreases. This is in accordance with Bernoulli's Principle which states that as the velocity of a fluid increases, the pressure it exerts decreases.



Example:

Introduction – The instructor does a demonstration outside showing a sprinkler head attached to a garden hose. A funnel is used to pour a bucket of water into the hose to see how well the sprinkler operates. Students will discuss why the sprinkler does not work well. The reason is that the sprinkler has plenty of water, but not enough water pressure.

Question – What happens to water pressure as the diameter of a tube or pipe is decreased?

Hypothesis – If the diameter of a tube decreases then the pressure is going to increase.

Procedure

- 1) Design an irrigation line made from PVC that involves a reduction from a 2 inch pipe to a 1 inch pipe.
- 2) A pressure gauge will be located before and after the reduction via a threaded tee fitting.



- 3) Once the designs are built, the student's systems will be attached to a preexisting waterline. The dynamic water pressure can now be read as the water flows through the system.
- 4) Students will take measurements of the pressure before the reduction and after the reduction.

Data

Reduction Type <i>(starting diameter to final diameter)</i>	Pressure (pounds per square inch, PSI)	
	Before Reduction	After Reduction
2 inch to 1 inch		
3 inch to 2 inch		
3 inch to 1 inch		

- Students will summarize the importance of pressure on the irrigation system and should make predictions on what could be done to increase the pressure delivered to the sprinkler head if not enough pressure is available (some options include increasing the mainline size, increase the size of the backflow preventer, reduce pressure loss in the laterals, change the sprinkler head pressure, or add a booster pump). Students will describe what pressure is (pressure = force x area) and what effect too little or too much pressure could have on an irrigation system.

DESE Statewide Articulation Agreements

No Statewide Articulation Agreements at this time.

Industry Recognized Credentials (Licenses and Certifications/Specialty Programs)

Horticulture Potential Certifications/Credentials

1. Massachusetts Pesticide Applicators License
Massachusetts Department of Agricultural Resources
2. 10-Hour OSHA General Industry Card/Credential*
OSHA Construction Industry Training Guidelines
3. 10-hour Construction Industry Card/Credential*
OSHA Construction Industry Training Guidelines
4. CPR & First Aid Training Card/Credential*
American Heart Association and American Red Cross

Arboriculture Concentration Potential Certifications/Credentials

1. Massachusetts Certified Arborist
Massachusetts Arborist Association
2. Certified Tree Climber
International Society of Arboriculture
3. Electrical Hazard Awareness Program
Tree Care Industries Association
4. Massachusetts Commercial Driver's License
Massachusetts Department of Motor Vehicles
5. Massachusetts Hoisters License
Massachusetts Executive Office of Public Safety and Security

*Can be earned by student prior to graduation.

Greenhouse Management and Floriculture Concentration Potential Certifications/Credentials

1. Certified Floral Designer
American Institute of Floral Designers
2. Accredited AFID Member
American Institute of Floral Designers

*Can be earned by student prior to graduation.

Landscaping and Turf Management Concentration Potential Certifications/Credentials

1. Massachusetts Hoisting License
Massachusetts Executive Office of Public Safety and Security
2. Massachusetts Certified Horticulturist
Massachusetts Nursery and Landscape Association
3. NOFA Organic Land Care Professional*
Northeast Organic Farming Association
4. Massachusetts Certified Landscape Professional
Massachusetts Association of Landscape Professionals
5. Soil Science Society of America Certification
Soil Science Society of America
6. Certified Golf Course Superintendent
U.S. Golf Course Superintendents Association
7. Certified Turf Sports Field Manager
Sports Turf Managers Association

8. Landscape Industry Certified Technician
Professional Landcare Network
9. Landscape Industry Horticulturalist Technician
Professional Landcare Network
10. Landscape Industry Lawn Care Technician
Professional Landcare Network
*Can be earned by student prior to graduation.

Other

Reference Materials

Horticulture Recommended Texts

- Agrios George. (2005). *Plant pathology*. (5 ed). Academic Press.
- Castner, James. (2000). *Photographic atlas of entomology and guide to insect identification*. Scientific Publishers Journals Dept.
- Chemicals-Pesticides Program Cornell University. (2000). *Massachusetts pesticide core manual with supplement*. (2 ed). Cornell University
- Eash, Green, Ravzi, Bennett. (2008). *Soil science simplified*. (5 ed). Wiley-Blackwell.
- Gregory, P. (2013). *Soil conditions and plant growth*. Wiley-Blackwell.
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- Taiz & Zeiger. (2002). *Plant physiology*. (3 ed). Sinauer Associate, Inc., Publishers.

Arboriculture Concentration Recommended Texts

- ANSI, (2006-2012). *A300-tree care operations*.
- Dirr, Michael, A. (2009). *Manual of woody landscape plants: Their identification, ornamental characteristics, culture, propagation and uses*. (6 ed.). Champaign, IL: Stipes Publishing LLC.
- International Society of Arboriculture. (2010). *Arborists' certification study guide*.
- Jepson Jeff. (2009). *The tree climber's companion*. (2 ed.). Longville, MN: Beaver Tree Publishing.
- Massachusetts Arborist Association. (2012). *Massachusetts certified arborist study guide*. (Version 2.0 CD).

Greenhouse Management and Floriculture Concentration Recommended Texts

- Boodley, J. W. & Newman, S. E. (2009). *The Commercial Greenhouse*. (3 ed). Clifton Park, NY: Delmar Cengage Learning
- DelPrince, J. M. (2012). *Interior plantscaping: principles and practices*. Clifton Park, NY: Delmar Cengage Learning.
- Griner, C. (2011). *Floriculture: Designing & merchandising*. (3 ed.). Clifton Park, NY: Delmar Cengage Learning.
- Hunter, N. T. (2013). *The art of floral design*. (3 ed). Clifton Park, NY: Delmar Cengage Learning.
- Noland, D. A. (2004). *Floral design & interior landscape management*. Pearson/Prentice Hall.
- Reiley, H. E. & Shry, Jr. C. L. (2011). *Introduction to horticulture*. (8 ed). Clifton Park, NY: Thomson Delmar Learning.

Landscaping and Turf Management Concentration Recommended Texts

- Brady, Nyle. & Weil, Ray. (2002). *The nature and property of soils*, (14 ed). Pearson Education.
- Brickell, C., & Joyce D. (1996). *American horticulture society pruning and training*. D.K. Adult.
- Christians N., & Agnew M. (2008). *The mathematics of turfgrass maintenance*. (4 ed). John Wiley and Sons Publishing.

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- Gregory, P. (2006). *Plant roots: growth, activity, and interactions with the soil*. Wiley-Blackwell.
- Havlin, Tisdale, Beaton, & Nelson. (2005). *Soil fertility and fertilizers: an introduction to nutrient management*. (7 ed). Pearson Education.
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- Massachusetts Nursery Landscape Association. (2010). *Massachusetts nursery and landscape resource guide*.
- Roth, A. (2009). *Small gas engines*. Goodheat-Willcox Company.
- Sauter, David. (2003). *Plan it, dig it, build it: your step- by- step guide to landscape projects*. Cengage Learning.
- Reiley, H. E. & Shry, Jr. C. L. (2011). *Introduction to horticulture*. (8 ed). Clifton Park, NY: Thomson Delmar Learning.
- Shroeder, Seagle, Felton, Reuter, Kelley, Krewer. (2009). *Introduction to horticulture*. (4 ed). Interstate Agriscience and Technology.

Related National, Regional, and State Professional Organizations

- National Gardening Association (NGA) <https://assoc.garden.org/>
- American Horticultural Society www.ahs.org/

Student Organizations

- Skills USA www.maskillsusa.org
- FFA www.ffa.org

Selected Websites

- U.S. Department of Agriculture (USDA) www.USDA.gov/
- U. S. Environmental Protection Agency (EPA) www.epa.gov/
- U. S. National Park Service www.nps.gov