



Kathy Cox, State Superintendent of Schools

Title: Roof Systems – Area, Volume, Material Estimation, and Construction (embedding mathematics into CTAE)

Grade: 10, 11, 12

Designers: Pam Fails

## Unit Development Template

### Introduction

#### Unit Title

Roof Systems – Area, Volume, Material Estimation, and Construction (embedding mathematics into CTAE)

#### Unit Annotations

Building a roof in the construction industry requires the ability to accurately lay-out and cut rafters. In this project, students will accurately calculate length, determine layout and cut rafters for a specified building size. In addition, students will use construction and mathematics vocabulary interchangeably. Learning activities involve using the Pythagorean formula to calculate rafter length, estimation skills to create the materials and cost list.

#### Grade(s)

- 10
- 11
- 12

#### Subject(s)

Math / Mathematics 1
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#### (Optional) Approximate Duration of Unit

This unit was taught on a 4x4 block schedule and lasted approximately 3 days for the CTAE teacher and 1-30 minute lesson for the Math teacher.

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### Unit Author

Pam Fails (Georgia Standards)

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### (optional) Additional Author(s) and their Email Address(es)

Tim Cockrell – CTAE cockrell-t@harris.k12.ga.us Jon Bentley - Math bentley-j@harris.k12.ga.us

## Unit Focus Standards

### Unit Focus Standards

**MM1A2 Students will simplify and operate with radical expressions, polynomials, and rational expressions.**

- a. Simplify algebraic and numeric expressions involving square root.
- b. Perform operations with square roots.
- g. Use area and volume models for polynomial arithmetic.

### Unit Focus Standards

**MM1P1. Students will solve problems (using appropriate technology).**

- a. Build new mathematical knowledge through problem solving.
- b. Solve problems that arise in mathematics and in other contexts.
- c. Apply and adapt a variety of appropriate strategies to solve problems.
- d. Monitor and reflect on the process of mathematical problem solving.

### Unit Focus Standards

**MM1P3. Students will communicate mathematically.**

- a. Organize and consolidate their mathematical thinking through communication.
- b. Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.
- c. Analyze and evaluate the mathematical thinking and strategies of others.
- d. Use the language of mathematics to express mathematical ideas precisely.

### Unit Focus Standards

**MM1P4. Students will make connections among mathematical ideas and to other disciplines.**

- a. Recognize and use connections among mathematical ideas.
- b. Understand how mathematical ideas interconnect and build on one another to produce a coherent whole.
- c. Recognize and apply mathematics in contexts outside of mathematics.

## Unit Focus Standards

### **MC1P3. Students will communicate mathematically.**

- a. Organize and consolidate their mathematical thinking through communication.
- b. Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.
- c. Analyze and evaluate the mathematical thinking and strategies of others.
- d. Use the language of mathematics to express mathematical ideas precisely.

## Unit Focus Standards

### **MC4P1. Students will solve problems (using appropriate technology).**

- a. Build new mathematical knowledge through problem solving.
- b. Solve problems that arise in mathematics and in other contexts.
- c. Apply and adapt a variety of appropriate strategies to solve problems.
- d. Monitor and reflect on the process of mathematical problem solving.

## Unit Focus Standards

### **ELA9LSV1 The student participates in student-to-teacher, student-to-student, and group verbal interactions. The student**

- a. Initiates new topics and responds to adult-initiated topics.
- b. Asks relevant questions.
- c. Responds to questions with appropriate information.
- d. Actively solicits another person's comments or opinions.
- e. Offers own opinion forcefully without domineering.
- f. Volunteers contributions and responds when directly solicited by teacher or discussion leader.
- g. Gives reasons in support of opinions expressed.
- h. Clarifies, illustrates, or expands on a response when asked to do so; asks classmates for similar expansions.
- i. Employs group decision-making techniques such as brainstorming or a problem-solving sequence (e.g., recognizes problem, defines problem, identifies possible solutions, selects optimal solution, implement).
- j. Divides labor to achieve the overall group goal efficiently.

## Unit Focus Standards

### **SEV4 Students will understand and describe availability, allocation and conservation of energy and other resources.**

- a. Differentiate between renewable and nonrenewable resources including how different resources are produced, rates of use, renewal rates, and limitations of sources. Distinguish between natural and produced resources.
- b. Describe how technology is increasing the efficiency of utilization and accessibility of resources.
- c. Describe how energy and other resource utilization impact the environment and recognize that individuals as well as larger entities (businesses, governments, etc.) have impact on energy efficiency.
- d. Describe the relationship of energy consumption and the living standards of societies.
- e. Describe the commonly used fuels (e.g. fossil fuels, nuclear fuels, etc.) and some alternative fuels (e.g. wind, solar, ethanol, etc.) including the required technology, availability, pollution problems and implementation problems. Recognize the origin of fossil fuels and the problems associated with our dependence on this energy source.
- f. Describe the need for informed decision making of resource utilization. (i.e. energy and water usage allocation, conservation, food and land, and long-term depletion)

**Unit Focus Standards**

**SEV5 Students will recognize that human beings are part of the global ecosystem and will evaluate the effects of human activities and technology on ecosystems.**

- a. Describe factors affecting population growth of all organisms, including humans. Relate these to factors affecting growth rates and carrying capacity of the environment.
- b. Describe the effects of population growth, demographic transitions, cultural differences, emergent diseases, etc. on societal stability.
- c. Explain how human activities affect global and local sustainability.
- d. Describe the actual and potential effects of habitat destruction, erosion, and depletion of soil fertility associated with human activities.
- e. Describe the effects and potential implications of pollution and resource depletion on the environment at the local and global levels (e.g. air and water pollution, solid waste disposal, depletion of the stratospheric ozone, global warming, and land uses).
- f. Describe how political, legal, social, and economic decisions may affect global and local ecosystems.

<b>Unit Complementary Standards</b>
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<b>National / Local Standards / Industry / ISTE</b>
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**(Recommended) National / Local Standards / Industry / ISTE**

**Literacy Strategies**

2- Column Notes

Exit Slips

**Habits of Success**

Working in teams

Time management

Keeping up with materials

Revising writing to meet skills

Problem solving

Synthesizing information

Being accountable

Making real-world connections

**Algebra 1 QCC****QCC 1**

Topic: Problem solving, Reasoning

Standard: Solve problems that involve:

- ü Selecting appropriate approaches and tools,
- ü Using estimating strategies to predict computational results
- ü Judging reasonableness of results

**QCC 2**

Topic: Problem Solving, Connections

Standard: Solves problems that link concepts to one another and to practical applications using tools such as scientific or graphing calculators, computers, and manipulative.

**QCC 3**

Topic: Communication

Standard: Communicates mathematical ideas by using language and symbolism:

- ü Reflects upon and clarifies thinking about mathematical ideas and relationships.
- ü Formulates mathematical definitions and expresses generalizations discovered throughout investigations.
- ü Express mathematical ideas both orally and in writing.
- ü Interprets written presentations of mathematics, and asks clarifying and extending questions related to mathematics about which they have read or heard.

### QCC 19

Topic: Linear equations in two variables

Standard: Identifies the slope and intercepts of a linear equation.

### QCC 33

Topic: Rational and irrational numbers and radical expressions

Standard: Applies the Pythagorean theorem and its converse in problem solving situations.

## CTAE Standards:

### Carpentry I

ACT-C1-2. Students will use tools and equipment in a professional and safe manner

- a. Demonstrate the use of the proper tools for a specific carpentry building procedure.
- b. Demonstrate knowledge of specific regulations as related to specific equipment.

ACT-C1-3. Students will become familiar with the selection, handling, storage, and proper use of construction materials used in site layout and floor and wall construction.

- a. Demonstrate knowledge of proper selection of materials for site layout, floors and walls.
- b. Demonstrate knowledge of individual components used in site layout, floors and walls.
- c. Demonstrate knowledge of layout as it relates to site layout, floors, and walls.

### Carpentry II

ACT-C2-1. Students will know and understand proper and necessary carpentry tasks that enable a team to construct ceiling and roof systems.

- a. Measure, layout, and cut all types of ceiling framing members.
- b. Measure, layout, and cut all types of roof framing members.
- c. Demonstrate a basic knowledge of truss systems.

## Understanding and Goals

### Unit Enduring Understandings

Understand how to use mathematical and construction formulas to estimate materials needed.

Understand the process of cutting rafters for a roof system.

Estimate materials cost of components of a roof system.

Understand the mathematical and construction vocabulary related to components of a roof system.

Understand that rafters are an important component of a roof system and that the roof design influences the overall cost of a building.

Understand that the floor system must be laid out and constructed correctly in order to support walls and roof systems.

Realize that the floor system being square impacts the outcome and quality of the building.

## Unit Essential Questions

How do mathematical formulas simplify the material estimation process?

How do mathematical formulas help you to layout and cut rafters correctly?

How is unit conversion used in determining the layout and cutting of rafters?

## (Recommended) Pre-Requisite Knowledge & Skills / Current Unit Knowledge & Skills

### Assessment & Instruction

#### Formative Assessments for Learning

- Subjective assessment - Subjective assessments require the teacher's judgment to determine the grade. These include short answer as well as essay tests.
- Post-test - A helpful way to find out whether your students have mastered the basic knowledge and skill levels required.
- Objective assessment - Objective assessments (usually multiple-choice, true- false, short answer) have correct answers.
- Pre-test - A helpful way to find out whether your students meet the basic knowledge and skill levels required to learn your materials.
- Peer-assessment - Peer evaluations consist of student analysis and assessment of peer proficiency using specific criteria. Peer evaluations may use checklists or rubrics.

### Describe the Assessments

#### Describe the Assessment(s)

##### CTAE teacher

Objective Assessment-Comprehensive quizzes and a roofing worksheet

Attachment: Roof Worksheet

Subjective Assessment- Informal observations to see if students are selecting correct building material, laying out rafters, and using hand and power tool safely.

Peer Assessments- Students will view and comment on the work of their peers.

Pre-Test- Assess student understanding of volume and area calculations, unit conversions and word problems, and construction and mathematical terminology.

Attachment: Roof\_Pretest CATE and Math

Post-Test- Determine comprehension and ability to apply mathematical formulas.

Attachment: Roof\_Post test CATE

##### Math teacher

Subjective assessment- Discussion held about area and volume of a roof, vocabulary, and completion of the CTAE Roof Worksheet.

Attachment: Math Mini Lesson

Pre-assessment- Assess understanding of volume and area calculations, unit conversions and word problems involving Pythagorean formula, and construction and mathematical terminology.

Attachment: Roof\_Pretest CATE and Math

**Assessment(s) Attachment**

**(Optional) Attachment**

Uploaded file: [Roof\\_Pretest CTAE and Math.doc](#)

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**(Optional) Attachments (Typically a Rubric or Checklist)**

**(Optional) Attachment**

Uploaded file: [Roof Post test CTAE.doc](#)

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**(Optional) Attachments (Typically a Rubric or Checklist)**

**(Optional) Attachment**

Uploaded file: [RoofWorksheet.jpg](#)

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**(Optional) Attachments (Typically a Rubric or Checklist)**

**(Optional) Attachment**

Uploaded file: [Math Mini Lesson\\_roof.doc](#)

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**(Optional) Attachments (Typically a Rubric or Checklist)**

**Instructional Planning**

**Instructional Planning**

Volume, Area, estimation of materials, cost of materials, construction/math vocabulary, cutting rafters, construction of a roof system

**Instructional Planning Attachment**

**(Optional) Instructional Planning Attachment**

Uploaded file: [Construction rafter daily lesson plan.doc](#)

**Materials and Equipment / Homework Extensions**

**Materials and Equipment**

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**(Optional) Homework Extensions**

**Attachment – Homework Extensions**

## Culminating Unit Performance Task

### (Optional) Culminating Unit Performance Task

Laying out and cutting a rafter

### Culminating Unit Performance Task Description/Directions/Differentiated Instruction

**Situation:** In this exercise students will learn to accurately determine, layout and cut a rafter based on blueprints for a roof system. Students will learn to use construction and mathematics vocabulary interchangeably, estimate cost, calculate length, measure, cut, and layout a rafter. These learning activities will include mathematical calculations using the Pythagorean Theorem, volume and area formulas, and the basics of constructing roof systems.

### (Optional) Attach Rubric or Checklist for Unit Performance Task

Uploaded file: [Rubric for Rafter.doc](#)

### (Optional) Attachment - May be Student Directions or other attachment

Uploaded file: [Student Rafter Project Information Handout.doc](#)

### (Optional) Attach Student Handout or other attachment

### (Optional) Attachment – May be Teacher Directions or other attachment

## Student Work Sample Title / Description

(Optional) Student Work Sample Title / Description

## Attachment - Student Work Sample

## Teacher Commentary Title / Description

(Optional) Teacher Commentary Title / Description

## Attachment - Teacher Commentary

## Language of the Standards

(Optional) Language of the Standards

## Unit Resources

(Optional) Web Resources

(Optional) Ancillary Materials



**(Optional) What 21st Century Technology was used in this Unit Development Template?****(Optional) Notes and Reflections**

A Math teacher collaborated with the CTAE teacher to design and integrate lessons for presentations to students. Math teacher taught a mini lesson parallel to the CTAE teacher teaching the unit however the teachers were not teaching the same students. The Math teacher created contextual problems for both CTAE and Math classes.

*Enhancing the Unit:* To make this project more rigorous and require more academics, require students to create a CAD drawing/blueprint of the roof system. If CAD is not available, consider using Google SketchUp--a free downloadable CAD program. Require students to make a presentation with slideshow software to demonstrate their understanding of simple blueprints and the mathematics involved in designing a roof system.

*This unit was developed in response to the requirements of the reauthorization of Carl Perkins legislation which requires CTAE teachers to embed the instruction of rigorous academics into CTAE courses. This CTAE teacher paired with a mathematics teacher who served as a consultant to help find embedded high school mathematics and to serve as a support in the instruction of the embedded mathematics. The CTAE teacher served as a consultant to the mathematics teacher as he/she prepared mathematics lesson plans in which students applied mathematics to real-world authentic CTAE projects. For more information about the eight-step unit development process, please contact Leslie Carson at [leslie.carson@sreb.org](mailto:leslie.carson@sreb.org). For more information about the implementation of the unit instruction, please contact the additional authors listed above.*