Title 7: Education K-12

Part 122: Architecture and Construction

2014 HVAC

Mississippi Department of Education

Program CIP: 47.0201 Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician

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Published by

Office of Career and Technical Education
Mississippi Department of Education
Jackson, MS 39205

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The Research and Curriculum Unit (RCU), located in Starkville, MS, as part of Mississippi State University, was established to foster educational enhancements and innovations. In keeping with the land grant mission of Mississippi State University, the RCU is dedicated to improving the quality of life for Mississippians. The RCU enhances intellectual and professional development of Mississippi students and educators while applying knowledge and educational research to the lives of the people of the state. The RCU works within the contexts of curriculum development and revision, research, assessment, professional development, and industrial training.

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Acknowledgments

The HVAC curriculum was presented to the Mississippi Board of Education on November 14-15, 2013.

The following persons were serving on the state board at the time:

Dr. Lynn House, Interim State Superintendent of Education
Dr. O. Wayne Gann, Chair
Mr. Howell "Hal" N. Gage, Vice Chair
Ms. Kami Bumgarner
Mr. William Harold Jones
Dr. John R. Kelly
Mr. Charles McClelland
Mr. Richard Morrison
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Mr. Simon F. Weir, II

Jean Massey, Associate Superintendent of Education for the Office of Career and Technical Education at the Mississippi Department of Education, assembled a taskforce committee to provide input throughout the development of the HVAC *Curriculum Framework and Supporting Materials.*

Lemond Irvin, Instructional Design Specialist for the Research and Curriculum Unit at Mississippi State University researched and authored this framework.
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Also, special thanks are extended to the teachers who contributed teaching and assessment materials that are included in the framework and supporting materials:

Ellis Orlansky, Thomas C. Randle Center, Belzoni, MS
Jacob Green, Pascagoula Applied Technology Center, Pascagoula, MS
Bennett Williams, Career and Development Center, Jackson, MS

Appreciation is expressed to the following professional, who provided guidance and insight throughout the development process:

Mike Barkett, Program Coordinator, Mississippi Construction Education Foundation President, mike@mcef.net

Standards

Standards are superscripted in each unit and are referenced in the appendices. Standards in the HVAC *Curriculum Framework and Supporting Materials* are based on the following:

NCCER Learning Series from the National Center for Construction Education and Research
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Common Core State Standards Initiative
The Common Core State Standards provide a consistent, clear understanding of what students are expected to learn, so teachers and parents know what they need to do to help them. The standards are designed to be robust and relevant to the real world, reflecting the knowledge and skills that our young people need for success in college and careers. With American students fully prepared for the future, our communities will be best positioned to compete successfully in the global economy. Copyright 2010. National Governors Association Center for Best Practices and Council of Chief State School Officers. All rights reserved. States and territories of the United States as well as the District of Columbia that have adopted the Common Core State Standards in whole are exempt from this provision, and no attribution to the National Governors Association Center for Best Practices and Council of Chief State School Officers is required. Reprinted from http://www.corestandards.org/.

National Educational Technology Standards for Students
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21st Century Skills and Information and Communication Technologies Literacy Standards
In defining 21st century learning, the Partnership for 21st Century Skills has embraced five content and skill areas that represent the essential knowledge for the 21st century: global awareness; civic engagement; financial, economic, and business literacy; learning skills that encompass problem-solving, critical-thinking, and self-directional skills; and information and communication technology (ICT) literacy.

Preface

Secondary career and technical education programs in Mississippi face with many challenges resulting from sweeping educational reforms at the national and state levels. Schools and teachers are increasingly being held accountable for providing true learning activities to every student in the classroom. This accountability is measured through increased requirements for mastery and attainment of competency as documented through both formative and summative assessments.

The courses in this document reflect the statutory requirements as found in Section 37-3-49, *Mississippi Code of 1972*, as amended (Section 37-3-46). In addition, this curriculum reflects guidelines imposed by federal and state mandates (Laws, 1988, Ch. 487, §14; Laws, 1991, Ch. 423, §1; Laws, 1992, Ch. 519, §4 eff. from and after July 1, 1992; Carl D. Perkins Vocational Education Act IV, 2007; and No Child Left Behind Act of 2001).

Mississippi Teacher Professional Resources

The following are resources for Mississippi teachers.

Curriculum, Assessment, Professional Learning, and other program resources can be found at The Research and Curriculum Unit's website: http://www.rcu.msstate.edu

Learning Management System: An online resource

Learning Management System information can be found at the RCU's website, under Professional Learning.

Should you need additional instructions, please call 662.325.2510.

My PLC: An online registration for all professional-development sessions

To register for any session, teachers will need an account in the registration system, MyPLC, https://myplc.rcu.msstate.edu. To create an account, click on the link and navigate to the "Request a Guest ID" link. The ID should be the teacher's first initial and last name and the last four (4) digits of the social security number. Teachers should complete the entire form, which will then be sent to a secure server. Upon activation of the teacher's account, he or she will receive an e-mail with login instructions. The teacher may then browse for the available sessions and register for the desired courses.

Should you need additional instructions, please call 662.325.2510.

Executive Summary

Pathway Description

The HVAC pathway is a curriculum that provides an educational option for students who have successfully completed the Installation and Service Core (2 Carnegie credits). This option is an instructional program that prepares students for employment or continued education in the occupations of heating, ventilation, and air-conditioning. The curriculum framework for this program was developed in partnership with the Mississippi Construction Education Foundation (MCEF). MCEF is the accredited sponsor for the National Center for Construction Education and Research (NCCER).

Industry Certification

The NCCER developed and published a set of industry standards that are taught nationwide by contractors, associations, construction users, and secondary and postsecondary schools called the **NCCER Learning Series.** When developing this set of standards, the NCCER assembled a team of subject matter experts that represented construction companies and schools across the nation. Each committee met several times and combined experts' knowledge and experience to finalize the set of national industry standards.

As a part of the accreditation process, all Mississippi Construction Technology instructors will be required to successfully complete the **Instructor Certification Training Program**. This program ensures that instructors possess a deep knowledge of content of the standards.

This state-of-the-art curriculum is modeled after the eight Mississippi **NCCER Accredited Training and Education Facilities (ATEF)**. In order to become an NCCER ATEF program, school districts must meet a set of guidelines including the following:

1. Use the approved curriculum.
2. All instructors must be NCCER certified.
3. All completed Form 200s and release forms on all student completions are to be forwarded to MCEF for proper approval. MCEF will in turn forward to NCCER for processing.
4. Follow NCCER guidelines on test security and performance profiles.
5. Have an active advisory committee with at least two commercial contractors involved.
6. Follow safety practices and Occupational Safety and Health Administration (OSHA) standards used in the class and lab areas.
7. Involve commercial contractors in class presentations or field trips.
8. All construction programs must be included in the accreditation process.
9. Show active involvement in student leadership development (e.g., SkillsUSA).
10. Provide demonstrated placement into construction-related occupations, and provide timely reports to MCEF.

Districts will be required to complete a self-evaluation of all programs and host a site visit from industry to ensure proper lab, safety, and instructional procedures are in place.

Assessment

The latest assessment blueprint for the curriculum can be found at http://www.rcu.msstate.edu/Curriculum/CurriculumDownload.aspx

Student Prerequisites

In order for students to be able to experience success in the HVAC program, the following student prerequisites are suggested:

1. C or higher in English (the previous year)
2. C or higher in Math (last course taken or the instructor can specify the math)
3. Instructor Approval and TABE Reading Score (eighth grade or higher)

or

1. TABE Reading Score (eighth grade or higher)
2. Instructor Approval

or

1. Instructor Approval

Teacher Licensure

The latest teacher licensure information can be found at

http://www.mde.k12.ms.us/educator-licensure

Professional Learning

If you have specific questions about the content of any of training sessions provided, please contact the Research and Curriculum Unit at 662.325.2510 and ask for a professional-learning specialist.

Course Outlines

Option 1—Two, One-Carnegie-Unit Courses

Upon completion of this option, the student will be prepared to take the **HVAC Level 1 Certification** exams. This curriculum consists of two, one-credit courses, which should be completed in the following sequence:

1. **Beginning HVAC—Course Code: 993022**
2. **Advanced HVAC—Course Code: 993023**

Course Description: Beginning HVAC

Beginning HVAC includes an in-depth study of the heating, ventilation, and air-conditioning profession, HVAC math, ferrous metal piping practice, introduction to cooling, and introduction to heating. This course also reinforces safety related to the installation and service of HVAC applications. This one-Carnegie-unit course should only be taken after students successfully complete Installation and Service Core.

Course Description: Advanced HVAC

Advanced HVAC includes an in-depth study of the heating, ventilation, and air conditioning profession, air distribution systems, leak detection evacuation recovery and charging, alternating current, and basic electronics. This course also reinforces safety related to the installation and service of HVAC applications. This one-Carnegie-unit course should only be taken after students successfully complete Beginning HVAC (course code 993022).

- Scheduling and operating more than one course in the same classroom/laboratory with the same instructor is not allowed.
- Safety will be reinforced and tested at the beginning of each course.

- Students must complete **Installation and Service Core** with a score of 80/C or higher in classwork to advance to the next level.

Beginning HVAC—Course Code: 993022

Unit		Title	Hours
1		Orientation and Safety (Review and Reinforcement)	20
2		Trade Math, Ferrous Metal Piping Practice,	60
3		Introduction to Cooling, and Introduction to Heating	60
			140

Advanced HVAC—Course Code: 993023

Unit		Title	Hours
4		Air Distribution Systems	40
5		Leak Detection Evacuation Recovery and Charging	60
6		Alternating Current and Basic Electronics	40
			140

Option 2—One, Two-Carnegie-Unit Courses

This curriculum consists of one, two-credit course, as follows:

1. **HVAC—Course Code: 993021**

Course Description: HVAC

HVAC (Heating, Ventilation and Air-Conditioning) is an emphasis on Heating, Ventilation, and Air-Conditioning. Topics include employability skills, safety, ferrous metal piping, introduction to cooling, introduction to heating, air distribution, leak detection evacuation recovery and charging, alternating current, and basic electronics. The course should be taken after the student has successfully completed Installation and Service Core.

- Scheduling and operating more than one course in the same classroom/laboratory with the same instructor is not allowed.
- Safety will be reinforced and tested at the beginning of each course.
- Students must complete **Installation and Service Core** with a score of 80/C or higher in classwork to advance to the next level.

Heating, Ventilation and Air-Conditioning-HVAC—Course Code: 993021

Unit		Title	Hours
1		Orientation and Safety (Review and Reinforcement)	20
2		Trade Math, Ferrous Metal Piping Practice	60
3		Introduction to Cooling, and Introduction to Heating	60
4		Air Distribution Systems	40
5		Leak Detection Evacuation Recovery and Charging	60
6		Alternating Current and Basic Electronics	40
			280

Research Synopsis

Needs of the Future Workforce

Occupations in the HVAC fields are projected to have about as fast as average to faster than average growth in Mississippi between 2008 and 2018. Heating, Air Conditioning, and Refrigeration Mechanic and Installer occupations are projected to have the fastest growth rate at 26.7% over the projection date. The U.S. Bureau of Labor Statistics reports that job prospects will be excellent for technicians in this field, particularly those who have received training at accredited technical schools.

Table 1.1: Current and Projected Occupation Report for Installation and Service Technology

Description	Jobs, 2008	Projected Jobs, 2018	Change (Number)	Change (Percent)	Average Hourly Wage
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	2,400	3,040	640	26.7	$16.61
Helpers—Installation, Maintenance, and Repair Workers	1,850	2,100	250	13.5	$11.90
Installation, Maintenance, and Repair Workers, All Other	450	500	50	11.1	$21.03

Source: Mississippi Department of Employment Security; www.mdes.ms.gov (accessed March 8, 2013).

Perkins IV Requirements

The HVAC curriculum meets Perkins IV requirements of high-skill, high-wage, and/or high-demand occupations by introducing students to and preparing students for occupations. It also offers students a program of study including secondary, postsecondary, and IHL courses that will prepare them for occupations in these fields. Additionally, the HVAC curriculum is integrated with academic common core standards. Lastly, the HVAC curriculum focuses on

ongoing and meaningful professional development for teachers as well as relationships with industry.

Curriculum Content

Summary of Standards

The standards to be included in the HVAC curriculum are the Common Core Standards for Mathematics and Science, 21st Century Skills, and the National Educational Technology Standards (NETS) for Students. Combining these standards to create this document will result in highly skilled, well-rounded students who are prepared to enter a secondary academic or career and technical program of study. They will also be prepared to academically compete nationally as the Common Core Standards are designed to prep students for success in community colleges, Institutions of Higher Learning and careers.

Academic Credit

If academic credit is awarded, please review the Research and Curriculum Unit link at https://www.rcu.msstate.edu/MDE/PathwaystoSuccess.aspx.

Click "*Curriculum Enhancement List"*. Check this site often as it is updated frequently.

Transition to Postsecondary Education

The latest articulation information for Secondary to Postsecondary can be found at the Mississippi Community College Board (MCCB) website http://www.mccb.edu/

Best Practices

Innovative Instructional Technologies

Recognizing that today's students are digital learners, the classroom should be equipped with tools that will teach them in the way they need to learn. The HVAC teacher's goal should be to include teaching strategies that incorporate current technology. It is suggested that each

classroom house a classroom set of desktop student computers and one teacher laptop. To make use of the latest online communication tools such as wikis, blogs, and podcasts, the classroom teacher is encouraged to use a learning management system.

Differentiated Instruction

Students learn in a variety of ways. Some are visual learners, needing only to read information and study it to succeed. Others are auditory learners, thriving best when information is read aloud to them. Still others are tactile learners, needing to participate actively in their learning experiences. Add the student's background, emotional health, and circumstances, and a very unique learner emerges. By providing various teaching and assessment strategies, students with various learning styles can succeed.

Career and Technical Education Student Organizations

Teachers should investigate opportunities to sponsor a student organization. There are several here in Mississippi that will foster the types of learning expected from the HVAC curriculum. SkillsUSA is the student's organization for HVAC. Skills USA provides students with growth opportunities and competitive events. It also opens the doors to the world of HVAC and scholarships opportunities.

Cooperative Learning

Cooperative learning can help students understand topics when independent learning cannot. Therefore, you will see several opportunities in the HVAC curriculum for group work. To function in today's workforce, students need to be able to work collaboratively with others and solve problems without excessive conflict.

Conclusions

The HVAC is one of Mississippi's most comprehensive installation management curriculums. Students that complete these programs are well equipped for a variety of endeavors. Instructors are urged to encourage HVAC students to pursue educational opportunities at community colleges and universities in Mississippi.

Professional Organizations

Association for Career and Technical Education (ACTE)
1410 King Street
Alexandria, VA 22314
800.826.9972
http://www.acteonline.org

SkillsUSA
14001 SkillsUSA Way
Leesburg, VA 20176
703.777.8810
FAX: 703.777.8999
http://www.skillsusa.org/

Using This Document

Suggested Time on Task
This section indicates an estimated number of clock hours of instruction that should be required to teach the competencies and objectives of the unit. A minimum of 140 hours of instruction is required for each Carnegie unit credit. The curriculum framework should account for approximately 75–80% of the time in the course.

Competencies and Suggested Objectives
A competency represents a general concept or performance that students are expected to master as a requirement for satisfactorily completing a unit. Students will be expected to receive instruction on all competencies. The suggested objectives represent the enabling and supporting knowledge and performances that will indicate mastery of the competency at the course level.

Integrated Academic Topics, 21st Century Skills and Information and Communication Technology Literacy Standards, ACT College Readiness Standards, and Technology Standards for Students
This section identifies related academic topics as required in the Subject Area Testing Program (SATP) in Algebra I, Biology I, English II, and U.S. History from 1877, which are integrated into the content of the unit. Research-based teaching strategies also incorporate ACT College Readiness standards. This section also identifies the 21st Century Skills and Information and Communication Technology Literacy skills. In addition, national technology standards for students associated with the competencies and suggested objectives for the unit are also identified.

References
A list of suggested references is provided for each unit. The list includes some of the primary instructional resources that may be used to teach the competencies and suggested objectives. Again, these resources are suggested, and the list may be modified or enhanced based on needs and abilities of students and on available resources.

Unit 1: Orientation and Safety (Review and Reinforcement)

Competencies and Suggested Objectives
1. Describe local program and vocational/career technical center policies and procedures. DOK2, a. Describe local program and vocational/career technical center policies and procedures.
2. Describe employment opportunities and responsibilities of the industrial and HVAC mechanic. DOK2, EMP a. Describe employer expectations in the workplace.
3. Explore leadership skills and personal development opportunities provided for students by student organizations to include SkillsUSA. DOK2, a. Demonstrate effective team-building and leadership skills. b. Demonstrate through practice appropriate work ethics.
4. Describe general safety rules for working in a shop/lab and industry. DOK2, BAS a. Discuss safety issues and prevention associated with the installation and service shop area. b. Explain fire safety and prevention in the workplace.
5. Review and Reinforce the year one content. (Ongoing)

Scenario

No Scenario is necessary for review and reinforcement

Unit 1

Attachments for Scenario

None

Unit 2: Trade Math, Ferrous Metal Piping Practice

Competencies and Suggested Objectives
1. Identify proper math to use for problem solving; use English and metric measurement; use powers, algebra, and geometric calculation to solve for HVAC problems; and convert Fahrenheit to Celsius. DOK2, TMA a. Demonstrate how to calculate mathematic problems found in the HVAC area.
2. Recognize types and sizes of ferrous metal piping and pipe fittings, and also recognize and use tools used to cut, ream, and thread ferrous pipe in the HVAC application. DOK2, FMP a. Explain the uses of ferrous metal pipes in the HVAC trade.

Scenario

Cut and Thread

Unit 2

Have the students measure, cut, and install a piece of pipe. Students will install pipe from main gas source to gas valve on the air handler. Assess the student using a performance rubric.

Attachments for Scenario

See the rubric in the teacher resources document found on the RCU Curriculum Download page: www.rcu.msstate.edu/Curriculum/CurriculumDownload.aspx

Unit 3: Introduction to Cooling, and Introduction to Heating

Competencies and Suggested Objectives
1. Explain the basic cooling systems, heat transfer, trade terms, refrigerants, components of the cooling system, controls, and proper piping of the cooling system. DOK2, ITC a. Explain how an HVAC system removes heat from an air-conditioned area of an HVAC system. b. Identify the major components, accessories, and control devices available for cooling systems, and explain how each works.
2. Explain methods of heat transfer and characteristics of combustion, identify types of fuels and types of furnaces and components of the electric and gas furnace, identify and safely use meters in gas measurement, and perform maintenance on electric and gas furnaces. DOK2, ITH a. Explain how an HVAC heating system operates. b. Describe how an electric furnace works. c. With supervision, perform basic furnace preventive maintenance procedures such as cleaning and filter replacement.

Scenario

Four Strikes, You're Out

Unit 3

The student will label a diagram of the refrigerant cycle shown as a baseball diamond and how the refrigerant is compressed and pumped around the base to move the heat from where we don't want it to where it doesn't matter. The drawing will be evaluated using a drawing key.

Attachments for Scenario

Provide a diagram of a baseball diamond

Unit 4: Air Distribution Systems

Competencies and Suggested Objectives
1. Demonstrate designing and installing HVAC duct and piping systems. DOK2, ADS a. Discuss and explain the patterns of air flow and pressures in an HVAC duct. b. Identify types of duct systems, and explain where each is used in installation and service applications.

Scenario

Snip and Cut

Unit 4

Have students cut a 6" piece of round sheet metal pipe 6"long, snap the pipe together, cut a hole, and screw to pleum box. Evaluate using the performance rubric.

Attachments for Scenario

See the rubric in the teacher resources document found on the RCU Curriculum Download page: www.rcu.msstate.edu/Curriculum/CurriculumDownload.aspx

Unit 5: Leak Detection Evacuation Recovery and Charging

Competencies and Suggested Objectives
1. Identify leaks in an HVAC system and perform the proper steps to repair the leak restoring the unit to operation. DOK2, LDE a. Define and perform a leak test on an HVAC system. b. Use nitrogen to purge a system and charge refrigerant into a system by the following methods. • Weight • Superheat • Subcooling • Charging pressure
2. Identify/install a basic vacuum pump service operation. DOK2, LDE a. Describe safety procedures using a vacuum pump. b. Install a vacuum pump on a system. c. Pull the vacuum to 500mic.

Scenario

The Perfect Vacuum

Unit 5

The students will vacuum a system to 500 microns to establish there are no leaks in the system. Evaluate using the Performance Rubric.

Attachments for Scenario

See the rubric in the teacher resources document found on the RCU Curriculum Download page: www.rcu.msstate.edu/Curriculum/CurriculumDownload.aspx

Unit 6: Alternating Current,and Basic Electronics

Competencies and Suggested Objectives
1. Gain an understanding of the safe operation of electrical transformers, motors, and single- and three-phase HVAC devices. DOK2, ALT a. Explain and demonstrate the safe operation of various types of transformers. b. Describe the types of capacitors and motors found in the HVAC unit. c. State and demonstrate the safety precautions that must be followed when working with electrical equipment and testing AC components, including capacitors, transformers, and motors.
2. Explain and apply basic electrical theory to HVAC applications and how to troubleshoot common electronic devices found in HVAC systems. DOK2, BAE a. Explain basic electronic theory of semiconductors, and test the operation of various semiconductor devices such as resistors, diodes, LEDs, thermistors, cad cells, and photo diodes. Explain how these devices are used in power and control circuits.

Scenario

Check, Check, Check

Unit 6

The students will demonstrate how to use a meter to measure voltage, ohms, and resistance. The exercise will be evaluated using a Performance Rubric.

Attachments for Scenario

See the rubric in the teacher resources document found on the RCU Curriculum Download page: www.rcu.msstate.edu/Curriculum/CurriculumDownload.aspx

Student Competency Profile

Student's Name: _____

This record is intended to serve as a method of noting student achievement of the competencies in each unit. It can be duplicated for each student, and it can serve as a cumulative record of competencies achieved in the course.

In the blank before each competency, place the date on which the student mastered the competency.

Unit 1: Orientation and Safety (Review and Reinforcement)		
	1.	Describe local program and vocational/career technical center policies and procedures.
	2.	Describe employment opportunities and responsibilities of the industrial and HVAC mechanic.
	3.	Explore leadership skills and personal development opportunities provided for students by student organizations to include SkillsUSA.
	4.	Describe general safety rules for working in a shop/lab and industry.
	5.	Review and Reinforce the year one content. (Ongoing)
Unit 2: Trade Math, Ferrous Metal Piping Practice		
	1.	Identify proper math to use for problem solving; use English and metric measurement; use powers, algebra, and geometric calculation to solve for HVAC problems; and convert Fahrenheit to Celsius.
	2.	Recognize types and sizes of ferrous metal piping and pipe fittings, and also recognize and use tools used to cut, ream, and thread ferrous pipe in the HVAC application.
Unit 3: Introduction to Cooling, and Introduction to Heating		
	1.	Explain the basic cooling systems, heat transfer, trade terms, refrigerants, components of the cooling system, controls, and proper piping of the cooling system.
	2.	Explain methods of heat transfer and characteristics of combustion, identify types of fuels and types of furnaces and components of the electric and gas furnace, identify and safely use meters in gas measurement, and perform maintenance on electric and gas furnaces.
Unit 4: Air Distribution Systems		
	1.	Demonstrate designing and installing HVAC duct and piping systems.
Unit 5: Leak Detection Evacuation Recovery and Charging		
	1.	Identify leaks in an HVAC system and perform the proper steps to repair the leak restoring the unit to operation.
	2.	Identify/install a basic vacuum pump service operation.

Unit 6: Alternating Current, and Basic Electronics		
	1.	Gain an understanding of the safe operation of electrical transformers, motors, and single- and three-phase HVAC devices.
	2.	Explain and apply basic electrical theory to HVAC applications and how to troubleshoot common electronic devices found in HVAC systems.

Appendix A: Unit References

Unit 1

Davies, D. (n.d.). *Grammar? No problem!* Mission, KS: SkillPath.

Gould, M. C. (2002). *Developing literacy and workplace skills*. Bloomington, IN: Solution Tree

National Center for Construction Education and Research. (2009). *Core curriculum.* Upper Saddle River, NJ: Pearson Prentice Hall.

National Center for Construction Education and Research. (2009). *Tools for success.* Upper Saddle River, NJ: Pearson Prentice Hall.

SkillsUSA. (n.d.). *Leadership and competition curricula.* Tinley Park, IL: Goodheart-Willcox.

Associated Web Sites

Aragon, S. R. (Ed.). (n.d.). *Journal of Vocational Education Research.* Retrieved May 22, 2013, from http://scholar.lib.vt.edu/ejournals/JVER/

Dobbins, T. R. (Ed.). (n.d.). *Journal of Career and Technical Education.* Retrieved May 22, 2013, from http://scholar.lib.vt.edu/ejournals/JCTE/

E-School News. (n.d.). Retrieved May 22, 2013, from http://www.eschoolnews.com/news/top-news/index.cfm?i=50758

How stuff works. (n.d.). Retrieved May 22, 2013 , from http://www.howstuffworks.com/

Kathy Schrock's guide for educators. (n.d.). In *Discovery education*. Retrieved May 22, 2013, from http://school.discoveryeducation.com/schrockguide/

Teacher Vision. (n.d.). Retrieved May 22, 2013, from http://www.teachervision.fen.com/

Tech Learning. (n.d.). Retrieved May 22, 2013, from http://techlearning.com

Unit 2

Barrows, R., & Jones, B. (2002). *Fundamentals of math with career applications*. Upper Saddle River, NJ: Pearson Prentice Hall.

Boyce, J. G., Margolis, L., & Slade, S. (2000). *Mathematics for technical and vocational students*. Upper Saddle River, NJ: Prentice Hall.

Carman, R. A., & Saunders, H. M. (2011). *Mathematics for the trades: A guided approach*. Upper Saddle River, NJ: Pearson Prentice Hall.

Cook, N. P. (2004). *Mathematics for technical trades.* Upper Saddle River, NJ: Pearson Prentice Hall.

Cook, N. P. (2004). *Introductory mathematics.* Upper Saddle River, NJ: Pearson Prentice Hall.

Huth, M., & Wells, W. (2010). *Understanding construction drawings.* Albany, NY: Delmar Thomson Learning.

Madsen, D. (2013). *Print reading for engineering and manufacturing technology.* Clifton Park, NY: Delmar Thomson Learning.

National Center for Construction Education and Research. (2007). *HVAC Level I.* Upper Saddle River, NJ: Pearson Prentice Hall.

Silberstein, E. (2012). *Residential construction academy: HVAC*. Albany, NY: Delmar.

SkillsUSA. (2002). *Leadership and competition curricula*. Tinley Park, IL: Goodheart-Willcox.

Spears, R. (2003). *The ruler game*. Retrieved on May 22, 2013, from http://www.rickyspears.com/rulergame/

Stanfield, C., Skaves, D., (2013). *Fundamentals of HVACR.* Upper Saddle River, NJ: Pearson Prentice Hall.

Whitman, W., Johnson, W., & Tomczyk, J. (2013). *Refrigeration and air-conditioning technology.* Albany, NY: Delmar.

Unit 3

National Center for Construction Education and Research. (2007). *HVAC Level I.* Upper Saddle River, NJ: Pearson Prentice Hall.

Silberstein, E. (2012). *Residential construction academy: HVAC*. Albany, NY: Delmar.

SkillsUSA. (n.d.). *Leadership and competition curricula*. Tinley Park, IL: Goodheart-Willcox.

Stanfield, C., Skaves, D., (2013). *Fundamentals of HVACR.* Upper Saddle River, NJ: Pearson Prentice Hall.

Whitman, W., Johnson, W., & Tomczyk, J. (2013). *Refrigeration and air-conditioning technology.* Albany, NY: Delmar.

Unit 4

Herman, S., & Sparkman, B. (2013). *Electricity and controls for HVAC/R.* Albany, NY: Delmar.

National Center for Construction Education and Research. (2009). *Core curriculum*. Upper Saddle River, NJ: Pearson Prentice Hall.

National Center for Construction Education and Research. (2007). *HVAC level I*. Upper Saddle River, NJ: Pearson Prentice Hall.

National Center for Construction Education and Research. (2009). *Tools for success*. Upper Saddle River, NJ: Pearson Prentice Hall.

Silberstein, E. (2012). *Residential construction academy: HVAC*. Albany, NY: Delmar.

SkillsUSA. (n.d.). *Leadership and competition curricula*. Tinley Park, IL: Goodheart-Willcox.

Stanfield, C., Skaves, D., (2013). *Fundamentals of HVACR.* Upper Saddle River, NJ: Pearson Prentice Hall.

Whitman, W., Johnson, W., & Tomczyk, J. (2013). *Refrigeration and air-conditioning technology.* Albany, NY: Delmar.

Unit 5

Herman, S., & Sparkman, B. (2013). *Electricity and controls for HVAC/R.* Albany, NY: Delmar.

National Center for Construction Education and Research. (2009). *Core curriculum*. Upper Saddle River, NJ: Pearson Prentice Hall.

National Center for Construction Education and Research. (2007). *HVAC level II*. Upper Saddle River, NJ: Pearson Prentice Hall.

National Center for Construction Education and Research. (2009). *Tools for success*. Upper Saddle River, NJ: Pearson Prentice Hall.

Silberstein, E. (2012). *Residential construction academy: HVAC*. Albany, NY: Delmar.

SkillsUSA. (n.d.). *Leadership and competition curricula*. Tinley Park, IL: Goodheart-Willcox.

Stanfield, C., Skaves, D., (2013). *Fundamentals of HVACR.* Upper Saddle River, NJ: Pearson Prentice Hall.

Whitman, W., Johnson, W., & Tomczyk, J. (2013). *Refrigeration and air-conditioning technology.* Albany, NY: Delmar.

Unit 6

Herman, S., & Sparkman, B. (2013). *Electricity and controls for HVAC/R.* Albany, NY: Delmar.

National Center for Construction Education and Research. (2009). *Core curriculum*. Upper Saddle River, NJ: Pearson Prentice Hall.

National Center for Construction Education and Research. (2007). *HVAC level I*. Upper Saddle River, NJ: Pearson Prentice Hall.

National Center for Construction Education and Research. (2007). *HVAC level II*. Upper Saddle River, NJ: Pearson Prentice Hall.

National Center for Construction Education and Research. (2009). *Tools for success*. Upper Saddle River, NJ: Pearson Prentice Hall.

Silberstein, E. (2012). *Residential construction academy: HVAC*. Albany, NY: Delmar.

SkillsUSA. (n.d.). *Leadership and competition curricula*. Tinley Park, IL: Goodheart-Willcox.

Stanfield, C., Skaves, D., (2013). *Fundamentals of HVACR.* Upper Saddle River, NJ: Pearson Prentice Hall.

Whitman, W., Johnson, W., & Tomczyk, J. (2013). *Refrigeration and air-conditioning technology.* Albany, NY: Delmar.

Appendix B: Industry Standards

HVAC PATHWAY
CONTENT STANDARDS AND PERFORMANCE ELEMENTS[1]

Crosswalk for HVAC											
	Units	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**	**Unit 6**				
HVAC											
BAS		X									
EMP		X									
TMA			X								
FMP			X								
ITC				X							
ITH				X							
ADS					X						
LDE						X					
ALT							X				
BAE							X				

NCCER CORE
BSM – BASIC SAFETY (00101-09)
EMP – BASIC EMPLOYABILITY SKILLS (00108-09)

NCCER HVAC

LEVEL ONE

Level One

INT - MODULE 0310107–INTRODUCTION TO HVAC

TMA – MODULE 03102-07 – TRADE MATH

FMP – MODULE 03105-07 – FERROUS METAL PIPING PRACTICES

ITC - MODULE 0310707–INTRODUCTION TO COOLING

[1] *NCCER learning series.* Retrieved April 22, 2013, from http://www.nccer.org/

ITH - MODULE 0310807–INTRODUCTION TO HEATING

ADS - MODULE 0310907–AIR DISTRIBUTION SYSTEMS

Level 2

LDE - MODULE 03205-07 – LEAK DETECTION, EVACUATION, RECOVERY, AND CHARGING

ALT - MODULE 03206-07 – ALTERNATING CURRENT

BAE - MODULE 03207-07 – BASIC ELECTRONICS

Appendix C: Common Core Standards

Common Core Crosswalk for HVAC

	Units	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10
Common Core Standards											
CCR1		X									
CCR2			X	X	X	X	X				
CCR3			X	X	X						
CCR4		X	X	X	X	X	X				
CCR5		X	X	X	X	X	X				
CCR6			X	X	X	X					
CCR7		X									
CCR8											
CCR9											
CCR10		X	X	X	X	X	X				
CCW1				X	X	X	X				
CCW2			X	X	X	X	X				
CCW3		X									
CCW4							X				
CCW5											
CCW6											
CCW7											
CCW8											
CCW9					X		X				
CCW10				X							
CCSL1		X					X				
CCSL2											
CCSL3		X									
CCSL4											
CCSL5											
CCSL6		X			X		X				
CCL1		X			X		X				
CCL2		X			X						
CCL3											
CCL4		X					X				
CCL5		X		X	X	X	X				
CCL6		X			X						
CCM1			X	X	X	X	X	X			
CCM2			X	X	X	X	X	X			
CCM3			X	X	X	X	X	X			
CCM4			X	X	X	X	X	X			
CCM5			X	X	X	X					
CCM6			X	X	X	X		X			
CCM7			X		X						
CCM8			X		X						
CCM9			X		X						
CCM10			X	X	X	X	X	X			
CCM11			X		X						
CCM12			X		X						
CCM13					X						
CCM14			X		X						
CCM15			X		X						
CCM16			X		X						
CCM17			X		X						
CCM18			X	X	X	X	X	X			
CCM19			X	X	X						
CCM20			X	X	X						
CCM21			X	X	X						

CCM22			X	X	X						
CCM23			X		X						
CCM24			X		X						
CCM25			X		X						
CCM26			X		X						
CCM27			X	X	X						
CCM28			X		X						
CCM29					X						
CCM30			X		X						
CCM31					X						
CCM32			X		X						
CCM33			X		X						
CCM34							X				
CCM35							X				
CCM36					X						
CCM37			X		X						
CCM38					X						
CCM39					X						
CCM40					X						
CCM41					X						
CCM42					X		X				
CCM43					X						
CCM44					X						
CCM45					X						
CCM46					X						
CCM47					X						
CCM48					X						
CCM49					X		X				
CCM50							X				
CCM51					X						
CCM52			X	X	X						
CCM53			X	X	X		X				

English Language Arts (6-12)

College and Career Readiness Anchor Standards for *Reading*

Key Ideas and Details

CCR1: Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

CCR2: Determine central ideas or themes of a text, and analyze their development; summarize the key supporting details and ideas.

CCR3: Analyze how and why individuals, events, and ideas develop and interact over the course of a text.

Craft and Structure

CCR4: Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

CCR5: Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

CCR6: Assess how point of view or purpose shapes the content and style of a text.

Integration of Knowledge and Ideas

CCR7: Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

CCR8: Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

CCR9: Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

Range of Reading and Level of Text Complexity

CCR10: Read and comprehend complex literary and informational texts independently and proficiently. Mathematics (High School)

College and Career Readiness Anchor Standards for *Writing*

Text Types and Purposes

CCW1: Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.

CCW2: Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

CCW3: Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.

Production and Distribution of Writing

CCW4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

CCW5: Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

CCW6: Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

Research to Build and Present Knowledge

CCW7: Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

CCW8: Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

CCW9: Draw evidence from literary or informational texts to support analysis, reflection, and research.

Range of Writing

CCW10: 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.

College and Career Readiness Anchor Standards for *Speaking and Listening*

Comprehension and Collaboration

CCSL1: Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.

CCSL2: Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.

CCSL3: Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric.

Presentation of Knowledge and Ideas

CCSL4: Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.

CCSL5: Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.

CCSL6: Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

College and Career Readiness Anchor Standards for *Language*

Conventions of Standard English

CCL1: Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

CCL2: Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

Knowledge of Language

CCL3: Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening.

Vocabulary Acquisition and Use

CCL4: Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate.

CCL5: Demonstrate understanding of figurative language, word relationships, and nuances in word meanings.

CCL6: Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Mathematics (High School)

Number and Quantity

The Real Number System

CCM1: Extend the properties of exponents to rational exponents.

CCM2: Use properties of rational and irrational numbers.

Quantities

CCM3: Reason quantitatively and use units to solve problems.

The Complex Number System

CCM4: Perform arithmetic operations with complex numbers.

CCM5: Represent complex numbers and their operations on the complex plane.

CCM6: Use complex numbers in polynomial identities and equations.

Vector and Matrix Quantities

CCM7: Represent and model with vector quantities.

CCM8: Perform operations on vectors.

CCM9: Perform operations on matrices and use matrices in applications.

Algebra

Interpret the structure of expressions

CCM10: Write expressions in equivalent forms to solve problems.

Arithmetic with Polynomials and Rational Expressions

CCM11: Perform arithmetic operations on polynomials.

CCM12: Understand the relationship between zeros and factors of polynomials.

CCM13: Use polynomial identities to solve problems.

CCM14: Rewrite rational expressions.

Creating Equations

CCM15: Create equations that describe numbers or relationships.

Reasoning with Equations and Inequalities

CCM16: Understand solving equations as a process of reasoning, and explain the reasoning.

CCM17: Solve equations and inequalities in one variable.

CCM18: Solve systems of equations.

CCM19: Represent and solve equations and inequalities graphically.

Functions

CCM20: Understand the concept of a function and use function notation.

CCM21: Interpret functions that arise in applications in terms of the context.

CCM22: Analyze functions using different representations.

Building Functions

CCM23: Build a function that models a relationship between two quantities.

CCM24: Build new functions from existing functions.

Linear, Quadratic, and Exponential Models

CCM25: Construct and compare linear, quadratic, and exponential models, and solve problems.

CCM26: Interpret expressions for functions in terms of the situation they model.

Trigonometric Functions

CCM27: Extend the domain of trigonometric functions using the unit circle.

CCM28: Model periodic phenomena with trigonometric functions.

CCM29: Prove and apply trigonometric identities.

Geometry

CCM30: Experiment with transformations in the plane.

CCM31: Understand congruence in terms of rigid motions.

CCM32: Prove geometric theorems.

CCM33: Make geometric constructions.

Similarity, Right Triangles, and Trigonometry

CCM34: Understand similarity in terms of similarity transformations.

CCM35: Prove theorems involving similarity.

CCM36: Define trigonometric ratios, and solve problems involving right triangles.

CCM37: Apply trigonometry to general triangles.

Circles

CCM38: Understand and apply theorems about circles.

CCM39: Find arc lengths and areas of sectors of circles.

Expressing Geometric Properties with Equations

CCM40: Translate between the geometric description and the equation for a conic section.

CCM41: Use coordinates to prove simple geometric theorems algebraically.

Geometric Measurement and Dimension

CCM42: Explain volume formulas, and use them to solve problems.

CCM43: Visualize relationships between two-dimensional and three-dimensional objects.

Modeling with Geometry

CCM44: Apply geometric concepts in modeling situations.

Statistics and Probability

CCM45: Summarize, represent, and interpret data on a single count or measurement variable.

CCM46: Summarize, represent, and interpret data on two categorical and quantitative variables.

CCM47: Interpret linear models.

Making Inferences and Justifying Conclusions

CCM48: Understand and evaluate random processes underlying statistical experiments.

CCM49: Make inferences and justify conclusions from sample surveys, experiments, and observational studies.

Conditional Probability and the Rules of Probability

CCM50: Understand independence and conditional probability and use them to interpret data.

CCM51: Use the rules of probability to compute probabilities of compound events in a uniform probability model.

Using Probability to Make Decisions

CCM52: Calculate expected values, and use them to solve problems.

CCM53: Use probability to evaluate outcomes of decisions.

Appendix D: 21st Century Skills[2]

21st Century Crosswalk for HVAC											
	Units	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**	**Unit 6**				
21st Century Standards											
CS1		X		X		X					
CS2		X	X	X	X	X	X				
CS3		X				X					
CS4		X		X	X		X				
CS5		X		X		X					
CS6		X		X		X					
CS7		X	X	X	X	X	X				
CS8		X	X	X	X	X	X				
CS9		X	X	X	X	X	X				
CS10		X	X	X	X	X	X				
CS11				X	X	X	X				
CS12		X	X	X	X	X	X				
CS13		X	X	X	X	X	X				
CS14		X		X	X		X				
CS15				X	X	X	X				
CS16		X	X	X	X	X	X				

CSS1-21st Century Themes

CS1 Global Awareness

1. Using 21st century skills to understand and address global issues
2. Learning from and working collaboratively with individuals representing diverse cultures, religions, and lifestyles in a spirit of mutual respect and open dialogue in personal, work, and community contexts
3. Understanding other nations and cultures, including the use of non-English languages

CS2 Financial, Economic, Business, and Entrepreneurial Literacy

1. Knowing how to make appropriate personal economic choices
2. Understanding the role of the economy in society
3. Using entrepreneurial skills to enhance workplace productivity and career options

CS3 Civic Literacy

1. Participating effectively in civic life through knowing how to stay informed and understanding governmental processes
2. Exercising the rights and obligations of citizenship at local, state, national, and global levels
3. Understanding the local and global implications of civic decisions

CS4 Health Literacy

1. Obtaining, interpreting, and understanding basic health information and services and using such information and services in ways that enhance health
2. Understanding preventive physical and mental health measures, including proper diet, nutrition, exercise, risk avoidance, and stress reduction
3. Using available information to make appropriate health-related decisions
4. Establishing and monitoring personal and family health goals

[2] *21st century skills.* (n.d.). Washington, DC: Partnership for 21st Century Skills.

5. Understanding national and international public health and safety issues

CS5 Environmental Literacy

1. Demonstrate knowledge and understanding of the environment and the circumstances and conditions affecting it, particularly as relates to air, climate, land, food, energy, water, and ecosystems.
2. Demonstrate knowledge and understanding of society's impact on the natural world (e.g., population growth, population development, resource consumption rate, etc.).
3. Investigate and analyze environmental issues, and make accurate conclusions about effective solutions.
4. Take individual and collective action toward addressing environmental challenges (e.g., participating in global actions, designing solutions that inspire action on environmental issues).

CSS2-Learning and Innovation Skills

CS6 Creativity and Innovation

1. Think Creatively
2. Work Creatively with Others
3. Implement Innovations

CS7 Critical Thinking and Problem Solving

1. Reason Effectively
2. Use Systems Thinking
3. Make Judgments and Decisions
4. Solve Problems

CS8 Communication and Collaboration

1. Communicate Clearly
2. Collaborate with Others

CSS3-Information, Media and Technology Skills

CS9 Information Literacy

1. Access and Evaluate Information
2. Use and Manage Information

CS10 Media Literacy

1. Analyze Media
2. Create Media Products

CS11 ICT Literacy

1. Apply Technology Effectively

CSS4-Life and Career Skills

CS12 Flexibility and Adaptability

1. Adapt to change
2. Be Flexible

CS13 Initiative and Self-Direction

1. Manage Goals and Time
2. Work Independently
3. Be Self-directed Learners

CS14 Social and Cross-Cultural Skills

1. Interact Effectively with others
2. Work Effectively in Diverse Teams

CS15 Productivity and Accountability

1. Manage Projects
2. Produce Results

CS16 Leadership and Responsibility

1. Guide and Lead Others
2. Be Responsible to Others

Appendix E: National Educational Technology Standards for Students (NETS-S)

NETS Crosswalk for HVAC											
	Course	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**	**Unit 6**				
NETS Standards											
T1		X	X	X	X	X	X				
T2		X	X	X	X	X	X				
T3		X	X	X	X	X	X				
T4			X	X	X	X	X				
T5			X	X	X	X	X				
T6		X	X	X	X	X	X				

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

T1 Creativity and Innovation
Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students do the following:

a. Apply existing knowledge to generate new ideas, products, or processes.
b. Create original works as a means of personal or group expression.
c. Use models and simulations to explore complex systems and issues.
d. Identify trends and forecast possibilities.

T2 Communication and Collaboration
Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others. Students do the following:

a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media.
b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats.
c. Develop cultural understanding and global awareness by engaging with learners of other cultures.
d. Contribute to project teams to produce original works or solve problems.

T3 Research and Information Fluency

Students apply digital tools to gather, evaluate, and use information. Students do the following:

a. Plan strategies to guide inquiry.
b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks.
d. Process data and report results.

T4 Critical Thinking, Problem Solving, and Decision Making

Students use critical-thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources. Students do the following:

a. Identify and define authentic problems and significant questions for investigation.
b. Plan and manage activities to develop a solution or complete a project.
c. Collect and analyze data to identify solutions and/or make informed decisions.
d. Use multiple processes and diverse perspectives to explore alternative solutions.

T5 Digital Citizenship

Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. Students do the following:

a. Advocate and practice safe, legal, and responsible use of information and technology.
b. Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity.
c. Demonstrate personal responsibility for lifelong learning.
d. Exhibit leadership for digital citizenship.

T6 Technology Operations and Concepts

Students demonstrate a sound understanding of technology concepts, systems, and operations. Students do the following:

a. Understand and use technology systems.
b. Select and use applications effectively and productively.
c. Troubleshoot systems and applications.
d. Transfer current knowledge to learning of new technologies.