For more than 10 years, STEMfest! @The Works has been the premier event for middle and high school students to showcase their creative approach to solving the problems of today’s world. This year, we are excited to announce our expansion of the program to elementary students with STEMfest! Junior.

**Challenges.** Each of the challenges deals with a variety of disciplines and represents issues that professional scientists, technicians, engineers, and mathematicians encounter every day!

- From the Ground Up
- Going Green
- Reinventing Exhibit Design
- Technology Solutions

**Registration.** Teams (1-6 students) can be registered through a teacher or parent coach. Once registered, the team will be eligible to pick up any provided materials through The Works and get connected with industry & education mentors! **Coaches can register as many teams as needed to support the number of students interested in participating!**

Registrations for each challenge are processed in the order they are received. Please note that schools/organizations are limited to a maximum of (5) teams per challenge, additional teams will be placed on the waitlist until registration closes on January 31st, 2022.

**Event Information.** The official STEMfest competition will take place the weekend of March 5-6, 2022. Teams will present to a panel of industry & education representatives during the competition. The Works will announce the challenge winners at the end of each day of presentations. The awards ceremony will also be streamed live online.

We look forward to sharing another year of exciting STEM Design Challenges with you! If you have any questions about STEMfest or other education efforts at The Works, please email education@attheworks.org.

Sincerely,

Meghan R. Federer, PhD  
Assistant Director  

Rori P. Leath  
STEM Education Director  

Sadie A. Burger  
Youth & Family Programs Director
**STEMfest! @The Works**

March 5 & 6, 2022

**Important Update: STEMfest @The Works will be closed to the public.** Participating students, team coaches, and family members are all welcome to attend the event for team presentations and industry engagement!

**Challenge Presentations**

All presentations will take place at the museum on Saturday, March 5th and Sunday, March 6th, 2022. Teams will be assigned a judging time during which they will present to a panel of industry & education representatives. Challenges that require the production or design of a physical item must deliver it to The Works for testing prior to the competition date (schedule to be determined).

- **Elementary School Presentations (3rd – 5th):** Sunday, March 6, 9AM – Noon (tentative)
- **Middle School Presentations (6th-8th):** Saturday, March 5, 9AM – 3PM (tentative)
- **High School Presentations (9th – 12th):** Sunday, March 6, Noon – 3PM (tentative)

**Industry & Education Showcase & Scavenger Hunt**

Discover the local industries and businesses that are making a difference in STEM fields. This scavenger hunt will include videos, live presentations, and hands-on activities at the museum. Participants can earn rewards for engaging with industries!

**Drawings for daily prizes will take place at the end of each day and announced on our social media channels.**

**STEMfest Awards**

The Works will announce the challenge winners for each level at the culmination of the event (not at the end of each day).

The Works will announce awards and broadcast live on our social media channels on Sunday, March 6 at 6 PM *(date and time subject to change).*

**Winning High School team members from Licking County are eligible to receive a $1000 college scholarship, apply for internships, and more!**
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!

As the only individual award presented at STEMfest, the Persistant Scientist award recognizes a team member for their diligence, hard work, perseverance, and positive attitude throughout the STEMfest problem solving challenge.

This award is nomination based. Nominations can be submitted by team coaches or team members. All Nominees will be recognized during the Awards Ceremony with certificates of recognition. The recipient of the award will receive a glass award and other prizes!

2020 Persistent Scientist Middle School Winner

To nominate a student for the Persistent Scientist Award visit [https://forms.gle/M7RKD4b9oN1pAiWWA](https://forms.gle/M7RKD4b9oN1pAiWWA) and complete the nomination form.
IMPORTANT DATES & INFORMATION

December 01, 2021: STEMfest Registration Opens
Registration for STEMfest 2021 will be open from December 01, 2021 – January 31, 2022

- From the Ground Up: Reimagining Ohio Infrastructure: The Ohio STEM Learning Network & Central Ohio Technical College
- Going Green: Investigating Plant Energy: Department of Chemistry, Denison University
- Reinventing Museums: Design For Kids, By Kids: Red Frame Lab, Denison University
- Technovation: Technology for Good: Meta, New Albany Data Center

Registration must be completed by STEMfest Team Coaches (Teachers OR Parents) for each participating team. Please have the following information available for registration.
- STEMfest Team Name
- Coach Name, Phone, & Email
- School/Organization Name
- Team Member Names, Grade Levels

If you are registering multiple teams or multiple challenges per team, they MUST be registered separately. Visit https://forms.gle/PoFqMS5Lu9cdafxC7 to register your team.

December 2019 – February 15, 2020: Challenge Materials Available (Coaches)
FREE materials are available at The Works for applicable challenges. Not all challenges requires the use of specific materials. Review individual challenge details for full details.

Material pick-up needs to be scheduled in advance. The Works is open 9:00 AM – 4:00 PM, Tuesday – Saturday. Teams MUST be registered for STEMfest 2022 before requesting materials.

January 29 & February 19, 2022: Presentation Workshops - REDESIGNED

After all of your hard work leading up to STEMfest, you want to put your best foot forward with your presentation! Presentation and communication of your process make up a large portion of the scoring for each challenge.

Sign up for a time to meet with The Works Education Team to get feedback on your presentation! We will include tips to showcase your work, boost your confidence and improve your public speaking skills.

Registration information will be available on The Works website in January 2022. Visit www.attheworks.org/stemfest for more information.

Updated – 01/06/2022
ADDITONAL RESOURCES

Go to https://www.lickingcountylibrary.info/info and click on “research and homework help.”

**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.

Updated – 01/06/2022
Reimagining Ohio Infrastructure

Increase equity, access, or efficiency in your community.

Presented by The Ohio STEM Learning Network & Central Ohio Technical College

This year’s #STEMbuildsOhio Challenge invites students to consider how they can improve their school, community, or world by reimagining an existing physical space, system, product, or service so that it is more equitable, accessible, or efficient.

Background Information:
As we turn towards life in a post-pandemic society, we are inspired by the immense possibilities that lie ahead to rebuild our lives and communities to be even better than before. Infrastructure and design are part of so much of today’s world. From the roads we travel to the buildings we gather inside everything has been strategically designed to benefit our lives. But the way we interact with built infrastructure, products, and systems is changing. Under the influence of challenges like climate change, new technologies, and new goals, these elements of our world will surely look very different.

For this year’s challenge, the Ohio STEM Learning Network asks students to think about the structures and systems around them and envision how they can be altered to improve equity and inclusion.

For more information, visit www.designchallenge.osln.org/infastructure

Challenge Statement:
How can you improve your school, community, or world by reimagining an existing physical space, system, product, or service so that it is more equitable, accessible, or efficient?

Select one of the following tracks to focus your solution.

Updated – 01/06/2022
INFRASTRUCTURE AND DESIGN

Built Infrastructure: How can you repurpose an existing physical structure in your home, school, or county to ensure equitable access or improve the overall efficiency of that space?

The built environment touches all aspects of our lives, encompassing the buildings we live in, the distribution systems that provide us with water and electricity, and the roads, bridges, and transportation systems we use to get from place to place. It can generally be described as the man-made or modified structures that provide people with living, working, and recreational spaces. Creating all these spaces and systems requires enormous quantities of materials.

Product Design: What changes can you make to an existing product so that it is more equitable, accessible, or eco-friendly?

New product design is a lot like art. Creativity and vision come together to produce something new, attractive, and bold. But product designers have a different set of challenges than the artist. Product designers have to create with the users in mind. Their creations need to be useful. They need to be accepted into the homes of consumers where, instead of being mounted on the wall, they go on the bathroom sink or in the kitchen cupboard.

System Design: What changes can you make to an existing system to improve equity, efficiency, or access for people in your school or community?

When you encounter situations which are complex and messy, then systems thinking can help you understand the situation systemically. This helps us to see the big picture – from which we may identify multiple leverage points that can be addressed to support constructive change. It also helps us see the connectivity between elements in the situation, so as to support joined-up actions.

Material Specifications: None

Presentation Guidelines:
Updated – 01/06/2022
Presentations should be between 7-10 minutes in length and address:

1. Relevant background knowledge that communicates their understanding of the challenge statement.
2. Clear connections between the key issues underlying the issue and their proposed solution, including a justification of the proposed solution.
3. Description and explanation of design process, including testing and revision of solution.
   - Include photos that document the design process and prototype development. For example, digital renderings, key features, early prototypes, refined models, etc.
4. Education and career pathways related to increasing equity, access, and efficiency in infrastructure.

**Required Deliverables:** Digital or physical model of solution, as appropriate, that showcases how it improves equity, access, or efficiency as compared to the existing infrastructure, product, or system.
GOING GREEN WITH BIOFUELS

Investigate the energy of plants.

Presented by Department of Chemistry & Biochemistry, Denison University

Generate an effective form of energy from a plant source. The energy source will be tested for efficiency at STEMfest! @The Works.

Background Information:
One of the most important resources for our current way of life is energy. From charging a cell phone or running a computer, to powering a car or heating our homes in winter, we use energy in almost every aspect of our lives. Most of that energy comes to us from burning what are called fossil fuels. This includes natural gas (methane), propane gas, oil, and coal. In just the United States it is estimated that we use over 8 billion gallons of oil each day! Across the world, our energy consumption is significantly greater, and continues to grow. Finding enough energy sources to power the planet, and doing so in a environmentally responsible or ‘green’ way is a great challenge facing us now and in the future!

The fossil fuels mentioned above hold energy in the form of chemical bonds, and that energy is released through burning it with oxygen gas. These fuels are extracted from the ground using mining techniques that can sometimes be dangerous to people and the environment. There are many other ways to produce energy. Some include harvesting sunlight with solar panels, using heat from the earth called geothermal, or using the wind to turn large turbines. As humans, we get the energy to live and move by eating food, including plants. Of course, plants have been used as a power source for heating (such as a wood burning fireplace) for many years. With a little bit of chemistry, we can harness simple plant materials to give us energy in forms that can be used to power engines and charge your phone!
Challenge Overview:
Full guidelines detailed on subsequent pages.

- **Elementary School**: Investigate fruits as a source of stored chemical energy (i.e., a battery). Using just a few metal materials, you can turn an ordinary piece of fruit into a battery! This happens through a process known as electrochemistry, where the produce acts like a ‘salt bridge’ between two different metals, called ‘electrodes.’ Your job is to experiment with different fruits and circuit types to make the most efficient battery.

- **Middle School**: Investigate produce as a source of stored chemical energy (i.e., a battery). Using just a few metal materials, you can turn an ordinary piece of produce into a battery! This happens through a process known as electrochemistry, where the produce acts like a ‘salt bridge’ between two different metals, called ‘electrodes.’ Your job is to experiment with different produce and metals to make the most efficient battery.

- **High School**: Synthesize biodiesel as a portable fuel from various vegetable oils. Using a chemical reaction called saponification, plant oils such as soy oil can be converted into a type of fuel called biodiesel. This fuel can be used as a substitute for gasoline or propane in certain types of engines and generators. Your job will be to make the most efficient batch of biodiesel fuel possible, using any commonly available vegetable product. A basic procedure and materials for the conversion of vegetable oil into biodiesel is provided. You will need to research the chemical reaction and experiment with your technique and the available oils to generate the optimal fuel.

  Note: Making a biodiesel requires access to laboratory space and safety apparel. If this is not available to your team, contact The Works and space/apparel will be provided.
Elementary School Challenge: Making A Fruit Battery!
Investigate produce as a source of stored chemical energy.

**Background Research & Activity:**
- Can you describe different types of circuits? For example, simple, parallel, and series?
- How does a normal battery work? What is electrochemistry?
- What is the role of the fruit in a fruit battery? Why are some fruits better as a battery than others?

Explore circuits using our Snap Circuit kits prior to designing your fruit battery. Use this exploration to inform your fruit battery design. Teams can check out a free Snap Circuits Kit from The Works!

**Material Specifications:**
You must determine which produce and metals to use and how to assemble the battery to maximize voltage and current.
- Choices of Metal: Zinc and Copper
- Choices of Produce: **No more than 5 produce items can be used in the battery design.**
- Insulated copper wire with clips
- Light emitting diodes (LEDs): Use your LEDs to figure out the *highest voltage* (Hint: you can string the LED together) and the *highest current* (Hint: higher current makes the LED shine brighter).

**Required Deliverables:**
On the day of STEMfest you will set up your best battery and test it to see how much power it produces! **Make sure you prepare your battery with fresh produce the day of STEMfest! for optimal performance. Also, do not connect your battery until time for testing!**

**Evaluation:**
Your team will be evaluated on each of the following areas:
- Aesthetics (15%): How neat and professional does your battery appear?
- Presentation (35%): Communication of process and design.
- Material specification (15%): Battery includes only the specified functional materials.
- Battery Efficiency (35%): Calculated based on the current and voltage of your fruit battery relative to the maximum values achieved by an elementary team at STEMfest.

**Presentation Guidelines:**
Presentations should be between 7-10 minutes in length and address:
1. Background knowledge that communicates their understanding of circuits and batteries. Includes reference and documentation of Snap Circuits activity and how that helped inform their design process.
2. Clear connections between the choice of materials used and the flow of energy through the circuit.
3. Description and explanation of design process, including testing and revision of the battery:
   - Include photos that document the process and justification of choices
   - Efficiency of solution and comparison to earlier prototypes, including a justification of final model/solution.
4. Education and career pathways related to green energy.

**Middle School Challenge: Making A Fruit Battery!**
Investigate produce as a source of stored chemical energy.
- What is electrochemistry? Define salt bridge. How does a normal battery (not Li ion) work?
- Which metals conduct electricity better? What is an electrode? Why are different metals used for electrodes?
- What is the role of the fruit in your battery? Why are some fruits better as a battery than others?
- What careers are involved in the Biofuel Industry? What is unique about the emerging career cluster?

**Material Specifications:**
You must determine which produce and metals to use and how to assemble the battery to maximize voltage and current.
- Choices of Metal: Copper, Zinc, Nickel, Magnesium, Steel, Aluminum
- Choices of Produce: **No more than 5 produce items can be used in the battery design.**
- Insulated copper wire with clips
- Light emitting diodes (LEDs): Use your LEDs to figure out the highest voltage (Hint: you can string the LED together) and the highest current (Hint: higher current makes the LED shine brighter).

**Required Deliverables:**
On the day of STEMfest you will set up your best battery and test it to see how much power it produces!
Make sure you prepare your battery with fresh produce the day of STEMfest! for optimal performance. Also, do not connect your battery until time for testing!

**Evaluation:**
Your team will be evaluated on each of the following areas:
- Aesthetics (15%): How neat and professional does your battery appear?
- Presentation (35%): Communication of process and design.
- Material specification (15%): Battery includes only the specified functional materials.
- Battery Efficiency (35%): Calculated based on the current and voltage of your fruit battery relative to the maximum values achieved by a middle school team at STEMfest.

**Presentation Guidelines:**
Presentations should be between **7-10 minutes** in length and address:
1. Background knowledge that communicates their understanding of electrochemistry and relevant content knowledge
2. Clear connections between the choice of materials used and chemical processes taking place.
3. Description and explanation of experimental process, including testing and revision of the model.
   - Include photos that document the process and rationale of decisions made
   - Efficiency of solution and comparison to earlier prototypes, including a justification of final model/solution.
4. Education and career pathways related to green energy.
High School Challenge: Biodiesel Fuel
Synthesize biodiesel as a portable fuel from various vegetable oils.

Note: Making a biodiesel requires access to laboratory space and safety apparel. If this is not available to your team, contact The Works and space/apparel will be provided.

Required Background Research:
- What is biodiesel and how is it made?
- Explain the chemistry of the saponification reaction you carry out.
- How did you design your biodiesel production experiment? What factors did you consider in selecting oils to compare?
- What careers are involved in the Biofuel Industry? What is unique about the emerging career cluster?

Materials:
- You must research and compare a minimum of 3 different vegetable oils.
- Gloves
- Lye
- Methanol
- Isopropanol
- Jars
- Graduated cylinders

Required Deliverables
On the Thursday before STEMfest, (or sooner) bring at least 10 ml of your best fuel to The Works. An exact amount will be weighed and burned in a calorimeter to directly measure the efficiency, or amount of energy per mass, of your biodiesel. On the day of STEMfest, your sample will be examined for purity by color, turbidity, and consistency.

Evaluation:
Your team will be evaluated on each of the following areas:
- Aesthetics (10%): Color, clarity, and homogeneity of biodiesel
- Presentation (50%): Communication of research, experimental process and solution.
- Efficiency (40%): Amount of energy produced per gram of fuel, relative to the maximum amount produced by a high school team.

Presentation Guidelines:
Presentations should be between 7-10 minutes in length and address:
1. Background knowledge that communicates their background research into biodiesel and production
2. Clear connections between the choice of materials used and chemical processes taking place.
3. Description and explanation of experimental process, including testing and revision:
   - Include photos that document the process and rationale of decisions made
   - Comparison of at least (3) different oils and justification of final selection
4. Education and career pathways related to research, synthesis, and use of biodiesel fuels.
High School Challenge: Biodiesel Fuel
Basic Experimental Procedure: Making Fuel from Vegetable Oil

1. Always wear gloves and goggles!! Everyone must wear protective gear while handling chemicals.
2. Measure out 100 ml or more of new vegetable oil and pour it into a large beaker.
3. Heat 100 ml of new vegetable oil to 50 °C on a hotplate using a stirrer. One person in your group should watch the temperature closely so the oil does not overheat.

Perform the following two steps under the chemical hood or other well ventilated space.

4. Measure 25 ml of methanol in a graduated cylinder and pour into your mixing bottle. Cap the methanol bottle and your mixing bottle tightly.
5. Weigh out 0.5 grams of sodium hydroxide (lye) and add to the methanol in your mixing bottle. Cap the bottle and swirl gently for a few minutes until all of the lye dissolves. You now have sodium methoxide in your bottle, a strong base. Be careful!
6. When the lye is dissolved and the oil reaches 50 °C, add 100 ml of warm oil to the methoxide and cap the bottle tightly. Invert the bottle once over a sink to check for leaks. Caution: Be certain that the oil is not over 60 °C, or the methanol may boil!!
7. Shake the bottle vigorously for a few seconds then, while holding the bottle upright, open the cap to release any pressure. Retighten the cap and shake for at least one minute venting any pressure occasionally. Set the bottle on the bench and allow the layers to separate.
8. Over the next 30-60 minutes, you should see a darker layer (glycerol) forming on the bottom of the bottle, with a lighter layer (biodiesel) floating on top. Complete separation of the reaction mixture will require several hours to overnight. If your procedure worked correctly, there should be two distinct layers remaining after settling.
   a. The darker layer at the bottom is a crude glycerine byproduct, and the lighter layer on top is biodiesel. If you pick up the settling bottle and rock it slightly from side to side, notice how the darker layer is thicker than the fuel floating on top. This higher viscosity of glycerine is one of the reasons that it isn’t suitable for use in a diesel engine at room temperatures. By removing the heavier, more viscous part of the oil, the esters pass through the engine’s injectors and combust that much easier.
   b. It is common to see a whitish third layer floating between glycerine and the biodiesel. This soap-like material is a result of adding too much lye, or having water in the oil. It should be discarded with the glycerine.
   c. If you see more than two layers, or only one, then something is wrong – possibly excessive soap or monoglyceride formation. These are both emulsifiers, and in sufficient quantities they will prevent separation. In this case, check your scales, measurements, and temperatures.

You will need to research how to best separate and wash your biodiesel. Your actual procedures may differ based on the type of oil used and your results.
Background Information:
While walking through a museum, we will often encounter stunning and displays that invoke awe and wonder in children and adults alike. Some exhibits are designed to be permanent fixtures in a museum, while others are only temporary. Some may be designed to allow hands-on interaction, while others must be protected from curious museum-goers.

In many instances, the careful planning and set up of museum exhibits is left to the careful hands of museum exhibit designers. A museum exhibition designer is the developer of plans which ultimately lead to the construction of public displays for educational and enjoyment purposes.

Challenge Statement:
You’re hired! Develop a new exhibit concept that engages youth and provides an informal learning opportunity for K-12 STEM education. Exhibit design must also connect to and represent a local organization, business, or manufacturing partner.

- **Elementary & Middle School:** Create a single exhibit interactive that aligns with a current Works exhibit space:
  - Go Lab (Forces & Motion)
  - Me Lab (Health & Human Body)
  - Zap Lab (Electricity & Magnetism)
  - SciDome & Navigation (Earth & Space)

- **High School:** Create a new small room exhibit concept for The Works or another community/education partner (i.e., library, school, etc.). Maximum exhibit space is a 15 x 15 foot room.

Required Deliverable:
On the day of STEMfest, you will bring a model of your exhibit concept (digital or physical, as appropriate to the design). The final model does not have to be fully functional, but a clear explanation of how a user would engage with it is required. All models must consider ADA compliance and identify target audience (age band).

**Evaluation:**
Your team will be evaluated on each of the following areas:

- **Model Aesthetics (20%):** How well does the design represent and engage the user in the identified concept?
- **Presentation (50%):** Communication of design process and exhibit development.
- **Exhibit Concept (30%):** Concept connects to an appropriate K-12 STEM learning concept and is designed to allow the user to explore and demonstrate understanding.

**Presentation Guidelines:**
Presentations should be between 7-10 minutes in length and address:

1. Understanding of museum exhibits, human centered design, and relevant STEM concept knowledge.
2. Description of exhibit concept (including location and audience), connection to community partner, and collection of user data that justifies decision.
3. Clear demonstration of iterative design process, including at least two versions of the prototype exhibit design, along with an explanation of how the proposed design provides a relevant learning experience.
4. Education and career pathways related human centered design and exhibit development.
Background Information:  
A way to find safe drinking water. A tool to identify and remove invasive species, Air quality monitors. A symptom tracker for infectious disease. A way to connect people in need. Technovation encourages you to become a leader, creator, and problem solver to address big problems in your community!

Challenge Specifications:  
Participating teams should identify a problem, come up with possible solutions, and do some marketing research to make sure it is the best solution possible. Note: Solutions are not limited to App development. Visit www.technovationchallenge.org/curriculum/ for more ideas on how to get started!

Evaluation:  
Your team will be evaluated on each of the following areas:  
- Aesthetics (15%): Clear design and user experience  
- Presentation (50%): Communication of research, design process and developed solution.  
- Effectiveness (35%): Demonstration of functional technological solution

Presentation Guidelines:  
Presentations should be between 7-10 minutes in length and address:  
1. Background knowledge that communicates the importance of community problem and relevance of technological solutions  
2. Description of the design process, justification of changes made, and challenges faced in design.  
3. Clear demonstration of developed technological solution and its functionality/user experience. Include 2-6 images that showcase your design process and development.  
4. Education and career pathways related applied technology.

Required Materials: None