STEMfest® KNOX

Saturday, February 27, 2015

The STEMfest KNOX Team is dedicated to linking Science, Technology, Engineering & Math by acting as a catalyst between local industry, schools, parents & children.

Sponsors:

Central Ohio Technical College

Kenyon College

Mount Vernon Nazarene University — Life Changing

SPI — science play-space initiative

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Sponsorship opportunities still available.

The Works® — Ohio Center for History, Art & Technology

Eff. 10/13

November 2015

Re: STEMfest! Knox, February 27, 2016

Dear Teachers,

Enclosed are packages for middle, high, and post-secondary students interested in participating in the **2016 STEMfest! Knox Problem Solving Challenge**. Each packet includes:

- A letter of invitation
- STEMfest! Knox Objectives to Student Career Development
- Ohio and National Learning Standards Addressed by STEMfest! Knox
- "What You Need To Know" Informational Sheet and Resource Guide
- Three Problem Solving Challenge Statements
- Persistent Scientist Nomination Form
- Team Registration Form
- Scholarship Opportunities

To provide a thorough introduction to each Problem Solving Challenge, you and your students are invited to attend Challenge Presentations hosted by the experts in the field responsible for each challenge. Presentations include a chalkboard session to clearly introduce and outline the problem statement and an opportunity to ask questions about the problem or STEMfest! process. There are three presentations scheduled, one for each problem solving challenge, and students and teachers are invited to attend one, or all presentations. Our goal is to allow you and your students to gain a visual point of reference, ask questions, become comfortable with the STEMfest! Knox process, and to ultimately select a problem-solving challenge.

We hope you will find one – or more! – of the problems suitable for your students and are able to create a team or allow students to compete individually to represent your school for STEMfest! Knox problem solving competition will be at Central Ohio Technical College (COTC) Knox located at 236 South Main St., Mount Vernon and Mount Vernon Nazarene University (MVNU) Hunter Hall at 231 South Main St., Mount Vernon (right across the street from COTC-Knox). Additional exhibits and hands on activities will be located across the street at SPI SPOT 227 South Main St. Mount Vernon. ***STEMfest! Knox Kits will be available for pickup at SPI Spot to eliminate the cost to your school and the students.*** Please refer to the enclosed "What You Need To Know" information guide for a complete listing of supplies and the dates these packets will be available for pickup.

You, your students, and families are invited to attend STEMfest! Knox on February 27, 2016 from 10:00am – 4:00pm. In addition to the STEMfest! Knox Challenge presentations, the event will showcase local industry with hands-on activities for middle and high school students. Judging of the STEMfest! Knox Challenges will be on Saturday, February 27th for all participants. Judging times for each challenge will be sent out after registrations have been processed. To register a team, please visit http://tinyurl.com/STEMfestKnox2016. If you have time constraints please let us know with your registration, we will do our best to accommodate requests as received. Awards for both Middle and High School winners will be presented at 4:00pm on Saturday, February 27th.

Please bring your family and encourage your students who might not be participating on a team to attend as well! ***The event is free of charge*** and your students will be amazed by the opportunities for future employment in Knox County industries and the variety of careers that emphasize training in science, technology, engineering and math.

STEMfest! Knox is an annual event. The STEMfest Knox Team is already planning for 2017 and looks forward to hearing your feedback about how to improve this experience. A follow-up survey will be distributed to all participants, teachers and students, following STEMfest! Knox 2016.

Sincerely,
STEMfest Knox Team

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STEMfest! Knox Objectives to Student Career Development

SELF AWARENESS **GRADES K,1,6,9,11**
Gain knowledge of the importance of self-concept. Develop skills to interact with others. Gain awareness of the importance of growth and change.

CAREER INFORMATION **GRADES K,2,4,6,8,10,11**
Develop skills to understand and use career information.

EXPLORATION **GRADES 2,8,10,11**
Gain awareness of broad occupational areas. Experience the process of exploring careers.

REDUCTION OF BIAS **GRADES 6,7,8,9,10**
Gain awareness of different occupations and changing male and female roles. Gain awareness of what constitutes equal career opportunities for all individuals regardless of race, ethnic background and/or handicapping condition.

FUTURE TRENDS **GRADES 7,9,10,11,12**
Gain awareness of the importance of adapting to change.

EMPLOYABILITY SKILLS **GRADES 3,8,9,10,11,12**
Gain awareness of the relationship between work and learning. Gain awareness of the importance of personal responsibility and good work habits.

DECISION MAKING-GOAL SETTING **GRADES 3,4,6,7,10**
Understand how to make decisions and establish goals.

COMMUNITY INVOLVEMENT **GRADES 3,6,11,12**
Gain awareness of the importance of involvement in the community.
Gain awareness of the range of opportunities available for community service.

Beth Bronkar
Career Development Coordinator
150 Price Road
Newark OH 43055
(740) 364-2234 office
(740) 973-9460 cell

Ohio's New Learning Standards
Addressed by STEMfest! Knox

Toothpick Bridge Challenge Standards

Ohio's Learning Standards		
	Science	**Math**
Grade 6	**Matter and Motion (PS)** There are two categories of energy: kinetic and potential.	**Ratios and Proportional Relationships** Understand ratio concepts and use ratio reasoning to solve problems.
		Expressions and Equations Apply and extend previous understandings of arithmetic to algebraic expressions.
		Statistics and Probability Develop understanding of statistical variability. Summarize and describe distributions.
Grade 7	**Conservation of Mass and Energy (PS)** Energy can be transferred through a variety of ways.	**Ratios and Proportional Relationships** Analyze proportional relationships and use them to solve real-world and mathematical problems.
		Expressions and Equations Solve real-life and mathematical problems using numerical and algebraic expressions and equation.
Grade 8	**Forces and Motion (PS)** Forces between objects act when they are in direct contact or when they are not touching. Forces have magnitude and direction. There are different types of potential energy.	**Geometry** Understand congruence and similarity using physical models, transparencies, or geometry software
		Expressions and Equations Understand the connections between proportional relationships, lines, and linear equations.
		Functions Define, evaluate, and compare functions.
Grades 9 – 12	**Energy and Waves (PS)** Conservation of energy. Transfer and transformation of energy.	**Number and Quantity** Reason quantitatively and use units to solve problems.
	Forces and Motion (PS) Forces.	**Algebra** Understand solving equations as a process of reasoning and explain the reasoning. Represent and solve equations and inequalities graphically.
	Forces, Momentum, and Motion (P) Newton's laws applied to complex problems. Gravitational force and fields. Elastic forces. Friction force (static and kinetic).	**Geometry** Make geometric constructions. Visualize relationships between two-dimensional and three-dimensional objects. Apply geometric concepts in modeling situations.
		Statistics and Probability Summarize, represent, and interpret data on a single count or measurement variable.

Next Generation Science Standards – Engineering Design	
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combines into a new solution to better meet the criteria for success
HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts

English Language Arts	
Grades 6 – 12	Reading Standards for Literacy in Science and Technical Subjects
	Listening and Speaking Standards

Global Water Challenge Standards*

Ohio's Learning Standards		
	Science	**Math**
Grade 6	**Rocks, Minerals, and Soil (ESS)** Minerals have specific, quantifiable properties. Igneous metamorphic and sedimentary rocks have unique characteristics that can be used for identification and/or classification. Rocks, minerals, and soils have common and practical uses.	**Geometry** Solve real-world and mathematical problems involving area, surface area, and volume.
Grade 7	**Cycles and Patterns of Earth and the Moon (ESS)** The hydrologic cycle illustrates the changing states of water as it moves through the lithosphere, biosphere, hydrosphere, and atmosphere.	**Geometry** Solve real-world and mathematical problems involving angle, measure, area, surface area, and volume.
Grades 9 – 12	**Earth Systems (ES)** Surface and ground water flow patterns and movement. Movement of matter and energy through the hydrosphere, lithosphere, atmosphere, and biosphere. Energy transformations on global, regional, and local scales.	**Number and Quantity** Reason quantitatively and use units to solve problems. **Statistics and Probability** Summarize, represent, and interpret data on a single count or measurement variable.

Next Generation Science Standards – Earth and Human Activity	
MS-ESS3-1	Construct a scientific explanation based on evidence for how the uneven distribution of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.
MS-ESS3-2	Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ESS3-4	Construct an argument supported by evidence for how increases in human population and pre-capita consumption of natural resources impact Earth's systems.
HS-ESS3-1	Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Next Generation Science Standards – Ecosystems: Interactions, Energy, and Dynamics	
HS-LS2-7	Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Next Generation Science Standards – Engineering Design	
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combines into a new solution to better meet the criteria for success
HS-ETS1-1	Analyze a major global challenge to specify qualitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts

English Language Arts	
Grades 6 – 12	Reading Standards for Literacy in Science and Technical Subjects
	Listening and Speaking Standards
	Writing Standards

Home Energy Challenge Standards

Ohio's Learning Standards		
	Science	**Math**
Grade 6	--	**Geometry** Solve real-life mathematical problems involving area, surface area, and volume.
		Expressions and Equations Apply and extend previous understandings of arithmetic to algebraic expressions. Reason about and solve one-variable equations and inequalities. Represent and analyze quantitative relationships between dependent and independent variables.
		Statistics and Probability Develop understanding of statistical variability. Summarize and describe distributions.
Grade 7	**Conservation of Mass and Energy (PS)** Energy can be transformed or transferred but is never lost. Energy can be transferred through a variety of ways.	**Ratios and Proportional Relationships** Analyze proportional relationships and use them to solve real-world and mathematical problems.
		Expressions and Equations Solve real-life and mathematical problems using numerical and algebraic expressions and equation.
		Geometry Solve real-life mathematical problems involving angle, measure, area, surface area, and volume.
Grade 8	--	**Expressions and Equations** Understand the connections between proportional relationships, lines, and linear equations.
		Functions Define, evaluate, and compare functions.
Grades 9 – 12	**Energy and Waves (PS)** Conservation of energy. Energy is relative. Transfer and transformation of energy (including work). Waves: Refraction, reflection, diffraction, absorption, superposition Radiant energy and the electromagnetic spectrum Thermal energy Electricity Movement of electrons Electric potential (voltage) Resistors and transfer of energy	**Number and Quantity** Reason quantitatively and use units to solve problems.
		The Complex Number System Perform arithmetic operations with complex numbers. Represent complex numbers and their operations on the complex plane. Use complex numbers in polynomial identities and equations.

Next Generation Science Standards – Matter and Its Interactions	
MS-PS1-3	Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-PS1-4	Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

Next Generation Science Standards – Energy	
HS-PS3-1	Create a computational model to calculate the change in energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) ad energy associated with the relative position of particles (objects).
HS-PS3-4	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Next Generation Science Standards – Engineering Design	
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combines into a new solution to better meet the criteria for success
HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts

English Language Arts	
Grades 6 – 12	Reading Standards for Literacy in Science and Technical Subjects
	Listening and Speaking Standards

Dear Knox County Students,

The STEMfest Knox Team has created a partnership between you, your school and local industries to help you learn more about STEM (Science, Technology, Engineering and Math) and how it will impact your future at the college level and in your workplace. Scientists, Engineers and Technicians of local industries will display and engage you in interesting aspects of their technology used to produce a variety products and machinery**. A central part of this STEMfest! Knox are the education and industry sponsored Problem Solving Challenges** and you are invited to participate!

This year the challenges offered for your participation are related to **Bridge Construction, Global Water, and Home Energy.** Each of these problems deals with a variety of disciplines and relates to issues you may encounter in your future career. The problem statements are attached for you to review and to decide which one(s) you may want to select. You can accept the challenge to create solutions as an individual or form a team. More than one solution exists for each problem meaning there is no single "right answer." Solutions will differ based on the process of discovery and approach.

To provide a thorough overview of each challenge, you are invited to attend **Problem Solving Challenge Presentations** hosted by experts in each field posing a challenge. Presentations will be held at Mount Vernon Nazarene University (MVNU) – Hunter Hall and include a chalkboard session to serve as a way to clearly introduce and outline the problem statement. Three presentations are scheduled, one per problem solving challenge and you are invited to attend the presentation(s) of your choosing. The goal is to allow you to gain a visual point of reference, ask questions, become comfortable with the STEMfest! Knox process, and ultimately select a problem solving challenge.

Once you or your team has selected a challenge, all necessary supplies will be available for pickup at SPI Spot at no charge to you or your school. Please refer to the enclosed **"What You Need To Know"** information guide for a complete listing of supplies and the dates these supplies will be available for pickup.

During STEMfest! Knox you and your team will present your findings to an audience of teachers and visitors. Middle School Students and High School Students will present on Saturday, February 27th, 2016. A panel of industry professionals will judge your solution on its uniqueness and quality and your presentation skills including an explanation of the solution process and research. Awards for winners will be presented following judging of all Challenge Presentations.

Each one of the challenges will take a good bit of your time. Solving the challenge for your enjoyment may be the best reward. But here are some additional rewards that may be important to you.

- Awards for top honors for middle and high school categories
- Possible opportunity for scholarships for high school students
- Press coverage for the event
- Participation certificates for all students for their career passports
- Possible opportunity for internship or job shadowing with local business and industry.
- Ambassadors for the STEMfest! Knox in 2017

Whether or not you decide to participate we hope you attend STEMfest! Knox on February 27, 2016 from 10:00am – 4:00pm. This is a free event! You will see great hand-on displays and activities related to your future careers.

Sincerely,
STEMfest! Knox Team

What You Need To Know

Problem Solving Challenge Presentations Dates and Contact Information:

- **Global Water Challenge:** Presented by Dr. Thomas Marshall, Mount Vernon Nazarene University Engineering Department

  Date/Time: December 12, 2015 1:00 – 2:00pm

  Location: Hunter Hall, Mount Vernon Nazarene University
  221 S Main St, Mt Vernon, OH 43050

- **Contact information:** Dr. Thomas Marshall at Thomas.Marshall@mvnu.edu
  Mount Vernon Nazarene University Engineering Department

  Presentation video: Will be available through YouTube after presentation date.

- **Toothpick Bridge Challenge:** Presented by Whit Tussing, COTC Engineering Technology

  Date/Time: December 12, 2015 2:15 – 3:15pm

  Location: Hunter Hall, Mount Vernon Nazarene University
  221 S Main St, Mt Vernon, OH 43050

  Contact information: Whit Tussing at wtussing@cotc.edu
  COTC Engineering Technology

  Presentation video: Will be available through YouTube after presentation date.

- **Home Energy Challenge:** Presented by Dr. Eric Holdener, Kenyon College Physics and Environmental Science Department

  Date/Time: December 12, 2015 3:30 – 4:30pm

  Location: Hunter Hall, Mount Vernon Nazarene University
  221 S Main St, Mt Vernon, OH 43050

  Contact information: Eric Holdener at holdenere@kenyon.edu
  Kenyon College Physics and Environmental Science Department

  Presentation video: Will be available through YouTube after presentation date.

Presentation Skills Workshop

Supported by Weathervane Playhouse

Supported by:

Date/Time: Tuesday, February 2, 2016, 5:00 – 6:00pm
Location: The Works, 55 S. 1st St., Newark, Ohio 43058
Contact: Adam Karsten – info@weathervaneplayhouse.org or Kaitlin Brucker – tm@weathervaneplayhouse.org

Presentation Skills Workshop Information:
This "Presentation Skills Workshop" will help you, through the use of theatre exercises and acting skills, find the best way to present your projects! Come join theatre professionals from Weathervane Playhouse in Newark, Ohio for a fun, creative new way to present your projects and to find ways to make the whole process easy. Some of the things you will learn more about are detailed below:

1. IMPROVED PUBLIC SPEAKING SKILLS

A professional actor requires an ability to speak clearly and eloquently and to project a strong and steady voice – all while delivering convincing, persuasive and believable dialogue. The same skills that are the focus of almost any acting class are the exact same ones you need for public speaking engagements and to deliver persuasive oral presentations.

2. IMPROVED CONFIDENCE

How can you overcome self-consciousness and find the confidence you need to present a professional and convincing presentation? Just practicing a presentation or performance with classmates can help to build a strong sense of confidence that will carry over into your presentations and everyday life.

3. LEARNING TO WORK AS A TEAM

Acting classes often involve exercises of trust, teamwork and collaboration. Any good actor will tell you that they are only as good as the actors sharing the stage with them. To offer a truly compelling presentation you will have to show solidarity as a team. With this workshop you will learn about how work on the stage requires sharing thoughts and ideas, giving and receiving a lot of constructive feedback, and supporting your fellow actors and classmates as you work to make each other improve, as well as your presentations improve, in a safe and supportive environment.

4. COMPOSURE, CONVERSATION & CONVINCING

Learn to be aware of what your body is saying as well as your words. The awareness of body, posture and physical presence that is taught in acting classes and increased through experience is not abandoned on the stage or left in the classroom; instead, it can be utilized as part of how a person carries themselves, exudes confidence and becomes convincing. Actors also must learn to listen to what they are getting from other actors and have a clear understanding of what is being said, conveyed and how to respond. All of these things, and more, can help put your presentation on a whole new level.

Weathervane Playhouse is Ohio's oldest professional summer stock theatre presenting professional theatre productions for over 46 years.

Important Dates

- **November 18, 2015 – February 6, 2015:**
  Participants may pick-up free **Problem Solving Challenge Kits** at SPI Spot (227 South Main St, Mount Vernon, OH) from 10am – 5pm Monday, Tuesday, Thursday or Friday or 10am – 4pm on Saturdays.

  Teams MUST be registered for STEMfest! Knox before picking up a kit.
  Visit http://tinyurl.com/STEMfestKnox2016 to register your team.

  NOTE Please read the problem challenge carefully for information about specific materials for each challenge.

- **December 12, 2015: Problem Solving Challenge Presentations**
  Students and teachers may attend one or all **Problem Solving Challenge Presentations** at the above mentioned dates and times. Please register with Rori Leath at RoriLeath@attheworks.org.

- **January 15 – February 20, 2016: Persistent Scientist Nomination**
  Nominate **an individual team member** in recognition of their diligence, hard work and attitude throughout the STEMfest Knox problem solving challenge.

  A good scientist is always striving to find better, outside the box, inventive answers to any and all challenges. How a scientist approaches hurdles, works in a group and supports other team members is very important. Visit http://tinyurl.com/STEMfestKnoxScientist to nominate a student for the Persistent Scientist Award.

- **January 23, 2016: STEMfest Knox Registration Closes**
  Individual and/or team **Registration Forms MUST be submitted** to The Works by this date to participate in STEMfest! Knox.

  Please be sure to list a **Team Name** on the form and include contact information for your advisor.

  Visit http://tinyurl.com/STEMfestKnox2016 to register your team. After registration you will receive information regarding your problem choice. Some problems have a limited amount of space.

- **February 27, 2016: Judging, Event and Awards 10:30 – 3:30pm, *Awards to follow***
  Judging of the respective challenge solutions will take place in three (3) dedicated locations concurrently with the opportunities to explore the displays. The tentative schedule will be:

  10:30 – 3:30 Bridge Challenge
  10:30 – 3:30 Global Water Challenge
  10:30 – 3:30 Home Energy Challenge

  (This schedule is subject to change based on the number of teams participating. Registered teams will be notified as to any changes at the close of STEMfest! Knox registration.)

  Please bring your PowerPoint presentation on a flash drive. A computer and projection system will be available to you. The order of presentations will be posted at the front desk and outside of judging rooms.

Museum Contact Information

For more information about STEMfest! Knox, utilize these standard, on-line, and social media outlets.

SPI Spot

- **Web Site:** SPISpot.org
- **Mailing Address:** 227 S. Main St., Mount Vernon, OH
- **Phone:** 740-501-7616
- **E-Mail:** SPIConnection@gmail.com
- **Facebook:** Science Play-Space Initiative
- **Twitter:** SPI Spot @SPIConnection

The Works

- **Web Site:** www.attheworks.org
- **Mailing Address:** 55 S. 1st Street, P.O. Box 721, Newark, Ohio 43058-0721
- **Phone:** 740-349-9277
- **Fax:** 740-345-7252
- **E-Mail:** RoriLeath@attheworks.org or MeghanFederer@attheworks.org
- **Facebook:** http://www.facebook.com/attheworks
- **Twitter:** http://twitter.com/attheworks

Science **T**echnology **E**ngineering & **M**athematics Resources

Go to www.lickingcountylibrary.info/researchdatabaes.aspx
Access requires a valid LCL card.

Additional assistance: Amy Gantt, Head of Teen Services, Licking County Library 101 West Main Street, Newark, Ohio 740-349-5552 or agantt@lickingcountylibrary.info

Science, Environment & Technology

GreenFILE (EBSCOhost)
Drawing on the connection between the environment and disciplines such as agriculture, education, law, health and technology, GreenFILE serves as an informative resource for anyone concerned about the issues facing our planet.

Oxford Reference Online
100 subject dictionaries and reference books in a single cross-searchable database with subject coverage of biological, earth & physical sciences and mathematics.

Science Online--Facts on File
Comprehensive overview of specific disciplines.

Computer Source (EBSCOhost)
Provides researchers with the latest information and current trends in high technology. This database offers full text for nearly 300 publications and indexing and abstracts for nearly 450 publications.

Magazines & Newspapers

Academic Search Premier
A collection of thousands of scholarly, full-text journals covering nearly all academic areas of study.

Student Research Center
Resources for high school students including full-text articles from over 25 national and international newspapers, 500 popular magazines.

Books (Selected Titles)

Bridges

Blockley, D. I.. *Bridges: the science and art of the world's most inspiring structures*. Oxford [England: Oxford University Press, 2010. Print.

Goldwater, Daniel, and Harvey Weiss. *Bridges and how they are built*. New York: Young Scott Books, 1965. Print.

Richards, Julie. *Bridges*. North Mankato, Minn.: Smart Apple Media, 2004. Print.

Global Water

Berlatsky, Noah. *Water*. Detroit: Greenhaven, 2012. Print.

Fleischman, Paul. *Eyes Wide Open: Going behind the Environmental Headlines*. Print.

Kallen, Stuart A. *Running Dry: The Global Water Crisis*. Print.

Home Energy

Doeden, Matt. *Green Energy: Crucial Gains or Economic Strains?* Minneapolis: Twenty-First Century, 2010. Print.

Johnston, David, and Scott Gibson. *Toward a Zero Energy Home: A Complete Guide to Energy Self-sufficiency at Home*. Newtown, CT: Taunton, 2010. Print.

Krigger, John, and Chris Dorsi. *The Homeowner's Handbook to Energy Efficiency: A Guide to Big and Small Improvements*. Helena, Mont.: Saturn Resource Management, 2008. Print.

Toothpick Bridge Challenge
Rules and Specifications

Sponsored by: Central Ohio Technical College

Goal:
Design the most efficient, economical, functional and aesthetic bridge using only toothpicks and glue. Please note it will take time for your bridge to set and dry. Be sure to leave enough time for this process to occur before STEMfest Knox.

The structural efficiency is equal to the weight supported divided by the weight of the bridge. Dry weight as measured immediately before the STEMfest Knox testing will be used for ratio calculation. The aesthetics of the bridge will be determined through visual appeal, uniqueness, neatness and symmetry. The bridge will also be judged on cost effectiveness. For your bridge to be considered functional the supports must be on land.

Points will be awarded for presentation and presentation materials. PowerPoint presentations should be no longer than ten (10) minutes in length and include reasons your particular bridge design was chosen over another, your research into bridge designs, strength of shapes and the forces that act on structures, bridge cost information, cost effectiveness calculations, strength ratio calculations with data, and pertinent career information.

Bridge Specifications:
The bridge will serve as an overland route over a river. The layout of the river and location of the abutments is provided in the Support Images Section. Please note that your bridge must have the minimum clear span to enable it to sit on land.

Additional requirements for the bridge are as follows:

- **Clear Span**: The river is 12 inches wide. The bridge must have a ***minimum*** clear span over the water of 12 inches, and rest on abutments on land on either side of the river. The abutments are to be part of the bridge. (See Support Images)
- **Bridge Deck**: The bridge deck interior width must be at least 1.5 inches. This will be tested with a matchbox car. The deck must be solid so that the car can travel the length of the bridge. The loading block must be placed on the deck for testing. (See Support Images)
- **Bridge Width:** The maximum external width of the bridge is 2.5 inches.
- **Boat Clearance:** The bridge must be more than 2 inches above the water. A 2-inch high boat must be able to pass unobstructed underneath the bridge for the entire length of the clear span, 12 inches.
- **Bridge Height**: The maximum height of any part of the bridge is 8 inches from the river surface.
- **Loading Connection**: The bridge must be able to accommodate the loading block (1.5 inches by 2 inches) at the midpoint of the deck. The loading block will be placed on the vehicle deck of the bridge (the same place the matchbox car travels). ***A hole in the center of the bridge MUST allow for a 1/4-inch rod to pass through the vehicle deck.*** (See Support Images)

Research:

- Bridge Terminology and Designs.
  - Be sure to research the meaning of all terms including; clear span, bridge deck, bridge width, boat clearance, and bridge height. Understanding these concepts will allow you to build a successful bridge and score points in all categories.
- Explore the PowerPoint Presentation provided to your STEMfest Knox Coach.
- What forces act on a bridge? How?
- What careers are involved in designing, manufacturing and building bridges?

Material Specifications:

Supported by:

- Round uncoated toothpicks (maximum 800 toothpicks)
- Elmer's white glue. ***Epoxy, wood glue, hot glue, paint and super glues are not permitted.***
- Do not coat the bridge with any material (paint, stain or glue).
- Toothpicks may **ONLY** be glued in the following ways:
  - End to end
    - No more than ¼" of overlap.
  - End to side
    - No more than ¼" of overlap.
  - **NO side to side glue**
    - Toothpicks may be aligned side to side, but glue may NOT be applied to the entire length of the toothpick.
- Any bridge not meeting the specifications will be penalized.

Strength Ratio Calculations:

- Strength ratio is determined by dividing the weight held by the bridge by the weight of the bridge.
- Make strength ratio calculations using the weight of your bridge and the following weights, 10lbs, 20lbs, 30lbs, 40lbs, 50lbs, 60lbs and 70lbs.
- Show your results in a data table. Be prepared to share your results with the judges.

Bridge Cost:

Calculate the cost of your bridge by using the following

Cost Specifications:

$100 for 1 Toothpick
$100 for 1oz of Glue – This is the wet volume of glue used.

Cost Effectiveness Calculations:

- Cost effectiveness is determined by dividing the total cost of the bridge by weight held by the bridge.
- Make cost effectiveness ratio calculations using the total cost of your bridge and the following weights, 10lbs, 20lbs, 30lbs, 40lbs, 50lbs, 60lbs and 70lbs.
- Show your results in a data table. Be prepared to share your results with the judges.

Testing Procedures:

1. All bridges will be weighed and measured for compliance with the bridge specifications. Bridges that are completed but do not meet the bridge specifications can be penalized up to **eighty** points. **Bridges that do not meet the minimum clear span requirement will not receive a score for Bridge Loading.**
2. All bridges will be checked for compliance with material specifications. Bridges that do not meet material specifications can be penalized up to **twenty** points.
3. The loading block and testing apparatus will be provided and may not be altered. It is required that the loading block be placed on the bridge deck. Be sure that the bridge deck can be accessed for loading.
4. During the testing of the bridge, the bridge will be placed in the center of the testing apparatus.
5. The load will be applied to a 1.5 inches wide by 2 inches long by 1 inch high loading block resting midway in the river. A hole in the center of the bridge must allow a 1/4 inch rod to pass through.
6. A pulling cable will apply pulling force straight down until a ½ inch deflection is measured. On the day of STEMfest the stress-strain curve will be projected during bridge testing.

   ***NOTE* The loading process has been updated. A maximum load will be applied to all bridges until a deflection of ½ inch is achieved. Some bridges may fail, but not all bridges will be tested to failure beyond the maximum load as established for the test. You still need to allow for the loading block to rest on the vehicle deck of your bridge and a ¼" hole in the center of the bridge.**

Evaluation:

On the day of STEMfest your bridge will be examined for appearance, adherence to bridge specifications and strength.

Your team will be evaluated on each of the following categories:

1. Aesthetics (10 points)
2. Presentation (30 points)
   a. Presentation format and organization (15 points)
   b. Presentation engagement and participation (15 points)
   c. Presentation must include the total cost for your project, cost effectiveness predictions and table, strength ratio data and table.
   d. Share the process used to determine the bridge design you created.
3. Career Research (15 points)
   a. Share career titles, descriptions of careers and work done.
4. Bridge Specifications (10 points)
   a. Clear Span (5 points)
      i. MUST be at least 12 inches long.
      ii. A bridge with span less than 12 inches will receive **zero** clear span points.
      iii. A bridge with span less than 12 inches will also receive **zero** strength points.
   b. Bridge Deck (1 point)
      i. MUST be at least 1.5 inches wide for matchbox car.
   c. Bridge Width (1 point)
      i. Maximum width is 2.5 inches wide.
   d. Boat Clearance (1 point)

   i. A minimum of 2 inches clear distance from tabletop is required.
e. Bridge Height (1 point)
   i. Maximum of 8 inches tall.
f. Loading Connection (1 point)
   i. Must accommodate the loading block on top of bridge deck.

5. Material Specifications (20 points)
   a. No more than 800 toothpicks may be used. (-3 points)
   b. Only Round uncoated toothpicks may be used. (-2 points)
   c. Elmer's white glue must be used. (-3 points)
      i. ***Epoxy, wood glue, hot glue, paint and super glues are not permitted.***
   d. Bridges may not be coated with any material (paint, stain, glue, etc.). (-6 points)
   e. Toothpicks may **ONLY** be glued in the following ways: (-6 points)
      i. End to end – No more than ¼" overlap
      ii. End to side – No more than ¼" overlap
      iii. NO side to side glue
   f. Any bridge not meeting the material specifications will be penalized.
6. Strength Points (40 points)
   a. Points will be awarded as [(team ratio/maximum ratio)x40]
7. Cost Effectiveness Points (15 points)
   a. Cost of Bridge/Weight Held
   b. Points will be awarded as [(team cost effectiveness/maximum cost effectiveness)x15]
8. In the event of a tie the lightest bridge will be the winner.

Sources for more information:
http:// bridgecontest.usma.edu/ - West Point Bridge Design Software

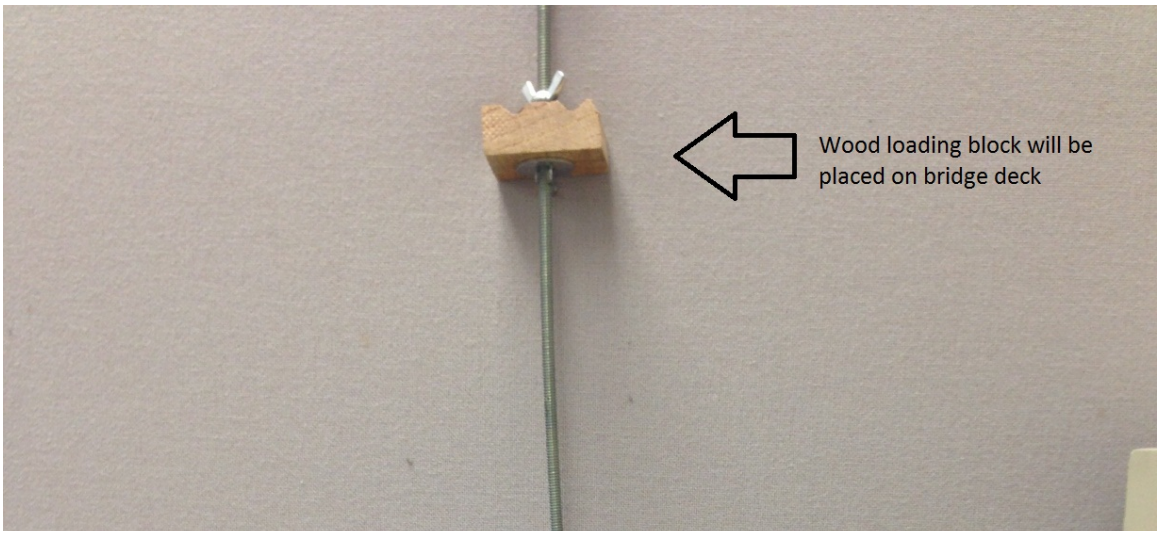
Scoring Rubric:

Presentation Format and Organization (15 points)	Preparation for presentation is **minimal** AND delivery is **disorganized/unclear** OR **no presentation** was prepared (0 points)	Presentation is **somewhat** organized AND only includes 1-2 **of the required** components (design process, strength graph, bridge terminology, or total cost) AND is **lacking in detail** (1-3 points)	Presentation is **mostly** organized AND: only includes 1-2 **of the required** components (design process, strength graph, bridge terminology, or total cost) OR is **lacking in detail** (4-7 points)	The presentation is **clear** and well **organized** AND includes **3 of the required** components (design process, strength graph, bridge terminology, or total cost) in **moderate detail**. (8-11 points)	The presentation is **clear** and well **organized**, includes **all required** components (design process, strength graph, bridge terminology, and total cost) in **good detail**. (12-15 points)
Category Points:					
Presentation Engagement and Participation (15 points)	Presentation delivery is **not very engaging** (e.g., flat, no enthusiasm, no eye contact) AND **only 1 team member** participates. (0 points)	Presentation delivery is **not very engaging** (e.g., flat, no enthusiasm, no eye contact) OR **only 1 team member** participates. (1-3 points)	Presentation delivery is **somewhat engaging** (e.g., exhibits moderate interest, some eye contact) with **only some of the team** members participating (4-7 points	Presentation delivery is **engaging** (e.g., enthusiastic and makes consistent eye contact) with **only some of the team** members participating. (8-11 points)	Presentation delivery is **engaging** (e.g., enthusiastic and makes consistent eye contact) with **all team members** participating equally. (12-15)
Category Points:					
Career research (15 points)	Career research was **not addressed** OR **only 1 career** was identified (but not discussed in depth). (0-2 points)	Career research only **briefly** discussed, sharing **only 2-3** titles OR descriptions (3-5 points)	Career research discussed with **some detail**, sharing **only 2-3** titles AND descriptions. (6-8 points)	Career research discussed **3 or more** examples with **good detail**, BUT the career research is **not diverse** (9-11 points)	**Detailed** discussion of career research, including a **diversity** of career titles and descriptions of work done. (12-15 points)
Category Points:					
Aesthetics (10 points)	Bridge is generally not visually appealing AND is **generally messy**, having multiple areas with extra glue and/or toothpicks (0-2 points)	Bridge has some visual appeal, but has **two or more** messy areas AND is **not very clean**. (3-4 points)	Bridge has some visual appeal, but has **two or more** messy areas OR is **not very clean**. (5-6 points)	Bridge has visual appeal, is mostly neat and clean, but has **at least 1** messy area (e.g., extra glue, toothpicks out of place). (7-8 points)	Bridge has visual appeal, is neat and clean with no messy areas, no visible extra glue, and no toothpicks out of place. (9-10 points)
Category Points:					
Bridge criteria (10 points)					
Clear span	Does not meet criteria (0 points & NO Load Test)		Meets criteria (5 points)		
Bridge Deck	Does not meet criteria (0 points)		Meets criteria (1 point)		
Bridge Width	Does not meet criteria (0 points)		Meets criteria (1 point)		
Boat Clearance	Does not meet criteria (0 points)		Meets criteria (1 point)		
Bridge Height	Does not meet criteria (0 points)		Meets criteria (1 point)		
Loading connection	Does not meet criteria (0 points)		Meets criteria (1 point)		
Material Specifications met (20 points)					
Points deducted for:					*Category Points:*
a. More than 800 toothpicks used (-3pts)					*Deductions:*
b. Other than round toothpicks used (-2pts)					
c. Other than Elmer's white glue used (-3pts)					
d. Bridge being coated (-6pts)					
e. Toothpicks glued with overlap, side to side or end to side (-6pts)					
Strength Points (40 points)					
Given as [[beam ratio]/[maximum ratio] *40]					
Team ratio:		Max ratio:			Category Points:
Cost Effectiveness (15 points) [cost of bridge/weight held)					
Given as [[beam cost effectiveness]/[maximum cost effectiveness]*15]					
Team ratio:		Max ratio:			Category Points:
Total Points (Sum of all Category Points):					

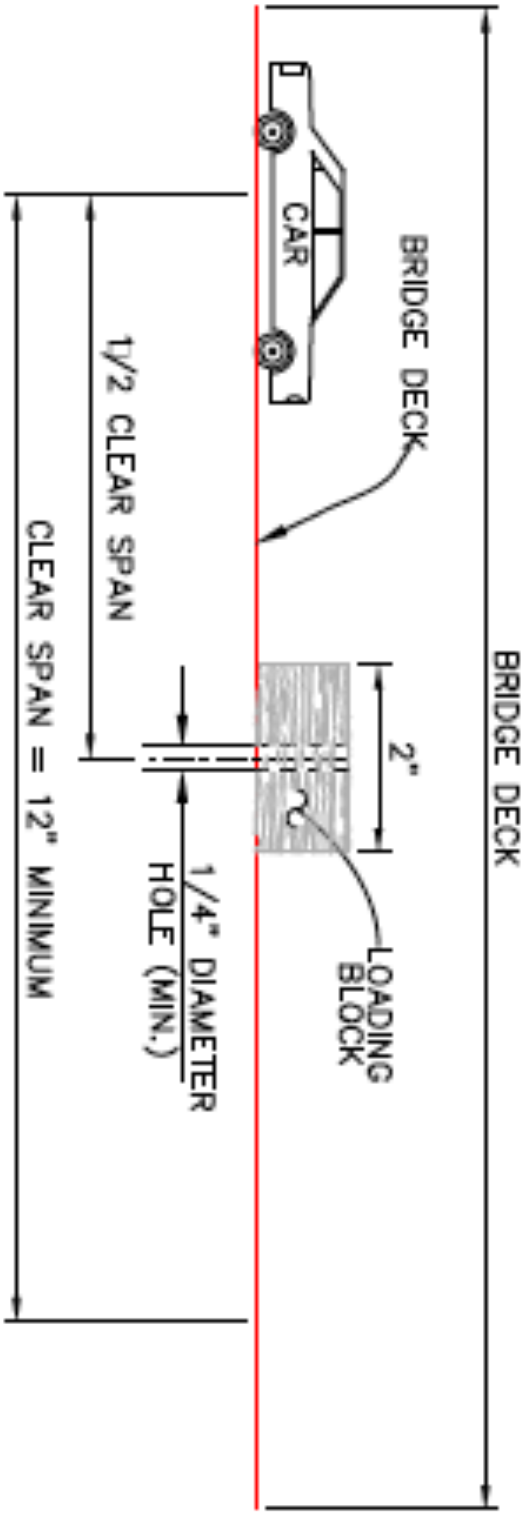
Supporting Images:

Bridge Loading Platform

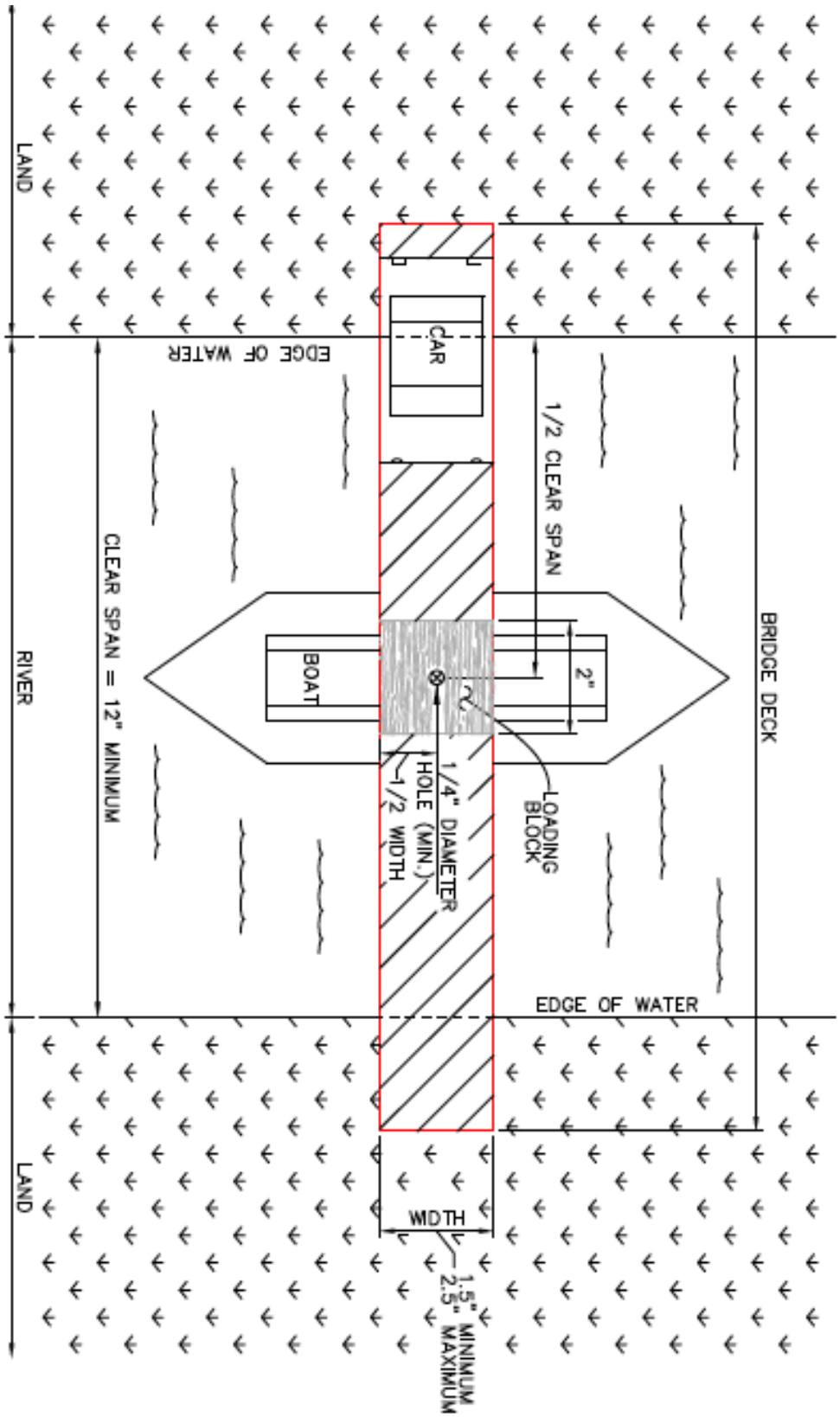
Bridge Loading Block



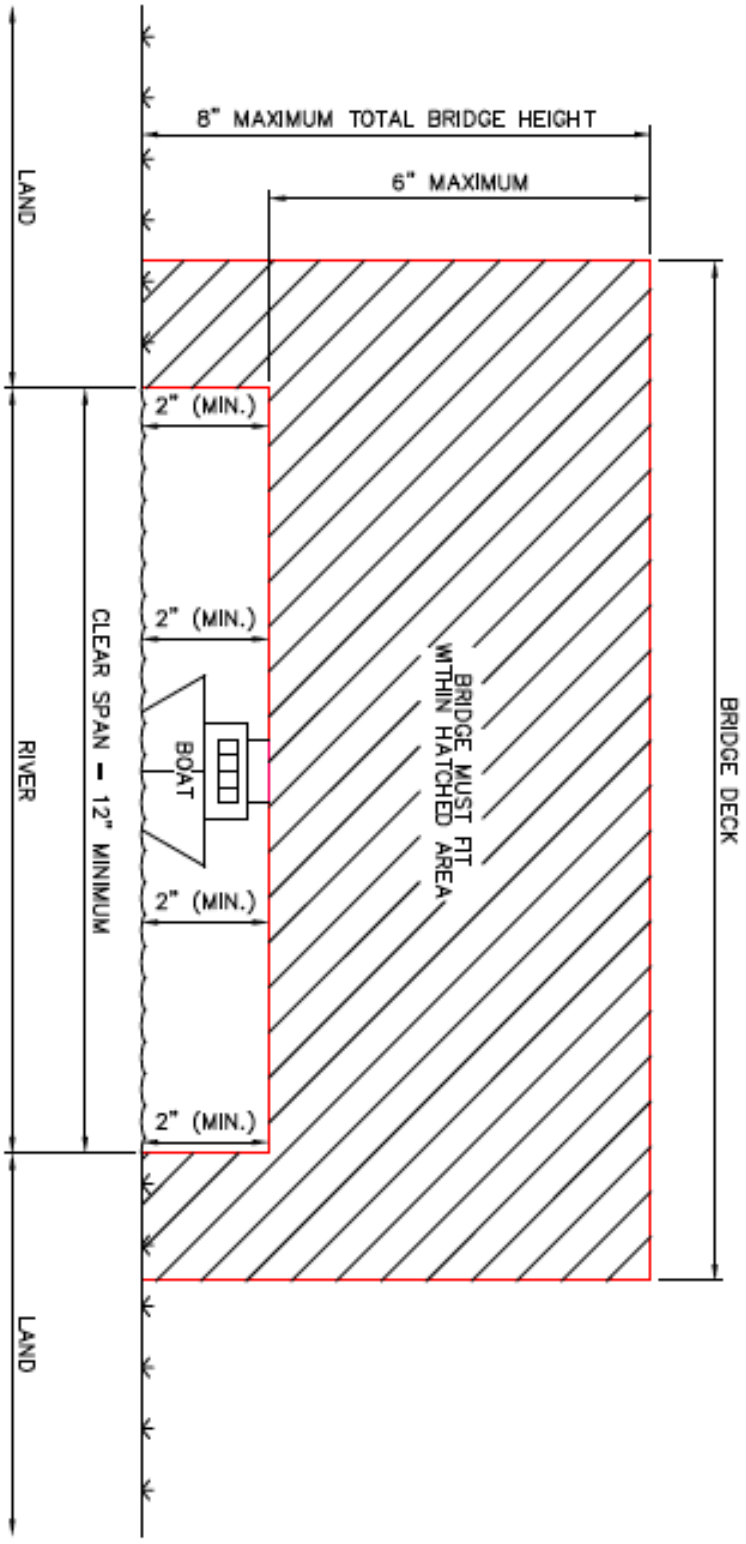
Bridge Deck Side View



Bridge Top View



Bridge Side View



Global Water Challenge

Rules and Specifications

Sponsored by: Mount Vernon Nazarene University

Background Information:

Goal: Design the most effective and efficient Household Water Treatment system out of simple materials. Your device will be used to filter local pond water on the day of STEMfest Knox, and you will present your design and testing process.

A Global Issue: Clean water for drinking and cooking is a necessity for human life. For most of the 300 million people in the United States, access to clean water is as simple as turning on the faucet, leading it to often be taken for granted. Although, the recent extreme drought conditions in California are causing concern over available clean water even in the USA! In other parts of the world, an estimated **1.1 billion** people go without ready access to a purified community water source. Most of these people must clean their own water using Household Water Treatment (HWT), without the ability to test its purity! Tragically, this results in over **1.5 million** water-bourn disease related deaths **every year**, and many million more illnesses. In addition, the most common way of treating water is heating; the use of wood and brush as fuel is associated with over 1.3 million deaths from accident and smoke inhalation. The World Health Organization (WHO) has named access to clean water as one of the 10 greatest challenges facing the world today. **Safe, available, and affordable HWT systems are greatly needed; your challenge is to design and test one!!**

HWT system: There are several alternatives to heat-purification. The water we drink in Licking County is purified by filtration followed by chemical treatment. This can potentially be achieved at the household level, using a few common materials! You will be provided with some materials for building an HWT, and for testing it. It is your challenge to think about and research these materials, and to build and test your own HWT. You will also be given a water sample for testing out of a local pond, river or stream.

HWT Materials:
- 1-liter plastic bottles (2-liter for middle school teams) to serve as the filtration chamber.
- Coffee filters
- Rubber bands
- Filtration materials: fine sand; course sand; gravel; alum; other…
- Chlorine Bleach for water decontamination
- Beaker and stir-rod
- dropper
- Chlorine test strips

Evaluation:
On the day of STEMfest Knox you will use your HWT procedure to produce **200 mL** of purified water from a raw water provided by MVNU.

Your HWT will be evaluated on each of the following criteria:
1) *Clean* appearance: A flashlight will be shown on the purified water and it will be compared to tap water for particulates.
2) Efficiency: How *quickly* can 200 mL of purified water be produced.
3) Chemical level: Upon standing *5 min*, how closely does the Chlorine level match to accepted standards (and the tap water).

4) Taste test. This water is meant for drinking! If it's deemed safe by the Chlorine test, the project organizer will taste your purified pond water and rate it's quality!!

While your water is filtering and being treated, you will also be evaluated on a short (10 min or less) presentation explaining: 1) your research into global water issues, 2) your research into building your HWT system, 3) your experimental process in making and testing your HWT systems to get to your final version.

On the day of STEMfest you will be judged on all of the following:

- Presentation format and organization (15 points)
- Presentation engagement and participation (15 points)
- Career research (15 points)
- Technical background (15 points)
- Filter Design and Construction (15 points)
- Filter Performance (15 points)
- Water Quality rating – Appearance (15 points)
- Water Quality rating – Taste (15 points)

Scoring Rubric:

Presentation Format and Organization (15 points)	Preparation for presentation is **minimal** AND delivery is **disorganized/unclear** OR **no presentation** was prepared (0 points)	Presentation is **somewhat** organized AND only includes **1 of the required** components (global water issues, background research on HWT, experimental process, lessons learned) AND is **lacking in detail** (1-3 points)	Presentation is **mostly** organized AND only includes **1-2 of the required** components (global water issues, background research on HWT, experimental process, lessons learned) OR is **lacking in detail** (4-7 points)	The presentation is **clear** and well **organized** AND includes **at least 2 of the required** components (global water issues, background research on HWT, experimental process, lessons learned) OR research on HWT, experimental process, lessons learned) in **moderate detail**. (8-11 points)	The presentation is **clear** and well **organized,** includes **all required** components global water issues, background research on HWT, experimental process, lessons learned) in **good detail**. (12-15 points)
Category Points:					
Presentation Engagement and Participation (15 points)	Presentation delivery is **not very engaging** (e.g., flat, no enthusiasm, no eye contact) AND **only 1 team member** participates. (0 points)	Presentation delivery is **not very engaging** (e.g., flat, no enthusiasm, no eye contact) OR **only 1 team member** participates. (1-3 points)	Presentation delivery is **somewhat engaging** (e.g., exhibits moderate interest, some eye contact) with **only some of the team** members participating (4-7 points	Presentation delivery is **engaging** (e.g., enthusiastic and makes consistent eye contact) with **only some of the team** members participating. (8-11 points)	Presentation delivery is **engaging** (e.g., enthusiastic and makes consistent eye contact) with **all team members** participating equally. (12-15)
Category Points:					
Career research (15 points)	Career research was **not addressed** OR **only 1 career** was identified (but not discussed in depth). (0-2 points)	Career research only **briefly** discussed, sharing **only 2 -3** titles OR descriptions (3-5 points)	Career research discussed with **some detail**, sharing **only 2-3** titles AND descriptions. (6-8 points)	Career research discussed **3 or more** examples with **good detail**, BUT the career research is **not diverse** (9-11 points)	**Detailed** discussion of career research, including **diversity** of career titles and descriptions of work done. (12-15 points)
Category Points:					
Technical Background (15 points)	**None** given OR **mostly in error** (0-2 points)	Demonstrates **understanding** and **successfully applies only 1** scientific and/or technical principle. (3-5 points)	Demonstrates **understanding** of and **successfully applies at least 2** scientific and/or technical principles (6-8points)	Demonstrates **good** understanding of relevant scientific, chemical terminology and/or technical principles, may or may not use multiple sources of evidence (9-11 points)	Demonstrates **thourough** understanding of relevant scientific, chemical terminology and/or technical principles using **multiple sources** of evidence (12 - 15 points)
Category Points:					
Filter Design and Construction (15 points)	**Poorly designed** filter with **flimsy** construction AND **litte to no creativity** in design AND **no evidence** of technical background and research applied (0 - 2 points)	Construction has **some instabilities** with **minimal design creativity** AND **minimal evidence** of technical background and research applied. (3 - 5 points)	**Stable** construction AND filter design **may or may not be** creative AND evidence of technical background OR research applied. (6 - 8 points)	Construction is **stable and secure** AND demonstrates **creative design** AND evidence of **technical background and research** applied. (9 - 11 points)	**Well designed** filter with **strong and sturdy** construction AND **innovative** filtration design AND evidence of **technical background and research** applied. (12 - 15 points)
Category Points:					
Filter Performance (15 points)	Succesful filtration of 200mL takes **over 300 seconds** OR successful filtration of 200mL is not reached. (0 - 2 points)	Successfully filters all 200 mL of water, but filtration takes between **241 - 300 seconds**. (3 - 5 points)	Successfully filters all 200 mL of water, but filtration takes between **121 - 240 seconds**. (6 - 8 points)	Successfully filters all 200 mL of water, but filtration **takes between 61 - 120 seconds**. (9 - 11 points)	Successfully filters all 200 mL of water in **60 seconds or less**. (12 - 15 points)
Category Points:					
Water Quality Rating - Appearance (15 points)	Dirty, cloudy, floating debris(0-2 points)	Milky, some floating materials, not clear, colored (3-5 points)	Lightly colored (6-8points)	Almost clear (9-11 points)	Clear (12 - 15 points)
Category Points:					
Water Quality Rating - Taste (15 points)	Not tasted (0 points)		Possibly tasted, strong flavor (1 - 5 points)	Drinkable, moderate flavor (6 - 10 points)	Drinkable, no aftertaste (11 - 15 points)
Category Points:					
Total Points (*Sum of all Category Points*):					

Home Energy Challenge
Rules and Specifications

Sponsored by: Kenyon College &
Owens Corning Science and Technology Center

Background: Approximately 40% of US energy goes into heating and cooling of residential and commercial buildings. Minimizing thermal losses in buildings is a huge opportunity area for global energy efficiency. Building a thermally efficient structure requires a balance between available construction techniques and insulation/air sealing know-how. A great deal of performance difference is due to what materials are used, exactly where they are placed, and details about how they are installed.

Goal: In this challenge you will be given a model building structure (approx. 20" on a side) and a supply of different insulating materials. Your job will be to "install" these to maximize the thermal efficiency of your "building". This will involve selecting what mix of materials to use and exactly where and how they will be installed.

The measurement of your building's thermal efficiency will be made at STEMfest Knox. The basic testing technique will involve placing a controlled heat source in your building and measuring the energy required to hold the inside temperature at a fixed temperature.

Suggested preparation for your insulation design:

- Research how heat travels in building structures. You'll want to understand these paths, so you can block as many as you can (such as conduction, convection, radiation, and infiltration).
- Consider how the building structure (framing) limits your ability to block thermal flow, and how those "short circuits" can be minimized.
- Look for any "best" insulation techniques and tips from installers.
- Discuss and debate how to trade off various material combinations and quantities vs. your $ "budget" (calculated, not real expense… more on that later).

Materials required (all provided by Kenyon College and/or Owens Corning):

- A framed "house", approximately 18x18x26"
- Insulation and other construction materials
- Specific instruction sheets with details on the rules (following pages of this document)

Evaluation/scoring:

- Team presentation of the background information you gathered and how that helped shape your insulation design (up to 110 points for Middle School or 120 points for High School, as broken down below and in following rubric)
    - Presentation (up to 30 points)
        - Presentation format and organization (15 points).
        - Presentation engagement and participation (15 points).
        - Explain how you decided on your insulation design.
    - Career Research (up to 15 points)

- Technical Background, including proper use of thermal energy terminology (up to 15 points)

- Thermal test results (up to 50 points)
  - The energy (in BTU/hour) required to hold the structure's interior at 130 degrees F will be adjusted by your team's materials "expense" vs. the budget given. (e.g. test results of 1000 BTU/hr would be increased if the team used more than the budget of materials). (Note: BTU = British thermal unit = measure of heat energy)
  - Actual points for thermal results will be obtained from a linear scale of 0 to 40 for the highest to lowest BTU/hr (adjusted test values).
- (HIGH SCHOOL ONLY) Prediction of energy required (up to 10 points)
  Estimate the energy rate required to keep your building interior at 130 degrees F (in units of BTU/hr). This will be compared with the actual test value (not adjusted by budget). There will be a sliding scale/formula to convert your estimate error to points. Closest estimate gets 10 points. Farthest estimate is 0 points.

Specifics/rules:

- The following materials are being provided in your kit. The exact initial weight will be marked on the container.

		grams			
Material	R-value	supplied	cents/sq ft	cents/gram	gms/sq ft
fiberglass	4.2	~900	19.0	0.462	41
foam	1	~470	16.2	0.810	20
foil	n/a	~510	5.4	0.922	5.9
tape	n/a	~155	5.4	0.555	9.8

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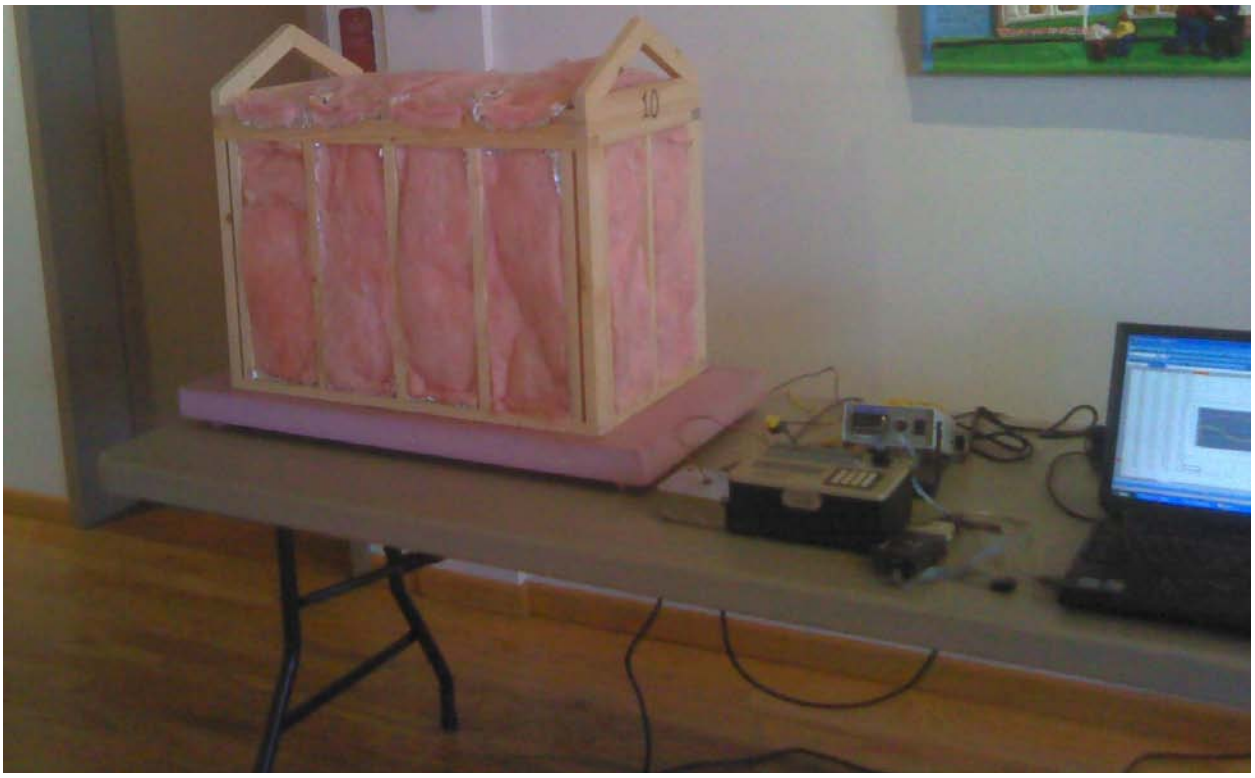
Notes:
  - The fiberglass is bisected (two layers). Each layer is R 4.2
  - The foil is provided as a potential reflective material
  - The masking tape can be used as an air sealer (instead of caulk)
  - Tacks (100) are to attach board materials to framing (no cost)
  - Cardstock is to cover the interior wall surface, like drywall (no cost)

- Your "budget" of materials is $3.00 for your house. Your thermal test result will be adjusted by your materials usage according to the following equation:
  net BTU/hr = test BTU/hr * (0.8 + 0.2*your $/budget $)
  Note that this means only 20% of your deviation from budget affects your thermal result. For example, if your team used materials totaling $3.75 you would be 25% over budget, but your thermal test result would be increased only 5%.
- Only materials provided with your kit can be used in the house. Judges reserve the right to disassemble any house to check materials (after thermal test)
- Keep all provided materials not used and bring them to the competition (preferably in their original container). These will be used to estimate materials used in your house. For example: If we provide 500 grams of insulation and you return 200 grams, we presume 300 grams were

used in the house. If you bring no left-overs, we will assume you used all of the material in your house.

- Scissors are provided in your kit to cut fiberglass, foam, or anything else. For safety reasons we recommend not using any type of knife.
- The interior wall (brown card stock) must be installed against the inside of the wall frame members. It is allowable to have materials between the frame and the interior wall, as long as the tacks can attach the card stock to the frame members.
- The brown card stock must be the interior wall final surface. I.e. If we look inside the house we need to see only brown card stock (also tacks and tape).
- The "floor" of the house must remain completely open.
- Test houses will be surrendered back to Kenyon College at STEMfest Knox!

1_Oct2015 dpa



House being tested at STEMfest!

Thermal 101

Houses – It takes energy to heat (or cool) a house. In the US 40% of energy is used for heating and cooling homes and businesses. How do we keep heat in (or out), making buildings more efficient?

Movement of heat (from a warmer to a colder area) is called heat transfer. There are three different kinds (with common examples following):

- Conduction (through a stationary material)
  - Heat through a pan bottom (on stove) into liquid inside
  - Body heat through your jacket into the winter air
- Convection (carried by moving material), natural or forced
  - Wind taking heat away from you (wind chill)
  - Hot air rises (over burning candle)
- Radiation (light)
  - Heat radiated from any hotter surface to a cooler one (becomes more significant with larger temperature differences)
  - Examples: warmth you "feel" from sun or light bulb or hot surface

All of these have a role in heat transfer in a house.

How can we limit or control heat flow of the various types?

- Conduction can be limited by use of "insulators", which are simply materials that do not conduct heat readily. A material's ability to conduct heat is characterized by a parameter called thermal conductivity, or, for building materials, an "R-value". You can look up tables with R-values for various materials. Metal is generally a good conductor (poor insulator). Wood is mid-range. Foam and fiberglass are good insulators. The better the insulator, the higher the R-value. For the materials supplied with your house, the following R-values apply (all for heat flow through a vertical or horizontal surface… e.g. from inside to outside):
  - 1.5" thick pine wood (R =1.8)
  - 1.5" thick fiberglass (R = 4.2)
  - 0.25" thick foam (R = 1)
  - During the thermal test, your house will sit on a thick slab of foam insulation (R=10)
  - Card stock ("dry wall"): ignore any insulation value (R=0)
- Convection in the context of heat transfer through a house's walls or ceiling is of two types: air flow through the walls ("leaks") and air flow along the walls (inside and out), affecting wall surface temperature.
  - Air flow through the walls is driven by a difference in air pressure (hot air rises!). This requires airflow paths (leaks) in the house structure. Try to eliminate all air leak paths. Some can be tough to find. Any 130F air leaving the house will be replaced by 70F ambient air coming in, requiring more heat to maintain the 130F. Remember that the floor of the house during the test will have an opening, so you can only seal the walls and ceiling.
  - Air flow along the walls affects wall temperature like wind chill does. This affects the difference between the surface temperature and the air next to it. There should be no "wind" during the testing, but there will be some circulation inside the house. In the calculation section you'll be shown how to account to this.

- Radiation transfer can increase heat transfer through windows and is a small, but significant, factor in porous insulators (like fiberglass). R-values quoted above include the radiation transfer. Shiny materials (like aluminum foil) radiate very little energy and can be used to block radiation transfer, however this cannot be represented in a simple R-value, as installation details dominate its effectiveness. People debate the effectiveness of radiation barriers in houses.

How can you **calculate** heat flow based on insulation value? The formulas below will combine the effects of conduction, convection, and radiation into one calculation for heat flow through a flat surface (e.g. wall or floor or ceiling or floor). This will need to be repeated for each type of surface: e.g. wall with wood, wall without wood, ceilings with wood, ceilings without wood, floor, etc. The only inputs will be the air temperature difference (inside to outside) and the net R-value for that surface. You'll need to be creative and decide how to figure in the corners ☺!

The general equation is:

Heat flux [btu/(hour*sq foot] = (high temperature-low temperature)/(net R-value)

Mind your units here!

Temperature is in degrees Fahrenheit

R is (ft^2*°F*hr)/BTU

For a non-uniform surface (like your house), you'll need to figure a net R-value for each type of surface area. For materials in series (specific heat path passes through both materials), it is straightforward:

R(layers 1 + 2) = R(layer 1) + R(layer 2) (This is like sweater + jacket)

If there are more than two layers, they still add up the same way.

For parallel paths the specific heat path is through different construction types (like through your ski pants vs. through your jacket or wood vs. insulation-in-cavity). Here it would be easiest to calculate the heat flowing through each type of structure independently and add the heat flows together. Remember that the heat flux must be multiplied by the appropriate area to get heat flow for that area. For example: heat flow through wood = total area of wood * heat flux through wood areas. If there is insulation in series with the wood, its R value would need to be added to that for wood.

To account for the heat transfer from a surface to the air, we must use another factor, called a heat transfer coefficient, usually designated by "h". For our test houses, we can approximate h for the outside surfaces to be 1.5 (units of BTU/(square foot*hour*degree F). For the inside surfaces use h = 2 (air circulation inside increases heat transfer there vs. "still air" conditions outside house).

To calculate a net R-value for some section of surface, use this equation:

Net R-value = surface R-value + 1/h(inside) + 1/h(outside)

This will give you a slightly larger R-value, accounting for the insulating value of the still (or near still) air next to the surfaces. Use this net R-value to calculate the heat flows through each kind of surface.

The total heat flow through your walls, ceiling, and floor will equal how much heat we need to add (inside) to maintain the constant interior temperature at 130F. Assume an "outside" temperature of 70F. We will adjust test results if ambient at the WORKS is not 70F when we test the houses.

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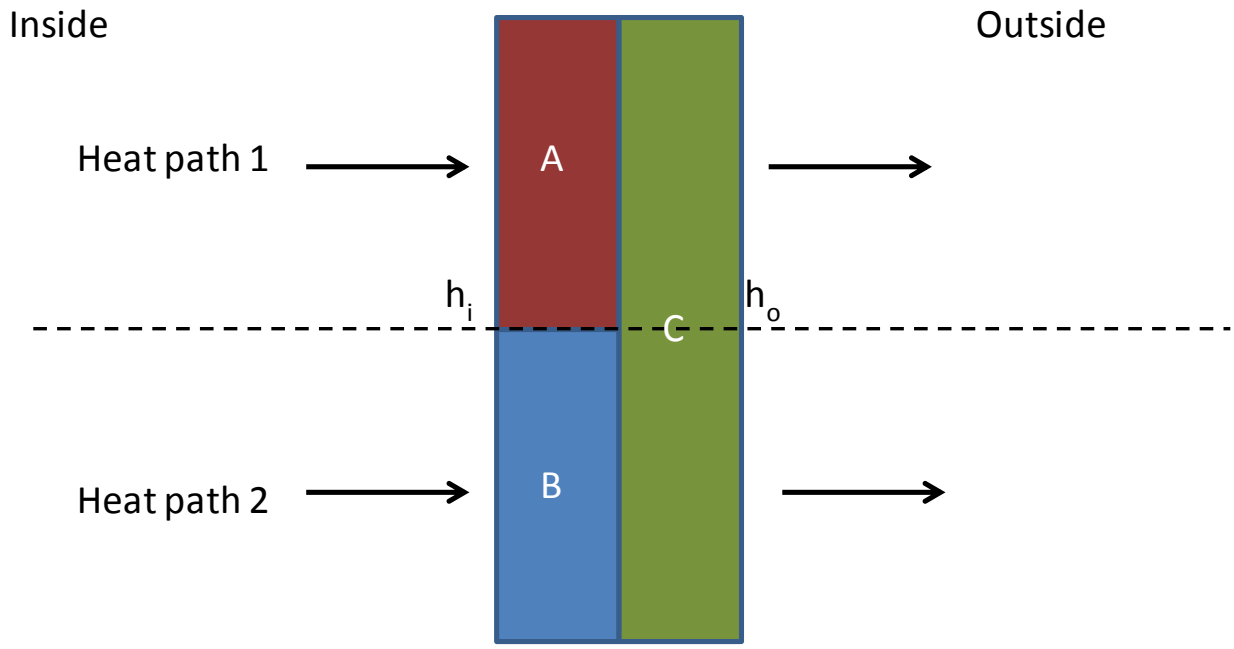
Graphic example:



Graphic of two parallel heat paths, each of which has two materials in series (A & C, B & C), along with heat transfer coefficients at each surface.
Net R-value for path_1 = $1/h_i + R_A + R_C + 1/h_o$

Scoring Rubric:

Presentation Format and Organization (15 points)	Preparation for presentation is **minimal** AND delivery is **disorganized/unclear** OR **no presentation** was prepared (0 points)	Presentation is **somewhat** organized AND only includes **1 of the required** components (background information and design process) AND is **lacking in detail** (1-3 points)	Presentation is **mostly** organized AND: only includes **1-2 of the required** components(background information and design process) OR is **lacking in detail** (4-7 points)	The presentation is **clear** and well **organized** AND includes **all required** components (background information and design process) in **moderate detail**. (8-11 points)	The presentation is **clear** and well **organized**, includes **all required** components (background information and design process) in **good detail**. (12-15 points)
Category Points:					
Presentation Engagement and Participation (15 points)	Presentation delivery is **not very engaging** (e.g., flat, no enthusiasm, no eye contact) AND **only 1 team member** participates. (0 points)	Presentation delivery is **not very engaging** (e.g., flat, no enthusiasm, no eye contact) OR **only 1 team member** participates. (1-3 points)	Presentation delivery is **somewhat engaging** (e.g., exhibits moderate interest, some eye contact) with **only some of the team** members participating (4-7 points	Presentation delivery is **engaging** (e.g., enthusiastic and makes consistent eye contact) with **only some of the team** members participating. (8-11 points)	Presentation delivery is **engaging** (e.g., enthusiastic and makes consistent eye contact) with **all team members** participating equally. (12-15)
Category Points:					
Career research (15 points)	Career research was **not addressed** OR **only 1 career** was identified (but not discussed in depth). (0-2 points)	Career research only **briefly** discussed, sharing **only 2 -3** titles OR descriptions (3-5 points)	Career research discussed with **some detail**, sharing **only 2-3** titles AND descriptions. (6-8 points)	Career research discussed **3 or more** examples with **good detail**, BUT the career research is **not diverse** (9-11 points)	**Detailed** discussion of career research, including a **diversity** of career titles and descriptions of work done. (12-15 points)
Category Points:					
Technical Background (15 points)	**None** given OR **mostly in error** (0-2 points)	Demonstrates **understanding** and **successfully applies only 1** scientific and/or technical principle. (3-5 points)	Demonstrates **understanding** of and **successfully applies at least 2** scientific and/or technical principles (6-8points)	Demonstrates **good** understanding of relevant scientific, thermal energy terminology and/or technical principles, may or may not use multiple sources of evidence (9-11 points)	Demonstrates **thorough** understanding of relevant scientific, thermal energy terminology and/or technical principles using **multiple sources** of evidence (12 - 15 points)
Category Points:					
Thermal Test Points (50 points)	Buildings will receive points based on how well they test. Score will be a calculated percentage based on how close their actual test result is compared to the lowest energy result. Given as team ratio/maximum ratio * 50				
Category Points:					
HIGH SCHOOL ONLY - Calculation-Estimate energy consumption for your building (10 points)	Teams will receive points based on how well their calculation matched actual results. Score will be a calculated percentage based on how close their calculation is to correct as compared to the closest team calculation. Given at team ratio/maximum ratio * 10				
Category Points:					
Total Points (*Sum of all Category Points*):					

Frequently Asked Home Energy Questions:

About thumb tacks:

- It has been noted that the thumb tacks supplied may not grip the wood very well, which may be a result of too-short "spike" length. You are free to use any other source of tacks or push pins to replace the function of the provided tacks. We are not concerned about # of tacks. Remember that steel readily conducts heat, so you won't want to go overboard on number or length of tacks. If you use a small hammer, lay the house down on a solid surface so you don't knock out the wood frame pieces!

Leftovers:

- Remember to keep all leftover and unused materials (fiberglass, foam, tape, foil) as these leftovers will be weighed at STEMfest Knox check-in to calculate what was actually used in your house. You do not need to weigh these items yourself. It is optional for teams to present or discuss what they think their material cost was (and strategy for trade-off).

I thought the calculation of cost of materials was for high school only. Do we do it for middle school?

- Calculation of thermal performance is for high schoolers only. Calculation (or tracking) of materials used is something all teams will probably want to do (at least rough estimates) in order to guide their decisions on "optimum" insulation configuration.

Why was the cardboard ("drywall") cut short? The pieces don't cover up the stud al the way.

- We undercut width so they would require taping (just like drywall and spackling!).

Are the insulation materials safe to handle?

- The pink foam board is polystyrene… similar to disposable coffee cups, etc.
- Fiberglass is also non-toxic. It is comprised of fine glass fibers with a small amount (~5%) of binder that holds it together. The binder is based on a plant-derived chemistry. There may be a few extra-sensitive-skinned folks that might think it itchy, but most do not. So gloves are fine, but totally optional.

Will our students get feedback on their insulation design and installation?

- Besides the judges' direct feedback at STEMfest Knox, I will provide some data and comments within a couple weeks of the event.

Persistent Scientist Award Information

The Persistent Scientist award is presented to **an individual team member** in recognition of their diligence, hard work and attitude throughout the STEMfest problem solving challenge.

A good scientist does not always get the correct answer, but a good scientist is always striving to find better, outside the box, inventive answers to any and all challenges. Struggling is part of the process. How a scientist approaches those hurdles, works in a group and supports other team members is very important.

To nominate a student for the Persistent Scientist Award visit http://tinyurl.com/STEMfestKnoxScientist complete the nomination form.

STEMfest! Team Registration Information

Visit http://tinyurl.com/STEMfestKnox2016 to register your team.

Scholarship Opportunities

Winning high school teams competing in STEMFest Knox Problem Solving Challenge will have following scholarship opportunities.

Each winning team member of the Toothpick Bridge challenge will receive a $1,000 college scholarship to attend Central Ohio Technical College.

Each winning team member of the Global Water challenge will receive a $1,000 college scholarship, which will be distributed as $250 over four years, to attend Mount Vernon Nazarene University.

Summer Science Institute Opportunity

Winning teams high school teams competing in STEMFest Knox Problem Solving Challenge in the Home Energy Challenge will be eligible for a Summer Science Institute at Kenyon College. On this experience students will be VIPs for a one-day Kenyon College Summer Science specialized educational experience. Each student's area of interest will be explored through connections with student researchers, faculty mentors and laboratory visits.