2026

CONNECTICUT TECHNICAL EDUCATION AND CAREER SYSTEM

CTECS 9-12 Plumbing & Heating Curriculum ©

CTECS 9TH – 12TH GRADE PLUMBING & HEATING CURRICULUM©

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Connecticut Technical Education and Career System

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CTECS Instructional Model

CTECS uses the Marzano Compendium to guide research-based instructional strategies that differentiate learning and promote access, engagement, and success for all students. Teachers apply these strategies to support diverse learners (including multilingual learners, students with disabilities, and students with varied academic or technical backgrounds) through scaffolds, modeling, guided practice, and multiple ways to participate and show understanding. This approach ensures every student can work toward proficiency in the Priority Standards and the competencies outlined in the CTECS Vision of a Graduate.

Feedback	Content	Context
Providing and Communicating Clear Learning Goals 1. Providing scales and rubrics 2. Tracking student progress 3. Celebrating success **Using Assessments** 4. Using informal assessments of the whole class 5. Using formal assessments of individual students	**Conducting Direct Instruction Lessons** 6. Chunking content 7. Processing content 8. Recording and representing content **Conducting Practicing and Deepening Lessons** 9. Using structured practice sessions 10. Examining similarities and differences 11. Examining errors in reasoning **Conducting Knowledge Application Lessons** 12. Engaging students in cognitively complex tasks 13. Providing resources and guidance 14. Generating and defending claims **Using Strategies That Appear in All Types of Lessons** 15. Previewing strategies 16. Highlighting critical information 17. Reviewing content 18. Revising knowledge 19. Reflecting on learning 20. Assigning purposeful homework 21. Elaborating on information 22. Organizing students to interact	**Using Engagement Strategies** 23. Noticing and reacting when students are not engaged 24. Increasing response rates 25. Using physical movement 26. Maintaining a lively pace 27. Demonstrating intensity and enthusiasm 28. Presenting unusual information 29. Using friendly controversy 30. Using academic games 31. Providing opportunities for students to talk about themselves 32. Motivating and inspiring students **Implementing Rules and Procedures** 33. Establishing rules and procedures 34. Organizing the physical layout of the classroom 35. Demonstrating withitness 36. Acknowledging adherence to rules and procedures 37. Acknowledging lack of adherence to rules and procedures **Building Relationships** 38. Using verbal and nonverbal behaviors that indicate affection for students 39. Understanding students' backgrounds and interests 40. Displaying objectivity and control **Communicating High Expectations** 41. Demonstrating value and respect for reluctant learners 42. Asking in-depth questions of reluctant learners 43. Probing incorrect answers with reluctant learners

CTECS Plumbing & Heating

Curriculum Introduction

This curriculum document outlines the essential learning for this trade program and provides a clear structure for planning, instruction, and assessment. It includes the components required by NEASC Standard 2.2a, along with elements that reflect the unique nature of CTECS technical programs. The curriculum is organized to show what students learn in each course, how learning progresses across grade levels, and how instruction supports both technical skill development and the CTECS Vision of a Graduate.

Teachers should use this document to:

- Understand the overall structure and expectations of the course sequence
- Reference the Course Map to see the scope and sequence of Priority Standards and the alignment to District Summative Assessments (DSAs)
- Use the Priority Standards and Units of Study to guide daily, weekly, and cycle-based planning
- Integrate Big Ideas, Essential Questions, Skills/Learning Outcomes, vocabulary, and resources during lesson design
- Identify required safety, industry, and technical content expectations
- Plan and implement formative assessments to monitor progress and guide instruction
- Prepare students for the District Summative Assessments, ensuring alignment with the Course Map
- Maintain consistency of technical and professional practice instruction across campuses while adapting to student needs and industry-based opportunities

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Curriculum Components

Course Map

A Course Map serves as the scope and sequence for this course by outlining the progression of instructional units and the standards that guide teaching and assessment. While each campus will have individual student needs, cycle schedules, and industry-based opportunities, all instructors are expected to teach the standards outlined in the Course Map. Using the Course Map below, teachers will intentionally plan learning experiences that prepare students to meet the identified standards within the designated assessment windows.

Priority Standards (Units of Study)

Priority Standards identify the most essential learning in the trade program. They reflect the core technical competencies, safety practices, and industry-aligned skills that require the greatest instructional focus and appear on program assessments. In CTE programs, each Priority Standard also functions as a Unit of Study, because it includes the required components such as big ideas, essential questions, content topics, and skills/learning outcomes aligned to assessments.

Vertical Alignment

Vertical alignment shows how Priority Standards and instructional expectations progress from grade to grade within the trade program. It provides a clear pathway of skill development, increasing complexity, and technical proficiency across the four-year sequence.

Learning Outcomes

Learning outcomes are what students will know (Concepts) and be able to do (Skills).

Concepts identify the major content topics within the Priority Standard (Unit of Study). They appear in the left column of the Learning Outcomes table and follow a similar coding structure as the Priority Standard.

Skills are learning objectives that describe the measurable actions students must be able to perform to demonstrate proficiency. They appear in the right column of the Learning Outcomes table and show the progression of learning evidence in the Priority Standard.

Vocabulary

Essential vocabulary includes the technical and academic terms students must understand and use accurately to engage in trade-specific learning and demonstrate proficiency on assessments. Vocabulary is foundational to safety, technical precision, and industry communication, and should be a primary initial focus within each unit and taught explicitly through modeling, demonstration, and repeated application.

Resources

Resources include the tools, equipment, texts, materials, and digital tools that support learning within each unit and reflect industry standards.

Assessment Practices

Teachers use ongoing formative assessments—such as questioning, checks for understanding, performance demonstrations, reflections, and teacher observation—to monitor progress, guide instruction, and support all learners in mastering the Priority Standards.

Each program also includes District Summative Assessments (DSAs), which measure proficiency on the Priority Standards identified in the Course Map. DSAs provide consistent evidence of student learning across campuses and ensure alignment to industry expectations, safety requirements, and program outcomes. Teachers should reference the Course Map and Units of Study when planning instruction to ensure students have opportunities to practice and demonstrate the skills and knowledge assessed on the DSA.

Proficiency Scale Alignment

Mastery by Design: Aligning to Marzano Proficiency Scales

To ensure every student reaches high-level learning, our curriculum utilizes **Marzano-aligned Proficiency Scales** directly embedded within each **Priority Standard**. Rather than a simple "pass/fail" metric, these scales provide a clear, consistent roadmap for growth, moving from foundational knowledge to complex application.

By placing these scales at the point of use within the curriculum, we bridge the gap between planning and instruction.

Why This Alignment Matters

- **Clarity of Expectation:** Teachers and students share a common language for what "Level 3.0" (Target Mastery) looks like versus "Level 4.0" (Exceeding the Standard).
- **Instructional Precision:** With scales linked to specific Priority Standards, you can instantly identify prerequisite skills (Level 2.0) to support struggling learners or provide enrichment for those ready to go beyond.
- **Scaffolded Success at Level 2**: To support foundational understanding, Level 2.0 includes explicitly aligned and tiered vocabulary required for each priority standard, ensuring students have the linguistic building blocks needed for mastery.
- **Data-Driven Feedback:** Grading becomes more objective and transparent, focusing on the evidence of learning rather than points earned.

The 4-Point Structure at a Glance

- 4.0: Exceeding: In-depth inferences and applications that go beyond what was taught.
- 3.0: The Target: Mastery of the specific Priority Standard as defined by the curriculum.
- 2.0: Foundational: Understanding of tiered vocabulary and basic processes related to the standard.
- 1.0: Emerging: Success with help or partial understanding of the 2.0 and 3.0 content.

Integrated for Ease of Access: When you open a Priority Standard in your curriculum docs, the specific success criteria and required vocabulary are right there, ready for your daily lesson plan or assessment design.

A link to the CTECS Proficiency Scales aligned to this curriculum is located below:

CTECS Plumbing & Heating Proficiency Scales

A more comprehensive guide to implementation can be found by clicking on the link below:

VANGUARD Trades PS Implementation Guide

CTECS Plumbing & Heating Math Integration & Competency Crosswalks

To fully illustrate the rigorous mathematical foundations embedded within the ***CTECS Plumbing and Heating*** curriculum, we have developed a comprehensive integration guide. While the priority standards within this document include specific embedded examples of math applications, a more exhaustive resource is available for instructional use. This guide features detailed mathematics competency crosswalks designed to bridge technical skills with academic standards. You can access the complete ***CTECS Plumbing & Heating Math Integration Guide*** on the Licensed Trades website or by clicking the link below:

Embedded Math

- **Point-of-Use Integration**: Each Priority Standard contains specific ***"Trade Math Crossover"*** sections that align mathematical concepts; such as Gas Pipe Sizing, ladder ratios, and DFU Calculations; directly to the technical task at hand.
- **Marzano-Aligned Scales**: Every standard is linked to a Marzano-aligned Proficiency Scale, providing a clear 4-point roadmap from foundational vocabulary (Level 2.0) to target mastery (Level 3.0) and advanced application (Level 4.0).
- **Cross-Over Tables**: Detailed tables in the curriculum and ***appendix*** sections provide a crosswalk between technical skills and apprenticeship standards, ensuring students meet the requirements for CT-DOL related instruction.

Additional Resources

For those seeking more in-depth information, a more comprehensive guide to implementation and the full ***Math Integration Guide*** can be found on the **Licensed Trades website**.

Access the Plumbing & Heating Math Integration Guide

Access the Math/SAT/Code Crossover Guide

CTECS Plumbing & Heating Philosophy

The ***PLUMBING AND HEATING*** course of studies is designed to create an appreciation of the industry and to develop entry-level skills within the ***PLUMBING AND HEATING*** construction trade. Opportunities to develop skills for personal use and to make a successful transition from school to the workplace or post-secondary institutions will be presented to students enrolled in this course.

The ***PLUMBING AND HEATING*** course is designed to provide Level I apprenticeship theory content within the trade. Practical experience will be gained within the school, through outside production experience, and through optional Cooperative Work Experience, employed by a licensed ***PLUMBING AND HEATING*** contractor or wholesale company.

Program Description

Students enrolled in the ***CTECS Plumbing & Heating*** career program will obtain instruction and demonstrate skills and knowledge in construction safety, measuring and blueprint reading, calculations of plumbing & heating systems including; drainage fixture units, water supply fixture units, gas pipe sizing, as well as calculating heat loss for hydronic heating applications. Students in the Plumbing & Heating program receive both on-site and off-campus jobsite learning opportunities. Students are instructed upon the installation and repair of water, waste, gas as well as mechanical systems in both residential homes and commercial buildings.

In addition, students enrolled in the Plumbing & Heating program will also obtain instruction in energy efficiency, environmental, renewable energy, as well as energy conservation practices.

The demand for plumbers and heating technicians is expected to outpace the supply of workers trained in this demanding but rewarding field. This career area is considered to be “In-Demand, Job Growth” Category as per CT-DOL. Plumbing & Heating are both licensed trades that

requires not only highly technical knowledge and skill, but also a thorough understanding of the Connecticut adopted ICC Plumbing and Mechanical Codes.

Students receive up to 720 hours of instruction towards their P-2 and also 576 hours of instruction up to an S-4 apprenticeship upon successful completion of the program. Students may be able to receive 1500 hours towards a career affiliated apprenticeship upon graduation* (*Upon Employer Acceptance)

Students are eligible to participate in Work-Based Learning (WBL) in grades 11 & 12. This program allows companies to hire students during the school day to work as a pre-apprentice in the plumbing & heating industry. Students will receive CT-DOL approved credit for their work experience which is an important pipeline for getting our students into industry.

CTECS Plumbing and Heating Goals

The ***CTECS PLUMBING AND HEATING*** Program will create an awareness of opportunities within the vast trade areas that comprise the Plumbing & Heating Industry. The program incorporates new developments and practices related to Plumbing & Heating in residential and commercial installations.

Program Goals

As a result of education in the PLUMBING AND HEATING Program grades 9-12 Students will know or do:

- Demonstrate safe work habits with hand and portable power tools.
- Demonstrate the ability to work safely by applying the O.S.H.A 1926 Standard.
- Demonstrate knowledge of Blueprint Reading, including building materials and fasteners. Demonstrate ability to apply trade related subjects.
- Demonstrate knowledge of various PLUMBING AND HEATING materials and components.
- Identification and installation of various PLUMBING, HEATING & Solar Thermal equipment and appliances.
- Demonstrate knowledge of residential hydronic heating systems including basic wiring and controls. Demonstrate knowledge of fuel gas systems and venting.
- Apply various building, plumbing and mechanical codes and standards.
- Demonstrate the ability to research and apply the PLUMBING AND HEATING Codes for a safe and acceptable installation.
- Layout and install a complete residential PLUMBING AND HEATING system according to the International Residential Code.
- Demonstrate knowledge of various water supply and systems including backflow protection Demonstrate knowledge of various drain waste, vent, and storm water systems. Apply learned knowledge in the installation of fixture and appliances.
- Be prepared with entry-level job skills.

- Present a Student Competency Checklist that is a purposeful collection of work that documents the student's efforts, progress or achievements in the PLUMBING AND HEATING trade during their four (4) years in the CTECS

Program Standards

- Building Science Principles Certificate
- CT-DOL – Apprenticeship Related Instruction 720 Hours
- First Aid/CPR/AED credentialing
- Fall Protection Certification
- Lockout Tagout Certification
- OSHA – 10, 30 Certification – CFR – 1926
- Roth Oil Tank Certification
- Ladder Safety Certification
- CSST Gas Piping Certification
- Fluke Meter Certification
- PEX Tubing Certification
- Electrical PPE Safety Certification
- Powder Actuated Tools Certification

Program Locations in CT

CTECS Plumbing and Heating:

1. A.I. Prince Technical High School, **Hartford**
2. Bullard-Havens Technical High School, **Bridgeport**
3. E.C. Goodwin Technical High School, **New Britain**
4. Ella T. Grasso Technical High School, **Groton**
5. Eli Whitney Technical High School, **Hamden**
6. H.C. Wilcox Technical High School, **Meriden**
7. Henry Abbott Technical High School, **Danbury**
8. Harvard H. Ellis Technical High School, **Danielson**
9. J.M. Wright Technical High School, **Stamford**
10. Norwich Technical High School, **Norwich**
11. Platt Technical High School, **Milford**
12. W.F. Kaynor Technical High School, **Waterbury**

CT-DOL Program Approval

CONNECTICUT DEPARTMENT OF LABOR

The CTECS Plumbing & Heating Curriculum is fully approved by the CT-DOL Office of Apprenticeship Training.

A CTECS Plumbing & Heating graduate who *successfully completes* the program is entitled to 720 hours of related instruction training* towards a P-2 and up to an S-4 apprenticeship.

(*Contingent upon student receiving OSHA 30 certification)

Curriculum Legend	
Bold	**Powered-Need to know**
Non-Bold	Nice to Know
Green Font	**Green Technology Alignment**
Red Font	**Common Core Technical Standards Alignment**
Blue Font	**Alignment to the CTECS Vision of a Graduate Standards (VOG)**

CTECS Vision of a Graduate

The CTECS Vision of the Graduate: A Roadmap for Instructional Excellence

The ***CTECS Vision of the Graduate (VOG)*** represents the collective voice of our stakeholders, capturing the essential traits, attitudes, and skills our students need to excel both in our classrooms and in their future careers. More than just a list of aspirations, the VOG serves as a framework to help you deliver purposeful, high-quality instruction that prepares every student for the demands of the modern workforce.

How to Use This Document: To help you bridge the gap between curriculum standards and real-world application, we have integrated the VOG directly into your teaching tools:

- **Integrated Standards:** Each Priority Standard within this curriculum has been intentionally aligned with the CTECS VOG. To make these connections easy to identify at a glance, all VOG-aligned standards are denoted in ***blue font*** throughout this document.

- **Teacher Support Tools:** We have developed a comprehensive resource site to support your daily instruction. This hub provides the materials and strategies needed to bring these VOG traits to life in your shop or classroom.

Access your teaching resources here: CTECS Licensed Trades VOG Resource Site

The following page has a pictograph that depicts the six CTECS VOG traits we strive to adhere to:

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CTECS Plumbing & Heating

CTECS VOG 1

CTECS Plumbing & Heating Course Map

Grade 9: Semester 1

- 9-1 Introduce shop and site safety.
- 9-2 Plumbing & Mechanical trades licensing process and procedure.
- 9-3 Basic math skills, sketching and blue print reading necessary in the Plumbing & Heating profession.
- 9-4 The various code books, and reference materials used in residential construction.
- 9-5 The proper use of the basic hand tools used in the Plumbing & Heating industry.
- 9-6 Demonstration of student's proficiency in basic techniques used to join pipe.

Grade 9: Semester 2

- 9-1 Demonstrate Shop Safety & knowledge of site safety
- 9-1a-Working Safely with Solar Hot Water and Pool Heating Systems (Reference NABCEP 1.1,1.3- 1.5, 1.7, 1.8)
- 9-2 Plumbing & Mechanical trades licensing process and procedure.
- 9-3 Basic math skills, sketching and blue print reading necessary in the Plumbing & Heating profession.
- 9-3a Conducting a Solar Thermal Site Assessment. (Reference NABCEP 4.1-4.9)
- 9-4 The various code books, and reference materials used in residential construction.
- 9-5 Demonstrate the proper use of the basic hand tools used in the Plumbing & Heating industry.
- 9-6 Demonstration of student's proficiency in basic techniques used to join pipe.
- 9-6a-Installing Piping, Pipe Insulation and Connecting System Piping as it pertains to Solar Thermal installations. (Reference NABCEP 7.1-7.15)
- **End of Term DSA:** (Please refer to DSA Study Guide for in-depth topics listed on the exam)

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Grade 10: Semester 1

- 10-1 Safety protocol and OSHA
- 10-2 Common piping and installation practices of common piping used in the Plumbing & Heating trades.
- 10-2a- Solar Thermal Piping: (Reference: NABCEP 7.16-7.26)
- 10-3: The relationship between math, science and the Plumbing & Heating trade.
- 10-4: Introduction to Pumping Systems
- 10-5: Introduction to Residential Fixtures, Appliances, and Solar Thermal.
- 10-6: Employer expectations
- 10-7: BPR skills in the Plumbing & Heating trades.
- 10-8 Repair and service of residential Plumbing, Heating & Solar Thermal Systems.
- **End of Term DSA**: (Please refer to DSA Study Guide for in-depth topics listed on the exam)

Grade 10: Semester 2

- 10-1 Demonstrate Shop Safety & knowledge of site safety
- 10-2 Common piping and installation practices of common piping used in the Plumbing & Heating trades.
- 10-2a- Solar Thermal Piping: (Reference: NABCEP 7.16-7.26)
- 10-3: The relationship between math, science and the Plumbing & Heating trade.
- 10-4: Introduction to pumping systems
- 10-4a- Installing Electrical Control Systems as it pertains to Solar Thermal Systems (Reference NABCEP 9.1, 9.2, 9.4-9.8)
- 10-5: Introduction to Residential Fixtures, Appliances, and Solar Thermal.
- 10-5a-Solar Thermal Systems and their components Reference (NABCEP 2.1-2.5)
- 10-5b-Installing Solar Hot Water Heaters and Storage Tanks. (Reference NABCEP 6.1-6.18)
- **End of Term DSA:** (Please refer to DSA Study Guide for in-depth topics listed on the

exam)

Grade 11: Semester 1

- 11- 1 Demonstrate Safety in Construction Environment
- 11-1a-Installing Solar Collectors (Reference NABCEP 5.1-5.13)
- 11-2 Code related theory required to design a Plumbing, Heating & Solar Thermal system, including related math and science.
- 11-2a-Adapting a Solar Thermal System Design (Reference NABCEP 3.1-3.9)
- 11-6 Demonstrate Jobsite protocol, customer and employer expectations
- 11-6a-Customer Expectations as it pertains to Solar Thermal Installations. (Reference NABCEP 11.7-11.13)
- 11-7 Reading and interpreting Plumbing and Heating plans and specifications.
- 11-8 Employer expectations: the ability to find employment in the Plumbing & Heating trade and become a quality employee.
- **End of Term DSA:** (Please refer to DSA Study Guide for in-depth topics listed on the exam)

Grade 11: Semester 2

- 11-1 Demonstrate Safety in Construction Environment
- 11-1a-Installing Solar Collectors (Reference NABCEP 5.1-5.13)
- 11-2 Code related theory required to design a Plumbing, Heating & Solar Thermal system, including related math and science.
- 11-2a-Adapting a Solar Thermal System Design (Reference NABCEP 3.1-3.9)
- 11-3 Installation, design, and layout of a DWV systems.
- 11-4 Theory requirements of the fuel gas code, including the venting of appliances.
- 11-5 Introduction of hydronic heating systems and components of both hot water and steam heating systems.
- 11-6: Delivery and storage of fuel oil in heating systems.

- 11-6a-Customer Expectations as it pertains to Solar Thermal Installations. (Reference NABCEP 11.7-11.13)
- **End of Term DSA:** (Please refer to DSA Study Guide for in-depth topics listed on the exam)

Grade 12: Semester 1

- 12- 1 Jobsite Safety on/off campus and WBL
- 12-1 Reinforce 9th, 10th and 11th grade safety issues and stress job site safety required for students performing production work.
- 12-2 Introduction to mechanical system blueprints.
- 12-3 BPR skills relating to plumbing systems in accordance with the International Plumbing Code
- 12-5 Installation and testing of heating systems and components
- 12-5a-Performing a Solar Thermal System Checkout, Reference: NABCEP 10.1,10.2,11.1-11.6
- **End of Term DSA:** (Please refer to DSA Study Guide for in-depth topics listed on the exam)

Grade 12: Semester 2

- 12- 1 Jobsite Safety on/off campus and WBL
- 12-2 Introduction to mechanical system blueprints.
- 12-4 Reinforce student achievement in a timed/graded activity.
- 12-5 Installation of hydronic heating systems and components.
- 12-5a-Performing a Solar Thermal System Checkout, Reference: NABCEP 10.1,10.2,11.1-11.6
- 12-6 Troubleshooting and testing of hydronic heating systems and components, including safety and operating controls.
- 12-7 Obtaining employment in the Plumbing & Heating Trades.

- 12-8 Construction Management Opportunities in the Plumbing & Heating Trades.
- **End of Term DSA:** (Please refer to DSA Study Guide for in-depth topics listed on the exam)

CONNECTICUT TECHNICAL EDUCATION AND CAREER SYSTEM

Plumbing and Heating

Grade 9

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Grade 9 Curriculum

Priority Standard 9.1 - Shop and site safety.	
Big Idea(s): 1. The ability to earn a living in our trade is based upon safe work practices. Safety needs to be a habit and a consideration throughout daily living as well as in the work environment. 2. Safety is not just a set of rules but a continuous practice required to protect oneself and others in a high-risk environment.	
Essential Question(s): 1. How does practicing safe work habits help guarantee your future in the trade? 2. Why do you think that OSHA training is a requirement in order to be employed in the construction trade?	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1**. Safe Work Habits** ● **Hand tools** ● **Portable power tools** ● **Stationary power tools** ● **Eye safety** ● **Potential work area safety risks** ● **Horseplay** ● **Potential injuries of unsafe work practices** ● **Hearing protection** ● **Proper clothing** ● **Removal of jewelry** ● **Ladders**	● **Scoring 100% on all safety tests or retests.** ● **Model's safe practices:** ● **Collaborates with peers to ensure the safe use of tools and equipment.** ● **Identifies work areas that have potential safety risks.** ● **Discuss possible consequences of talking to a co-worker while using tools or throwing an object.** ● **Proper use of eye safety protection and hearing protection.** ● **Demonstrates the safe handling of hand tools and portable power tools.** ● **Listed safety rules for stationary and portable power tools** ● **Models a strong work ethic (VOG-Work Ready).**
2. Fire and Lockdown Procedures.	● **Students identified locations of fire alarm pull stations, attenuators, and fire extinguishers.** ● **Demonstrates knowledge of evacuation routes and procedures. (VOG- Effective Communicator)**
3. Correct procedure for dealing with an injury.	● Identifies that the cause of the injury is no

• Puncture wounds • **Electric shock** • **Trips and falls** • **Blood borne pathogens** • **Location of nurse's office.**	longer a threat. • **Explain the dangers of coming in contact with the blood of an injured party (Universal Precautions.)** • **Clearly communicated with the instructor(s) all injuries.** • Students identified location of eye wash stations, and power shut-off locations
4. **Appropriate clothing/equipment required to work on a construction site**	• **Wear appropriate clothing including: hard hat, safety glasses, hearing protection, safety shoes, gloves, etc. as required.**
5. **Hazardous** materials handling procedures.	• **Explain purpose and application of SDS Sheets.** • **Analyze a confined space and choose the proper procedures for entry** • **Communicates with instructor to identify proper location of SOS Sheets (VOG- Effective Communicator)**
6. Proper lifting.	• **Explain and demonstrate proper lifting Procedures.**
7. Solar Hot Water and Pool Heating Systems (Reference NABCEP 1.1,1.3- 1.5, 1.7, 1.8)	• Reference NABCEP 1.1,1.3- 1.5, 1.7, 1.8) • Maintain safe work habits and clean, orderly work area • Demonstrate safe and accepted practices for • personnel protection • Demonstrate awareness of safety hazards and how to avoid them • Identify and implement appropriate codes and standards concerning worker safety and public safety • **Identify personnel safety hazards associated with solar thermal installations** • Identify environmental hazards associated with solar thermal installations through demonstrated awareness of pertinent Material Safety Data Sheets and other appropriate documents

[Link to Proficiency Scale]

Tiered Vocab- Plumbing and Heating students build a professional vocabulary, we have broken down the terms into three tiers based on the standard educational model:

- **Tier 1:** Common, everyday words (Basic communication).
- **Tier 2:** High-frequency academic words (Used across various subjects/trades).
- **Tier 3:** Low-frequency, domain-specific technical terms (The "Language of the Trade").

Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Helmet • Warning • Ladder • Fire • Safe	• Hazard • Compliance • Precaution • Regulation • Inspect	• Ampere • PPE (Personal Protective Equipment) • SDS (Safety Data Sheet) • GFCI (Ground Fault Circuit Interrupter) • Lockout/Tagout (LOTO)

Trade Math Crossover: **(VOG- Problem Solver)**

Focus: Ratios, load limits, and safety dimensions.

1. **The 4-to-1 Ladder Ratio:** To ensure a safe climbing angle, a ladder should be placed so that the base is 1 foot away from the wall for every 4 feet of height to the point where the ladder touches the structure. If a plumber needs to reach a pipe located 16 feet up a wall, calculate exactly how many inches the base of the ladder must be placed away from the wall to maintain this safety standard.
2. **Scaffolding Load Calculations:** A piece of scaffolding is rated for a maximum load of 500 lbs. If a 9th-grade student weighs 165 lbs. and their toolkit weighs 42 lbs., how many 20-foot lengths of Schedule 40 steel pipe (weighing approximately 2.17 lbs. per foot) can they safely bring onto the scaffolding before exceeding the safety limit?

Resources to compliment learning-

- OSHA CFR 1926,
- Modern Plumbing Textbook Chapter 1

Crossover to Apprenticeship Standards:

- A0099 Building Trades Safety OSHA 30 for construction certification

VOG Portfolio Collection Examples:

VOG- Critical Thinker

- Students will have the ability to develop a Fire Evacuation plan with proper egress and exits

VOG Trait: Work Ready

- **Example:** A student consistently arrives at the shop with proper PPE (safety glasses, work boots, and appropriate clothing) and performs a "pre-flight" safety check of their workstation and tools without being prompted by the instructor.

VOG Trait: An Effective Communicator

- **Example:** During a simulated lockdown or fire drill, the student clearly and calmly directs peers to the designated evacuation routes and identifies the nearest fire extinguisher and power shut-off locations.

Priority Standard 9.2 - Plumbing and Mechanical trades licensing process and procedure.

Big Idea(s):

1. Only licensed professionals and registered apprentices can legally perform trade work; the plumber's primary role is to "protect the health of the nation".

Essential Question(s):

1. Why do apprentices need to serve a 4-year apprenticeship?
2. Why is it important to adhere to testing requirements for the plumbing and mechanical trades?
3. How do the requirements needed to install Solar Thermal Systems vary by geographical area?
4. **Why is it important to work collaboratively as a member of a team?**

Learning Outcomes

Students will know:	*As evidenced by: (oral, written, or performance)*
1. Licensure Process in the State of Connecticut • **Apprenticeship** • **OJT** • **Related Instruction** • **Classroom Training** • **Testing** • **CEU's** • **Solar Certification**	• **List five job opportunities a student might pursue in our trade.** • Complete a web-based research paper on employment opportunities in the student's geographical area and one other area that appeals to the student. • Identify several trade related job opportunities from a local newspaper and discuss why the student is qualified or not. • **Complete an essay describing why we say "The plumber protects the health of the nation" with supporting evidence.** • Complete a web-based research paper on the steps of the licensing process with regards to hours, record keeping and employee/employer responsibilities. • Develop skills that will initiate motivation for continued learning. (VOG-Work Ready) • Demonstrates basic problem-solving skills
2. Code Identification as it relates to the solar trades. (Reference NABCEP 1.6)	• Identify and implement appropriate codes and standards concerning installation, operation and maintenance of solar thermal

	systems and equipment. (Reference NABCEP 1.6)
3. Customer and employer expectations including the following: • **Teamwork** • **Coming to work on time** • **Problem solving and using new ideas to come up with solutions** • **Problem solving skills** • **Technology to gain access to information**	• Explain the importance of coming to work/school every day on time • Compose an essay on why it's important to be willing to take direction. • Write an essay on importance of coming to work on time • Explain Importance of contributing to a team and ensuring team members do not fail. • Contributes new ideas and works with initiatives • Selects and safely uses technological resources to accomplish work responsibilities in a productive manner. • **Respects organizational structures (VOG- Respectful)**
Link to Proficiency Scale	

Tiered Vocab- Plumbing and Heating students build a professional vocabulary, we have broken down the terms into three tiers based on the standard educational model:

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- **Tier 2:** High-frequency academic words (Used across various subjects/trades).
- **Tier 3:** Low-frequency, domain-specific technical terms (The "Language of the Trade").

Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Rules • Test • Job • Permission • Boss • Paperwork, • Law • Hours	• Compliance • Certification • Credential • Authorization • Supervision • Documentation • Statute • Requirement	• Jurisdiction • Journeyperson Exam Apprenticeship • Permit • Master Plumber • Affidavit of Experience • Code (IPC/IRC/IMC) • OJT (On-the-Job Training)

Trade Math Crossover: **(VOG- Critical Thinker)**

Focus: Time management, apprenticeship hours, and record keeping.

1. **Apprenticeship Progress Tracking:**

   A P-2 Journeyperson license requires 720 hours of "Related Instruction" (classroom time) and 8,000 hours of On-the-Job Training (OJT). If a student completes 180 hours of instruction per school year, what percentage of the total required classroom hours will they have completed by the end of 9th grade?

2. **OJT Accumulation:**

   If an apprentice works 40 hours per week for 50 weeks a year, how many years will it take them to reach the 8,000-hour requirement for their license? Express the answer in both years and total months.

Resources to compliment learning-

- Modern Plumbing Textbook (chapter 32)
- Mathematics for Plumbers and Pipefitters (unit 8)
- CTECS Licensed Trades VOG Resources

Crossover to Apprenticeship Standards:

- A0014 Plumbing Math

VOG Portfolio Collection Examples:

VOG: Work Ready

- Develop a flow chart listing the various stages of the licensure process.

VOG Trait: An Effective Communicator

- **Example:** A student can clearly explain the difference between a P-2 (Journeyperson) and a P-1 (Contractor) license to a peer, including the specific on-the-job training hours and classroom requirements needed for each
- **Example:** The student practices a mock "elevator pitch" to a potential employer, articulately describing how their current CTECS coursework contributes to the 720 hours of related instruction required for their apprenticeship.

VOG Trait: A Critical Thinker

- **Example:** When reviewing the CT-DOL apprenticeship standards, the student analyzes how various certifications—such as **OSHA-10** or **PEX Tubing Certification**—increase their marketability and "value-add" to a future employer.

Priority Standard 9.3 - Basic math skills, sketching and blueprint reading necessary in the Plumbing and Heating professions.	
Big Idea(s): 1. The ability to read blueprints and perform calculations in the Plumbing and Heating industry are crucial to a successful installation. 2. Accuracy in measurements and the ability to interpret blueprints are critical to the success and quality of any installation	
Essential Question(s): 1. When measurements are not accurate, explain what you think can happen to the quality of the work? 2. What effect would the inability to properly read a blueprint have on the finished product of a building? 3. How does math impact the Plumbing and Heating trade on a daily basis?	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1. Basic math skills	• Review fractions, mixed numbers, decimals, using appropriate teacher/ text developed questions/examples. • Develop a grasp of linear measurement as it relates to trade math. (End to center, center to center, pitch etc.) • Review squares and square roots, cubes and cube roots, liquid measure and offsets. • Apply unbiased analysis and evaluation to mathematically solve necessary calculations for pipe layout. (VOG)
2. Sketching/blueprint reading skills required in every day trade practice.	• Practice sketching plumbing installations using single line drawings. • **Identify fixtures, fittings, piping, valves, etc. from single line, detailed drawings and blueprints.** • **Extract important information from rough-in sheets and single line drawings.**

3. Solar Thermal Site Assessment. (Reference NABCEP 4.1-4.9)	• Conducting a Solar Thermal Site Assessment. (Reference NABCEP 4.1-4.9) • Assess the required installation area, orientation, and tilt for proposed collector installation. • Establish whether there is suitable installation area • with unobstructed solar access for installing collector • Investigate the extent of current and future shading for any proposed collector location using typical sun path calculators or similar methods • Assure structural integrity and suitability of collector site. Test soil conditions and integrity for footing design and pipe path. (Local codes or site conditions might then require involving an engineer). • Determine suitable location for installing all subsystem components (This includes piping, water heater, valves, and ancillary equipment required for complete system installation.) • Practice all personnel safety requirements • Identify any other constraints and options for the installation related to local and state code requirements • Verify that system to be installed is appropriate for the building and climate • Verify with the homeowner the proposed location of the collector and other major components • **Actively listens to homeowners, business owners and fellow employees to successfully install a solar thermal system. (VOG-Communicator)**
Link to Proficiency Scale	
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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
Tier 1 (Everyday): ● Math ● Map ● Total ● Width ● Fraction	Tier 2 (Academic): ● Calculate ● Scale ● Proportion ● Dimension ● Accuracy	Tier 3 (Technical/Trade): ● Offset ● Isometric Drawing ● Center-to-Center (C-C) ● Rough-in ● O.D. vs. I.D. (Outside vs. Inside Diameter)

Trade Math Crossover: **(VOG- Critical Thinker)**

Focus: Pipe offsets, measurements, and fractions.

1. **45-Degree Pipe Offsets:**

   Using the standard 1.414 multiplier for a 45-degree offset: If two parallel pipes need to be connected with an offset that has a "rise" (center-to-center distance) of 10 inches, calculate the "travel" (the diagonal length of the pipe).

2. **Fitting Allowance & Cut Lengths:**

   A plumber is measuring for a "Center-to-Center" (C-C) distance of 24 inches between two 90-degree elbows. If the "fitting allowance" (the distance from the center of the fitting to the end of the pipe inside the hub) for each elbow is 1 ¼ inches, calculate the exact length the pipe needs to be cut.

3. **Fractional Subtraction:**

   A blueprint shows a total wall length of 12 3/8 feet. A vanity takes up 3 ¾ feet and a toilet requires a 1 ½ foot clearance. Calculate the remaining space on the wall in inches.

Resources to compliment learning-

- Modern Plumbing Textbook (chapter 4)
- Mathematics for Plumbers and Pipefitters (unit 19)
- Print Reading for Construction

Crossover to Apprenticeship Standards:

- A0014 Plumbing Math

VOG Portfolio Collection Examples:

VOG-Critical Thinker

- **Example:** Students will create a rubric for setting a water closet and evaluate classmate's installation practices. Applies unbiased analysis and evaluation.

VOG Trait: A Critical Thinker

- **Example:** When given a residential floor plan, the student accurately calculates the total linear footage of pipe required and identifies potential "conflicts" where plumbing lines might interfere with structural beams or electrical runs shown on the print

VOG Trait: A Problem Solver

- **Example:** A student uses a Solar Thermal Site Assessment tool to determine the optimal placement for a collector, factoring in shading from nearby trees and roof orientation to maximize energy efficiency.

Priority Standard 9.4 - Plumbing & Mechanical codes	
Big Idea(s): 1. Code books govern the minimum requirements of the plumbing and heating trade necessary to protect the health of the nation. 2. Codes and reference materials are the "law" of the trade, ensuring systems are safe and functional for residential use.	
Essential Question(s): 1. How can plumbing and mechanical codes guide decision-making during installation and inspection?	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1. Codes and practices ● ADA ● IPC ● IMC ● IRC ● IBC ● IFGC ● IECC ● NFPA ● NABCEP	● Identify the various codebooks, governing bodies and accepted practices the beginning plumber should follow. ● Define key terms a plumber uses in by trade. ● Explain where to find answers and information he/she will require as a plumber. Codebooks, websites etc. ● List the international codes their applications ● Possess the knowledge and skills for industry areas. (VOG: Work Ready)
2. Materials and various piping arrangements ● Threading ● Soldering ● Solvent cementing ● Copper ● Steel ● Plastics ● PEX ● Fusion	● List, discuss and identify various materials a plumber would use in the scope of his or her duties ● Practice proper piping arrangements and testing procedures a plumber might use in the scope of his duties. Project sheets/mockups/shop floor. ● Practices outside of the box thinking.

	{VOG: A Problem Solver)

Link to Proficiency Scale

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Rules • Safety • Space • Size • Air • Slant • Overlap • Check	• Standard • Mandatory • Clearance • Capacity • Ventilation • Gradient • Conflict • Inspection	• International Plumbing Code (IPC) • Minimum Requirements • Rough-in Dimensions • Fixture Unit (DFU/WSFU) • Back-Vent / Circuit Vent • Pitch / Slope • Cross-Connection • Hydrostatic Test

Trade Math Crossover: **(VOG- Critical Thinker)**

Focus: Code-required clearances and area calculations.

1. **Fixture Clearance Math:**

   According to code, a standard water closet (toilet) requires a minimum of 15 inches of clearance from its center to any side wall. If a bathroom is 65 inches wide and a plumber wants to center the toilet exactly in the middle of that space, how many inches will there be from the center of the toilet to each side wall? Is this installation code-compliant?

2. **Drainage Grade (Pitch):**

Code requires horizontal drainage piping to be pitched at ¼ inch per foot to ensure proper flow. If a waste line must run 18 feet from a sink to the main stack, calculate the total "drop" (vertical change in height) required for the pipe run.

Resources to compliment learning-

- Modern Plumbing Textbook (chapter 4)
- Mathematics for Plumbers and Pipefitters (unit 19)
- International Plumbing Code Book
- www.UPCODES.com

Crossover to Apprenticeship Standards:

- A0711 Plumbing Code 1
- A0741 Plumbing Code 2

VOG Portfolio Collection Examples:

VOG-Critical Thinker

- Students will have the ability to recite dimensions required by the IPC to properly rough in a ½ bath. Makes rational decisions based on application of evidence and observation.

Priority Standard 9.5 - The proper use of the basic hand tools used In the Plumbing & Heating Industry.

Big Idea(s):

1. Proper tool selection and maintenance are foundational to mechanical craftsmanship

Essential Question(s):

1. How does purchasing the proper hand tools affect your daily performance?
2. How does proper maintenance of tools promote safety?

Learning Outcomes

Students will know:	*As evidenced by: (oral, written, or performance)*
1. Hand tools • Hammers • Wrenches • Screwdrivers • Threaders • Pipe cutters • Saws • Pliers • Care for tools/store tools	• Model hand tool demonstration and practice proper user techniques of various hand tools. • Demonstrate safe and proper use of required tools and equipment used in the solar trades, (Reference NABCEP 1.2) • List sources for the purchase of hand tools. • Explain the need for purchasing "trade quality" tools. • Demonstrate ways in which we should care for tools/store Tools • Possesses the knowledge and skills for industry area. {VOG: Work Ready)

Link to Proficiency Scale

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Wrench • Saw • Pliers • Tape Measure • Air • Slant • Overlap • Check	• Manual • Precision • Versatile • Calibration • Ventilation • Gradient • Conflict • Inspection	• Basin Wrench • Tubing Cutter • Reamer • Torque Wrench • Back-Vent / Circuit Vent • Pitch / Slope • Cross-Connection • Hydrostatic Test

Trade Math Crossover: **(VOG: Critical Thinker)**

1. Leverage and Torque (The Pipe Wrench)

A pipe wrench is a second-class lever. Torque is calculated by multiplying the force applied by the distance from the pivot point (Torque = Force times Distance).

- **The Scenario:** A student is trying to loosen a stubborn 2-inch galvanized pipe nipple. They apply 40 lbs. of force to the end of a 14-inch pipe wrench.
- **The Math:** Calculate the torque in foot-pounds. (Hint: Convert 14 inches to feet first: 14 / 12 = 1.17 \ ft).
- **The Challenge:** If the pipe requires 60 foot-pounds of torque to break loose, how much force (lbs.) must the student apply to the same 14-inch wrench to succeed?

2. Precision Cutting and Kerf (The Hacksaw)

When cutting a pipe with a hacksaw, the blade removes a small amount of material called the "kerf."

- **The Scenario:** A student needs four exact 6-inch pieces of brass tubing. The hacksaw blade has a kerf (thickness) of 1/16 of an inch.
- **The Math:** If the student makes four cuts to get their four pieces, what is the total length of material "lost" to the saw blade?
- **The Precision Check:** If the student starts with a 24-inch piece of tubing and makes three cuts to get four pieces, will the final piece be exactly 6 inches long? Why or why not?

3. The Geometry of the Tubing Cutter

A tubing cutter must travel in a perfect circle around the pipe to avoid "threading" (spiraling).

- **The Scenario:** A student is cutting a piece of 1/2-inch Type L copper pipe. The outside diameter (OD) of the pipe is exactly 0.625 inches.
- **The Math:** Calculate the circumference of the pipe (C = π times d). This is the distance the cutting wheel travels in one complete revolution.
- **The Depth Challenge:** If the wall thickness of the pipe is 0.040 inches and each turn of the cutter handle sinks the blade 0.005 inches deeper, how many full revolutions around the pipe are required to cut completely through the wall?

4. Leveling and Slope (The Torpedo Level)

Plumbing tools are used to create "pitch" for drainage. A standard torpedo level has lines to indicate 1/8" and 1/4" slope.

- **The Scenario:** A student is using a level to install a 4-foot section of PVC pipe. The code requires a slope of 1/4 inch per foot.
- **The Math:** Calculate the total "drop" (the difference in height between the start and end of the pipe) for this 4-foot run.
- **The Verification:** If the student places the level on the pipe and the bubble is exactly halfway between the center and the 1/4" mark, what is the actual slope per foot?

5.Focus: Pipe Sizing (I.D. & O.D.)

Example: If you have a piece of 1" copper pipe, what is the inside diameter and the outside diameter of the pipe? What is the thickness of the pipe wall?

Resources to compliment learning-

- Modern Plumbing Textbook (chapter 2 and 4)

Crossover to Apprenticeship Standards:

- A0700 Introduction to Plumbing

VOG Portfolio Collection Examples:

VOG-Critical Thinker

- Applies unbiased analysis and evaluation.

VOG Trait: Work Ready

- **Example:** After completing a task, the student cleans, services, and returns all hand tools (such as pipe wrenches, cutters, and reamers) to their designated shop area, demonstrating the organizational skills and tool maintenance expected by a professional employer.

Priority Standard 9.6 - Demonstration of student's proficiency in basic techniques used to join pipe.

Big Idea(s):

1. Piping systems are expected to last for decades, proper connections are essential for proper system operation and longevity
2. Proficiency in joining various types of pipes (copper, PVC, etc.) is the core physical skill of the plumbing trade.

Essential Question(s):

1. Why is it essential to use the correct assembly methods for a given material?

Learning Outcomes

Students will know:	*As evidenced by: (oral, written, or performance)*
1. Pipe joining methods: steel pipe, copper tubing and plastics. ● Soldering ● Flaring ● Compression ● Threading ● Solvent cementing ● Mechanical	Demonstrate those skills that define proper techniques for joining materials. ● Identify schedules/types and lengths that pipes/tubing are available in. ● **Demonstrates a strong work ethic. (VOG: Work Ready.)**
2. Cast iron pipe by incorporating clamping/bell and spigot techniques that plumbers use in their daily tasks. ● no-hub pipe ● bell and spigot	● Identify the different types of cast iron soil pipe. ● Demonstrate clamping/bell and spigot techniques. ● Explain different methods of joining cast iron soil pipe. ● Complete teacher designed instruments for feedback on learning skills. (Questions, quizzes, tests,) ● **Innovates new styles and techniques for joining piping materials (VOG: A Critical Thinker)**

2. Piping, Pipe Insulation and Connecting System Piping as it pertains to Solar Thermal installations. (Reference NABCEP 7.1-7.15) • Copper Tube Installation • Plastic Piping Installation • Insulation Techniques • CSST Installation	• (Reference NABCEP 7.1-7.15) • Analyze the extent of, and make allowances for expansion of pipe and its effect on hangers and the integrity of the pipe. • Determine type, length, and diameter of copper piping required • Cut copper pipe to desired length • Solder copper piping connections • Test soldering fittings for leaks • Select the type, length, and diameter of plastic piping required • Cut plastic pipe to desired length • Glue plastic piping connections • Test glued fittings for leaks • Choose the type, diameter, and length of insulation required • Cut insulation and install over piping and plumbing fittings • Miter insulation ends, where appropriate • Glue and seal insulation joints, as required • Select ultraviolet radiation protective method • Protect insulation from ultraviolet degradation • Determine type, length, and diameter of CSST • piping required • Cut CSST pipe to desired length

	• Join CSST piping connections • Test CSST Tubing & fittings for leaks
3. Troubleshoots and determines problems found within a solar heating system.	• **Able to determine the root cause of issues. (VOG: A Problem Solver)**

Link to Proficiency Scale

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Glue • Pipe • Metal • Joint	• Adhesion • Component • Durability • Assembly	• Solvent Weld • PEX (Cross-linked Polyethylene) • Flux • Fitting (Ells, Tees, Couplings)

3.

Resources to compliment learning-
- Modern Plumbing Textbook (chapter 9)
- International Plumbing

Crossover to Apprenticeship Standards:
- A0700 Introduction to Plumbing

VOG Portfolio Collection Examples:

VOG- Work Ready

- Students will create a 10-step set up plan for an acetylene "B" Tank and torch

VOG Trait: A Problem Solver

- **Example:** After a pressure test on a newly joined copper line reveals a pinhole leak, the student analyzes the joint, identifies if the cause was improper fluxing or insufficient heat, and successfully executes a repair.

CONNECTICUT TECHNICAL EDUCATION AND CAREER SYSTEM

Plumbing and Heating

Grade 10

Grade 10 Curriculum

Priority Standard 10.1 - Safety protocols and OSHA regulations.	
Big Idea(s): 1. Your future depends on your health and well-being.	
Essential Question(s): How can little accidents cause catastrophic problems?	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1**. Safety practices** ● **Ladder Safety** ● **Hand and Power tool Safety** ● **Stationary Tool Safety**	● **Score 100% proficiency on all safety tests or retests.** ● **Demonstrate safe practices while using tools and power tools.** ● **Wear proper safety apparatus while in shop area.** ● **Recite fire safety procedures** ● **Identify potential safety risks associated with hazardous equipment.** ● **Explain ladder and scaffold safety precautions.** ● **Explain & demonstrate proper ladder setup and climbing techniques.** ● **Explain & Demonstrate knowledge of emergency cut-offs.** ● **Explain & demonstrate to others the knowledge of** ● **Lock Down, Secure the Building and Fire Escape Routes** ● **(VOG- An Effective Communicator)**
2. **Ground Fault Circuit Interrupters**.	● Explain & **demonstrate where and why GFCI are required and correct procedure for testing of GFCI.**

	• Explain & **demonstrate use of GFCI protected cords.**
3. Proper material handling	• **Correctly lift objects off the floor.** • Explain why it is necessary to use safety precautions while lifting
4. **O.S.H.A, and S.D.S.**	• **Explain why we have S.D.S sheets and be able to locate upon request.** • Created an essay on OSHA & SDS • **Explain what O.S.H.A. responsibilities are, and explain why they are important.** • **Interpret S.D.S. sheets.**
5.**Safety guidelines personal health**	• **Explain necessity for following safety protocol, while also managing personal health.**
6.Jobsite safety procedures	• **Clearly and concisely conveys information. (VOG: An Effective Communicator, Skilled Socially))**
Link to Proficiency Scale 9-1	

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Danger • Rules • Cleanup • Breathing • Falling • Electricity • Dirt Hole	• Hazardous • Mandatory • Mitigation • Respiratory • Elevation • Conductivity • Excavation	• OSHA 1926 (Construction Standards) • Housekeeping / Containment • SCBA / N95 Rating • Fall Arrest System / PFAS • Arc Flash / Grounding

• Chemicals	• Toxicity	• Trench Shoring / Sloping • HCS (Hazard Communication Standard)

Trade Math Crossover: **(VOG- Problem Solver)**

Focus: Load calculations and safety thresholds.

1. **OSHA Trenching Safety:** OSHA requires that any trench 5 feet or deeper must have a protective system (shoring, shielding, or sloping). If a plumber is excavating for a new sewer line that must drop 1/4 inch per foot, and the starting depth is 48 inches at the house, calculate the exact distance (in feet) the pipe can run before the trench reaches the 60-inch (5-foot) "safety threshold" requiring a trench box.
2. **Fall Protection Math:** A personal fall arrest system must be rigged so that a worker can neither free fall more than 6 feet nor contact any lower level. If a student is working on a platform 18 feet high using a 6-foot lanyard and a deceleration device that expands 3.5 feet, calculate the total "fall clearance" required (including a 3-foot safety factor). Does the 18-foot height provide enough clearance?
3. **Angle of Repose:** If you have an excavation of 15 feet in depth, a bottom width of 5 feet, type A soil, and an Angle of Repose of ¾:1 ratio, Determine the width at the top of the trench.

Resources to compliment learning-
- OSHA CFR 1926,
- Modern Plumbing Textbook Chapter 1

Crossover to Apprenticeship Standards:
- A0099 Building Trades Safety OSHA 30 for construction certification

VOG Portfolio Collection Examples:
VOG- Critical Thinker

CTECS Plumbing & Heating

- **Students will develop a basic shop safety plan for daily safety expectations and routines.**

Priority Standard 10.2 - Proper installation practices of common piping systems	
Big Idea(s): 1. Modern Plumbing & Heating systems must be designed and installed properly to ensure longevity.	
Essential Question(s): How do installation practices impact the performance of modern Plumbing & Heating systems? What factors do you need to know to insure a high-quality piping installation?	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1. Copper Tube ● **Types (identified as colors)** ● Lengths ● Drawn, Annealed ● Uses ● **Joining methods (Including Minimum Testing Requirements)** ● Wrought and cast (fittings) ● **Hanger types and spacing** ● Advantages and disadvantages	● **Demonstrates knowledge of copper tubing types and uses**
2. Steel Pipe ● **Schedule** ● Galvanize ● **Joining methods (including Minimum Testing Requirements)** ● **Fittings** ● **Hanger types and spacing** ● Malleable and cast iron ● Roll grooved flange type ● Advantages and disadvantages	● **Demonstrates knowledge of steel piping types and uses.**
3. Plastic Pipe ● **Schedules, types** ● **Joining methods (including Minimum Testing Requirements)** ● **Fittings**	● **Demonstrates knowledge of plastic types of piping materials.**

• **Hanger types and spacing** • Advantages and disadvantages	
4. Cast Iron Pipe • **Types** • Lengths • **Joining methods (including minimum testing requirements)** • **Fittings** • **Hanger types and spacing** • Advantages and disadvantaged	• **Demonstrates knowledge of cast iron piping types and uses.**
4. Fitting Allowance Calculations	• Demonstrates Face-to-Face, Center-to-Center, and other various fitting calculations. • **Practices creative outside the box thinking- (VOG- A problem Solver)**
5. Solar Thermal Piping: (Reference: NABCEP 7.16-7.26) • Flashing • Penetrations • Sealants • Slope Strategy • Hangers • Standoffs • Connection • Underground Piping Methods • Connection of components	• (Reference: NABCEP7.16-7.26) • Determine type of pipe flashing to use for specific roof type • Determine the area where pipe flashing will be installed • Make roof penetrations • Install pipe flashing and sealant • Determine slope strategy of piping to avoid traps on horizontal runs • Slope piping to avoid traps in horizontal pipe runs • Attach pipe hangers and supports • Install stand-off hangers beneath piping on roof if needed • Connect all system piping to the water heater tank, collector, valves, pumps, etc. • Determine underground piping method • Install underground piping
Link to Proficiency Scale	
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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Straight • Hang • Space • Expansion • Rubbing • Digging • Tight • Passing through	• Vertical / Horizontal • Suspension • Interval • Thermal Movement • Abrasion • Excavation • Compression • Penetration	• Plumb and Level • Clevis Hanger / Split Ring • Support Spacing (per Foot) • Expansion Loop / Offset • Dielectric Union / Isolator • Bedding and Backfilling • Torque Specifications • Firestopping / Sleeving

Trade Math Crossover: **(VOG- Critical Thinker)**

Focus: Fitting allowances and material efficiency.

1. **PVC Fitting Allowance:** You are installing a 2-inch PVC drain line. The center-to-center (C-C) measurement between two 90-degree elbows is 18 inches. If the fitting allowance (the distance from the center of the 90-degree elbow to the internal stop of the hub) is 2 3/16 inches for each fitting, calculate the precise "cut length" of the pipe needed to ensure a tight fit.
2. **Steel Pipe Threading:** When working with 1-inch threaded steel pipe, the "thread engagement" (the distance the pipe screws into the fitting) is approximately 11/16 of an inch. If you need a face-to-face finished length of 32 inches between two threaded tees, how long must your piece of pipe be before threading?
3. **Fitting Allowance**: If you have two 2" PVC 90-degree elbows with a face-to-face measurement of 12 inches, what would be the measurement for the cut piece of pipe needed?

Resources to compliment learning-

- Modern Plumbing Textbook (chapter 4)
- Mathematics for Plumbers and Pipefitters (unit 8)

Crossover to Apprenticeship Standards:

- A0014 Plumbing Math

VOG Portfolio Collection Examples:

VOG- Problem Solver

- Students will calculate pipe travel using fitting allowance charts from various fitting manufacturers.

VOG Trait: A Problem Solver

- **Example:** When installing a drainage run, a student encounters a structural obstacle not shown on the original plan. They apply "outside the box thinking" to recalculate the fitting allowance and adjust the pipe's path while maintaining the required 1/4" per foot slope.

VOG Trait: A Critical Thinker

- **Example:** Before making a cut, a student calculates the "Face-to-Face" and "Center-to-Center" measurements for a 2" PVC assembly, verifying their math against the physical fittings to ensure a leak-proof, high-quality installation.

Priority Standard 10.3 - Plumbing Math and Science.	
Big Idea(s): 1. Plumbing & Heating systems rely on design calculations based on math and science to function properly.	
Essential Question(s): 1. What are some ways that math and science are used in the Plumbing & Heating trade?	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1. Related math: ● **scale** ● **rulers** ● **decimal** ● **fractions** ● **decimals to fraction, fraction to decimals** ● **circles** ● **angles** ● **percentage** ● **Convert inches to feet, feet to inches** ● **Calculate mixed numbers** ● **Calculate offsets.** ● **Calculate area (Circle, square footage)** ● **Water pressure, Volume.**	● **Explain and demonstrate trade related math and science.** ● **Demonstrates knowledge of converting inches to feet and feet to inches:** ● **Calculating mixed numbers to add total lengths of piping** ● **Calculating maximum quantity of pipes that can be cut from a master length.** ● **Calculating offsets.** ● **Calculated area of a circle, square footage, volume, and water pressure.** ● **Applies unbiased analysis and evaluation (VOG-A Critical Thinker)**
2. Properties of: ● Waste products. ● Water and its sources. ● **Various gases.** ● Waste disposal. ● **Trap seal loss, ex: siphonage, aspiration, momentum, back pressure, evaporation & capillary action.**	● Demonstrates knowledge of trade related science. ● Demonstrates knowledge of dangers of waste products. ● Explains properties of water and its sources. ● Designated properties of various gasses. ● Described methods of waste disposal. ● **Demonstrates Trap seal loss, ex: siphonage, aspiration, momentum, back pressure, evaporation & capillary action.**

[Link to Proficiency Scale]

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Weight • Push • Falling Water • Taking up Space • Diagonal • Expanding • Sucking • Turning	• Mass / Density • Force / Resistance • Elevation Loss • Volume • Hypotenuse • Thermal Expansion • Vacuum • Mechanical Advantage	• Specific Gravity • PSI (Pounds per Square Inch) • Head Pressure • Cubic Capacities • Travel / Offset • Coefficient of Expansion • Siphonage / Backflow • Torque / Leverage

Trade Math Crossover: **(VOG- Critical Thinker)**

Focus: Pressure, head, and volume.

1. **Hydrostatic Pressure Calculations:** Water exerts a pressure of 0.433 psi for every foot of vertical "head" (height). If a building has a roof-mounted water storage tank 80 feet above the ground floor, calculate the static water pressure (psi) available at a faucet on the first floor.
2. **Volume and Weight:** A 40-gallon water heater is being installed on a second-floor shelf. If water weighs 8.34 lbs. per gallon and the empty water heater weighs 95 lbs., calculate the total weight the shelf must support when the tank is full.
3. **Expansion Calculations:** Copper pipe expands at a rate of 1.1 inches per 100 feet for every 100-degree Fahrenheit rise in temperature. If a hot water main is 60 feet long and the water temperature increases from 50°F to 150°F, calculate the total linear expansion in inches.
4. **Area/Volume**: If you have a water heater with no identification on it and is 24 inches in diameter

and 50 inches tall, calculate the capacity of the water heater.
Resources to compliment learning- ● Modern Plumbing Textbook (chapter 4) ● Mathematics for Plumbers and Pipefitters (unit 19)
Crossover to Apprenticeship Standards: ● A0014 Plumbing Math
VOG Portfolio Collection Examples: **VOG- Problem Solver** ● **Students will determine the size of a water heater that has no markings to install the proper size.**

Priority Standard 10.4 - Introduction to Pumping Systems.

Big Idea(s):

1. Fluids can be manipulated by several types of pumping systems.
2. Pumping systems are essential for the efficient movement of fluids in modern residential and commercial settings.

Essential Question(s):

How can we transfer fluids to make them work to our advantage? {VOG- A Critical Thinker)

Learning Outcomes

Students will know:	*As evidenced by: (oral, written, or performance)*
1. Pump types: ● **Well pumping systems (One pipe jet pump, two pipe jet pump, Submersible pump)** ● **Constant Pressure Systems** ● Booster pump ● **Sewage pump** ● **Dewatering pump (sump).** ● Transfer pumps ● **Oil Burner pumps, single and dual stage** ● Solar Thermal Circulating Pumps (Reference NABCEP 8.6, 8.7, 9.3)	● Knowledge of proper use and physical differences of various pumping systems. ● Describe the use of the following: one and two pipe jet pump, submersible pump, booster pump, sewage pump, dewatering pump. ● **Demonstrate installation practices for constant pressure well systems. (VOG- Work Ready: Possess knowledge and skills for industry area)** ● Describe the proper equipment necessary for each well application (tanks, accessories, etc.). ● Size pump equipment and accessories based on manufacturers specifications for specific applications. ● (Reference NABCEP 8.6, 8.7, 9.3) Determine pump location for solar thermal installations ● Install the solar thermal pump according to the manufacturer's installation manual

	• Install photovoltaic module controller and pump
2. Types of wells and Well Equipment • Types of wells • Tanks • Pump switches • Pump accessories	• Differentiate types of wells and methods of digging and drilling. • Describe how well sources are located. • Determine the GPH of a well • Demonstrate how to calculate well recovery and drawdown • Demonstrate knowledge of pump controls.
3.Types of well pumps • Jet • Submersible • Sewage pumps	• **Identify physical differences between jet, submersible, and sewage pumps and equipment.**
4. Electrical testing instruments. • Electrical Control Systems as it pertains to Solar Thermal Systems (Reference NABCEP 9.1, 9.2, 9.4, 9.8)	• **Demonstrate knowledge of basic electricity.** • (Reference NABCEP 9.1, 9.2, 9.4-9.8) • Determine the location of the controller • Install differential controller and sensors • Install a timer controller • Install control wiring • Select ultraviolet radiation protective method for external wiring • Protect external wiring from ultraviolet degradation • Test operation of controller
5. Water Supply Systems • Design methods • Pipe sizing • Water Treatment • Installation Methods • Supply piping testing procedures	• **Classify the different styles of water supply systems** • **Size a residential water distribution system** • **Explain different types of water filtration and treatment systems** • **Layout and design of a residential water distribution system**

[Link to Proficiency Scale]

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Pump • Suction • Spinning Part • Back-up • Pushing Power • One-way Valve • Float • Air Lock	• Circulation • Intake / Vacuum • Component • Redundancy • Efficiency • Prevention • Activation • Obstruction	• Centrifugal Pump • NPSH (Net Positive Suction Head) • Impeller • Duplex System • Total Dynamic Head (TDH) • Check Valve / Backwater Valve • Mechanical Float Switch • Cavitation

Trade Math Crossover:

Focus: Pump curves, flow rates, and head pressure.

1. **Reading a Pump Curve:** A circulator pump must move water through a secondary heating loop that has a calculated "Total Dynamic Head" (resistance) of 12 feet. Using a manufacturer's pump curve (Performance Map), if the pump is set to Speed 2 and provides 8 Gallons Per Minute (GPM) at 10 feet of head, but only 4 GPM at 14 feet of head, use linear interpolation to estimate the GPM the pump will deliver at exactly 12 feet of head.
2. **Sizing a Sump Pump:** A basement sump pit is 24 inches in diameter and 30 inches deep. To prevent flooding during a storm, the pump must be able to empty the pit in 90 seconds.

- **Step A:** Calculate the volume of the pit in cubic inches ($V = \pi r^2 h$).
- **Step B:** Convert that volume to gallons (231 cubic inches = 1 gallon).
- **Step C:** Determine the minimum GPM rating the pump must have to meet the 90-second requirement.

3. **Static Head vs. Total Head:** A pump is lifting water from a storage tank in the basement to a fixture on the third floor, a vertical distance of 32 feet. If the friction loss in the pipes adds an additional 5 feet of "resistance head," calculate the total pressure in PSI the pump must generate to just break even (1 foot of head = 0.433 PSI)
4. **Volume/Pressure:** Example: If you have a well line that is 100 feet in length,1inch in diameter and is full of water, calculate the head pressure for that line.

Resources to compliment learning-

- Modern Plumbing Textbook (chapter 4 & 11)
- Mathematics for Plumbers and Pipefitters (unit 47)
- International Plumbing Code Book (section 6)
- www.pumps.org

Crossover to Apprenticeship Standards:

- A0014 Plumbing Math
- A0750 Wells Pumps and Piping 1
- A0751 Wells Pumps and Piping 2

VOG Portfolio Collection Examples:

VOG- Work Ready

- **Students will determine well capacities and fixture demands to properly size a well pump.**

Priority Standard 10.5 - Residential Fixtures, Appliances, and Solar Thermal.	
Big Idea(s): 1. Standard and ADA layouts have very different rules for health and accessibility 2. Fixtures and Appliances contribute to our health and wellbeing in everyday life	
Essential Question(s): 1. **How do plumbing fixtures and appliances impact our daily lives? (VOG-A Critical Thinker)**	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1. Fixtures ● Types of fixtures and designs ● ADA Compliant ● Standard	● **Demonstrated knowledge and application of fixtures and appliances including water heaters.** ● **Explain where and why fixtures are required.** ● Explain & demonstrate correct procedure for testing of fixtures and appliances ● Installation Methods
2. Appliances ● Water heaters ● Boilers ● clearance codes ● Water conservation ● Safety valves & Controls	● Identify and Install Appliances ● Apply Applicable code regulations ● Apply minimum fixture installation clearances ● **Describe importance of safety valves and controls** ● **Compare & Contrast High-Efficiency appliances versus non-HE Appliances (VOG-Critical Thinker)** ● **Explain where and why fixtures are required.** ● **Explain & demonstrate correct procedure for testing of fixtures and appliances (VOG-Critical Thinker)** ● Identify and Apply Water conservation requirements.

	• Safety requirements for fixtures and appliances (tempering valves, T&P relief valves, backflow preventers etc.).
3. Solar Thermal Systems and their components Reference (NABCEP 2.1-2.5) • Active • Passive • Indirect • Swimming Pool	• Reference Solar Thermal Systems and their components Reference (NABCEP 2.1-2.5) • Identify components specific to an active direct solar system including: collector, tank, pump, controller, sensors, isolation and drain valves, pressure and temperature relief valves, air vent, piping, insulation, flashing, etc. This would apply to the components relevant to each specific type of system. • Identify components specific to an active indirect solar system • Identify components specific to a passive direct solar System • Identify components specific to a passive indirect solar system • Identify components specific to a swimming pool heating solar system
4. Solar Hot Water Heaters and Storage Tanks. (Reference NABCEP 6.1-6.18) • Environmental • Inspection • Piping strategy • Retrofit installation • Auxiliary storage • System fills and start-up procedures	(Reference NABCEP 6.1-6.18) • Prepare the environment for tank installation (water and power source) • Determine by inspection that the new water heater and/or storage tank and required subcomponents are damage free • Determine tank ports to be used for plumbing lines • Determine dip tube strategy • Determine plumbing retrofit method to be used if conventional water heater tank (electric or gas) is used

	• Install drain pan per local codes • Remove the old conventional water heater tank, if required • Install dip tubes • Install port fittings if required • Install tank valves (drain, pressure temperature relief, etc.) • Connect plumbing and valves between solar tank • and conventional auxiliary tank (if required) • Connect water heater and/or storage tank to water source • Fill tank with water • Connect the water heater and/or storage tank to power source • Determine that water heater and storage tanks are installed per manufacturer's' recommendations and code • Determine that installed tank and fittings have no leaks

Link to Proficiency Scale

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Sewer Gas • Hot Water • Sun Power • Panel	• Protection • Domestic Supply • Renewable Energy • Collection	• P-Trap / Water Seal • Solar Storage Tank • Photovoltaic (PV) vs. Thermal

• Liquid • Dishwasher • Water Saver • Glass	• Transfer Medium • Appliance • Conservation • Glazing	• Flat-Plate / Evacuated Tube • Glycol / Heat Transfer Fluid • Air Gap / High Loop • Low-Flow / Water-Sense • Selective Surface Coating

Trade Math Crossover:

Focus: ADA clearances and rough-in dimensions.

1. **ADA Turning Radius:** ADA code requires a 60-inch diameter clear turning space in a bathroom for wheelchair accessibility. If a small bathroom is 5 feet 6 inches wide by 8 feet long, and a vanity depth is 22 inches, calculate the remaining width of the floor. Does this remaining space meet the 60-inch (5-foot) diameter requirement?
2. **Water Closet Rough-In:** A standard water closet has a "rough-in" dimension (distance from the finished wall to the center of the drain) of 12 inches. If the framed wall is currently bare studs and you will be adding 1/2-inch cement board and 3/8-inch-thick tile, what is the exact distance the center of the drain should be placed from the *raw stud* to ensure a perfect 12-inch finished rough-in?
3. **Water Closet Rough-In**: Determine the rough in dimensions of a standard water closet from a fixture rough-in sheet and the International Plumbing Code.

Resources to compliment learning-

- Modern Plumbing Textbook Chapter 13 and Chapter 17
- International Plumbing Code Chapter 4
- https://up.codes/building-codes-online
- https://codes.iccsafe.org/

Crossover to Apprenticeship Standards:

- A0708 Fixtures and Appliances
- A0711 Plumbing Code 1

VOG Portfolio Collection Examples:

VOG- Work Ready:

- Students will extract information from rough in sheets and blue prints for a standard half- bath rough.

VOG Trait: A Critical Thinker

- **Example:** Using an AI-embedded project, a student acts as a "Code Inspector" to verify if a bathroom layout meets **ADA (Americans with Disabilities Act)** standards. They mark out the floor in the shop to physically test if a wheelchair has the required turning radius based on their research.

VOG Trait: Work Ready

- **Example:** A student extracts specific information from a manufacturer's "rough-in sheet" to accurately position the water and waste lines for a standard half-bath, demonstrating the industry-specific technical literacy required for the workforce.

Priority Standard 10.6- Employer expectations

Big Idea(s):

1. **Quality employees are the backbone to an organization; there are many attributes that encompass a good employee; personal attributes are as important as technical expertise**

Essential Question(s):

How are personal attributes as important as technical expertise?

What is the relationship between organization and productivity?

Learning Outcomes

Students will know:	*As evidenced by: (oral, written, or performance)*
1. Customer and employer expectations on the job site: • **Time on task** • **Organizational skills** • **Conflict resolution** • **Teamwork** • **Personal appearance** • **Safe work habits** • **Appropriate workplace language** • Proper written expression	• Explains the importance of being punctual, considerate, organized, well-groomed, respectful, neat, team-player, and even tempered • Explains the need for keeping truck and tools organized • **Explains teamwork and the need for it. (VOG- An effective communicator)** • **Contributes new ideas when working on a project.** • **Collaborate with fellow co-workers and offer assistance when needed.** • **Works well in resolving conflict within an organization.** • Write detailed paper describing why needless conversation creates an uneasy feeling between customers and employees • Explains why using proper procedures are essential in the trade • **Explains why it is essential to keep**

	growing in the trade
2. Organizational skills required to be successful in the trade areas • making material lists, • organizing tools, • notebook, • creation of job sheets, • man-hours taken to do tasks • materials required to complete tasks	• Using student created material list complete proscribed project to industry standards • Cleans, services and returns tools and equipment to designated shop area as required by shop policies • Produce organized shop notebook in accordance with rubric • Produce customer acceptable job sheets for ongoing projects which include man hours and material sheets for instructor grading by rubric.
3. Job applications & mock interview.	• Filled out mock applications and conducted mock interview.
4. Technology solutions	• Selects and safely uses technological resources to accomplish work responsibilities in a productive manner. • Uses computers, file management techniques and software programs effectively.
Link to Proficiency Scale	

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)

• On time • Clean clothes • Talking • Hard work • Nice • Helping others • Doing it right • Learning	• Punctuality • Professionalism • Communication • Work Ethic • Courtesy • Collaboration • Accountability • Adaptability	• Reliability / Shift Adherence • Standard Operating Procedure (SOP) • Active Listening / Soft Skills • Productivity / Billable Hours • Customer Relations Management (CRM) • Team Dynamics / Interpersonal Skills • Quality Assurance (QA) • Continuous Improvement / Lifelong Learning

Trade Math Crossover: **(VOG: Problem Solver)**

Focus: Labor costs, material markups, and project management.

1. **Labor Burdens and Profitability:** An employer charges a customer $110 per hour for a 10th-grade apprentice's labor. The apprentice is paid $18 per hour, but the employer also pays 25% in "labor burden" (taxes, insurance, and benefits). If a water heater installation takes 4.5 hours, calculate the **gross profit** the company makes on labor after paying the apprentice's total costs.
2. **The "Take-Off" and Material Markup:** A student is tasked with creating a material list for a bathroom rough-in. The total cost of materials (PVC, glue, hangers) from the supply house is $415.60. The company policy is to apply a 30% "markup" to all materials. Calculate the final price the customer will be billed for these materials.
3. **Time Management and Efficiency:** A plumbing firm estimates that a standard residential "stack" takes 8 man-hours to complete. If a lead journeyman and a 10th-grade apprentice work together, and the apprentice works at 60% of the speed of the journeyman, calculate how many clock hours it will take the two-person team to complete the task.

4. **Tool Inventory Depreciation:** A contractor purchases a new $1,200 press tool for the shop. If the tool loses 20% of its value every year (depreciation), calculate the tool's remaining value after the student completes their 10th and 11th-grade years (2 years total)
5. **Apprentice to Licensed Plumber ratio:** If a company has 4 apprentices, how many licensed plumbers do they need to have?

Resources to compliment learning-

- Modern Plumbing Textbook (chapter 32)
- CTECS Licensed Trades VOG Resources

Crossover to Apprenticeship Standards:

- A0700 Introduction to Plumbing

VOG Portfolio Collection Examples:

VOG: An Effective Communicator

- Students will conduct a mock interview as a candidate and as an employer.

VOG Trait: An Effective Communicator

- **Example:** During a group project, a student takes the lead in "circling up" for peer feedback. They clearly explain their installation choices to their teammates and listen to suggestions to resolve conflicts and improve the team's efficiency.

VOG Trait: Work Ready

- **Example:** The student maintains a professional shop notebook and digital portfolio, documenting each project with photos and technical reflections. They consistently clean and service their tools after use, treating the school shop like a professional job site.

Connecticut Technical Education and Career System

CTECS Plumbing & Heating

Priority Standard 10-7 - Plumbing & Heating Blue Print Reading	
Big Idea(s): 1. Blueprints are concepts on paper that give objects dimensions and shapes.	
Essential Question(s): 1. How does blueprint reading help turn an abstract concept into a concrete object? 2. What kinds of information are available to you from a blueprint?	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1. **Basic blueprint skills.** ● **Symbols** ● **Scale** ● **Rough in sheets and single line drawings** ● Transfer information from blueprint to mechanical drawing ● Orthographic and isometric drawings	● Demonstrate skills that define proper blueprint interpretation ● Complete instructor driven project using the architect scale ● **Reference rough in sheet to properly lay out specific plumbing task** ● Create various scale drawings of residential installation using appropriate tools and techniques in accordance with industry standards ● Use and application of orthographic and isometric drawings ● Complete proficiency assessment on plumbing symbols on blueprints ● Extract information from prints or drawings and apply them to practical work
Link to Proficiency Scale	
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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Drawing • Signs • Top View • Side View • Size • Labels • Change • Measurements	• Illustration • Symbols • Perspective • Elevation • Proportion • Specifications • Modification • Dimensions	• Schematic / Isometric Projection • Legend / Abbreviations • Plan View • Section View / Detail • Scale (e.g., 1/4" = 1') • Schedules (Fixture/Pipe) • Addendum / RFI (Request for Info) • Center-to-Center / Rough-in

Trade Math Crossover: **(VOG: Critical Thinker)**

Focus: Scaling and material take-offs.

1. **Architectural Scaling:** A blueprint is drawn to a scale of 1/4" = 1'-0". Using a ruler, a plumber measures a run of pipe on the drawing at 5 3/4 inches long. Calculate the actual real-world length of the pipe that needs to be ordered.
2. **Fixture Spacing Math:** A commercial restroom blueprint shows a wall 15 feet long with four identical sinks to be installed with equal spacing between them and equal spacing from the end walls. If each sink is 20 inches wide, calculate the exact measurement (in inches) that should be between each sink.
3. **Scale**: Students will create a chalk line outline of a full-size bathroom on the floor or ground from a scaled drawing.

Resources to compliment learning-

- Modern Plumbing Textbook (chapter 6)
- International Plumbing (section 4)
- https://up.codes/building-codes-online
- https://codes.iccsafe.org/

• Print Reading for Construction
Crossover to Apprenticeship Standards: • A0700 Intro to Plumbing • A0031 Basic Blueprint Reading
VOG Portfolio Collection Examples: **VOG- A Critical Thinker** • Students will create an Isometric drawing of a residential 2 bath floor plan.

Priority Standard 10-8 - Repair and service of residential Plumbing, Heating & Solar Thermal Systems.	
Big Idea(s): 1. Plumbing, Heating & Solar Thermal systems require maintenance and qualified technicians to service them.	
Essential Question(s): 1. **How would you calculate the typical expenses for a service call?**	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1. **Troubleshooting and repair**	• Identifies when to repair or replace equipment. • Repairs/replaces various faucets and fixtures and appliances. • Repairs/replaces domestic water heating equipment. • Repairs /replaces pumps and systems. • Identifies tools and equipment used in the service and repair of fixtures
2. Drainage system blockage troubleshooting.	• Repairs/replaces defective piping. • Correctly identify location of stoppage. • Describes how best to clear pipeline obstruction. • Determines the proper use of the drain cleaning equipment. • Describes the proper use of PPE. • Lists the dangers of chemical drain cleaners
2. Solar thermal system troubleshooting. (Reference NABCEP 12.1-12.6)	• Reference NABCEP 12.1-12.6) • Demonstrates proficiency in using tools and materials required for

	maintenance and troubleshooting • Interprets installation manual, wiring diagrams, drawings, and other specifications to plan maintenance or repair work • Determines evaluation points for system monitoring, maintenance and troubleshooting (i.e., sensor calibration, heat exchanger fluid integrity, pump operation) • Identifies cause of problems based on evaluation Results • Determines what repairs or system modifications are needed to restore the system to its baseline operating conditions • Performs any identified repairs or modifications to restore system to manufacturer's or operator's specifications

Link to Proficiency Scale

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)

• Fixing • Why it broke • Cleaning • Worn out • Noise • Testing • Old parts • Taking apart	• Remediation • Diagnosis • Maintenance • Degradation • Indication • Verification • Replacement • Disassembly	• Preventative Maintenance • Root Cause Analysis • Descaling / Flushing • Erosion / Galvanic Corrosion • Water Hammer / Cavitation • Manometer Testing / Delta T • OEM Components (Original Equipment Manufacturer) • Rebuild / Overhaul

Trade Math Crossover: **(VOG: Problem Solver)**

Focus: Diagnostic math, efficiency, and system restoration.

1. **Thermal Efficiency Loss (Heating):** A technician is servicing an older oil-fired boiler. The manufacturer states the unit originally operated at 85% efficiency. After performing a combustion analysis, the technician finds the unit is currently operating at only 72% efficiency due to soot buildup. If the homeowner spends $3,200 annually on heating oil, calculate exactly how much money is being "wasted" per year due to this loss in efficiency.
2. **Solar Thermal Collector Performance:** A residential solar thermal system has a 40-square-foot collector. On a clear day, the collector receives 2,000 BTUs of solar energy per square foot. If the system has an overall efficiency of 60% in converting that solar energy into heated water, calculate the total BTUs added to the household's water storage tank over the course of the day.
3. **Drip Waste and Water Conservation:** During a service call, a student identifies a "slow leak" in a kitchen faucet that drips at a rate of 15 milliliters per minute.
    - **Step A:** Calculate how many liters are wasted in a 24-hour period.
    - **Step B:** If there are 3.785 liters in a gallon, how many gallons are wasted in one month (30 days)?

- **Step C:** If the local utility charge is $0.005 per gallon, what is the monthly cost of this "small" leak?

4. **Temperature Rise (Troubleshooting):** An electric water heater is underperforming. To check the heating elements, a technician measures the "Temperature Rise." If the cold water entering the tank is 52°F and the hot water leaving the tank is 118°F, calculate the temperature rise. If the system's design calls for a 75°F rise to meet the household's peak demand, by how many degrees is the system currently failing?
5. **Ohm's Law in Repair (Electrical Crossover):** When troubleshooting a 240-volt electric water heater element, a technician uses a multimeter to check resistance. According to the manufacturer, a 4,500-watt element should have a resistance of approximately 12.8 ohms ($R = V^2/P$). If the student measures the resistance and finds it is 45 ohms, use math to explain whether the element is functioning correctly or needs to be replaced.
6. **Repair Orders:** If a customer's bill totals $235.90, and they have a credit of $28.50 plus a 10% discount, what is the total that you will be charging them?

Resources to compliment learning-

- Modern Plumbing Textbook (chapter 30)
- International Plumbing (section 7)
- NABCEP Solar Thermal Guide
- Hydronic Heating: Systems and Application

Crossover to Apprenticeship Standards:

- A0700 Intro to Plumbing
- A0031 Basic Blueprint Reading

VOG Portfolio Collection Examples:

VOG- Work Ready:

- Students will create mock customer invoices for various service calls to become proficient in pricing and invoicing.

VOG Trait: A Problem Solver

- **Example:** A student identifies a malfunctioning solar thermal pump. Instead of just replacing it, they use diagnostic tools to determine if the failure was caused by a faulty sensor or a scale buildup in the heat exchanger, then develops a plan for a long-term fix.

CONNECTICUT TECHNICAL EDUCATION AND CAREER SYSTEM

Plumbing and Heating

Grade 11

Grade 11 Curriculum

Priority Standard 11.1 - Safety in Construction Environment	
Big Idea(s): **1. Safety applies to every aspect of your life, both on and off the job.**	
Essential Question(s): How does poor maintenance of tools and equipment contribute to accidents?	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1. **Safety practices, including OSHA.** ● **Eye Safety** ● **Hand tool** ● **Power tool** ● **Stationary Power Tools** ● **Ladder safety** ● **Construction site related safety risks** ● **PPE** ● **Emergency related items** ● **First aid**	● **Scores 100% on all written safety test and retests.** ● **Model's safe practices.** ● **Identifies construction site work areas that have potential safety risks.** ● **Discusses possible consequences of unsafe work** ● **conditions on an outside production site.** ● **Wears eye safety protection, hearing and other required personal protective devices.** ● **Demonstrates the safe handling of hand tools and power tools.** ● **Lists safety rules for portable power tools.** ● **Identifies fire alarms, eye wash stations, power shut-offs and first aid kits**
2. Lockout Tag-out when working with equipment.	● **Practices the correct procedure of removing a piece of equipment from service and then putting it back online.** ● **Creates remediation plans for potential hazards. (VOG- Critical Thinker)**
3. Safety harnesses and trench safety. ● **Angle of repose** ● **Trench safety** ● **Harness requirements**	● **Describes the requirement of wearing a safety harness.** ● **Describe trench safety issues.** ● **Practice the use of a safety harness.**

4. Function and responsibilities of OSHA.	• **Discusses the requirement that every employer have an OSHA committee and issues of workplace safety should be brought to the attention of the committee, if they cannot be resolved on the job. Larger sites have a safety office on site.**
5. **Solar Collectors (Reference NABCEP 5.1-5.13)**	• 1.5 Installing Solar Collectors (Reference NABCEP 5.1- 5.13 • Identifies specific manufacturer's mounting design and materials • Identifies acceptable National Roofing Contractors Association roof mounting and penetration methods • Identifies different collector mounting methods • suitable for roof types or other installation areas • Identifies different system (in the case of ICS and thermosiphon systems, due to extra weight and components) mounting methods suitable for roof type • Identifies locations for roof/ wall, foundation penetrations, and structural attachments • Evaluates the suitability of selected mounting structural attachments and compliance with applicable local codes • Determines multi-collector piping strategy • Installs collector mounting device to installation area • Weather seal roof penetrations and other structural devices with flashings and sealants • Lifts collectors to installation area • Attaches mounting bracket and struts (if required) to collector • Secures collector to collector mounting device • Connect collector to piping
6. Safety guidelines and manages personal health	• **Explains necessity for following safety protocol, while also managing personal**

	health.

Link to Proficiency Scale

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Danger Zone • Air Quality • Safety Meeting • Checking • Fire Plan • Heavy Lifting • Record • Sign-off	• Perimeter • Atmosphere • Briefing • Evaluation • Prevention • Ergonomics • Compliance • Validation	• Controlled Access Zone (CAZ) • Confined Space Entry / PEL • Toolbox Talk / JHA (Job Hazard Analysis) • Competent Person Oversight • Hot Work Permit / Fire Watch • Mechanical Advantage / Rigging • OSHA 300 Log / Incident Report • Work Authorization

Trade Math Crossover: **(VOG- Problem Solver)**

Focus: Hazard mitigation, load limits, and emergency response timing.

1. **Trench Excavation Safety (Shoring Math):** According to OSHA 1926 standards, trenches deeper than 5 feet require protective systems. If a student is excavating for a 100-foot sewer main that drops at a pitch of ¼ inch per foot, and the starting depth is 52 inches:
    - **Calculation:** At what linear foot mark will the trench reach the 60-inch (5-foot) depth

where shoring or a trench box becomes a legal requirement?

2. **Scaffolding Load Distribution:** A rolling scaffold has a maximum work load of 1,000 lbs. Two 11th-grade students (170 lbs. and 195 lbs.) are on the scaffold with a heavy-duty threading machine (120 lbs.) and twelve 21-foot lengths of 2-inch black iron pipe. If 2-inch black iron pipe weighs 3.66 lbs. per foot, calculate the total load. Does the total weight exceed the scaffold's safety rating?
3. **Rigging and Sling Angles:** When lifting a 400 lb. boiler using a two-leg sling, the tension on the legs increases as the angle of the sling decreases. If the legs are at a 30-degree angle, the load on each leg is equal to the total weight (400 lbs.). If the angle is increased to 60 degrees, the load on each leg drops to approximately 231 lbs. Calculate the percentage reduction in stress on the rigging equipment when moving from a 30-degree to a 60-degree lift angle.
4. **Ladder Length**: Taking OSHA Standards and ladder ratio into consideration, how long should a ladder be if you have a wall 20 feet in height?

Resources to compliment learning-

- OSHA CFR 1926,
- Modern Plumbing Textbook Chapter 1
- Basic Principles for Construction Chapter 2

Crossover to Apprenticeship Standards:

- A0099 Building Trades Safety OSHA 30 for construction certification

VOG Portfolio Collection Examples:

- **Students will create a ladder safety instructional plan for instructors to use on 11th grade safety. (VOG: A Critical Thinker)**

Priority Standard 11.2 - Code-compliant design principles for Plumbing, Heating, and Solar Thermal systems.

Big Idea(s):

1. Mechanical systems are complex, integrated networks where every component's size and placement are governed by scientific principles and legal mandates.
2. Because codes are designed to ensure public safety and system efficiency, a technician must prioritize code-compliance over installation convenience to prevent system failure and health hazards."

Essential Question(s):

1. How can mechanical systems be designed and sized using the code?
2. How are science and math related to the sizing of plumbing systems?

Learning Outcomes

Students will know:	*As evidenced by: (oral, written, or performance)*
1. Information from IPC, IBC, & IMC Code ● General regulations ● Administration ● Definitions ● ADA ● Use of fittings/pipe/valves ● Clearance codes ● Backflow requirements ● Minimum Testing Procedures	● Explains the use and application of the IPC and related sections of the IMC & IBC. ● **Compare and Contrast different types of backflow protection** ● Extracts information from rough-in sheets.
2. International Mechanical Code. ● **Makeup air** ● **Combustion air** ● **Vent sizing** ● **Gas sizing** ● **BTU's** ● **Linear expansion**	● **Calculates make-up air required for diverse scenarios** ● **Calculates Combustion air calculations** ● **Designs vent sizing calculations** ● **Calculates Gas pipe sizing for specific designs** ● **Calculates BTU load for heating systems.** ● **Completes worksheets on linear expansion**
3. Water distribution systems ● **Water chemistry**	● Explain water chemistry and make-up ● Completes worksheets on pressure and head

• **Manifold sizing** • **WSFU sizing** • **Velocity** • **psi calculations** • **pump curve**	• Size a basic tree distribution system • Size a manifold system. • Completes worksheets on velocity • Completes worksheets on pump curves • **Calculates head pressures for given pipe lengths and heights.** • **Extracts pump curve information from manufacturers specification sheets**
4. Volume of pipe and tanks.	• Calculate volume of tanks and capacities/weights
5. Solar Thermal System Design (Reference NABCEP 3.1-3.9)	• (Reference NABCEP 3.1-3.9) • Determines active direct system components' location and system layout and configuration • Determines active indirect system components' location and system layout and configuration • Determines passive direct system components' location and system layout and configuration • Determines passive indirect system components' location and system layout and configuration • Determine solar pool system components' location and system layout and configuration • Apply for building permits • Estimates time, materials, tools and labor required for installation • Determines installation sequence to optimize use of time and materials • Inspects all provided system components for damage prior to installation
6. Mechanical/Plumbing Equipment and other components added to Solar Thermal Systems: Reference NABCEP: 8.1-8.5 • System components	• Reference NABCEP: 8.1-8.5 • Identifies system plumbing, valves and other components required, (This includes the following: valves, air vent, check, drain, auto

• Location of components • System monitoring components • Heat exchanger • Heat exchanger fluids	drain down, expansion tanks, flow control, isolation, diverting, solenoid, mixing, anti-scald, pressure relief, temperature pressure relief, vacuum relief, balancing, freeze, etc. as well as the following monitoring components; flow meter, temperature gauge, pressure gauge, etc.) • Justifies the location of plumbing valves and other components • Installs system plumbing valves and monitoring system components as specified in component manufacturer's or solar manufacturer's installation manual and schematic • Determines the heat exchanger location and Installs heat exchanger and heat exchanger fluids as specified in manufacturers installation manuals and schematics

Link to Proficiency Scale

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Plan • Big enough • Space • Air flow • Heat Loss • Sun angle • Safety valve • Rules book	• Design / Strategy • Sizing / Adequate • Clearance • Venting • Thermal Efficiency • Orientation • Protection • Compliance	• System Schematic / Engineered Layout • Fixture Unit Calculation (DFU/WSFU) • Access & Working Space (Code Minima) • Air Admittance Valve (AAV) / Developed Length • U-Factor / R-Value

		• Azimuth / Solar Altitude • T&P Relief Valve (Temperature & Pressure) • Jurisdictional Amendments

Trade Math Crossover: **(VOG- Critical Thinker)**

Focus: Sizing water distribution, pump curves, and thermal expansion.

1. **Water Supply Fixture Unit (WSFU) Sizing:** Using the International Plumbing Code (IPC) tables, a student must size a "tree" distribution system for a residential building. If the branch serves two flush-tank water closets (2.2 WSFU each), a bathtub (1.4 WSFU), and a kitchen sink (1.4 WSFU), calculate the total WSFU load. Based on a maximum velocity of 8 feet per second for copper tubing, determine the minimum pipe diameter required for this branch.
2. **Pump Curve and Head Pressure:** A technician is selecting a circulator pump for a hydronic loop. The system has 150 feet of 3/4-inch copper pipe, and the "Head Loss" is calculated at 4 feet of head per 100 feet of pipe. Calculate the total head pressure. Then, examine a manufacturer's pump curve to identify if a specific pump model can deliver the required 5 Gallons Per Minute (GPM) at that calculated head.
3. **Linear Expansion of Copper:** Copper pipe expands significantly when heated. The formula for expansion is: *Expansion = Length × Change in Temp × Coefficient* (0.0000112 per inch per °F). Calculate the total expansion in inches for a 120-foot run of hot water main when the temperature rises from 60°F to 140°F.
4. **Volume:** Calculate the capacity of a tank in gallons if the dimensions of the tank are 2 feet in diameter and 6 feet in height.

Resources to compliment learning-

- Modern Plumbing Textbook (chapter 4)
- Mathematics for Plumbers and Pipefitters (unit 8)

Crossover to Apprenticeship Standards:

- A0014 Plumbing Math

VOG Portfolio Collection Examples:

VOG- A Problem Solver:

- Students will create an isometric drawing of a 2-bath floor plan water supply system with correct sizes.

VOG Trait: A Critical Thinker

- **Example:** A student uses the International Plumbing Code (IPC) to design a water distribution system for a multi-story building. They must justify their choice of pipe material and sizing based on calculated **WSFU (Water Supply Fixture Units)** and required pressure at the furthest fixture.

VOG Trait: A Problem Solver

- **Example:** When designing a solar thermal layout, the student calculates the **BTU load** and estimates the necessary collector area to meet 70% of a household's hot water needs, adjusting the design for potential shading obstacles identified during a site assessment.

Priority Standard 11.3 - Installation, design, and layout and repair of DWV systems

Big Idea(s):

1. A functional DWV system relies on the precise balance of gravity and atmospheric pressure. Proper venting and pitch are not optional design features but are essential 'unseen' mechanics that maintain the water seals in traps, preventing the entry of lethal sewer gases into living spaces
2. A properly designed and installed DWV system will self-scour and maintain constant water velocity when in use.
3. A properly vented DWV system will maintain atmospheric pressure in all areas.

Essential Question(s):

1. **How do DFUs apply to the sizing of DWV systems?**

Learning Outcomes

Students will know:	*As evidenced by: (oral, written, or performance)*
1. Sizing of various DWV systems ● **DFU's** ● **Hanger spacing** ● **Slopes/pitch** ● **DWV Service**	● **Calculate drainage fixture units to size a DWV system from an instructor created floor plan or isometric sketch. (VOG-Problem-Solver & Work Ready)** ● **Solve various slopes - pitch problems.** ● **Design a basic DWV system. Including hangers and cleanout requirements.** ● **Basic repairs and service of DWV Systems**
2. Sizing of storm systems ● Roof drains ● Leaders ● Conductors	● Design a basic storm water system

Link to Proficiency Scale

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Slant / Slope • Air Pipe • Going down • Clog • Smell • Pipe Size • The Main Line • Testing	• Gradient • Ventilation • Vertical Drop • Obstruction • Contamination • Capacity • Distribution • Verification	• Pitch (1/8", 1/4", 1/2" per foot) • Stack Vent / Vent Stack • Fall / Invert Elevation • Hydraulic Jump / Scouring Action • Siphonage / Sewer Gas Incursion • DFU (Drainage Fixture Unit) • Building Drain vs. Building Sewer • Peppermint Test / Smoke Test

Trade Math Crossover: **(VOG- Critical Thinker)**

Focus: Drainage Fixture Units (DFU) and venting slopes.

1. **DFU Load and Sewer Sizing:** A commercial bathroom battery consists of 6 wall-hung urinals (2 DFUs each) and 4 floor-mount water closets (4 DFUs each). Calculate the total DFU load. Using the IPC sizing tables, determine the minimum size of the horizontal building drain if it is installed at a 1/8-inch-per-foot pitch.
2. **Vent Distance Math:** The code limits the distance a trap can be from its vent based on the pipe's diameter and slope. For a 2-inch drain line sloped at 1/4 inch per foot, the maximum distance to the vent is 8 feet. If a kitchen island sink is located 9 feet 6 inches from the nearest wall vent, calculate the "excess distance" and describe the mathematical adjustment (or additional venting) required to meet code.
3. **DFU Sizing**: Using a common residential floor plan, calculate the DFU totals and DWV system pipe sizes per International Plumbing Code requirements.

Resources to compliment learning-

- International Plumbing Code
- Modern Plumbing Textbook (Chapter 17)

Crossover to Apprenticeship Standards:

- A0014 Plumbing Math
- A0706 Drains, Wastes and Vents 1

VOG Portfolio Collection Examples:

VOG: Work Ready-

- Students will create an isometric drawing of a floor plan with proper DWV pipe sizes listed.

Priority Standard 11.4 - Fuel Gas Code

Big Idea(s):

1. The safe conveyance of combustible fuel requires absolute technical precision because even minor sizing errors or improper venting can lead to catastrophic system failure.
2. Mastery of the Fuel Gas Code allows a technician to ensure that appliance input ratings (BTU/hr) are perfectly matched to the supply source and delivery pressure.
3. Today's increasing technology requires highly specialized training to ensure proper sizing for all fuel gasses, both input and output.

Essential Question(s):

1. Why is attention to detail so important when working with fuel gas?
2. **How has increased efficiency contributed to the need for more education pertaining to fuel gas systems?**

Learning Outcomes

Students will know:	*As evidenced by: (oral, written, or performance)*
1. Application of the fuel gas codes. • **Gas pipe sizing** • **Gas vent sizing** • **Gas pipe testing** • **Gas properties** • **Piping** • **Makeup air** • **Minimum clearances**	• **Complete gas pipe sizing worksheets** • **Complete gas venting worksheets of various appliances.** • **Solves code related problems.** • **Explains the testing of gas piping requirements** • **Explains the different types of gasses.** • **Describes fittings and connections that are not permissible by code.** • **Demonstrates knowledge of CSST systems, including dual pressure.** • **Completes worksheets on area and volume for makeup air.** • **Completes worksheets on clearances from combustibles.**

Link to Proficiency Scale

Connecticut Technical Education and Career System

CTECS Plumbing & Heating

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Gas Pipe • Leak • Air for fire • Size • The Meter • Drip Leg • Pressure • Gas Smells	• Conveyance • Escapement • Combustion • Volume / Demand • Supply Source • Collection • Regulation • Odorant	• Black Iron / CSST (Tubing) • Combustible Gas Leak Detection • Make-up Air / Primary & Secondary Air • BTU/hr (Input Rating) • Point of Delivery • Sediment Trap • Manometer / Inches of Water Column • Mercaptan

Trade Math Crossover: **(VOG: Critical Thinker)**

Focus: BTU loads and gas pipe sizing.

1. **Gas Pipe Sizing (Longest Run Method):** A natural gas system serves a boiler (150,000 BTU/hr.), a water heater (40,000 BTU/hr.), and a range (65,000 BTU/hr.). The "Longest Run" from the meter to the furthest appliance is 60 feet. Calculate the total BTU load. Using the IFGC Sizing Tables for Schedule 40 metallic pipe, determine the required diameter for the main header at the point of delivery.
2. **Combustion Air Requirements:** For an appliance to burn fuel safely, it requires "Make-up Air." The code requires 50 cubic feet of room volume for every 1,000 BTU/hr. of combined input rating. If a boiler room contains a 200,000 BTU boiler, calculate the minimum volume (in cubic feet) the room must have to be considered an "unconfined space." If the room has an 8-foot ceiling, what

is the minimum required square footage?

3. **Gas Pipe Calculations**: Using a common floor plan. Calculate the proper gas pipe sizes for a floor plan that has a gas boiler, gas range, gas dryer and gas water heater. Pipe size shall be determined for a natural gas system.

Resources to compliment learning-

- Mathematics for Plumbers and Pipefitters (unit 58)
- International Fuel Gas Code
- NFPA 54 & 58
- NABCEP Solar Thermal Guide
- Hydronic Heating: Systems and Application

Crossover to Apprenticeship Standards:

- A0784 Heating Fundamentals
- A0006 HVAC Math

VOG Portfolio Collection Examples:

VOG: A Critical Thinker- Innovates

- Students will create a gas piping schematic from a single-family home blueprint with appliances and equipment specified by the instructor.

VOG Trait: A Critical Thinker

- **Example:** In a "Durable AI" assignment, the student asks an AI to size a gas line for a commercial kitchen. The student then acts as the "Expert Verifier," checking the AI's output against physical code books to ensure the pipe can handle the total BTU input of all appliances simultaneously

VOG Trait: Work Ready

- **Example:** For their digital portfolio, the student creates a detailed gas piping schematic for a single-family home. They include a "Bill of Materials" and a testing plan that follows the specific safety protocols for high-pressure gas systems.

Priority Standard 11.5 - Basics of hydronic, hot water, and steam heating systems.

Big Idea(s):

1. Efficiency in modern heating is achieved by matching the specific thermal properties of a building (heat loss) to the correct system design (hydronic vs. steam).
2. A technician's value lies in their ability to diagnose component interactions—such as how a circulator pump affects a primary/secondary circuit; to optimize comfort and fuel consumption for the end-user.
3. Being able to identify different parts of a heating system is a higher-level skill that employers are looking for when hiring technicians.
4. Being able to compare and contrast dissimilar heating systems is a question that you will constantly be asked by the consumer, especially when fuel prices are high.

Essential Question(s):

1. Why do you think it is necessary to perform a heat-loss prior to installing heating equipment?
2. How do different system designs impact efficiency?

Learning Outcomes

Students will know:	*As evidenced by: (oral, written, or performance)*
1. Boiler's components and controls. • **Boilers wet and dry base** • **Boiler's oil/gas** • **Indirect Heaters** • **Tankless heaters** • **Primary/secondary circuits** • **Zone control devices** • **LWCO** • **Backflow Devices** • **Feed valves** • **Motors** • **Pumps** • **Thermostats** • **Flow checks** • **Draft regulator** • **Expansion tank** • **Burner assembly**	• Demonstrate knowledge of various heating systems and equipment, i.e., one pipe steam and hot water, two pipe steam and hot water, hydro-air, radiant, including appropriate safety and operating equipment. • **Demonstrate knowledge of the types of boilers and pressure vessels. (Dry base, wet base, fire-tube, water tube, horizontal single and multi-pass.** • **Demonstrate proficiency in the disassembly and assembly of an oil burner** • Demonstrate knowledge of high efficiency on demand boilers and explain the

	installation process. (VOG- Work Ready)
2.Types of heating systems, boilers and pressure vessels. • **Oil, gas, electric** • **Hot water and steam** • **Direct and split loop** • **Two-pipe** • **Direct and reverse return** • **Radiant** • **Hydro-air** • **Alternative fuels (geothermal, solar)** • **Types of Gases** • **Fuel Oil Classifications** • **BTU'S** • **Heat Loss** • **Pressure and Temperature**	• Draw a detailed blue print to demonstrate knowledge of various hydronic systems. • **Explain basic Heating Fundamentals and Concepts** • **Explain types of fuels and their properties used in the heating industry**

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Heater • Pump • Pipe Loop • Hot/Cold Side • Steam • Air in Pipe • Expansion	• Generation • Circulation • Distribution • Differential • Vaporization • Elimination • Containment	• Cast Iron vs. High-Efficiency Boiler • Circulator / Zone Valve • Hydronic Loop / Secondary Piping • Delta T (Delta T) • Latent Heat of

• Thermostat	• Interface	Vaporization • Air Scoops / Automatic Air Vent • Expansion Tank (Diaphragm Type) • Aquastat / Outdoor Reset

Trade Math Crossover: **(VOG: Critical Thinker)**

Focus: Heat loss and system volume.

1. **Heat Loss Calculation:** A room is 12' x 15' with an 8-foot ceiling. Using a simplified heat loss factor of 40 BTUs per square foot for an average insulated room, calculate the total BTU requirement for the space. If the baseboard radiation output is 600 BTUs per linear foot at 180°F water, how many feet of baseboard must be installed to heat the room?
2. **Total System Volume:** To size an expansion tank, a technician must know the total water volume. A system has 200 feet of 3/4" pipe (0.025 gal/ft) and a boiler that holds 12 gallons. Calculate the total system volume. If water expands by 4% when heated, calculate the "acceptance volume" the expansion tank must be able to handle.
3. **BTU**: Define a BTU and list the heating content for each of the common fuels to compare and contrast efficiencies based on BTU per fuel type.

Resources to compliment learning-

- Modern Plumbing Textbook (chapter 2 & 4)
- Hydronic Heating Systems and Applications Textbook (chapter 3 & 7)
- NABCEP Solar Thermal Guide
- Hydronic Heating: Systems and Application

Crossover to Apprenticeship Standards:

- A0700 Introduction to Plumbing

VOG Portfolio Collection Examples:

VOG-Critical Thinker

- Applies unbiased analysis and evaluation.

Priority Standard 11.6 - Fuel Oil Systems	
Big Idea(s): 1. Fuel oil is essential to the heating industry in certain geographic areas. **2.** The integrity of a fuel oil delivery system is the primary defense against environmental catastrophe and system malfunction. Because fuel oil is a hazardous combustible, a technician's mastery of OSHA safety protocols, tank venting, and leak prevention is not merely a mechanical skill but a critical responsibility to protect the client's property and the local ecosystem from high-cost environmental remediation	
Essential Question(s): 1. Why is fuel oil a viable option compared to other forms of energy? 2. Why is a strong knowledge of fuel storage important?	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1**. Trade related science and math in relation to heating theory.** ● **Area** ● **Volume** ● **Pressure** ● **Force**	● Research the related theory of heat energy and fuels used in the heating industry.
2. **Oil tanks and pumps.** ● **Standard oil tanks** ● **Single - pipe gravity feed** ● **Single - pipe lift feed oil tank below burner** ● **Two - pipe gravity feed** ● **Two - pipe lift feed oil tank below burner** ● **Dual tank installations** ● **Special tanks** ● **Underground tanks** ● **Safety devices**	● **Performs installations of oil tanks in accordance with industry standards (single and twin tanks)** ● Demonstrates use of oil transfer pumps for different job applications.
3. Codes governing the storage and delivery of fuel oil. ● Containment methods ● Transferring fuels	● Compares and contrasts different fossil fuels and efficiencies of different oil grades. ● Installs all safety controls based on the

	International Mechanical Code and the local administrative authority.

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Oil Tank • Oil Pipe • Filter • Fire Maker • Electric Spark • Eye Sensor • Smoke/Ash • Pump	• Storage Vessel • Supply Line • Purification • Atomization • Ignition • Detection • Byproduct • Pressurization	• UL-80 Standard / Tank Gauge • OSV (Oil Safety Valve) / Firomatic • Micron Rating / Canister Filter • Retention Head Burner / Nozzle • Electrode / Transformer (Ignitor) • Cad Cell / Primary Control • Soot / CO2 & Stack Temperature • Two-Stage Fuel Unit / Gear Pump

Trade Math Crossover: **(VOG: Critical Thinker)**

Focus: Tank capacity, burner consumption, and combustion math.

1. **Total System Volume & "Sludge" Calculation:** A standard residential "Roth" oil tank is rectangular. If a tank measures 43 inches long, 28 inches wide, and 63 inches high:
    - **Step A:** Calculate the total volume in cubic inches.
    - **Step B:** Convert to gallons (231 cubic inches = 1 gallon).

- **Step C:** To protect the burner, the "usable" oil stops 4 inches from the bottom to avoid sucking up sludge. Calculate the "dead storage" (unusable gallons) at the bottom of this tank.

2. **Fuel Consumption and Run-Time:** An oil burner nozzle is rated at 0.85 GPH (Gallons Per Hour). During a cold CT week, the burner runs for an average of 8 hours a day. Calculate the total fuel consumption for the week. If the tank currently holds 145 gallons, how many days can the system run before it reaches the "15-gallon" emergency refill level?
3. **Combustion Air Ratios:** Fuel oil requires approximately 1,540 cubic feet of air to burn 1 gallon of oil completely. If a boiler consumes 1.25 gallons of oil per hour, calculate the total cubic feet of fresh "make-up air" required by the mechanical room per hour to ensure complete combustion and prevent carbon monoxide buildup
4. **Pressure Drop and Specific Gravity**: Using the International Gas code, find the pressure drop and specific gravity of natural gas.

Resources to compliment learning-

- International Fuel Gas Code
- Hydronic Heating Systems and Applications (Chapters 4 & 5)
- Mathematics for Plumbers and Pipefitters (unit 58)

Crossover to Apprenticeship Standards:

- A0784 Heating Fundamentals
- A0789 Heating, Hydronic and Steam
- A0006 HVAC Math

VOG Portfolio Collection Examples:

VOG: A Critical Thinker

- Students will pipe a boiler and create a near boiler piping diagram.

Priority Standard 11.7 - Plumbing & Heating Blue Print Reading

Big Idea(s):

1. Blueprints are the legal and technical bridge between a conceptual design and a physical, high-performing mechanical system.
2. Because a single misinterpretation of scale or symbol can lead to costly material waste and structural conflicts, a technician must be able to translate 2D schematics; including orthographic and isometric projections; into a precise 3D installation plan that respects both architectural constraints and mandatory code clearances
3. Proper interpretation of plans and specifications ensures overall project efficiency.
4. Specifications are written to the owner's wishes, requirements and applicable codes.

Essential Question(s):

1. **How would you resolve a plan-related conflict?**
2. **Why is it important to have a full and detailed set of plans?**

Learning Outcomes

Students will know:	*As evidenced by: (oral, written, or performance)*
1**. Mechanical drawings.** ● **Square footage** ● **Piping installations** ● **Spec out a plumbing job**	● **Explains the importance of roughing sheets for specific fixtures and appliances.** ● Calculates the minimum size of bathrooms. ● Sketch various plumbing/ piping ● installations in order to create an estimate of materials. ● Complete an estimate using labor factors for total hours. ● **Complete various materials list for plumbing/piping jobs.** ● **Create a set of specifications for a plumbing job. (VOG- A Critical Thinker)** ● **Write a paper on the importance of**

	work schedules.
2. **Job specifications** • **fixture specs** • **take-off sheet** • **layout** • **minimum code requirements** • **cutting and notching requirements**	• **Write a paper on job conditions that affect productivity.** • **Describe the penalties involved with the non- performance of work.** • **Write a paper on the importance of job specifications.** • **Complete instructor driven worksheets on cutting and notching of buildings.**

Link to Proficiency Scale

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Mistake • Material List • Pipe Layout • Notes • Layers • Updates • Flat View • The "How-to"	• Discrepancy • Procurement • Coordination • Clarification • Overlay • Revision • Orientation • Standardization	• RFI (Request for Information) • Take-off / Bill of Materials • Mechanical Shop Drawings • General Notes & Special Provisions • MEP Drawings (Mech/Elec/Plumb) • As-Built Drawings / Red-lines • Orthographic Projection • Installation Details / Blow-ups

Trade Math Crossover: **(VOG: Problem Solver)**

Focus: Scaling and area calculations.

1. **Square Footage for Estimating:** Using a residential floor plan at a 1/4" = 1'-0" scale, calculate the square footage of a master bathroom that measures 3.5 inches by 2.75 inches on the drawing.
2. **Material "Take-Off" Math:** Perform a material take-off for a DWV system shown on a blueprint. If 10-foot lengths of PVC cost $24.50 each and the blueprint shows a total run of 86 feet, calculate the total cost of pipe including an 8% waste factor and 6.35% Connecticut sales tax.
3. **Square Footage**: Using a floor plan for a residential home, Calculate the square footage of each room.

Resources to compliment learning-

- Modern Plumbing Chapter 4 & 5
- Print Reading for Construction

Crossover to Apprenticeship Standards:

- A000l Basic Math Computations
- A0031 Blueprint Reading
- A0014 Plumbing Math
- A0006 HVAC Math

VOG Portfolio Collection Examples:

VOG: A Critical Thinker

- Students will create a floor plan of their dream home.

VOG Trait: A Problem Solver

- **Example:** Students work in teams to perform a "take-off" from a set of commercial blueprints. They must "circle up" to resolve a conflict where the plumbing lines intersect with the HVAC ductwork, proposing a reroute that maintains the required drainage pitch.

VOG Trait: An Effective Communicator

- **Example:** A student develops a set of written specifications for a plumbing project. They then present their "bid" to the class, explaining the labor factors and material costs used to arrive at their final estimate.

Priority Standard 11.8 - Employer expectations

Big Idea(s):

1. Professionalism in the trade is a measurable form of 'human capital' that directly impacts a company's reputation, safety record, and profitability.
2. Because the plumbing trade relies on trust and high-stakes liability, a technician must consistently demonstrate self-regulation, ethical decision-making, and 'Work Ready' behaviors—such as punctuality and active communication—to transition from a supervised apprentice to a self-directed lead technician
3. Quality employees are the backbone to an organization; there are many attributes that encompass a good employee.

Essential Question(s):

1. **How are personal attributes as important as technical expertise?**
2. **What is the relationship between organization and productivity?**

Learning Outcomes

Students will know:	*As evidenced by: (oral, written, or performance)*
1**. Customer and employer expectations on the job site:** • **Time on task** • **Organizational skills** • **Teamwork** • **Personal appearance** • **Safe work habits** • **Appropriate workplace language** • **Proper written expression**	• **Explain the importance of being punctual, considerate, organized, well-groomed, respectful, neat, team-player, and even-tempered. (Effective Communicator, Skilled Socially))** • **Explain the need for keeping truck and tools organized.** • **Explain teamwork and the need for it.** • **Write a detailed paper describing why needless conversation creates an uneasy feeling between customers and employees.** • **Explains why using proper procedures are essential in the trade.**
2. **Organizational skills required to be successful in the trade areas** • **making material lists**	• **Using student created material list complete proscribed project to**

• organizing tools • notebook • creation of job sheets • man-hours taken to do tasks • materials required to complete	industry standards • Cleans, services and returns tools and equipment to designated areas as required by individual shop grading policies. • Produce organized shop notebooks in accordance with rubric. • Produce customer acceptable job sheets for ongoing projects which include man hours and material sheets for instructor grading by rubric. • Identify and address customers' needs in a courteous, professional and knowledgeable manner.
3. **Job application & interview skills.**	• Fills out mock applications and conducted mock interviews.
4. Customer Expectations as it pertains to Solar Thermal Installations. (Reference NABCEP 11.7-11.13)	• Customer Expectations as it pertains to Solar Thermal Installations. (Reference NABCEP 11.7-11.13)(VOG-Respectful) • Demonstrate to the owner operation and functionality of system • Demonstrate to the owner start-up and shutdown procedures for system • Demonstrate to owner simple maintenance and diagnostic procedures • Identify for owner all markings and labels for system service and owner interaction • Identify for owner safety issues associated with operation and maintenance of system • Complete and transfer documentation package to system owner/operators • Review system/component warranties

	and requirements with owner
5. Methods of utilizing technology to come up with solutions as well as complete school/workplace responsibilities.	• **Selects and safely uses technological resources to accomplish work responsibilities in a productive manner.** • **Uses computers, file management techniques and software programs effectively.**

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Leading • Money-making • Doing the right thing • Keeping track • Saving time • Boss's rules • Talking to clients • Job growth	• Management • Profitability • Ethical Standards • Documentation • Efficiency • Policy • Professionalism • Advancement	• Project Supervision / Foreman Roles • Overhead vs. Labor Burden • Code of Ethics / Trade Integrity • Daily Logs / Field Reports • Production Rate / Lean Construction • Employee Handbook / Risk Management • Conflict Resolution / Change Orders • Apprenticeship Standards / Licensure

Trade Math Crossover: **(VOG: Problem Solver)**

Focus: Project management, labor efficiency, and professional estimating.

1. **The "Labor Factor" Challenge:** An employer uses a "labor factor" of 0.5 hours to install 1 linear

foot of 4-inch cast iron pipe (including hangers and joining). An 11th-grade apprentice is tasked with installing a 40-foot horizontal run.

- **Calculation:** If the apprentice's "efficiency rate" is 80% compared to a journeyman, how many total clock hours should the employer budget for the apprentice to finish this task?

2. **Profit Margin and Overhead:** A plumbing company has a "break-even" cost of $65 per hour (covering the plumber's wage, gas, insurance, and office rent). The employer wants to make a 22% profit on every service call. Calculate the "Contractor Rate" the student must quote a customer for a 4-hour repair job, including $120 in parts marked up by 15%.
3. **Time-Sheet Accuracy:** An apprentice works 7:30 AM to 4:00 PM with a 30-minute unpaid lunch. Over a 5-day week, they spend 1 hour each morning loading the truck and 45 minutes each afternoon cleaning the shop. Calculate the "billable percentage"; the ratio of time spent on actual customer jobs versus "unbilled" shop time.
4. **Material Waste Percentage:** You are ordering PEX tubing for a radiant heat floor. The room is 20' x 20' and requires loops spaced 6 inches apart (approx. 2 feet of pipe per square foot of floor). Calculate the base footage. If the company policy is to add a 12% "waste factor" to account for bends and connections, what is the final total footage of PEX that must be ordered?
5. **Calculations, Mark-up and Percentages**: Create a repair order and write a bill to a customer for a mock service call generated by instructor.

Resources to compliment learning-

- Modern Plumbing Chapter 3 & 33
- CTECS Licensed Trades VOG Resources

Crossover to Apprenticeship Standards:

- A0007 Intro to Plumbing

VOG Portfolio Collection Examples:

VOG- An Effective Communicator

- **Example:** Students will write a proposal and estimate for work that a customer need done on their house.

VOG Trait: An Effective Communicator

- **Example:** The student participates in a mock job interview with an industry professional. They use their **Student Competency Checklist** to provide evidence of their skills in copper brazing, PEX installation, and code research.

VOG Trait: Work Ready

- **Example:** On a "Live Work" job site, the student maintains a professional demeanor by arriving on time with all necessary tools, keeping their work area organized, and communicating technical progress clearly to the "customer" (instructor).

Plumbing and Heating

Grade 12

Grade 12 Curriculum

Priority Standard 12.1 - Safety Practices	
Big Idea(s): 1. Safety in the senior year evolves from following rules to becoming a Competent Person responsible for the collective well-being of a job site. **2.** Because high-level trade work involves lethal hazards like electrical continuity, fuel oil contamination, and confined spaces, a technician must master Hazard Mitigation (such as Lock-Out/Tag-Out) to ensure that technical errors do not result in environmental or human catastrophe	
Essential Question(s): **1. How might unsafe work practices affect your life?** **2. How does poor maintenance of tools and equipment contribute to accidents?** 3. **What are some examples of poor indoor air quality related to the Plumbing & Heating industry?**	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1. Essential safety practices ● **Ladder and scaffolding safety** ● **Hand and power tool safety** ● **Stationary tool safety** ● **GFCI use** ● **Safe lifting techniques** ● **OSHA requirements** ● **SDS procedures.**	● **Scored 100% on all written safety test and retests.** ● **Modeling safe practices.** ● **Identified construction site work areas that have potential safety risks.** ● **Discussed possible consequences of unsafe work conditions on an outside production site.** ● **Demonstrated the safe handling of hand tools and power tools.** ● **Listed safety rules for portable power tools.** ● **Identified location of safety shut offs in shop.** ● **Describe the correct procedure in case of a fire.** ● **Demonstrate correct procedure for dealing with an injury.** ● **Explain where Emergency Cut-Offs are located and where evacuation route is.**

	• **Demonstrate wearing the appropriate clothing/ equipment (including PPE) required to work on a construction site.**
2. Fuel Oil Hazards • EPA regulations • DEP regulations • IAQ/mold	• **Complete a research paper on the cost of environmental cleanup of oil spills.** • **Research articles regarding IAQ problems in Connecticut.**

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Danger Signs • Paperwork • Air Test • Falling Gear • Keeping Watch • Stopping Work • Safe Space • Checking Tools	• Potential Hazards • Compliance • Monitoring • Mitigation • Supervision • Authority • Zone Control • Inspection	• Leading Indicators / Root Cause • SDS (Safety Data Sheets) / OSHA 300 Log • Four-Gas Monitor / LEL (Lower Explosive Limit) • Engineered Controls / PFAS • Competent Person / Attendant • Stop Work Authority (SWA) • Non-Permit vs. Permit Required Confined Space • Pre-Shift Inspection / Continuity Test

Trade Math Crossover: **(VOG- Problem Solver)**

Focus: Scaling, overhead, and competitive bidding.

1. **Comprehensive Material Take-Off:** A commercial blueprint for a medical office is drawn at 1/8" = 1'-0" scale. The domestic cold water main measures 14.5 inches on the drawing.
    - **Calculation:** Determine the actual length in feet.
    - **Advanced Adjustment:** If the pipe must navigate around two HVAC ducts, adding an estimated 8 feet of "offset" travel, and you must account for a 10% waste factor, how many 20-foot lengths of Type L Copper must be ordered?
2. **The "Job Costing" Equation:** You are bidding on a project that requires 120 man-hours. Your journeyman rate is $45/hr., and your apprentice rate is $22/hr. Your "burdened" labor multiplier is 1.4 (to cover taxes/insurance). If the materials cost $6,500 and you want a 15% net profit on the total job cost, calculate your final bid price.
3. **Scaffolds**: You have a scaffold set up 20 feet high and a width of 30feet, how high will you need to make the toe boards on the scaffolds?

Resources to compliment learning-

- OSHA CFR 1926,
- Modern Plumbing Textbook Chapter 1
- Hydronic Heating: Systems and Application

Crossover to Apprenticeship Standards:

- A0099 Building Trades Safety OSHA 30 for construction certification

VOG Portfolio Collection Examples:

VOG- An Effective Communicator

- **Example:** Students will develop a scaffold safety plan as if they were designated the "Competent Person".

VOG Trait: An Effective Communicator

- **Example:** A student develops a comprehensive scaffold safety plan, acting as the designated "Competent Person" for a job site. They must clearly communicate the plan's requirements—such as toe board heights and load capacities—to their team to ensure 100% compliance.

VOG Trait: A Problem Solver

- **Example:** When using a multimeter to test a water heater element, the student identifies that an AI-generated instruction missed a critical step. They demonstrate "Hazard Mitigation" by correctly performing a Lock-Out/Tag-Out (LOTO) procedure before touching any terminals.

<table>
<tr><th colspan="2">Priority Standard 12.2 - Mechanical system Blue Print reading.</th></tr>
<tr><td colspan="2">Big Idea(s):
1. Blueprints are dynamic living documents that require Cross-Functional Coordination between multiple trades.
2. Because mechanical systems often compete for the same structural space (plenums), a lead technician must use Clash Detection skills to resolve inter-trade interferences before they become costly physical conflicts on the job site</td></tr>
<tr><td colspan="2">Essential Question(s):
1. How can mechanical systems design and sized using the code?
2. How are science and math related to the sizing of plumbing systems?
3. How would you resolve a plan-related conflict?</td></tr>
<tr><td colspan="2">Learning Outcomes</td></tr>
<tr><td>Students will know:</td><td>As evidenced by: (oral, written, or performance)</td></tr>
<tr><td>1. Layout of a single zone hot water loop
● Boiler accessories needed for a working system.
● Terminal units
● Piping
● Valves
● Pumps
● LWCO
● Specialty Items
● Hangers
● Electrical Controls
● Oil tank or gas piping</td><td>● Complete a basic system design with all accessories needed for a working system</td></tr>
<tr><td>2. Heating symbols and isometrics.</td><td>● Identify and draw symbols and piping schematics pertaining to a hydronic heating system.</td></tr>
<tr><td>3. Residential heating system take-off
● Material list
● Labor
● Heat loss calculations</td><td>● Complete a heat loss calculation of a residential heating system.
● Complete a scale drawing of a residential heating system</td></tr>
</table>

[Link to Proficiency Scale]

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Big Picture • Space Rules • Special Parts • Hidden Lines • Job Progress • Final Check • Cut-out View • Matching Up	• Integration • Constraints • Categorization • Subsurface • Phasing • Verification • Internal Geometry • Alignment	• Cross-Functional Coordination • Easements and Right-of-Way • Equipment Schedules (Pump/Boiler) • Invert Elevations / Sloping Grade • Critical Path / Sequencing • Commissioning / Punch List • Cross-Sectional Detail • Inter-Trade Interference / Clash

Trade Math Crossover: **(VOG- Critical Thinker)**

Focus: Well-pump sizing, drawdown, and leaching fields.

1. **Septic Leaching Area:** According to the CT Public Health Code, a residential leaching system is sized based on the number of bedrooms and the "percolation rate" of the soil.
    - **Calculation:** A 4-bedroom house requires a minimum effective leaching area of 900 sq. ft. If you are using 2-foot-wide stone-filled trenches, how many total linear feet of trenching must be excavated to meet the 900 sq. ft. requirement?
2. **Well Pump Drawdown:** A captive air pressure tank has a total volume of 80 gallons. The "drawdown" (the actual amount of water available between the pump turning off at 60 psi and turning on at 40 psi) is typically 25% of the total volume. If a house has a peak demand of 5

gallons per minute (GPM), how many minutes can the family run the water before the well pump is forced to cycle on?

3. **Heat Loss**: Using the heat loss calculations from 11th grade, calculate the amount of baseboard heaters in each room.

Resources to compliment learning-

- Hydronic Heating Systems and Applications (Chapters 11 & 13)
- Print Reading for Construction

Crossover to Apprenticeship Standards:

- A0784 Heating Fundamentals
- A0789 Heating, Hydronic and Steam

VOG Portfolio Collection Examples:

VOG- Work Ready

- **Example:** Students will create a heating system material list for their floorplan including heat loss and all materials to complete a hydronic heating system.

VOG Trait: A Team Player

- **Example:** Acting as a "Conflict Coordinator," the student identifies a "clash" on a commercial print where a waste line and a large supply duct occupy the same ceiling space. They collaborate with other trades to suggest a code-compliant reroute that maintains the required 1/4" per foot pitch.

VOG Trait: Work Ready

- **Example:** The student creates a professional material list and "take-off" for a residential heating system. This includes calculating total heat loss for each room and matching it to the correct linear footage of baseboard radiation.

Priority Standard 12.3 - BPR skills relating to the International Mechanical and Plumbing Codes	
Big Idea(s): **It is not only important to be able to interpret a set of prints; you must also make sure everything is up to code.**	
Essential Question(s): 1. **What problems could arise if plumbers do not review the prints for the other trades working on the same project?**	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1. Floor plan showing all code clearances for a half bath. ● **Isometric** ● **Plan view** ● **Sectional view** ● **Takeoff** ● **Minimum code requirements** ● **Digital Plans**	● **Draw an isometric sketch of a half bath with all dimensions and a material list needed to complete the job.** ● **Demonstrated proper use of rough-in sheets and code compliance.** ● **Interpret information found in digital and CAD/three dimensional drawings**
Link to Proficiency Scale	

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Tier 1 (Everyday)	**Tier 2 (Academic)**	**Tier 3 (Technical/Trade)**
● Code Book ● Fixing it ● Proof ● Allowed ● Way out ● Blocking ● Water path ● Check-up	● Regulatory Framework ● Compliance ● Evidence ● Permissible ● Exhaust ● Obstruction ● Distribution ● Evaluation	● IPC / IMC Standards ● Mandatory Provisions ● Certification of Occupancy ● Non-Potable vs. Potable ● Combustion Air Requirements ● Clearance to

		Combustibles ● Cross-Connection Control ● Third-Party Testing / Listing

Trade Math Crossover: **(VOG- Critical Thinker)**

1. Focus: Drainage and Venting Audits (IPC Compliance)

Students must use blueprints to calculate if the proposed Waste and Vent system can handle the hydraulic load.

- **The DFU Accumulation Challenge:** A blueprint for a 4-story apartment building shows a 4-inch vertical stack serving 8-bathroom groups (each bathroom group = 5 Drainage Fixture Units).
    - **Math:** Calculate the total DFU load (8 times 5 = 40 DFUs).
    - **Code Check:** Consult IPC Table 710.1(2). If the table limit for a 4-inch stack is 500 DFUs, is the design compliant? If the engineer mistakenly labeled the stack as 3-inch (limit 48 DFUs), how close is the system to maximum capacity?
- **Horizontal Branch Sizing:** A horizontal branch on a blueprint serves three floor-mount water closets. IPC Section 704.2 requires horizontal branches to be sized based on the total DFU. If the branch is labeled as 3-inch pipe, but the IPC requires 4-inch for more than two water closets on a horizontal branch, the student must identify this as a "BPR Code Conflict."

2. Focus: Hydronic and Mechanical Systems (IMC Compliance)

Standard 12.3 requires students to interpret mechanical schedules (tables on the blueprint) to ensure heating systems are safe and efficient.

- **Combustion Air Requirements (IMC 701):**

A mechanical room blueprint shows two boilers, each with an input of 250,000 BTUs. The room dimensions are 10' x 15' x 8'.

- **Math:** Calculate the room volume (1,200 cubic feet).
- **Code Check:** The IMC requires 50 cubic feet of space per 1,000 BTUs for "unconfined" combustion air. (500,000 / 1,000 times 50 = 25,000 cubic feet required).

- **Application:** Since 1,200 < 25,000, the student must identify that the blueprint is missing the required "Make-up Air" louvers or mechanical ductwork.

- **Thermal Expansion Calculation:** A hydronic blueprint shows 600 linear feet of 2-inch steel pipe for a heating loop.
  - **Math:** Calculate the total water volume in the pipe (2-inch steel holds approx. 0.17 gallons per foot). 600 times 0.17 = 102 gallons.
  - **Code Check:** Using the IPC/IMC expansion formulas, determine if the expansion tank specified in the "Equipment Schedule" on the blueprint has the necessary "Acceptance Volume" (typically 4% of total volume) to prevent the pressure relief valve from tripping.

3. Focus: Commercial Interceptors (IPC 1003)

Standard 12.3 emphasizes the calculation of flow rates for grease and sand interceptors in commercial blueprints.

- **Grease Interceptor Sizing (The 2-Minute Rule):**

  A blueprint for a restaurant shows a 3-compartment sink. Each compartment is 24" x 24" x 12".

  - **Step A:** Calculate the total volume in cubic inches (24 times 24 times 12 times 3 = 20,736 cu in).
  - **Step B:** Convert to gallons (20,736 / 231 = 89.7 gallons).
  - **Step C:** IPC requires interceptors to be sized for a 1-minute or 2-minute drainage period. If using a 2-minute period, the flow rate is 44.8 GPM.
  - **Code Audit:** If the blueprint specifies a "35 GPM Grease Interceptor," the student must flag this as a code violation because the interceptor is undersized for the sink's volume.

4. Focus: Advanced Blueprint Symbols & Abbreviations

Mastery of 12.3 involves recognizing specific code-driven symbols that dictate installation:

- **F.D. (Floor Drain):** Must be checked for a "Trap Primer" connection (IPC 1002.4) to prevent sewer gas.
- **A.A.V. (Air Admittance Valve):** Students must check the blueprint to ensure they are not placed in "non-vented" spaces or crawlspaces without access (IPC 918).
- **R.P.Z. (Reduced Pressure Zone Backflow Preventer):** Students must ensure the blueprint shows a floor drain nearby, as these valves are designed to discharge water during a backflow event (IPC 608).

5.Focus: Fixture Take-offs: Using a fixture rough in sheet, correctly rough in a fixture of your choice.

Resources to compliment learning-

- International Plumbing Code
- Modern Plumbing Textbook (Chapter 17)
- Print Reading for Construction

Crossover to Apprenticeship Standards:

- A0700 Intro to Plumbing
- A0031 Blue Print Reading
- A0729 International Mechanical Code
- A0711 Plumbing Code, I
- A0741 Plumbing Code II
- A0730 Related Codes and Standards

VOG Portfolio Collection Examples:

VOG- A Critical Thinker:

- **Example:** Students will select a fixture from the shop and create a fixture rough in sheet for that specific fixture.

VOG Trait: A Critical Thinker

- **Example:** The student performs a "Code-Compliant Design Review" on a digital plumbing layout for a commercial kitchen. They must catch a "hidden error" (such as an improper distance from a trap to a vent) by citing the specific IPC or IMC section that the design violates.

Priority Standard 12.4 - Plumbing code application.

Big Idea(s):

1. **When assigned a specific job, it is important to be able to complete the job in a specified amount of time.**

Essential Question(s):

1. Why do you think timing of jobs is important in our trade?

Learning Outcomes

Students will know:	*As evidenced by: (oral, written, or performance)*
1. Timed performance-based assessments. ● **Create material list** ● **Install plastic piping** ● **Install copper tubing** ● **Install proper pipe protection** ● **Layout and drill holes in workstations** ● **Prepare and test systems** ● **Complete required paperwork** ● **Clean area** ● **Replace tools and equipment**	● **Work independently within a time limit to produce a high-quality project. (VOG- Work Ready)** ● **Demonstrates proper tool selection and usage.** ● **Tests end product to insure a leak proof product.** ● **Safe use of tools** ● **Job neatness to rubric standard** ● **Measurement/accuracy (rubric)** ● **Demonstrates an ability to work from a drawing or print within designated tolerances.** ● **Wears proper safety gear in the completion of their tasks.** ● **Completes tasks in a professional manner.** ● **Cleans work area to professional standards**

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Connecticut Technical Education and Career System

CTECS Plumbing & Heating

Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Dirty Water • Air Pressure • Hospital Pipes • Big Water Heater • Back-up Pump • Grease Trap • Check Valve • Fire Sprinkler	• Contamination • Pneumatics • Sanitization • High Capacity • Redundancy • Interception • Prevention • Suppression	• Backflow / Cross-Connection • PSI / Compressed Air Systems • Medical Gas (MedGas) / Brazing • Commercial Storage / Mixing Valve • Duplex Sump Pump / Alternator • Oil/Water Separator / FOGs • RPZ (Reduced Pressure Zone) / DCVA • Wet-Pipe vs. Dry-Pipe Systems

Trade Math Crossover: **(VOG: Critical Thinker)**

1. Water Distribution Sizing (IPC Chapter 6)

Focus: Determining the "Available Pressure" after accounting for friction and elevation.

A three-story apartment building has a water meter at the street providing **65 PSI**. The highest fixture is a showerhead located **28 feet** above the meter. The total developed length of the piping from the meter to that shower is **120 feet**.

- **Step A (Elevation Loss):** Calculate the pressure loss due to elevation (0.433 PSI per foot of head).
- **Step B (Friction Loss):** If the pipe sizing results in a friction loss of **4.2 PSI per 100 feet**, calculate the total pressure lost to friction over the 120-foot run.
- **Step C (Code Check):** IPC 604.3 requires a minimum of **8 PSI** at a showerhead. Subtract the elevation and friction losses from the starting 65 PSI. Does the system meet the code-required minimum pressure at the highest fixture?

2. Maximum Fixtures on a Stack (IPC Chapter 7)

Focus: Evaluating "Stack Loading" in multi-story drainage systems.

You are auditing a blueprint for a 5-story building using a **4-inch Drainage Stack**.

- **The Data:** Each floor has two "Bathroom Groups" (one group = 1 toilet, 1 sink, 1 tub/shower). According to IPC Table 709.1, a bathroom group is rated at **5 DFUs** (Drainage Fixture Units).
- **The Math:** Calculate the total DFU load for all 5 floors (5 floors times 2 groups times 5 DFUs).
- **Code Application:** Consult IPC Table 710.1(2). If the maximum DFU load for a 4-inch stack is **500 DFUs** (for buildings over 3 stories), is this design compliant? What would happen to the code requirement if the stack diameter was reduced to **3 inches** (which has a limit of 48 DFUs)?

3. Circuit Venting and Slope (IPC Chapter 9)

Focus: Horizontal branch limits and air-flow ratios.

A commercial bathroom battery uses **Circuit Venting** for 6 floor-outlet water closets (toilets).

- **The Code:** IPC 911.3 states that the horizontal branch shall be installed at a slope of not more than 1 unit vertical in 12 units horizontal (8.3% slope).
- **The Math:** If the horizontal branch pipe is **45 feet long**, calculate the maximum "total drop" (vertical change) allowed by code to maintain the air gap necessary for the circuit vent to function.
- **Advanced Check:** If the plumber accidentally installed the pipe with a **1/4-inch per foot** pitch, calculate the total drop. Does this exceed the 1:12 slope limit?

5. Gas Pipe Sizing - Pressure Drop (IFGC/IPC Crossover)

Focus: Sizing for "Longest Run" to ensure appliance safety.

A 12th-grade student must size a gas line for a rooftop unit (RTU) rated at **450,000 BTU/hr**. The total length of the pipe from the meter to the RTU is **180 feet**.

- **The Math:** Using the **International Fuel Gas Code (IFGC)** tables for "Schedule 40 Metallic Pipe" with a 0.5 PSI inlet pressure and a 0.5-inch water column pressure drop:
  - Find the required pipe diameter for 450,000 BTUs at the 180-foot or 200-foot column.
- **Code Application:** If a junior apprentice installed **1.25-inch pipe**, calculate the "BTU Deficit" (the difference between what the RTU needs and what the 1.25-inch pipe can actually deliver at that distance).

Blue Print Reading

Topic: **Rough -in**

Example: **Using the blueprint provided, measure and drill, cut or notch all holes and penetrations for project rough in.**

Resources to compliment learning-

- Modern Plumbing (Chapter: 6, 13, 15, 16, 17, 19, 21, 22, 23,)
- International Plumbing Code (Chapter 6, 7 & 9)
- Print Reading for Construction
- CSST Sizing Charts

Crossover to Apprenticeship Standards:

- A0700 Intro to Plumbing
- A0031 Blueprint Reading
- A0706 Drains Waste and Vents 1
- A0746 Drains Waste and Vents 2

VOG Portfolio Collection Examples:

VOG- Work Ready

- **Example:** Students will create an isometric drawing of the DWV system and Water Supply system of their project.

VOG Trait: Work Ready

- **Example:** During a timed performance assessment, the student independently manages a workstation project from layout to testing. They demonstrate "Industry Readiness" by completing the installation within designated tolerances, filing all required paperwork, and leaving the job site professional and clean

Priority Standard 12.5 - Hydronic heating systems and components.	
Big Idea(s): 1. System efficiency is the result of the perfect synergy between mechanical components and electrical controls. **2.** Mastery of hydronic systems requires a technician to move beyond part-replacement and into Root Cause Analysis, using diagnostic tools to verify that every component; from circulators to expansion tanks; is performing to its design specifications	
Essential Question(s): 1. What are the benefits of a hydronic heating system in comparison to other types of heating systems? 2. How does the contractor determine the appropriate type of hydronic heating system to install for a particular job?	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1. Trade-related science and math in relation to heating theory. ● **Area** ● **Volume** ● **Pressure** ● **Force**	● **Research the related theory of heat energy and fuels used in the heating industry including thermodynamics and expansion of water.**
2. Application of applicable codes.	● **Interprets the IPC and IMC to correct standards and applications**
3. Heating boilers, components and controls. ● Boilers wet and dry base ● Boiler's oil /gas ● Indirect Heaters ● Tankless heaters ● Primary/ secondary circuits ● Zone control devices ● LWCO ● Backflow Devices ● Feed valves ● Motors	● Performs basic installation of boilers, residential heating systems and specialties.

• Pumps • Thermostats • Flow checks • Draft regulator • Expansion tank • Burner assembly	
4. **Heating systems, boilers and pressure vessels** • **Oil, gas, and electric** • **Hot water and steam** • **Direct and split loop** • **One pipe, two pipe, direct, and reverse return** • **Radiant** • **Hydro-air**	• Demonstrates knowledge of various heating systems and equipment, i.e., one pipe steam and hot water, two pipe steam and hot water, hydro-air, radiant, including appropriate safety and operating equipment.
5. Oil tanks and pumps. • Standard oil tanks • Single - pipe gravity feed • Single - pipe lift feed oil tank below burner • Two - pipe gravity feed • Two - pipe lift feed oil tank below burner • Dual tank installations • Special tanks • Underground tanks • Safety devices	• **Performs installations of oil tanks in accordance with industry standards (single and twin tanks)** • Demonstrates use of oil transfer pumps for different job applications.
6. Codes governing the storage and delivery of fuel oil • Containment methods • Transferring fuels	• Compares and contrasts different fossil fuels and efficiencies of different oil grades. • Installs all safety controls based on the International Mechanical Code and the local administrative authority
7. Solar Thermal System Checkout Reference: NABCEP 10.1,10.2,11.1-11.6 • Correct Material • Structural Integrity • Piping System • Electrical System • System Operation • Proper Tagging and Labeling	• Reference: NABCEP 10.1,10.2,11.1-11.6 • Determines components that require identification tag and/or label • Installs identification tags and/or label • Identify any deficiencies in materials, workmanship, function or appearance by visually inspecting entire installation

	• Determine that the system mechanical installation has structural integrity and is weather sealed • Determine that the system plumbing installation is correctly installed • Determine that the electrical installation is correctly installed • Verify system start-up and shut-down functionality • Verify overall system operation

Link to Proficiency Scale

Tiered Vocab- Plumbing and Heating students build a professional vocabulary, we have broken down the terms into three tiers based on the standard educational model:

- Tier 1: Common, everyday words (Basic communication).
- Tier 2: High-frequency academic words (Used across various subjects/trades).
- Tier 3: Low-frequency, domain-specific technical terms (The "Language of the Trade").

Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Even-Heat • Air Remover • Hot Water Tank • Mixer • Heat Passer • Small Pipes • Boiler • Pressure Gauge	• Equalization • Deaeration • Indirect Heating • Temperature Control • Thermal Transfer • Radiant Surface • System Logic • Monitoring	• Hydronic Balancing / Flow Rate (GPM) • Micro-bubble Resorber / Air Separator • Indirect-Fired Water Heater • Thermostatic Mixing Valve / 3-Way Valve • Plate Heat Exchanger • PEX-AL-PEX / Oxygen Barrier Tubing • Outdoor Reset Curve / Modulating-Condensing • Tridicator / Pressure Differential

Trade Math Crossover: **(VOG: Critical Thinker)**

Focus: Flow rates and electrical diagnostics.

1. **GPM Flow Rate Testing:** A customer complains of "low pressure." You perform a bucket test at the furthest fixture. The fixture fills a 5-gallon bucket in 1 minute and 40 seconds.
    - **Calculation:** Calculate the GPM (Gallons Per Minute). If the code-required minimum for this fixture type is 2.2 GPM, determine if the system is underperforming and by what percentage.
2. **Gas Valve Millivolt Testing:** You are troubleshooting a standing pilot gas water heater. The thermopile should generate 750 millivolts (mV) when heated. If the multimeter reads 0.450 Volts, convert this value to millivolts. Is the thermopile producing enough power to hold the safety magnet open (which requires a minimum of 350 mV)?
3. **IMC and Related Codes application:** Install an oil tank to specifications and distances as stated in the IMC and NFPA Codes.

Resources to compliment learning-

- Modern Plumbing Textbook (chapter 2 and 4)
- NABCEP Solar Thermal Guide
- Hydronic Heating: Systems and Application

Crossover to Apprenticeship Standards:

- A0700 Intro to Plumbing
- A0031 Blueprint Reading
- A0729 International Mechanical Code
- A0730 Related Codes and Standards

VOG Portfolio Collection Examples:

VOG- Work Ready

- **Example:** Students will pipe a boiler and oil tank to IMC Standards and Codes.

Priority Standard 12.6 - Troubleshooting hydronic heating systems and components.	
Big Idea(s): **1. Being able to identify and troubleshoot different parts of a heating system is a higher-level skill that employers are looking for when hiring technicians.** **2. Being able to compare and contrast dissimilar heating systems is a question that you will constantly be asked by the consumer, especially when trying to decide what kind of electrical components/controls should be installed.** **3. It is important that technicians can perform efficiency tests correctly and keep equipment running safely and efficiently.**	
Essential Question(s): 1. Why do you think it is necessary to perform a heat-loss prior to installing heating equipment? 2. Why is an efficiency test so important?	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1**. Trade related science and math in relation to heating theory.** ● **Ohm's Law** ● **Series circuits** ● **Parallel circuits**	● Demonstrates knowledge of the I_B_R_ heat loss method and shows a working knowledge of hand and computer heat loss calculations. ● **Demonstrate knowledge of applications of series and parallel circuits. (VOG-Critical Thinker)**
2. **Electrical components.** ● **Zone control devices** ● **Motors** ● **Pumps** ● **Thermostats**	● **Perform basic electrical control wiring, troubleshooting, and testing.**
3. Efficiency Testing -Oil and Gas Containment methods	● Perform efficiency test on oil and gas equipment using combustion analyzers or electronic testing tools.

4. Service and Repair high efficiency wall hung boilers	• Installs and services high efficiency wall hung boilers and water heaters to manufacturer specifications.

Link to Proficiency Scale

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- Tier 3: Low-frequency, domain-specific technical terms (The "Language of the Trade").

Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• No Heat • Leaking • Cold Spots • Noisy Pipe • Too Hot • Broken Part • Testing Power • Fixing it	• System Failure • Fluid Loss • Inefficiency • Acoustic Indication • Overheating • Defective Component • Electrical Verification • Resolution	• Intermittent Lockout / Flame Failure • Gasket Degradation / Weep Hole Leak • Air Binding / Short Cycling • Cavitation / Expansion Noise • Runaway Boiler / High-Limit Trip • Frozen Circulator / Failed Thermocouple • Multimeter Continuity / 24V Control Circuit • System Purge / Component Replacement

Trade Math Crossover: **(VOG: Problem Solver & Critical Thinker)**

1. Calculating GPM from BTU Load (The Hydronic Formula)

When a room is cold, a technician must determine if the circulator pump is moving enough water.

- **The Formula:** GPM = BTU/500 times Δ T (where Δ T is the temperature difference between the supply and return).

- **The Scenario:** A high-efficiency boiler is supplying a zone with a 40,000 BTU/hr. load. The technician measures the supply pipe at 180°F and the return pipe at 160°F (Δ T = 20).
- **The Math:** Calculate the required GPM. If the installed circulator is only capable of 2.5 GPM at the current head pressure, is the pump undersized for this zone?

2. Expansion Tank Troubleshooting (Air-to-Water Ratio)

A common service call involves a "weeping" relief valve. This often means the expansion tank has failed or is waterlogged.

- **The Data:** A residential system has a total water volume of 120 gallons. Water expands by roughly 4% when heated from 50°F to 180°F.
- **Step A:** Calculate the required "Acceptance Volume" in gallons (120 times 0.04).
- **Step B:** If the technician checks the expansion tank and finds it is a 4.5-gallon tank, but it is half-filled with water (waterlogged), calculate the remaining air space.
- **The Diagnostic:** Compare the remaining air space to the required expansion volume. Will the relief valve open when the boiler hits high limit?

3. Velocity and Pipe Noise Diagnostics

A customer complains of "banging" or "whistling" in the copper baseboard heating pipes.

- **The Code/Standard:** To prevent noise and erosion, water velocity in copper tubing should stay between 2 and 4 feet per second (fps).
- **The Scenario:** A technician finds a 3/4" copper loop (Area ≈ 0.00307 sq ft) carrying 8 GPM.
- **The Math:** Use the formula Velocity = GPM times $0.408/d^2$ (or simplified flow charts). If 8 GPM in a 3/4" pipe results in a velocity of roughly 5.8 fps, use the math to explain to the customer why they are hearing "velocity noise."

4. Electrical Troubleshooting: Ohms and Voltage Drop

A zone valve fails to open. The technician must use a multimeter to diagnose the 24V transformer or the valve motor.

- **Ohm's Law:** A healthy 24V zone valve motor typically has a resistance of 20 to 30 Ohms.
- **The Scenario:** The technician measures the resistance (R) of the motor and gets a reading of 1,200 Ohms.
- **The Calculation:** Using I = V / R, calculate the amperage (I) the motor is drawing.
- **The Diagnostic:** If the current is near zero, explain mathematically why the motor is "open" and requires replacement.

5. Pump Head and Pressure Drop

When adding a new radiator to an existing system, the technician must calculate if the pump can handle the added "Head" (friction).

- **The Data:** Each foot of 3/4" pipe adds 0.04 feet of head. Each 90-degree elbow adds the equivalent of 2 feet of pipe.
- **The Scenario:** A student adds 50 feet of pipe and ten 90-degree elbows to a system.
- **The Math:** Calculate the total "equivalent feet" of pipe added (50 + (10 times 2) = 70 feet). Then calculate the total additional head pressure (70 times 0.04).
- **The Diagnostic:** If the existing pump is already operating at its maximum of 12 feet of head, and the current system head is 10.5 feet, does the addition of this radiator push the pump "off its curve"?

Resources to compliment learning-

- International Mechanical Code
- Hydronic Heating Systems and Applications (Chapter 8 &16)

Crossover to Apprenticeship Standards:

- A0784 Heating Fundamentals
- A0789 Heating, Hydronic and Steam
- A0006 HVAC Math
- A0782 Electrical Fundamentals

VOG Portfolio Collection Examples:

VOG- A Problem Solver & A Critical Thinker

- **Example:** Students will troubleshoot basic boiler control issues created by instructor.

VOG Trait: A Critical Thinker

- **Example:** A student calculates the "Total System Volume" for a hydronic loop to select the correctly sized expansion tank. They must justify their selection based on the formula for water expansion to prevent the system's relief valve from blowing under pressure.

Priority Standard 12.7 - Career Opportunities	
Big Idea(s): 1. The transition from student to professional is defined by Marketability and Business Logic. 2. A graduate's value is determined not just by their ability to join pipe, but by their understanding of Labor Market Information, fringe benefit calculations, and their capacity to represent a company's brand through ethical customer service and leadership	
Essential Question(s): 1. If you were an employer looking to hire some new employees, what are skills that you would want them to have?	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1. • **Employer expectations** • **Customer expectations**	• **Fills out practice job applications along with preparing a resume for future employment.** • **Conducts mock interviews to prepare for employment.** • Demonstrates knowledge of GREEN TECHNOLOGIES. • **Present a student portfolio demonstrating interview skills and knowledge. (VOG- Effective Communicator)** • Explains and demonstrates customer and employer expectations (ex: attendance policy, dress, being neat, treating others property as if their own, avoid needless conversation, avoid the use of profanity, being prepared for weather conditions, respecting employers and customer's needs, jobsite safety, consideration to

	others, etc.) through role play.

Link to Proficiency Scale

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Job Search • Learning on the job • Own my business • Special Job • Money • Union vs Non-Union • Resume • Moving up	• Market Analysis • Career Path • Entrepreneurship • Niche Market • Compensation • Affiliation • Portfolio • Advancement	• Labor Market Information (LMI) • Registered Apprenticeship (RA) • Master License / Contractor Liability • BIM Technician / Backflow Tester • Prevailing Wage / Fringe Benefits • UA (United Association) vs. Open Shop • Credentials / Certifications (OSHA, EPA) • Journeyman Status / Continuing Education

Trade Math Crossover:

Focus: Service call ROI and scheduling.

1. **Service Van "Overhead" Math:** A service van costs $45,000 to purchase, costs $4.00 per gallon in fuel (averaging 12 MPG), and requires $1,500 in annual maintenance. If the van travels 15,000 miles per year, calculate the "Vehicle Operating Cost per Mile." How much should be added to every service call just to cover the cost of the van arriving at the job site?
2. **Project Management (Gantt Math):** You are managing a crew for a 10-unit apartment complex.

Each unit takes 18 hours to "rough-in" and 6 hours to "trim-out." If you have 3 plumbers working 8-hour days, calculate the total number of workdays required to complete the entire complex.

3. **Calculations**: **Hourly Wage and fringe calculations:** If an employer is offering a 60% benefit package of the base hourly salary, what would the total wage and benefit package be if the hourly pay rate is 20.00 per hour?

Resources to compliment learning-

- Modern Plumbing (chapter 32)
- CTECS Licensed Trades VOG Resources

Crossover to Apprenticeship Standards:

- A0700 Intro to Plumbing

VOG Portfolio Collection Examples:

VOG- An Effective Communicator

- **Example:** Students will create a portfolio show their accomplishments and achievements to be used in a job interview setting.

VOG Trait: An Effective Communicator

- **Example:** The student refines their digital portfolio and Student Competency Checklist to present to a Work-Based Learning (WBL) employer. They can articulately describe their 720 hours of related instruction and how it applies to a P-2 apprenticeship.

Priority Standard 12.8 - Construction Management Opportunities	
Big Idea(s): 1. **Successful construction management requires balancing time, cost, and quality through organized leadership and communication.**	
Essential Question(s): **1. If you were an employer looking to hire some new employees, what are skills that you would want them to have?** **2. Do you know how to describe all of the skills and knowledge that we have passed along to you to an employer?**	
Learning Outcomes	
Students will know:	*As evidenced by: (oral, written, or performance)*
1**. Job application and interview skills.**	• **Fills out practice job applications along with preparing a resume for future employment.** • **Conducts mock interviews to prepare for employment.** • **Demonstrates knowledge of GREEN TECHNOLOGIES.**
2. **Pre-construction Career Pathways**	• **Justify design solutions through the use of research documentation and analysis of data.** • **Use effective communication skills and strategies (listening, speaking, reading, writing, and graphic communications) to work with clients and colleagues.** • **Understand the integral systems that impact the design of buildings and structures.**

	• Apply building codes, laws, and rules in the design and construction of projects. • Identify the diversity of needs, values, and social patterns in project design, including accessibility standards, to appropriately meet client needs. • Apply the techniques and skills of modern drafting, design, engineering, and construction to projects. • Employ appropriate representational media to communicate concepts and design. • Apply principles, conventions, standards, applications, and restrictions pertaining to the selection and use of construction materials, components, and assemblies for project design.
3. Construction Career Pathways	• Understand contractual relationships with all parties involved in the building process to ensure successful build of a project. (VOG-Respectful) • Understand approval procedures to ensure effective flow of information in the construction process. • Understand and implement testing and inspection procedures to ensure successful completion of a construction project. • Understand the purpose of scheduling as it relates to the successful

	completion of a construction project • Understand and apply practices and procedures required to maintain jobsite safety. • Manage relationships with internal and external parties to successfully complete construction projects. • Compare and contrast the building systems and components for a given project. • Demonstrate the construction crafts required for each phase of a given project • Safely use and maintain appropriate tools, machinery, equipment, and resources to accomplish construction project goals.
4. Maintenance/Operations Career Pathway	• Safely use and maintain appropriate tools, machinery, equipment, and resources to accomplish construction project goals. • Recognize and employ universal construction signs and symbols to function safely in the workplace. • Troubleshoot and solve a maintenance problem to maintain buildings and structures. (VOG-Problem Solver) • Apply construction skills when repairing, restoring, or renovating existing structures. • Determine work required to repair or renovate an existing building or structure, • Plan and practice preventative maintenance activities to service existing structures.

	• **Maintain and inspect building systems to achieve safe and efficient operation of facilities.** • **Explains and demonstrates customer and employer expectations (ex: attendance policy, dress, being neat, treating others property as if their own, avoid needless conversation, avoid the use of profanity, being prepared for weather conditions, respecting employers and customer's needs, jobsite safety, consideration to others, etc.) through role play.**

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Tier 1 (Everyday)	Tier 2 (Academic)	Tier 3 (Technical/Trade)
• Project Leader • Planning • Money Management • Material List • Sub-contractor • Paperwork • Quality Check • Future Planning	• Supervision • Scheduling • Financial Oversight • Procurement • Coordination • Documentation • Accountability • Forecasting	• Project Manager (PM) / Foreman • Critical Path Method (CPM) / Gantt Chart • Cost Estimation / Budget Variance • Submittals / Lead Time • Inter-Trade Relations / Site Logistics • RFI / Change Orders / Closeout • Quality Assurance & Quality Control (QA/QC) • Man-Hour Projections / Backlog

Trade Math Crossover: **(VOG: Problem Solver)**

1. Labor Burden and True Cost of Employment

In construction management, the "hourly wage" is not the "actual cost" to the company. A manager must calculate the **Labor Burden** to bid jobs accurately.

- **The Data:** A lead plumber is paid **$42.00/hour**. However, the company also pays:
  - Social Security/Medicare: 7.65%
  - Workers' Comp Insurance: 12%
  - Health Insurance/Benefits: $4.50/hour
  - 401k Match: 3%
- **The Math:** Calculate the "Burdened Labor Rate."
- **Management Application:** If a project is estimated to take 200 man-hours, calculate the total labor cost difference between using the $42/hour base rate versus the true burdened rate. Why would bidding at the base rate cause the company to lose money?

2. Calculating "Break-Even" and Overhead

A construction manager must determine the **Minimum Daily Billable Rate** to keep the shop doors open.

- **The Data:** Monthly fixed expenses (Shop rent, office staff, truck leases, insurance, and utilities) total **$18,500**. The company has 4 service vans on the road.
- **The Math:** Assuming 20 billable workdays per month, calculate how much "overhead" each van must generate *per day* just to reach the break-even point before any profit is made.
- **Management Application:** If a van only bills 4 hours in a day at $110/hour, did that van cover its share of the daily overhead?

3. Production Rates and Scheduling (Gantt Math)

Managers use **Production Rates** to schedule large-scale commercial projects.

- **The Scenario:** A blueprint shows 1,200 linear feet of copper domestic water piping in a new school wing. History shows your crew's production rate is **15 feet per man-hour** for this type of installation.
- **The Math:** * Step A: Calculate the total man-hours required for the pipe installation (1,200 / 15).
    - Step B: If the general contractor demands the wing be finished in 5 working days (8 hours per day), how many plumbers must the manager assign to this task to meet the deadline?

4. Profit Margin vs. Markup

Construction managers often confuse "Markup" and "Margin," which can lead to financial errors in bidding.

- **The Data:** A high-efficiency boiler costs the company **$4,500** at the supply house.
- **The Challenge:** * **Part A (Markup):** Calculate the sales price if the manager applies a **30% markup** to the cost.
    - **Part B (Margin):** Calculate the sales price if the manager wants to achieve a **30% profit margin** (Formula: Cost / (1 - 0.30).
- **The Diagnostic:** Which method results in a higher sales price? As a manager, why is the "Margin" calculation more accurate for maintaining a specific bottom line?

5. Retainage and Cash Flow Management

In large commercial construction, the General Contractor often holds **"Retainage"** (usually 10%) until the very end of the project.

- **The Scenario:** Your plumbing firm is halfway through a **$250,000** contract. You have billed for **$125,000** worth of completed work.
- **The Math:** If the GC holds 10% retainage on all progress payments, calculate the actual cash amount your company has received.

- **The Management Problem:** If your material and labor costs for that work totaled **$115,000**, use the math to explain why your company is currently "in the red" (negative cash flow) despite the job being profitable on paper.

6. Equipment ROI (Return on Investment)

A manager is considering purchasing a **$12,000** ProPress tool system to replace manual soldering.

- **The Data:** Manual soldering takes 5 minutes per joint. ProPress takes 1 minute per joint. The burdened labor rate is $60/hour ($1.00 per minute).
- **The Math:** Calculate the labor savings per joint ($4.00). How many total press joints must the crew perform to "pay off" the $12,000 investment?
- **Management Application:** If a typical apartment building has 1,500 joints, is the tool worth the investment for a single project?

Resources to compliment learning-

- Mathematics for Plumbers (Unit 66)

Crossover to Apprenticeship Standards:

- A0007 Intro to Plumbing

VOG Portfolio Collection Examples:

VOG- Skilled Socially

- **Example:** Students will Interview and take part in the Work Based Learning Program.

VOG Trait: Skilled Socially

- **Example:** The student analyzes the role of a project manager in sustainable construction. They research how implementing high-efficiency boilers and solar thermal systems contributes to a community's energy goals and environmental health.

Appendix

Link to NABCEP Solar Thermal Strands

Link to CTECS Licensed Trade VOG Guides & Resources

Link to Instructional Guidebook Resources

Grade 9 Math/Trade Crossover

In the 9th-grade year, the focus is on "Foundational Competencies," where students transition from general middle-school math to the specific precision required for a licensed trade:

Grade 9 Math Connection Master Review Table

Priority Standard	Trade Topic	Primary Math Application	Core Formula / Code Reference
9.1: Shop and Site Safety	Ladder Safety	Calculating the 4:1 safety ratio for extension ladders to ensure a stable climbing angle.	Ratio: Height÷4=Base
9.2: Licensing & Procedure	Apprenticeship Hours	Calculating total required "Related Instruction" and "On-the-Job Training" hours for P-2 or S-4 licensing.	Addition: Summing hours over 4 years
9.3: Basic Math & Sketching	Blueprint Scaling	Using an architectural scale to convert paper measurements into actual installation lengths for pipe runs.	Scaling: 1/4"=1’0" or 1/8"=1’0"
9.4: Plumbing Codes	Minimum Clearances	Measuring and maintaining specific code-required distances for residential "rough-in" installations.	Linear Measurement: Fractions to 1/16"
9.5: Hand Tool Usage	Precision Cutting	Determining "End-to-End" vs. "Center-to-Center" measurements when using saws and tubing cutters.	Subtraction: Total Length−Fitting Take−off

9.6: Joining Pipe	Fitting Allowances	Calculating the depth of a pipe "socket" or "thread" to ensure accurate assembly of copper, PVC, or steel systems.	Geometry: Adding socket depths to the laying length

Visualizing the 9th Grade Trade Math

- **Measurement Tip:** In the plumbing trade, a 1/8" error can cause a drain to lose its required "pitch," leading to clogs.
    - Grade 9 students must master reading a rule to the 1/16".
- **Blueprint Tip:** Students learn that a line measuring 2 inches on a 1/4" scale plan actually represents 8 feet of physical pipe in the building.
- **Calculation Tip:** To cut a pipe to the correct length, students must subtract the "fitting allowance" (the distance from the center of the fitting to the start of the pipe) from their total measurement.

Student "Quick-Check" Challenges

1. **The Ladder Challenge:** You need to reach a roof line that is 16 feet high. How many feet away from the wall should you place the feet of your ladder? (Answer: **4 feet**).
2. **The Scaling Challenge:** On a 1/8" = 1'0" blueprint, a bathroom wall measures 1.5 inches. How long is the actual wall? (Answer: **12 feet**).
3. **The Hours Challenge:** If a student completes 180 hours of related instruction (RI) each year, how many total RI hours toward their P-2 license will they have after 4 years? (Answer: **720 hours).**

Connecticut Technical Education and Career System

CTECS Plumbing & Heating

Grade 10 Math/Trade Crossover

The math in Grade 10 shifts from simple linear measurement to **applied science**, where students calculate the relationship between water, pressure, and fixture requirements using the **International Plumbing Code (IPC)** and **International Residential Code (IRC)**.

Grade 10 Math Connection Master Review Table

PRIORITY STANDARD	TRADE TOPIC	PRIMARY MATH APPLICATION	CORE FORMULA / CODE REFERENCE
10.2: PIPING SYSTEMS	Solar Thermal Piping	Calculating pipe expansion and contraction over long runs due to high-temperature solar fluids.	Coefficient of Thermal Expansion
10.3: PLUMBING MATH & SCIENCE	Pressure & Force	Calculating the weight of water in a system and the pressure (PSI) exerted at the base of a vertical stack.	1 foot of head =.433 PSI
10.4: PUMPING SYSTEMS	Pump Curves	Using X-Y axis graphs to plot "Head Pressure" against "Gallons Per Minute" (GPM) to select the correct circulator.	Manufacturer Pump Performance Curves
10.5: RESIDENTIAL FIXTURES	ADA Clearances	Calculating floor space and mounting heights for ADA-compliant water closets and lavatories.	IPC Chapter 4 / ICC A117.1
10.7: BLUEPRINT READING	Rough-in Dimensions	Interpreting "Rough-in Sheets" to determine the exact center-line of a drain based on finished wall thickness.	Addition/Subtraction of Finished Wall Material

10.8: REPAIR & SERVICE	Thermal Efficiency	Comparing the fuel consumption and "Energy Factor" (EF) of high-efficiency vs. standard water heaters.	Percentage of Efficiency (%)

Visualizing the Grade 10 Trade Math

- **Science Tip:** In Grade 10, students learn that water "wants" to push down. For every **1 foot** they go up in a building, they need to overcome **0.433 PSI** of pressure.
- **Code Tip (Standard 10.5):** Students use the IPC to ensure a wheelchair can perform a **60-inch** "U-turn" in a bathroom. This is where geometry meets life-safety.
- **Pumping Tip (Standard 10.4):** Selecting a pump is not a guess. Students must calculate the **Total Dynamic Head** (friction loss) of the pipe and then find the intersection point on the manufacturer's curve.

Student "Quick-Check" Challenges

1. **The Head Pressure Challenge:** A water tank is located on the roof, 50 feet above the basement faucet. What is the static pressure at that faucet? (Calculation: 50 \times 0.433 = 21.65 **PSI**).
2. **The ADA Clearance Challenge:** According to the ADA standards in your curriculum, how high must the seat of a toilet be from the floor? (Reference IPC/ADA: **17 to 19 inches**).
3. **The Rough-in Challenge:** A toilet requires a **12-inch** rough-in from the *finished* wall. If you are currently at the *stud* wall and adding 1/2" drywall and 1/4" tile, what is your rough-in measurement from the stud? (Calculation: 12 + 0.5 + 0.25 = **12.75 inches**).

Connecticut Technical Education and Career System

CTECS Plumbing & Heating

Grade 11 Math/Trade Crossover

Grade 11 represents a significant shift into **design, layout, and complex system sizing**. Students move beyond basic residential repair into commercial-scale applications where math is used to ensure system safety and legal compliance with the **International Plumbing Code (IPC)** and **Fuel Gas Codes.** In Grade 11, students move into "Code-Compliant Design," where math is the tool used to bridge the gap between a 2D blueprint and a functional, legal mechanical system.

Grade 11 Math Connection Master Review Table

PRIORITY STANDARD	CODE FOCUS	PRIMARY MATH APPLICATION	CODE / FORMULA REFERENCE
11.2: CODE DESIGN	IPC / IMC	**WSFU/DFU Sizing:** Calculating total load for water supply and drainage systems across a building.	IPC Chapters 6 & 7
11.2: CODE DESIGN	IMC	**Combustion Air:** Calculating the required cubic feet of "makeup air" for fuel-burning appliances to prevent carbon monoxide buildup.	IMC Chapter 7 / NFPA 54
11.3: DWV SYSTEMS	IPC / IRC	**Pitch & Gradient:** Calculating the vertical "fall" over a horizontal run to maintain self-scouring velocity (2 ft/sec).	1/4" or 1/8" per foot
11.4: FUEL GAS	IFGC	**Longest Length Method**: Determining pipe diameter by totaling BTU loads and measuring the distance from the meter to the furthest outlet.	NFPA 54 / IFGC Tables
11.5: HEATING	IMC / IRC	**Heat Loss (Q):** Calculating BTUs required based on room square footage, insulation R-values, and U-factors.	Heat Loss $=A \times \Delta T \times U$

11.7: BLUEPRINTS	All Codes	**Isometric Scaling:** Using 30°/60° geometry to draw 3D "scaled" representations of 2D floor plans.	3D Isometric Projection

Visualizing the Multi-Code Math

- **Mechanical Tip (Standard 11.2):** Under the **IMC**, students must calculate if a room has enough "indoor air" for combustion. If not, they use math to size the two permanent openings (one high, one low) to bring in outdoor air.
- **Fuel Gas Tip (Standard 11.4):** Sizing is not about the pipe you are holding; it's about the **Longest Run**. Even if a branch is only 5 feet long, if the total system run is 60 feet, students must use the 60-foot column in the **IFGC tables** to ensure pressure stays constant.
- **Design Tip (Standard 11.2 & 11.7):** Students use **Drainage Fixture Units (DFUs)** to determine the diameter of the main stack. A "3-unit" bathroom battery requires a different math-set than a single residential powder room.

Student "Quick-Check" Challenges

1. **The IMC Makeup Air Challenge:** A mechanical room is 10' x 10' x 8' (800 cubic feet). If an appliance requires 50 cubic feet of air per 1,000 BTU/hr., how many BTUs can this room safely support without outside vents? (Answer: **16,000 BTU/hr.**).
2. **The IPC Slope Challenge:** You are running a horizontal branch for 48 feet. If the code allows a minimum pitch of 1/8" per foot, what is the total vertical drop required? (Calculation: 48 \times 0.125 = **6 inches**).
3. **The IRC Heat Loss Challenge:** A room has 200 sq. ft. of floor space. If the design requires 40 BTUs per sq. ft., what is the total heat load for the room? (Calculation: 200 \times 40 = **8,000 BTUs**)

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Grade 12 Math/Trade Crossover

Grade 12 is the **"Mastery and Management"** year. Students transition from being installers to "Project Managers," where the math involves high-level system integration, multi-code compliance (IPC, IMC, IRC, and IFGC), and the financial mathematics of the trade.

Grade 12 Math Connection Master Review Table

PRIORITY STANDARD	CODE FOCUS	PRIMARY MATH APPLICATION	CODE / FORMULA REFERENCE
12.2: ADVANCED DESIGN	IPC / IRC	**Sizing Interceptors:** Calculating the flow rate (GPM) and capacity for grease traps in commercial kitchens.	IPC Chapter 10
12.3: HYDRONIC HEATING	IMC / IRC	**Expansion Tank Sizing:** Calculating the volume of water expansion in a closed-loop system based on temperature rise.	IMC Chapter 10
12.4: FUEL GAS SYSTEMS	IFGC / NFPA 54	**Pressure Drop Calcs**: Adjusting pipe sizes for high-pressure gas systems and calculating regulator settings.	IFGC Chapter 4
12.5: PRIVATE SYSTEMS	State Health Code	**Septic Sizing:** Calculating "Percolation Rates" (minutes per inch) to size leaching fields and septic tank volume.	PHC Table 1
12.6: SOLAR THERMAL	IMC / IRC	**Array Efficiency:** Calculating "Solar Fraction" and collector angles for maximum BTU gain based on latitude.	IMC Chapter 14
12.8: EXAM PREP / PM	All Codes	**Estimation & Labor**: Calculating "Man-Hours," material overhead, and "Change Order" costs for a project.	Project Management Math

Visualizing Grade 12 Management Math

- **Commercial Tip (Standard 12.2):** In Grade 12, students must use math to protect the city's infrastructure. They calculate the **Flow Rate** from commercial sinks to ensure the grease interceptor is large enough to allow fats/oils to separate before the water enters the main sewer.
- **Hydronic Tip (Standard 12.3):** Heated water expands. Students must calculate the **Total System Volume** (all the water in the boiler, pipes, and radiators) and then use a formula to select an expansion tank that can handle that increased volume without blowing the relief valve.
- **Site Math (Standard 12.5):** For private systems, math is literal "dirt work." Students calculate how many square feet of **Leaching Area** are required based on the number of bedrooms in the house and how fast the soil absorbs water.

Student "Quick-Check" Challenges

1. **The Expansion Tank Challenge:** A system holds 100 gallons of water. If the water expands by 4% when heated, how many gallons of "acceptance volume" must the expansion tank be able to hold? (Calculation: 100 \times 0.04 = **4 Gallons**).
2. **The Project Management Challenge:** A blueprint shows 400 feet of copper pipe. If one plumber can install 50 feet per day, and the labor rate is $85/hour, what is the estimated labor cost for the pipe installation? (Calculation: $400 / 50 = 8 days. 8 \times 8 \ hours = 64 hours. 64 times 85 = **$5,440**).
3. **The Fuel Gas Regulator Challenge:** You are dropping gas pressure from 2 PSI to 7 inches of Water Column. If the total load is 500,000 BTUs, what size regulator is required? (Reference: **IFGC Regulator Sizing Tables**).