ENGINEERING
MACHINE DESIGN CONTEST

2024 Engineering Machine Design Contest

# Official Handbook

ADVANCING TECHNOLOGY BY REVERSE ENGINEERING THE BODY

HUMAN TO TECH
TRANSFER

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Revised March 28, 2024

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# 1 Overview

The Engineering Machine Design Contest is an opportunity for 5th-12th grade youth to learn about and explore science, technology, engineering, and mathematic principles while having fun in a collaborative environment. Teams of 3-12 youth work together to design and build a complex machine using everyday objects. The completed machine will use multiple steps to complete a simple task. Each year a competition theme is chosen to guide the machine build and allow for whimsical creativity to flourish.

At the competition, teams are evaluated on a Team Journal, Team Presentation, and Machine Design and Operation. Top scoring teams from the Preliminary Round advance to the Finals Round where a winner is determined. In addition to 1st, 2nd, 3rd, and so on placings, teams also compete for special awards such as best technical construction, theme award, and more.

The use of recycled items or materials in the machine is strongly encouraged. Teams should look for useful items around the house, yard, garage, and classroom; searching for materials that are already on hand and do not need to be purchased. The use of recycled items and materials will not only boost a team's score, but it also facilitates creativity and innovation and reinforces the responsible use of limited resources.

Considering the various aspects that go into designing and building a machine, a team should plan ahead and allow plenty of time for the build. Most teams will spend a several weeks of planning and building, while others may only have a couple weeks available. Regardless of the time allocated for the build, teams should always be prepared for things to not go as planned and be ready and open for a needed redesign. When building the machine, a good tip is to start with the end in mind and following the Backwards Design Process (see Section 4.6).

# 2 Contest Mission

The process of designing and building a machine should be fun and encourage teamwork through the Engineering Design Process (see Section 4.7). Through participation in the Engineering Machine Design Contest and incorporating science, technology, engineering, and mathematic principles, youth will gain hands-on experience identifying problems, making and testing solutions, evaluating results, and learning to share their experience with others. This experience may be the first of many steps youth will take in exploring themselves and their career pathway.

# 3 Contest Outline and Rules

## 3.1 Teams

1. Teams from public, private, and home schools may participate. If necessary, the team may be made by combining students across multiple schools.
2. Teams consist of 3-12 students. Each school may register any number of teams. An individual student may participate on only one team.
3. Teams will enter in either the Junior Division (5th-8th grade) or the Senior Division (9th-12th grade). Each division will be judged separately following the same process. If a single team has students spanning both grade divisions, that team must enter the Senior Division.
4. Each team may wish to seek the assistance of a mentor along with the help of a teacher or coach. This mentor could be a technical professional or post-secondary student with an engineering or science background. The mentor can provide technical leadership and assistance as needed.

## 3.2 Machine Specifications and Penalties

**Required Specifications**

| | | |
|---|---|---|
| 1. | Machine Dimensions | No more than 5’ x 5’ x 5’. |
| 2. | Number of Steps | Senior Division: 15 – 20 Steps<br>Junior Division: 10 – 15 Steps |
| 3. | Steps Labeled | Each step must be labeled on the machine with a number and correspond with a written list of steps in Team Journal. |
| 4. | Advanced Components | Senior Division:<br>• At least 1 Chemical Reaction Step<br>• At Least 1 Electrical Step<br>• At Least 1 Fluid Power Step<br>• At Least 1 Mechanical Action Step<br><br>Junior Division: Encouraged to incorporate Advanced Components, but not required. |
| 5. | Safety | Machines must be safe for all team members and observers. Refer to Advanced Components section for additional safety guidelines. |
| 7. | Flying Objects | All objects must stay within the parameters of the machine. |
| 8. | Run Time | No more than 2 minutes. There is no minimum Run Time. |

**Disqualifications**

1. Corporate logos without written permission. If permission to use a logo is granted, a written letter of permission must be provided and be kept with the machine.
2. Safety issues as deemed by the Judging Committee.
3. Use of live animals, hazardous material (toxic, noxious, dangerous), explosives, or flames.
4. Use of profane, indecent or lewd expressions, offensive symbols, graphics, or language.
5. Any device requiring a combustion engine.
6. Unsafe machine or intentionally causing loose/flying objects to go outside set boundaries of machine.
7. Damaging another team's machine.

**Penalty Deductions**

| | |
|---|---|
| 3-Point Deductions | • Human Intervention |
| 5-Point Deductions | • Restarting the machine during a run.<br>• Machine run longer than 2 minutes.<br>• Resetting of machine for more than 4 minutes during a restart.<br>• Causing a delay in judging.<br>• Unintentionally causing a loose/flying object to go outside set boundaries of machine. |
| 10-Point Deductions | • Exceeding the machine dimensional limits.<br>• Too many or too few steps.<br>• Any number of steps not labeled on the machine.<br>• Each missing Advanced Component required (Senior Division ONLY).<br>• Exceeding the Team Journal Reflection 1-page limit.<br>• Coaching or questioning by team’s teacher, mentor, a parent or a student not on the team during judging. |
| 20-Point Deduction | • Unsportsmanlike conduct by team members or affiliates. |

## 3.3 Machine Dimensions

The maximum allowed machine size is 5 foot by 5 foot by 5 foot. Machines exceeding these dimensions will incur a 10-point penalty. Machine dimensions are measured from the floor up (even if machine is placed on a table) and will include the entire machine structure and all components. **Only** electrical cord may be outside the parameters.

It is important to note that the size of the machine DOES NOT depict the success of the machine. Smaller machines are equally successful and easier to transport. Smaller machines may also be displayed on a tabletop. Larger machines will be displayed on the floor.

## 3.4 Steps

Senior Division machines are required to have 15-20 steps and Junior Division machines are required to have 10-15 steps. Failure to have the appropriate number of steps will result in a 10-point penalty. A step is an action that results in the initiation of another action. It is important to distinguish the difference between a step and a motion. For example, a swinging pendulum hitting a lever that releases a marble is one step. The motion of the swinging pendulum on its own is not a step. Additionally, a series of the same repeating actions is considered one step, such as a row of dominoes falling.

On the completed machine, each step should be labeled with its corresponding sequential number. Failure to include any labeled steps on the machine will result in a 10-point penalty. The Team Journal is to also include a numbered list of the machine steps with a description of each step.

Any steps or components deemed obviously unsafe by the judges will need to be removed or bypassed.

## 3.5 Advanced Components

Senior Division teams are required to incorporate at least four Advanced Components into the design of their machine; at minimum, one of each of the Advanced Components described below. Failure to incorporate all four Advanced Components will result in a 10-point penalty for each missing component. Junior Division teams are encouraged to incorporate at least two Advanced Components. For information or ideas of how to incorporate these components, visit engineering.mnsu.edu/engineering-machine-design-contest/. The Judging Committee will have final say on the safety of all components. Do not hesitate to contact the contest coordinator with any questions regarding the integration of the Advanced Components or use of certain materials or substances.

### 3.5.1 Chemical Reaction Components

A chemical reaction is defined as two or more molecules reacting to create a new compound or change in molecular structure. For a chemical reaction to occur, a chemical change must occur (i.e. start with one molecule and turn it into another). This is achieved by either making or breaking chemical bonds. An example of this is the rusting of steel or bleach removing a stain. It is important to note that a chemical reaction is not the same as a physical change. An example of a physical change is melting an ice cube into a liquid.

Protective eyewear and gloves are required for team members to handling chemicals. Teams not following safe handling and safety procedures will be immediately disqualified. Chemical reaction(s) should not splash outside of the dimensions of the machine. Bystanders and judges must be able to view your machine without having to wear protective eyewear.

The chemical reaction should be simple and safe. Examples of acceptable chemicals to be used in reactions include:

- Baking soda,
- Vinegar,
- Cornstarch,
- Dry Ice (with appropriate safety measures),
- Borax, OTC Hydrogen Peroxide,
- Sugar,
- Flour, etc.

Examples of **restricted** chemicals or reactions include:

- Open flames or any fire,
- Explosions,
- Excessive heat,
- Bunsen burners,
- Chemicals or compounds created by reactions that cannot be put in the trash or poured down the drain, etc.

### 3.5.2 Electrical Components

An electrical component is one that is powered by the flow of electrical charges. Charges can flow through switches, circuits, pulleys, or other devices to control the electricity.

**Junior Division** | All electrical components must be powered from a source contained within the machine, such as a battery.

**Senior Division** | Electrical components may be powered from a source contained within the machine, such as a battery, or via a wall outlet. If using a wall outlet, the machine must have a ground-fault circuit interrupter (GFCI) between the machine and the source wall outlet (if the source wall outlet is not a GFCI outlet).

All electrical components must be used as intended by the manufacturer. Electrical components that are broken, repaired, or used in a way not intended by the manufacturer will not be permitted.

### 3.5.3 Mechanical Components

A mechanical component or a "simple machine" is one that transfers energy from one source to another physically. It is the simplest form of using one thing to accomplish something faster or easier.

Examples of mechanical components include:

- Lever,
- Wedge,
- Pulley,
- Wheel and axle,
- Screw, and
- Inclined plane.

Each of these mechanisms transfers energy using different sources of energy with varying amounts of efficiency. Mechanical devices are the most commonly used in machines steps.

### 3.5.4 Fluid Power Components

A fluid power component is one that uses fluids to move something in order to complete a task. Fluid power consists of hydraulic and pneumatic technologies which use a fluid (liquid or gas) to transmit power from one location to another. Fluid power should not be confused with hydropower which uses power derived from moving water.

Hydraulics are a perfect example of a fluid powered component. When one cylinder is compressed it moves the fluid into another cylinder causing it to move (for every action there is an equal and opposite reaction). Hydraulics are used in everyday devices such as the brakes on a car, gas pumps, and carnival rides. They are extremely efficient in transferring energy in a linear motion in a confined space.

The use of syringes connected with tubing is the most popular tactic for creating a simple fluid powered component. With a little creativity, by using different sized syringes or connecting multiple syringes together, teams can create unique systems. For example, cylinders (syringes) can be secured to the machine; one of the cylinders would serve as the pump, the other attached cylinder would serve as the actuator that causes the next step.

The fluid power component must be activated by a step in the machine design, such as a weight that is triggered or released applies pressure to an extended cylinder plunger which results in the movement of the actuator plunger on a second cylinder. At no time during the run of the machine can the cylinder pump or the actuator be triggered or manually operated by a team member. This would be considered a Human Intervention and result in a penalty.

## 3.6 Recycled Materials

Teams are encouraged to use recycled materials to build their machines. Recycled materials are items that have been previously used for other purposes. Comparatively, new materials are items that are purchased or donated in new condition. When determining the cost of new materials, the actual cost of purchased items should be used and the fair market value of donated new materials should be used. For example, if a new sheet of plywood was donated to the team, the price of a comparable sheet of plywood at Menards or Home Depot should be used. When determining the cost of purchased used materials, the actual purchase price should be used. To assess the percent of recycled materials used to build a machine, look at the machine in its entirety and make the best reasonable assessment.

## 3.7 Contest Theme and Machine Story

Machines must incorporate the contest theme. It is up to the team to interpret and determine how best to incorporate the contest theme. It is also recommended that teams create a story around their machine that provides context, helping to explain the overall purpose or justification of the machine. The story can be imaginative, but should also relate to the real world. Teams are encouraged to gain inspiration from the National Academy of Engineering's Grand Challenges for Engineering (www.engineeringchallenges.org/challenges.aspx).

The machine story should be communicated through the machine design, Team Presentation, and Team Journal. Teams are allowed to use costumes, music, and decorations. However, these must not disrupt the competition and decorations are not allowed outside the parameters of the machine.

## 3.8 Team Journal

Each team is required to keep a journal that captures the ***iterative*** design process and development of their machine. Teams should articulate in their journal how they have used the Engineering Design Process to identify a problem and design a solution to address it. In doing so, teams should document the things they tried that did not work and why aspects of the machine may have changed over time. All of this is part of the Engineering Design Process.

There is no predetermined journal format, however, the final journal should be able to be submitted digitally as a PDF. Journals will be submitted prior to the competition at the direction of the contest organizer.

The Team Journal must contain and clearly identify the following information. It should be well organized so judges can easily find and review all components.

- **Planned Machine Design Sketch and Description** | Sketch of planned machine with clearly articulated description of planned machine including labeled components with technical details (i.e. anticipated transfers of energy, directions of force, materials, etc.). This is the team's original plan, prior to building.
- **Final (or Near Final) Machine Design Drawing/Image and Description** | Drawing or image of final machine with clearly articulated description of machine and labeled components with technical details (i.e. observed transfers of energy, directions of force, pertinent material specs, electrical details, etc.).
- **List of Machine Steps** | Clearly describe and number machine steps. Advanced Component steps clearly identified.
- **Cost of Machine and Percent of Recycled Materials Used** | Complete itemization and calculations of machine cost and percent of recycled materials provided.
- **Applied STEM Processes** | Documentation (i.e. sketches, images, etc.) of four or more applied STEM processes with clear details provided (i.e. labels on sketched/images, arrows indicating direction of motion/force, written explanations, etc.). For Senior Division teams, this section should include the Advanced Components.
- **Reflection** (1-page maximum length, 11 point minimum font)| Reflection highlighting learning or growth (i.e. hard or soft skills, knowledge, etc.) from start to end of build and connection to future application (i.e. future classes, projects, career, life). Three or more major successes/challenges identified with clear details. Reflections more than 1-page will result in a 10-point penalty.
- **Bibliography** | Four or more credible references listed with clear relevance to technical aspects of project.

Refer to the Team Journal Score Sheet found later in this document for scoring details.

## 3.9 Team Presentation

During the contest, teams will give a Team Presentation to the judges prior to their first machine run in both the Preliminary and Finals Rounds. The presentation must be less than five minutes and should cover the following:

1. Introduction of Team Members and Machine
2. Machine Storyline and Theme
3. Use of Engineering Design Process
4. Integration of STEM Processes (Jr. Div.) / Advanced Components (Chemical Reaction, Electrical Step, Fluid Power, and Mechanical Action) (Sr. Div.)
5. Explanation of Machine Steps (Including relevant and age appropriate scientific and engineering principles related to how steps operate.)
6. Challenge(s) Faced

Presentations over five minutes will incur a 5-point penalty for being five to six minutes and a 10-point penalty for going over six minutes. At the six minute mark the presenters will be asked to stop.

Following the presentation, judges will ask the team a series of questions related to their presentation and machine design. The asking and answering of questions are not included in the five minute time limit. Refer to the Team Presentation Score Sheet found later in this document for scoring details.

## 3.10 Judged Rounds

A contest may consist of one round of judging or two rounds (a Preliminary Round and a Finals Round). The number of rounds is determined by the contest organizer.

If there will be two rounds of judging, teams will compete in the Preliminary Round first and may be randomly split into clusters for this round of judging. The number of clusters and number of teams per cluster will be determined by the number of teams registered. Team order will also be determined by random draw. Each cluster may be judged by a separate group of judges. The final score for each team will be based on the combined total of the scores from the Team Journal, Team Presentation, and Machine Design and Operation. Prior to the start of the Preliminary Round, judges will inspect the machines to deem them safe and assess potential rule infractions.

The top-scoring team from each Preliminary Round cluster will advance to the second round of judging, the Finals Round, with any remaining Finals Round slots being filled by the highest scoring teams that remain. The total number of advancing teams will be determined by the number of registered teams. The Finals Round will proceed in the same manner as the Preliminary Round, however, with the same group of judges scoring all teams. Preliminary Round scores will not be taken into account during the Finals Round except for Team Journal scores which will carry forward to the Finals Round. Scores will be based on the combined total of the scores from the Team Journal, Team Presentation, and Machine Design and Operation.

## 3.11 Machine Runs

During each round, the Machine Design and Operation Score will be determined by having each machine run twice. There are two ways for how machine runs happen. The contest organizer will determine how their contest runs.

A single run should be no more than two minutes. After a machine finishes a run, a designated team member must announce to the judges that the run is complete. This is when the timer will stop the recorded run time. Machine runs over two minutes will incur a 5-point penalty.

**Machine Run Type 1:** Run One will take place immediately following the Team Presentation. After judging the Team Presentation and Run One, the judging group will move on to the next team in the cluster, leaving the previous team to reset their machine for Run Two. Between each run of the machine, teams will have at least four minutes to prepare their machines for Run Two. After the minimum four minute period the judges may return at any time. Any delay in judging due to a team continuing to work on their machine will result in a 5-point penalty.

**Machine Run Type 2:** Run One will take place immediately following the Team Presentation. After judging the Team Presentation and Run One, the judging group will observe the team as they reset their machine. Teams will have four minutes to prepare their machines for Run Two. The team will immediately complete Run Two. Any delay in judging due to a team continuing to work on their machine will result in a 5-point penalty.

### 3.11.1 Restart

A restart is when a team cancels the current run in progress and resets the machine to attempt the run again. During a run, the team may call for a restart if their machine is stalled and not performing as expected. Only one restart per round is permitted. A restart will result in a 5-point penalty. To initiate a restart, a designated member of the team must announce intent to conduct a restart, which must occur prior to completion of the final machine step. A restart can only be called while the machine is stalled. During a restart, the team will have four minutes to reset their machine. During this time, the judges will be on standby observing the reset. If the team fails to fully reset their machine in the allowed four minutes, an additional 5-point penalty will be assessed.

### 3.11.2 Human Intervention

A Human Intervention is any assistance or interference to the operation of the machine while a run is in progress. Once the machine is in motion, any Human Intervention will result in a 3-point penalty. Any number of Human Interventions during a single machine step will only count as one Human Intervention. If a restart is called after interventions have occurred, the interventions will not count. Any interventions after the restart will be assessed accordingly.

## 3.12 Judging

The Judging Committee will be responsible for determining and have final say in all scores given to a team. The Judging Committee will be made up of engineering and educational professionals, including but not limited to university faculty, engineering post-secondary students, career and technical education teachers, and industry members. The Judging Committee will be evenly split into Judging Groups and assigned to specific clusters of teams in the Preliminary Round. Each Judging Group will include a Lead Judge, Technical Judge, and Design Judge.

- The Lead Judge is responsible for keeping the Judging Group organized, moving in a timely manner, addressing questions other judges in the group may have, and facilitating any needed discussion.
- The Technical Judge is responsible for completing Score Sheet 3: Machine Specifications and Run Penalties while the other judges score teams on Score Sheet 4: Machine Design and Operation.
- The Design Judge is responsible for measuring the team's machine and reporting those measurements to the Technical Judge.

The decisions of the Judging Committee are final.

## 3.13 Scoring Summary

| | Score | Points |
|---|---|---|
| 1. | Team Journal | 50 |
| 2. | Team Presentation | 50 |
| 3. | Machine Design and Operation | 150 |
| | **Total Points Possible:** | 250 |

Scores resulting in a tie will be broken by the total Machine Design and Operation score, followed by Team Presentation score and Team Journal score. Refer to the Score Sheets in section four for specific scoring details.

## 3.14 Awards

Generally, the top three scoring teams will receive an award. Depending on the number of teams registered, additional placement awards may be given. All competing teams will be eligible for special awards. Each contest organizer determines the special awards for their event and how they will be awarded. Example special awards include:

- **Best Technical Construction** | for a machine with the best overall construction, fit, and finish. (Team Ballot)
- **College & Career Ready Award** | for being the team that exemplified skills in applied knowledge, effective relationships, and workplace skills.

- **Most Creative Use of Materials** | for being the team that used unusual objects to build their machine or used an everyday object in a new fun way.
- **Most Innovative Step** | for being the team with the most creative or ingenious step/transfer of energy.
- **People's Choice** | for being the fan favorite.
- **Persistence Award** | for being the team that displayed grit and persistence.
- **Above & Beyond** | for being the team whose determination was commendable.
- **Theme Award** | for being the team that best identifies and communicates the competition theme.

## 3.15 Arrival, Set Up, and Departure Logistics

Teams are responsible for their machine transportation and set up. It is recommended that machines arrive to the contest fully intact and require minimal assembly. For this reason, many teams create a sturdy base structure out of plywood and two-by-fours to build their machines on. It is important to note that this structure is included when measuring the machine dimensions.

Machine set up must be completed during the time allocated by the contest planning committee. Teams will have limited time to set up their machine. No new construction is permitted at the contest site. Teams must bring their own tools and equipment as none will be provided. It is advisable for teams to bring an emergency tool kit in case of unforeseen issues that may result from machine transportation. Set up time is for assembling the pre-constructed machine parts and any repairs due to transport. Each team will be provided at least an 8'x8'x8' area to set up and a table to set the machine on (if machine size permits). Teams are encouraged to store all items not in use under the table to prevent tripping hazards.

Following good sportsmanship practices, teams are strongly encouraged to stay for the entire competition and awards program. Removal of machines prior to the end of the competition is highly discouraged. Immediately following the completion of the contest, teams are responsible for cleaning their designated area.

## 3.16 Tips for Novice Teams

1. Read the handbook carefully and review the score sheets, machine specifications, and penalties.
2. For inspiration or ideas of what a machine might look visit https://engineering.mnsu.edu/engineering-machine-design-contest/example-machines.
3. Communicate clearly to the judges through the Team Journal and Team Presentation. It is best if information is clearly communicated so judges do not have to make assumptions or try to interpret what is meant. Judges are not experts in all areas.
4. Be creative in translating the theme to the machine. Enjoy the process and have fun as a team!
5. When designing the machine, avoid having action be hidden behind other parts of the machine. The judges are only able to evaluate what they can see.
6. Consider using more simple steps and actions as they are generally more repeatable and have less glitches. Some steps that are too complex are also more likely to cause issues in competition.

## 3.17 Handbook Updates

The following changes have been made to this handbook from the 2023 Engineering Machine Design Contest Handbook:

- **Section 3.3 Machine Dimensions.**
    - Clarification: Machine dimensions are measured from the floor up (even if machine is placed on a table) and will include the entire machine structure and all components. Only electrical cord may be outside the parameters.

- **Section 3.8 Team Journal.**
    - Changed reflection word count limit to a 1-page limit.
- **Section 4.4 Score Sheet 4: Machine Design and Operations**
    - Category 3: Innovation and Creativity changed “creative use of everyday items and materials in **new** or different ways” to “creative use of everyday items and materials in **unexpected** or different ways”.
    - Category 5: Machine Complexity changed “steps demonstrated a higher degree of difficulty and precise transfer of energy” to “steps demonstrated a higher degree of difficulty, **reliability**, and precise transfer of energy”.

# 4 Score Sheets and Supplemental Documents

## 4.1 Score Sheet 1: Team Journal

**Team:**_____ **Judge:**_____

| **Required Components** | | | **SCORE** |
|---|---|---|---|
| **1. Planned Machine Design Sketch and Description** | | | |
| *Minimal details provided. Sketch or description of planned machine not provided. 1-2 pts.* | *Sketch provided and clearly articulated planned machine description and label components. 3 pts.* | *Sketch provided, clearly articulated planned machine description and labeled components with technical details. 4-5 pts.* | ____ / 5 |
| **2. Final (or Near Final) Machine Design Drawing/Image and Description** | | | |
| *Minimal details provided. Drawing/image or description not provided. 1-2 pts.* | *Drawing/image provided and clearly articulated machine description and label components. 3 pts.* | *Drawing/image provided, clearly articulated machine description and labeled components with technical details. 4-5 pts.* | ____ / 5 |
| **3. List of Machine Steps** | | | |
| *Minimal details provided. Several steps not described or numbered. 1-2 pts.* | *Most machine steps clearly described and numbered. 3 pts.* | *All machine steps clearly described and numbered. Advanced Component steps clearly identified. 4-5 pts.* | ____ / 5 |
| **4. Cost of Machine and Percent of Recycled Materials Used** | | | |
| *Minimal details provided. Machine cost or percent of recycled material not provided. 1-2 pts.* | *Cost of machine and percent of recycled materials provided with some itemization details. 3 pts.* | *Complete itemization and calculations of machine cost and percent of recycled materials provided. 4-5 pts.* | ____ / 5 |
| **5. Applied STEM Processes** | | | |
| *Minimal details provided. Very little to no documentation of any STEM processes included. 1-4 pts.* | *Documentation of 2-3 applied STEM processes with details provided. 5-6 pts.* | *Documentation of 4 or more applied STEM processes with clear details provided. 7-10 pts.* | ____ / 10 |
| **6. *Reflection*** (More than 1 Page = 10-point Penalty) | | | |
| *Minimal details provided. Maybe 1 major success/challenge identified. Superficial reflection with no connection to learning or growth. 1-4 pts.* | *Reflection highlighting learning or growth from start to end of build. 2 major successes/challenges identified with clear details. 5-6 pts.* | *Reflection highlighting learning or growth from start to end of build and connection to future application. 3 or more major successes/challenges identified with clear details. 7-10 pts.* | ____ / 10 |
| **7. *Bibliography*** | | | |
| *1-2 references listed with minimum relevance to project or may not be credible sources. 1-2 pts.* | *3-4 credible references listed with clear relevance to project. 3 pts.* | *4 or more credible references listed with clear relevance to technical aspects of project. 4-5 pts.* | ____ / 5 |
| **Organization and Clearly Identified Required Components** | | | |
| *Little to no organization or identification of above components. Evaluator has to search to find most components. 1-2 pts.* | *Clear organization. Most above components are clearly identified and easy for evaluator to find. 3 pts.* | *Highly organized. All above components are clearly identified. It is no effort for evaluator to find and review all components. 4-5 pts.* | ____ / 5 |
| | | **TOTAL** | **____ / 50** |

## 4.2 Score Sheet 2: Team Presentation

**Team:**_____ **Presentation Time:**_____ **Judge Initials:**_____

| Required Components | | | | SCORE |
|---|---|---|---|---|
| **1. Introduction of Team Members and Machine** | | | | |
| *Little to no introduction. Several team members not introduced. 1-2 pts.* | | *Machine concept and all team members introduced. 3 pts.* | *Attention capturing introduction to machine concept and all team members. 4-5 pts.* | ____ / 5 |
| **2. Machine Storyline and Theme** | | | | |
| *Little to no explanation of machine storyline. 1-2 pts.* | | *Machine storyline explained and integration with theme is clear. 3 pts.* | *Machine storyline is well developed, explained, and clearly integrated with theme. 4-5 pts.* | ____ / 5 |
| **3. Use of Engineering Design Process** | | | | |
| *Little to no communicated understanding of Engineering Design Process or how it was utilized. 1-2 pts.* | | *Clearly communicated understanding of Engineering Design Process and how it was utilized for the build with limited examples. 3 pts.* | *Thoroughly communicated understanding of Engineering Design Process and how it was utilized for the build with detailed, relevant examples. 4-5 pts.* | ____ / 5 |
| **4. Integration of Advanced Components (Sr. Div.) / STEM Processes (Jr. Div.)** | | | | |
| *Jr. Div.* | *Little to no explanation of any STEM process used in machine. 1-2 pts.* | *Brief or incomplete explanation of a STEM process used in machine. 3 pts.* | *Clear explanation of a STEM process used in machine. 4-5 pts.* | |
| *Sr. Div.* | *Little to no explanation of Advanced Components or STEM processes involved in Advanced Components. 1-2 pts.* | *Clear explanation of primary Advanced Component and some explanation of STEM processes involved. 3 pts.* | *Clear explanation of primary Advanced Component and detailed explanation of STEM processes involved. 4-5 pts.* | ____ / 5 |
| **5. Explanation of Machine Steps (Including relevant and age appropriate scientific and engineering principles.)** | | | | |
| *Little to no explanation of machine steps including (age appropriate) scientific and engineering principles related to how the machine operates (energy transfer, physics, etc.). 1-2 pts.* | | *Clearly communicated understanding and explanation of machine steps including 2-3 (age appropriate) scientific and engineering principles related to how the machine operates (energy transfer, physics, etc.). 3 pts.* | *Clearly communicated understanding and comprehensive explanation of machine steps including 4 or more (age appropriate) scientific and engineering principles related to how the machine operates (energy transfer, physics, etc.). 4-5 pts.* | ____ / 5 |
| **6. Challenge(s) Faced** | | | | |
| *Little to no explanation of challenge(s) faced by team. 1-2 pts.* | | *Clear explanation of challenge(s) faced by team. 3 pts.* | *Clear explanation of challenge(s) faced by team and reflection or growth from it. 4-5 pts.* | ____ / 5 |
| **Teamwork** | | | | |
| *Not all members contributed to the machine or actively engaged in the presentation. 1-4 pts.* | | *All members contributed to the machine and most were actively engaged in the presentation. 5-6 pts.* | *All members contributed to the machine and were actively engaged in the presentation and supportive of members talking. 7-10 pts.* | ____ / 10 |
| **Overall Presentation and Handling of Questions** | | | | |
| *Little to no eye contact, enthusiasm, or organization, poor delivery. 1-4 pts.* | | *Some eye contact, enthusiasm, or organization, adequate delivery and confidence when answering questions. 5-6 pts.* | *Strong/appropriate eye contact, enthusiasm, or organization, exceptional delivery and confidence when answering questions. 7-10 pts.* | ____ / 10 |
| **Presentation Time Penalty** | | | | |
| *Up to 5 Minutes = No Penalty* | | *5 - Up to 6 Minutes = 5 Point Penalty* | *6 Minutes = 10 Point Penalty and Cut Off* | -____ |
| | | | **TOTAL** | ____ / 50 |

## 4.3 Score Sheet 3: Machine Specifications and Run Penalties (Technical Judge)

**Team:**_____ ☐ **Preliminary** ☐ **Finals** **Judge:**_____

| **Machine Specification Penalties** | | | | **SCORE** |
|---|---|---|---|---|
| 1. | Machine Dimensions < 5'x5'x5' | ☐ Yes | ☐ No \| -10 Points | |
| 2. | Sr. 15-20 / Jr. 10-15 Steps | ☐ Yes | ☐ No \| -10 Points | |
| 3. | Each Step Labeled | ☐ Yes | ☐ No \| -10 Points | |
| 4. | 4 Advanced Components (***Sr. Div. ONLY***) | ☐ Yes | ☐ No \| -10 Points (Per Missing Component) | |

**Machine Specification Subtotal:** _____

| **Machine Run Penalties** | | **Run 1** | **SCORE** | **Run 2** | **SCORE** |
|---|---|---|---|---|---|
| 5. | Human Intervention | ☐ -3 pts (Per Occurrence) | | ☐ -3 pts (Per Occurrence) | |
| 6. | Run Time > 2 Minutes | ☐ -5 Points | | ☐ -5 Points | |
| 7. | Machine Restart (1 Allowed per Round) | ☐ -5 Points | | ☐ -5 Points | |
| 8. | Resetting During Restart > 4 Minutes | ☐ -5 Points | | ☐ -5 Points | |
| 9. | Causing Delay in Judging | ☐ -5 Points | | ☐ -5 Points | |
| 10. | Unintentional Loose or Flying Object | ☐ -5 pts (Per Occurrence) | | ☐ -5 pts (Per Occurrence) | |
| 11. | Outside Coaching During Judging | ☐ -10 Points | | ☐ -10 Points | |
| 12. | Unsportsmanlike Conduct | ☐ -20 Points | | ☐ -20 Points | |
| | | **Run 1 Subtotal:** | | **Run 2 Subtotal:** | |

| **Disqualifications** | | |
|---|---|---|
| a. | Safety Issue(s) | ☐ DQ |
| b. | Intentional Loose or Flying Object(s) | ☐ DQ |
| c. | Corporate Logo without Permission | ☐ DQ |
| d. | Live Animals, Hazardous Material(s), Explosives, or Flames | ☐ DQ |
| e. | Profane, Indecent or Lewd Expressions, Offensive Symbols, Graphics, or Language | ☐ DQ |
| f. | Any Device Requiring a Combustion Engine | ☐ DQ |
| g. | Damaging Another Team's Machine | ☐ DQ |

**Machine Specification Penalties Subtotal:** _____

**Machine Run 1 Penalties Subtotal:** _____

**Machine Run 2 Penalties Subtotal:** _____

**Penalties TOTAL or Disqualification (DQ):** ☐

## 4.4 Score Sheet 4: Machine Design and Operation

**Team:**_____ **Judge:**_____

| | | | | SCORE |
|---|---|---|---|---|
| **1. Engineering Design** | | | | |
| ***Little to no*** *demonstrated competence in the machine design,* ***inadequate use*** *of appropriate processes and simple machines or* ***not*** *solving a problem. 1-9 pts.* | | *Demonstrated competence in the machine design, successfully solving a problem through the use of appropriate processes and simple machines. 10-15 pts.* | *Demonstrated* ***high level*** *of competence in the machine design, successfully solving a problem through the use of a* ***variety*** *of appropriate processes and simple machines. 16-20 pts.* | ____ / 20 |
| **2. Use of Building Materials** | | | | |
| ***Limited use*** *of recycled or repurposed materials and* ***lack*** *of resourcefulness and effective use of materials. 1-9 pts.* | | ***Most materials*** *are recycled or repurposed and used in a resourceful and effective way. 10-15 pts.* | ***All or nearly all*** *materials are recycled or repurposed and used in a* ***highly*** *resourceful and effective way. 16-20 pts.* | ____ / 20 |
| **3. Innovation and Creativity** | | | | |
| ***Limited to no*** *creative use of everyday items and materials in unexpected or different ways.* ***Lack*** *of innovative use of materials to construct machine. 1-9 pts.* | | ***Several*** *steps rely on creative use of everyday items and materials in unexpected or different ways.* ***Some*** *innovative use of materials to construct machine. 10-15 pts.* | ***Most*** *steps rely on creative use of everyday items and materials in unexpected or different ways.* ***Highly*** *innovative use of materials to construct machine. 16-20 pts.* | ____ / 20 |
| **4. Integration of Advanced Components (Sr. Div.) / STEM Processes (Jr. Div.)** | | | | |
| **Jr. Div.** | ***Little to no*** *demonstrated competence of STEM processes or precise integration of simple machines. 1-9 pts.* | ***Some*** *demonstrated competence of STEM processes and/or precise integration of simple machines. 10-15pts.* | ***High degree*** *of demonstrated competence of STEM processes and precise integration of simple machines. 16-20 pts.* | |
| **Sr. Div.** | ***Little to no*** *demonstrated competence of Advanced Components or precise integration with other steps. 1-9 pts.* | *Demonstrated competence of* ***some*** *Advanced Components and precise integration with other steps. 10-15pts.* | *Demonstrated competence of* ***all*** *Advanced Components and precise integration with other steps. 16-20 pts.* | ____ / 20 |
| **5. Machine Complexity** | | | | |
| *Simple transfers of energy from step to step with* ***little to no*** *degree of difficulty and reliability of machine. 1-9 pts.* | | ***Several*** *steps demonstrated a higher degree of difficulty, reliability, and precise transfer of energy. 10-15 pts.* | ***Most*** *steps demonstrated a higher degree of difficulty, reliability, and precise transfer of energy. 16-20 pts.* | ____ / 20 |
| **6. Step Sequence** | | | | |
| ***Limited*** *logical arrangement of steps and* ***poor*** *use of energy transfer. 1-9 pts.* | | ***Most*** *steps are arranged in a logical sequence with* ***good*** *use of energy transfer. 10-15 pts.* | ***All or nearly all*** *steps are arranged in a logical sequence with* ***exceptional*** *use of energy transfer. 16-20 pts.* | ____ / 20 |
| **7. Completion of Task** | | | | |
| *Machine executed the task or goal* ***poorly****. 1-7 pts.* | | *Machine executed the task or end goal* ***successfully****. 8-12 pts.* | *Machine executed the task or end goal* ***exceptionally and completely****. 13-15 pts.* | ____ / 15 |
| **8. Integration Theme** | | | | |
| *Centralized theme is* ***unclear*** *or* ***not well*** *integrated in the machine. 1-7 pts.* | | *Centralized theme is* ***clearly*** *integrated through* ***most*** *of the machine. 8-12 pts.* | *Centralized theme is* ***highly developed, cleaver and clearly*** *integrated through* ***all*** *aspects of the machine. 13-15 pts.* | ____ / 15 |
| | | | **TOTAL** | ____ / 150 |


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**Revised:** March 28, 2024

**Acknowledgements**. *Aspects of this framework were inspired by Westinghouse and Carnegie Science Center's 2017 Chain Reaction Contraption Contest Handbook and Minnesota 4-H's 2018 Engineering Design Challenge Level Two Handbook.*