South Dakota State University Extension

South Dakota 4-H STEM Challenge

2024 Challenge Packet

Photos courtesy of SDSU Department of Ag and Biosystems Engineering

Table of Contents

Challenge Overview

The South Dakota 4-H STEM Challenge is an opportunity for youth to apply their knowledge of science, technology, engineering and math to build a complex machine designed to perform a simple task, similar to a Rube Goldberg™ type machine. The challenge encourages creativity, collaboration, communication and critical thinking in young people.

Virtual Event Opportunity *New for 2024*

For this year, teams can submit a virtual submission if they are unable to attend the in-person event at the South Dakota State Fair. Teams will need to record their presentation and the successful run of their machine. The machine will need to be constructed following the same rules and guidelines for the in-person event. Instructions for how to submit recordings will be sent after registrations close.

In-Person Event Location

The event will be held Friday August 30, 2024 on the South Dakota State Fairgrounds, Huron, SD. The challenge will be held in the Nordby Exhibit Hall on the State Fair Grounds.

Eligibility

1. Team registration is taken on a first-come-first-serve basis through **August 13, 2024**. This registration deadline will be strictly enforced.
2. Teams **must have at least two** members with a **max of 3**.
3. Teams may consist of youth from different counties.
4. All participants must be actively enrolled in 4-H and at least 8 years of age by January 1, 2024, but not have turned 19 years old prior to January 1, 2024.

Schedule

Schedule is tentative and subject to change

12:30-1:30 p.m. Teams will check in and begin set up and testing of their machines. Teams can arrive at any time during this period and are not required to remain at their machines the whole time. However, machine set up should be completed by the youth and not coaches or parents.

1:30-4:30 p.m. Team judging*

*Teams will be present at their projects for the entirety of this time. This will allow them to share their projects with the public while waiting for the judges.

Challenge Task Guidelines

The theme of the 2024 South Dakota 4-H STEM Challenge is **Speedy Delivery!** Neither sleet nor snow nor an overly complicated machine will prevent the mail from being delivered.

Level 1 Machine

A level 1 machine should be created by teams that are in their first or second year of creating a multi-step machine. If your team has experience with creating these types of machines through school or previous participation in the South Dakota 4-H STEM Challenge, you should consider building a level 2 machine (see next section for level 2 requirements)

- Each team will need to create a machine that completes the task of delivering a package to a mailbox in the final step.
    - Completion of the task is NOT a step. There should be a minimum of 7 steps leading up to this task.
        - **One** of the steps must be a **mechanical engineering (simple machine)** step.
    - Completion is scored based on how well the machine operates under specified constraints as well as human interventions. **Human interventions** include any assistance the machine requires (not including its start) to complete the task. For example if a step does not trigger the next step and youth step in to start the next step.
- The package will be provided by the team and should measure at least five inches long, two inches wide, and one

inch tall (5”x 2”x 1”). It can be a pre-existing item or can be constructed by the team.

- The team will determine what will be used for a mailbox in the final step, however it should be apparent to the judges and the public that it is a mailbox (so something more than just a plain cardboard box or a plain ice cream bucket).

Level 1 Machine Specifications

Specification	Requirement/limitation
Complete the Official Task	Required
Safe for participants and observers	Required
Written list of all steps in your machine	Required
Number of steps	Minimum: 7 Maximum: 20 Minimum 1 Mechanical Engineering Step* *See Appendix B
Machine must represent the theme and solve the task	Required
Physical size of the machine	Maximum: 4 ft x 8 ft x 6 ft width x length x height
Single run time to complete the task	Minimum: None; Maximum: 5 minutes
Number of Resets Allowed	Teams may completely reset their machine **3** times during judging.
Objects flying beyond machine boundaries	Objects must stay within the maximum machine boundary
Corporate logos	Allowed with written permission from the logo owner. (Ensure the 4-H clover is present or visible somewhere on the machine)
Use of live animals	Not allowed
Hazardous (toxic, noxious, dangerous) materials, explosives, or flames	Not allowed
Combustion engines	Not allowed (No gasoline or other combustible fluid)
Use of profane, indecent, or lewd expressions, offensive symbols or graphics	Not allowed
Use of air compressors	Not allowed
Use of AC or DC power cords running to the machine	Not allowed

Level 2 Machine

A level 2 machine should be created by teams that have experience with creating basic multi-step machines and are ready for more of a challenge. If you are unsure if your team is ready to be at level 2, feel free to reach out to South Dakota 4-H STEM Field Specialist Christine Wood (christine.wood@sdstate.edu or 605-782-3290).

The theme of the 2024 South Dakota 4-H STEM Challenge is **Speedy Delivery!** Neither sleet nor snow nor an overly complicated machine will prevent the mail from being delivered.

- Each team will need to create a machine that completes the task of delivering a package to a mailbox in the final step.
    - There will also be the optional task of indicating the successful delivery of the package. This is not a mandatory part of the task but will result in bonus points if completed successfully.
        - An indication of a successful delivery could be symbolized by a flashing light, a flag popping up, creating applause, a sound being played, etc. The indication of the delivery must be a part of the machine steps and not a human response to the machines (ie, team members applauding).
    - Completion of the task is NOT a step. There should be a minimum of 10 steps leading up to this task.
        - **Two** of the steps must be **mechanical engineering (simple machine)** steps.
        - **One** of the steps must be an **electrical engineering** step.
- See Appendix A for more information about these requirements.

- Completion is scored based on how well the machine operates under specified constraints as well as human interventions. **Human interventions** include any assistance the machine requires (not including its start) to complete the task. For example if a step does not trigger the next step and youth step in to start the next step.

- The package will be provided by the team and should measure at least five inches long, two inches wide, and one inch tall (5"x 2"x 1"). It can be a pre-existing item or can be constructed by the team.
- The team will determine what will be used for a mailbox in the final step, however it should be apparent to the judges and the public that it is a mailbox (so something more than just a plain cardboard box or a plain ice cream bucket).

Level 2 Machine Specifications

Specification	Requirement/limitation
Complete the Official Task	Required
Safe for participants and observers	Required
Written list of all steps in your machine	Required
Number of steps	Minimum: 10 Maximum: 20 Minimum 2 Mechanical Engineering Steps* Minimum 1 Electrical Engineering Steps* *See Appendix B
Machine must represent the theme and solve the task	Required
Physical size of the machine	Maximum: 4 ft x 8 ft x 6 ft width x length x height
Single run time to complete the task	Minimum: None Maximum: 5 minutes
Number of Resets Allowed	Teams may completely reset their machine **3** times during judging.
Objects flying beyond machine boundaries	Objects must stay within the maximum machine boundary
Corporate logos	Allowed with written permission from the logo owner. (Ensure the 4-H clover is present or visible somewhere on the machine)
Use of live animals	Not allowed
Hazardous (toxic, noxious, dangerous) materials, explosives, or flames	Not allowed
Combustion engines	Not allowed (No gasoline or other combustible fluid)
Use of profane, indecent, or lewd expressions, offensive symbols or graphics	Not allowed
Use of air compressors	Not allowed
Use of AC or DC power cords running to the machine	Not allowed

Appendix A: Additional Challenge Information

Machine Steps

Each machine has to include a minimum number of "steps." **A step in the machine is a transfer of energy from one action to another action.**

- Example 1: A ball rolls down a ramp. This equals one transfer-of-energy or one step (ball rolling along a surface).
- Example 2: A ball rolls down a ramp and causes a row of dominoes to fall over. This is two transfers of energy or two steps (ball rolling along a surface and dominoes falling over).
- Example 3: A ball rolls down a ramp, hits a row of dominoes, the dominoes trigger a mousetrap. This is three *transfers of energy or three steps* (ball rolling along a surface, dominoes falling over, and a mousetrap being triggered).

Identical transfers of energy in succession are only counted as one-step. For example, a line of dominos hitting each other only counts as one-step. Counting 100 dominoes as 100 steps does not meet the guidelines.

Steps will be scored based on precision. Youth are allowed to provide assistance if steps are not precise enough to start the next step. However, points will be docked for these human assists (see score sheet).

Step Ideas

There is an infinite number of actions that can be utilized as a step including simple machines. For some visualization, check out these YouTube videos:

50 Rube Goldberg™ Machine Ideas (youtube.com/watch?v=WiHn5_RfKjE)
75 Rube Goldberg™ Ideas and Inventions (youtube.com/watch?v=cv5WLLYo-fk)
A Minnesota 4-H Engineering Design Challenge team in action (youtube.com/watch?v=UIC5ViQFPnU)

Team Notebook

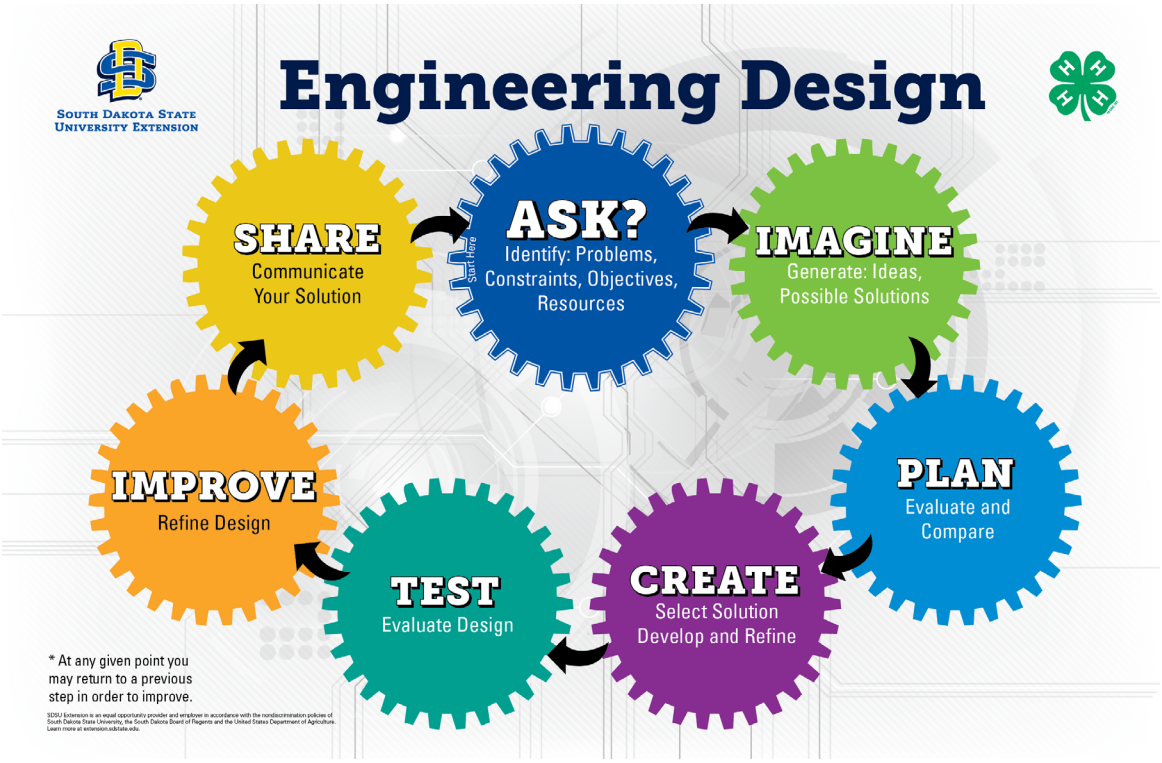
As teams work to design and build their machine, they should be diligently documenting their progress in a **Team Notebook**.

- Each team needs to keep a written team notebook to document the team's work, including research, successes, setbacks and progress.
- It serves as a record of the team's ideas and accomplishments throughout the process of designing and building the machine.
- The notebook is a means of reflecting on what they learned and accomplished each time they met, and how the engineering design process guided the team's work.

Engineering Design Process

Teams are required to use this process to help guide the machine planning and creation. **Teams are required to use the Design Process throughout creating their machine and be able to explain how they did so.**

1. **Ask:** Define the challenge objectives, constraints, and resources.
2. **Imagine:** Information gathering/idea generation.
3. **Plan:** Make a plan.
4. **Create:** Begin constructing and refining design.
5. **Test:** What works and what needs improved.
6. **Improve:** Redesign.
7. **Share:** Participate in the State 4-H STEM Challenge.



Notebook Tips & Suggestions

- The notebook can be a spiral-bound school notebook, a three-ring binder with loose-leaf sheets, a bound book with blank pages or an electronic notebook in a computer file.
- Should be accessible to all the team members and everyone should have the opportunity to make entries and record information.
- A useful notebook contains both writing and drawings as a way of capturing ideas and figuring out how to make the machine work. If an idea is not used or if something does not work, make a note next to the drawing or writing explaining why the idea was not used or why it did not work.
- We recommend that each time the team meets, use the last 10 minutes of the meeting to discuss and add an entry to the team notebook.
- The best notebooks are used consistently throughout the process of building the machine.

For examples of what your notebook can look like, visit Minnesota 4-H's Engineering Design Challenge for Teams section: extension.umn.edu/projects-and-more/4-h-engineering-design-challenge#for-teams-1397213

Theme and Story

While developing the design for the EDC machine, consider a theme you would like to have that addresses the 2024 energy conservation **theme and the story** about your machine based on the theme **Speedy Delivery**.

- The theme and story should be a fun part of creating a machine, not an obstacle. Some teams start with a story first and develop their machines from there.
- Teams should consider how they will share their story through some type of presentation to illustrate their work.
- Teams will have the opportunity to give a presentation to audiences and judges at their local county fair, the state 4-H Engineering Design Challenge State Showcase Event or any public opportunity available.
- Presentations should be from 5-10 minutes in length and each member of the team needs to participate in sharing the information.

Presentation

A big part of sharing the story of the machine creation experience is being able to share that information in a **summary**.

- The purpose of the summary is to help teams describe their experience during the conference judging experience.
- The summary can be a one or two page account that highlights the team's experience, or it can be a poster, photographs, video or any other medium the team wants to use to demonstrate their team's experience.
- While the notebook helps the team think about what they've learned in each small step, the presentation highlights the "aha moments," the fun, and maybe also some of the frustrations the team had from the time they first began to plan their machine to the day they decided it was finished.

Appendix B: Engineering Steps

Adapted from Minnesota 4-H Engineering Design Challenge materials.

Mechanical Engineering Steps – Simple Machines

- There are 6 basic simple machines;
  - Lever
  - Wheel and axle
  - Inclined plane
  - Wedge
  - Pulley
  - Screw
- A simple machine is a mechanical device that changes the direction or magnitude of a force.
- Simple machines are a tool used to accomplish a task and make work faster or easier.
- Work is the amount of energy necessary to move an object. The further you move an object, the more work is required.

Using Newton's Laws

Using simple machines in the Engineering Design Challenge machine will require motion/movement from one step to another.

To help understand motion, examine Newton's Laws and how they affect the transfers of energy that take place in your machine.

- **Newton's first law of motion** is often called the law of inertia. Objects at rest stay at rest, and those in motion stay in motion, unless acted upon by an outside force.
- **The second law of motion** states that when F is the force applied to an object, m is the object's mass, and a is its acceleration, then F = ma. Therefore it takes less force to move an object with a lower mass than an object with a higher mass.
- **Newton's third law of motion** states that for every action there is an equal and opposite reaction. Every time an object moves, there is an equal force in the opposite direction acting on the object that caused the motion.

Using simple machines to create your machine

- Simple machines can be found anywhere. Look around your house, at school, in your garage, ask a friend, teacher or neighbor for items to use.
- To visualize your machine, think about the Challenge two-step task and how simple machines can play a role in completing the Challenge task. Think about the six different simple machines and how you can apply them to your engineer design machine.
- Team members should be able to name the three simple machines used in their machine and how each of them function.

Learn more about Mechanical Engineering/Simple Machines

Simple machines for kids (video)
Simple machines explained (video)

Electrical Engineering

Level 2 Teams are required to contain at least one electrical engineering step in their machine. Teams are encouraged to use any type of power (with the exception of wall outlets), such as batteries, circuits and controls using electricity. The electrical reaction should be simple and safe. If at any time you have questions about what is safe, see contact the person listed at the end of this resource.

What is electricity?

- Electricity is the presence and flow of electrical charges.

- While certain aspects of electricity had been observed for centuries, like lightning and static electricity, it wasn't until the 1600s that people tried to harness this energy.

Electrical Safety

- Water is an excellent conductor. It is important to keep all electrical items away from water, and make sure your hands are dry and you are not standing in water when you touch anything electrical.

What CAN and CANNOT be used for Electrical equipment in a machine

- Items teams **ALLOWED** to use:
  - Up to four batteries (nothing larger than a 6 volt or 12 amp sealed dry cell battery)
  - Light bulbs
  - Power switches
  - Wire
  - Or any other item that will help you with completing this step
- Items teams **NOT ALLOWED** to use:
  - Wall outlets
  - Air compressor
  - More than two power strips
  - Broken, taped (repaired) and or modified power cords
  - Any dry cell batteries larger than a 6 volt.
  - Any cords connected to a wall outlet

Learn More About Electricity

- Try Engineering (handout)
- Electricity Connect (Website, materials for students and teachers)
- Introduction to electricity (video)
- Explaining an Electrical Circuit (Power Bytz video)
- Introduction to circuits (video)
- Ohm's Law and Power (tutorial)

Appendix C Odds and Ends

Role of the Adult Leader/Coach

This is the kids' event! Thank you for all the hard work you do to make these amazing experiences and learning opportunities available to 4-H'ers. Now is the time to watch with pride as they once again put it all together and show their stuff. You're here to supervise and provide guidance and encouragement from your coach's box. Let's watch them shine!

Education Resources

An effective Engineering Design team will have a thorough understanding of simple machines and a basic understanding of physics. To further knowledge in these areas consider these education resources:

- Engineering Explorers Challenge 1: Wind Powered Vehicle (docs.google.com/document/d/1xAj-WQeg_u6wb6Z7fplNQJaqPpt6r7elbx666ADfCNs/edit)
- Engineering Explorers Challenge 2: Catapult (docs.google.com/document/d/1yli4_yKkmLwFUFiblNXPPuy55X39SZkK9FKvLhu307I/edit)
- Engineering Explorers Challenge 3: Pulley Power (docs.google.com/document/d/1mXcDfrkiyoj6Ls7QJEipzUBLRR-SJQlFHzoeXFpRnrM/edit)
- Engineering Explorers Challenge 4: Energy on the Move (docs.google.com/document/d/1mXcDfrkiyoj6Ls7QJEipzUBLRR-SJQlFHzoeXFpRnrM/edit)
- Engineering Challenge 5: Build that Machine (docs.google.com/document/d/19HO5SIeecIZ9jNcs5DdqP3JbddSTkv4qxTzU88kEC6o/edit)
- Engineering Simple Machines: Wedge and Wheel & Axle (umn.qualtrics.com/jfe/form/SV_0kbGvPmxFybKeTX?Q_JFE=qdg)
- Engineering Simple Machines: Lever and Screw (umn.qualtrics.com/jfe/form/SV_0kbGvPmxFybKeTX?Q_JFE=qdg)
- Engineering Simple Machines: Inclined Plane and Pulley (umn.qualtrics.com/jfe/form/SV_0kbGvPmxFybKeTX?Q_JFE=qdg)
- Engineering Simple Machines: Energy Transfer (umn.qualtrics.com/jfe/form/SV_0kbGvPmxFybKeTX?Q_JFE=qdg)
- Engineering Simple Machines: The Machine Build (umn.qualtrics.com/jfe/form/SV_0kbGvPmxFybKeTX?Q_JFE=qdg)

Frequently Asked Questions

Q: What is a step?
A: A step in the machine is a transfer of energy from one action to another action; identical transfers of energy in succession should be counted as one-step. Example: A sequence of dominos hitting each other counts as one-step. Counting 100 dominoes as 100 steps is repetitive and not in the spirit of the Engineering Design Challenge.

Q: What do we mean by “machine”?
A: A Rube Goldberg™ machine is an overly complex contraption that does a simple task and uses everyday items in a fun or amusing way. The machine uses a series of chain-reaction steps that culminate in accomplishing a task.

Q: What does human intervention mean?
A: Once the first step in your machine takes place (e.g. someone pushes a ball onto a ramp), the machine should function all the way to the end without a person touching it. However, sometimes the machine may fail to reach the last steps to accomplish the task. If a machine fails before it completes the task, it may be necessary for a person to start it again from the point where it failed. That is a human intervention.

Q: Can I enter a machine that has been previously built and posted online?
A: No. All entries must be new machines created for the current challenge year and theme.

Q: Does our machine have to fill the whole 4’ x 8’ x 6’ space?
A: No, your machine can be smaller than the maximum allowed dimensions, it just can’t be larger.

Q: What sources can we use for research?
A: Information gathering is a key step in the design process. Some of the information may be what you and your teammates already knew before you started to think about your machine. In that case, your source is your other teammates or maybe the class in school where you learned the information, or maybe a parent or relative or a 4-H volunteer who taught it to you. But you probably won’t know everything before you start. The library, your teachers, the Internet, your family and friends are all good sources for helping you figure out how to solve a problem.

Q: Can a team be made up of youth from different school grades?
A: Yes. Adult leaders should carefully consider the benefits and challenges of widely varying age/grade groups. Youth in different grades vary greatly, not only in their attention span and ability to stay on task, but also in the amount and type of planning they are capable of, the guidance and recognition they require, and the types of personal development they seek.

4-H STEM Challenge Contact Information

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SDSU Extension 4-H Science Technology Engineering and Math Field Specialist
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Robotics Committee Co-Chair
SDSU Extension 4-H Youth Program Advisor
Nathan.Skadsen@sdstate.edu

Please contact us with any questions or concerns.

Acknowledgements

The SD 4-H STEM Challenge is adapted from the Minnesota 4-H Engineering Design Challenge. We would like to thank the Minnesota 4-H STEM Team for their guidance and resources.

Score Sheet

County: _____ Team Name: _____

Participants Name: _____ Age: _____ Participants Name: _____ Age: _____

_____ _____ _____ _____

Presentation & Judge Interview

Criteria	Much improvement needed (1 point)	Some improvement needed (2-3 points)	Meets Expectations (4-5 points)
Theme or story about the machine.	There is no story OR The story does not match the theme or machine steps	X	The story told aligns well with the theme as well as the steps completed by the machine.
Worked as a team, the role of each team member is identified and described	No teamwork identified	Unequal distribution of workload or input	Each team member had a clearly defined role that was articulated or demonstrated to the evaluators in some method
Discovered ways problems were solved and described using examples; demonstrates perseverance	None identified	Problem solving was evident but not clearly described	Team was able to describe how one or more problems were solved using examples; demonstrated perseverance to get through problems
Elements of the Engineering Design process are evident	Youth lack knowledge of the Engineering Design process OR Youth are unable to describe utilization of the Engineering Design process.	Youth have some knowledge of the Engineering Design process or how it was utilized in the construction of the machine	Youth know the steps of the Engineering Design process and can identify how they are utilized in the construction of the machine
Sequence of steps are clear and described, energy transfer is described, simple machines are identified	Not discussion of the sequence of steps, energy transfer or simple machines	One of these criteria were not described clearly: • sequence of steps • energy transfer • simple machines	The sequence of steps are clearly described, energy transfer is described, simple machines are identified

Presentation and Interview Judging Total Points: _____

Machine Specifications

Criteria	Much improvement needed (1 point)	Some improvement needed (2-3 points)	Meets Expectations (4-5 points)
Task completed & Degree of human interaction	Task not completed OR Task completed with multiple interventions human outside of the specified time constraints	Task completed with multiple human interventions in the specified time constraints OR Task completed with 2 human interventions in the specified time constraints	Task completed with one human intervention in the specified time constraints OR Task completed with no human intervention in the specified time constraints
Number of steps completed: minimum of 7, max of 20	Less than 7 steps or more than 20 steps	X	7 to 20 steps
Degree of innovation, creative use of everyday items in new ways	None identified	Less than half of the steps demonstrate an innovative, different, creative use of tools	Over half of the steps demonstrate an innovative, different, creative use of tools (tools/machines are “re-purposed”)
Objects leaving the machine area	Objects left machine area	X	Objects didn’t leave machine area
Size Requirements	Not Met	X	Met
Safety Requirements	Not Met	X	Met
Machine Run Time	3-5 min	2-3 min	Up to 2 min

Machine Specification Total Points: _____

Presentation and Interview Judging Total Points: _____

Purple (53-70) _____ Blue (35-53) _____ Red (17-34) _____ White(<17) _____

Ribbon Colors and What They Mean

Purple. The exhibit meets all standards. The exhibitor has shown complete understanding of what, how, and why the exhibit was done, and has a thorough knowledge of the subject. The exhibit needs minimal to no improvement.

Blue. The exhibit meets most standards. The exhibitor can explain what, how, and why the exhibit was done and has a good knowledge of the subject. The exhibit is well organized and well done.

Red. The exhibit meets some standards. The exhibitor can somewhat explain what, how, and why the exhibit was done and has a fair knowledge of the subject. Some improvements may be needed on the exhibit.

White. The exhibit meets few standards and lacks the quality of other exhibits. The exhibitor cannot adequately explain the what, how, and why of the exhibit. Possibly they have overlooked a safety flaw. Improvement is needed in either the exhibit, the knowledge of the subject, or both.

4-H STEM Challenge Registration

Due: August 13, 2024

Email Forms to: Christine Wood – christine.wood@sdstate.edu

County: _____

Team: _____

Coach: _____ Phone Number: _____

Email: _____

How will your team present?
In-Person at SD State Fair _____ Virtually _____

Team Member	Age
1.	
2.	
3.	
4.	
5.	

Please indicate your preference for where you will build your machine. *Note: This does not change the dimension requirements listed above, this is specifically to allow us to better plan for space set-up.*

_____ 8x4 tabletops (provided by event) Or _____ Floor space

Please indicate your preference for judging time (1 most preferable, 4 least). Note: This is NOT set-up time, this is when you will need to be present at your machine. Set up times are noted within the schedule.

_____ 12-1:30 pm.

_____ 1-2:30 p.m.

_____ 2-3:30 p.m.

_____ 3-4:30 p.m.

MC-03287