MINNESOTA STATE
Engineering Center of Excellence

2019 Engineering Machine Design Contest

Official Handbook

ENGINEERING.MNSU.EDU/ENGINEERING-MACHINE-DESIGN-CONTEST/

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I. Overview

The Engineering Machine Design Contest is an opportunity for 6th-12th grade youth to learn about and explore science, technology, engineering, and mathematic principles while having fun in a collaborative environment. Teams of 3-10 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.

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*The 2019 Engineering Machine Design Contest theme is "***Help a Superhero Save the Planet!***".*

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 the *Theme Award*, *People's Choice Award*, and *Everything but the Kitchen Sink Award*.

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 few months of planning and building, while others may only have a few 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 IV).

II. Contest Mission

The process of designing and building a machine should be fun and encourage teamwork through the Engineering Design Process (see Section IV). Through participation in the Engineering Machine Design Contest, 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. By incorporating science, technology, engineering, and mathematic principles, youth will grow as professional leaders and problem solvers.

III. Contest Outline and Rules

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 3-10 students. Each school may register any number of teams. An individual student may participate on only one machine team.
3. Teams will enter in either the Junior Division (6th-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.

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 Junior Division: 10 – 15 Steps
3.	Steps Labeled	Each step number must be labeled on the machine and correspond with written list of steps in Team Journal.
4.	Advanced Components	Senior Division: • At least 1 Chemical Reaction Step • At Least 1 Electrical Step • At Least 1 Fluid Power Step • At Least 1 Mechanical Action Step 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.

Disqualification

1. Corporate Logos without written permission. If permission to use a logo is granted, 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. Use of motors or any device requiring an outlet or combustion engines.
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. • Machine run longer than 2 minutes. • Resetting of machine for more than 4 minutes during a restart. • Causing a delay in judging. • Unintentionally causing a loose/flying object to go outside set boundaries of machine.
10-Point Deductions	• Exceeding the machine dimensional limits. • Too many or too few steps. • Any number of steps not labeled on machine. • Each missing Advanced Component required (Senior Division ONLY). • 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 affiliate.

Machine Dimensions

The maximum allowed machine size is 5 foot by 5 foot by 5 foot. Machines exceeding these dimension will incur a 10-point penalty. 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 table, which is provided at the contest. Larger machines will be displayed on the floor.

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.

Advanced Components – NEW THIS YEAR!

Senior Division teams are required to incorporate at least four Advanced Component 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 team 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 material or substances.

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, at minimum, for team members to handle their chemical reaction step(s). 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 heats,
- Bunsen burners,
- Chemicals or compounds created by reactions that cannot be put in the trash or flushed down the drain, etc.

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. All electrical components must be powered from a source contained within the machine. External power cords or batteries not contained within the machine will NOT be permitted.

Examples of acceptable items for electrical components include:

- Up to four batteries (nothing larger than a 6 volt or 12 amp sealed dry cell battery),
- Light bulbs,
- Power switches,
- Wire, etc.

Examples of restricted components include:

- Wall outlets,
- Air compressor,
- More than two power strips,
- Broken, taped (repaired) or modified power cords,
- Dry cell battery larger than 6 volts, etc.

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 often the most commonly used machine components, so look to use a variety of mechanical components in your machine.

Fluid Power Components

A fluid power component is one that uses fluids to move something in order to complete a task. 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 your 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.

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.

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. This story should be communicated through the machine design and Team Presentation. 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.

Team Journal

Each team is required to keep a journal that captures the design process and development of their machine. Teams will be required to submit this journal prior to the completion. The team is encouraged to include drawings and pictures of the machine, as well as written entries documenting progress, challenges, and successes of their machine build. It is important for teams to 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.

Teams should journal throughout their entire design and build process, updating their journal regularly. A best practice would be to update the journal during or at the end of each designing or building session. There is no predetermined journal format, however, the final journal will be submitted electronically as a PDF. The Team Journal must contain and clearly identify the following information:

1. Initial Sketch and Description of Machine Design Planned
2. Progress Photos
3. Written Description and Image of Final Machine Design (or near final)
4. Written and Numbered List of Machine Steps
5. Cost of Machine and Percent of Recycled Materials Used
6. Written or Visual Documentation of Major Successes and Challenges

7. Written or Visual Documentation of the Incorporation of Advanced Components (Chemical Reaction, Electrical Step, Fluid Power, and Mechanical Action)
    a. This should include materials used for all Chemical and Electrical Components
8. Written Reflections of Entire Process – Team and/or Individual

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

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 Advanced Components (Chemical Reaction, Electrical Step, Fluid Power, and Mechanical Action)
5. Relevant Technical Details
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 is not included in the five minute time limit. Refer to the Team Presentation Score Sheet found later in this document for scoring details.

Preliminary Round

The contest will consist of a Preliminary Round and a Finals Round. All teams will compete in the Preliminary Round and will be randomly split into several clusters for Preliminary Round 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 determine by random draw. Each cluster will 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.

Finals Round

The top-scoring team from each Preliminary Round cluster will advance to the Finals Round with any remaining Finals Round slots being filled by the highest scoring teams that remain. At least six teams will advance to the finals. 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. Scores will be based on the combined total of the scores from the Team Journal, Team Presentation, and Machine Design and Operation.

Machine Runs

During each round, the Machine Design and Operation Score will be determined by having each machine run twice. 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 ten minutes to prepare

their machines for Run Two. After the minimum ten 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.

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.

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.

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.

Judging

The Judging Committee will be responsible for determining and have final say in all scores given to a team. The Judging Committee will consist of University Faculty, Engineering Post-Secondary Students, and Industry Members, whom will be evenly split into judging groups and assigned to specific clusters of teams in the Preliminary Round. The decisions of the Judging Committee are final.

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 determined by the total Machine Design and Operation score, followed by Team Presentation score and Team Journal score. Refer to the Score Sheets in section IV for specific scoring details.

Awards

At minimum, the top three scoring teams from the Finals Round will receive an award. Depending on the number of teams registered, additional placement awards may be given. All competing teams will be eligible for the following Special Awards:

- **Die Hard** - A design and machine that is durable, built to last, and dependable. Awarded by the Judging Committee.
- **Theme Award** - A design and machine that best identifies and communicates the competition theme. Awarded by the Judging Committee.
- **People's Choice Award** - Awarded by a team ballot process.

- **Curb Appeal** - The best curb appeal and you just want to see it operate. Awarded by a team ballot process.
- **Everything but the Kitchen Sink** - The machine that includes extensive use of household items. Awarded by a team ballot process.
- **Wonderfully Wacky** - The machine that has a humorous/entertaining appeal. Awarded by a team ballot process.

See Team Ballot in section IV.

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 setup 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 competition is highly discouraged. Immediately following completion of the contest, teams are responsible for cleaning their designated area.

Tips for Novice Teams

1. Read the handbook carefully and review the score sheets, machine specification, and penalties.
2. For inspiration or ideas of what a machine might look like try searching in a web browser for "rube goldberg machine" or "chain reaction machine".
3. Communicate clearly to the judges through the Team Journal and Team Presentation. It is best if information is clearly communities so judges do not have to make assumptions or try to interpret what is meant. Judges are not experts in all areas, so it is best to provide excess detail than not enough.
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.

IV. Score Sheets and Supplemental Documents

Score Sheet 1: Team Journal

Team:_____ **Judge:**_____

Required Components			Score and Comments
1. Initial Sketch and Description of Machine Design Planned			
Minimal details provided. Machine steps or storyline not provided. 1-2 pts.	*Most machine steps identified and storyline clearly articulated through sketch and description. 3 pts.*	*All machine steps identified with design details and storyline clearly articulated through sketch and description. 4-5 pts.*	____ / 5
2. Progress Photos			
Only 1 or 2 progress photos. 1-2 pts.	*3 or 4 progress photos, documenting most major aspects of the build. 3 pts.*	*5 or more progress photos, documenting all major aspects of the build. 4-5 pts.*	____ / 5
3. Written Description and Image of Final (or Near Final) Machine Design			
Minimal details provided. Image or storyline not provided. 1-2 pts.	*Image provided and clearly articulated machine description and storyline. 3 pts.*	*Image provided, clearly articulated machine description and storyline with technical details. 4-5 pts.*	____ / 5
4. Written and Numbered 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
5. 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
6. Written or Visual Documentation of Major Successes and Challenges			
Minimal details provided. Only 1 major success/challenge included. 1-2 pts.	*2 major successes/challenges included with clear details. 3 pts.*	*3 or more successes/challenges included with clear details. 4-5 pts.*	____ / 5
7. Written or Visual Documentation of the Incorporation of Advanced Components			
Minimal details provided. Documentation of only 1 Advanced Component included. 1-2 pts.	*Documentation of most Advanced Components with details provided. 3 pts.*	*Documentation of all Advanced Components with clear details provided. 4-5 pts.*	____ / 5
8. Written Reflection(s) of Entire Process (Team and/or Individual)			
Minimal details provided. Superficial reflection(s) with no connection to personal or team learning. 1-4 pts.	*Reflection(s) highlighting personal or team learning from start to end of build. 5-6 pts.*	*Reflection(s) highlighting personal or team learning from start to end of build and connection to future career or pursuits. 7-10 pts.*	____ / 10
Organization and Clearly Identified Required Components			
Little to no organization or identification of above 8 components. Evaluator has to search to find most components. 1-2 pts.	*Clear organization. Most above 8 components are clearly identified and easy for evaluator to find. 3 pts.*	*Highly organized. All above 8 components are clearly identified. It is no effort for evaluator to find all components. 4-5 pts.*	____ / 5
			Total Score: _____ / 50

Score Sheet 2: Team Presentation

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

Required Components			**Score and Comments**
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			
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. Relevant Technical Details			
Little to no explanation of technical details related to how the machine or aspects of the machine operates (energy transfer, physics, etc.). 1-2 pts.	*Clearly communicated understanding and explanation of primary technical details related to how aspects of the machine operates (energy transfer, physics, etc.). 3 pts.*	*Clearly communicated understanding and comprehensive explanation of primary technical details 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 were 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 Score: _____ / 50

Score Sheet 3: Machine Specifications and Run Penalties – Lead 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.	Four (4) Advanced Components (*Sr. ONLY*)	☐ Yes	☐ No | -10 Points (Per Missing Component)	

Machine Specification Subtotal: _____

5.	**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. Motor or Other Device Requiring Outlet or Combustion Engine	☐ DQ
	g. Damaging Another Team's Machine	☐ DQ

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

Run 1 Subtotal: _____ **Run 2 Subtotal:** _____

Machine Specification Penalties Subtotal: _____

Machine Run 1 Penalties Subtotal: _____

Machine Run 2 Penalties Subtotal: _____

Penalties TOTAL: ☐

DISQUALIFICATION: ☐ YES ☐ NO

Score Sheet 4: Machine Design and Operation

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

			Score and Comments
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
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
Innovation and Creativity			
Limited to no *creative use of everyday items and materials in new 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 new 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 new or different ways.* ***Highly*** *innovative use of materials to construct machine. 16-20 pts.*	____ / 20
Integration of Advanced Components			
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
Machine Complexity			
Simple transfers of energy from step to step with ***little to no*** *degree of difficulty. 1-9 pts.*	***Several*** *steps demonstrated a higher degree of difficulty and precise transfer of energy. 10-15 pts.*	***Most*** *steps demonstrated a higher degree of difficulty and precise transfer of energy. 16-20 pts.*	____ / 20
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
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
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 Score: _____ / 150

Score Sheet 5: Score Summary

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

Team Journal, Team Presentation, and Machine Design and Operation Score Averages

	Journal	Presentation	Machine Design and Operation
Judge 1	_____	_____	_____
Judge 2	_____	_____	_____
Judge 3	_____	_____	_____
Judge 4	_____	_____	_____
Judge 5	_____	_____	_____
SUBTOTAL:			
AVERAGE:			

Final Score

Team Journal Average:	+ _____
Team Presentation Average:	+ _____
Machine Design and Operation Average:	+ _____
SUBTOTAL:	
Machine Specifications and Run Penalties Subtotal:	- _____
TOTAL:	
DISQUALIFICATION:	☐ YES ☐ NO

Final Placing

Special Awards

- ☐ Die Hard
- ☐ Theme Award
- ☐ People's Choice Award
- ☐ Curb Appeal
- ☐ Everything but the Kitchen Sink
- ☐ Wonderfully Wacky

Special Awards Ballot

Each team will receive one (1) ballot. Please circle only **one team per award** and **do not select the same team** for multiple awards.

"**People's Choice Award**"

Team: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

"**Curb Appeal**" (A design and machine that has the most curb appeal and you just want to see it operate.)

Team: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

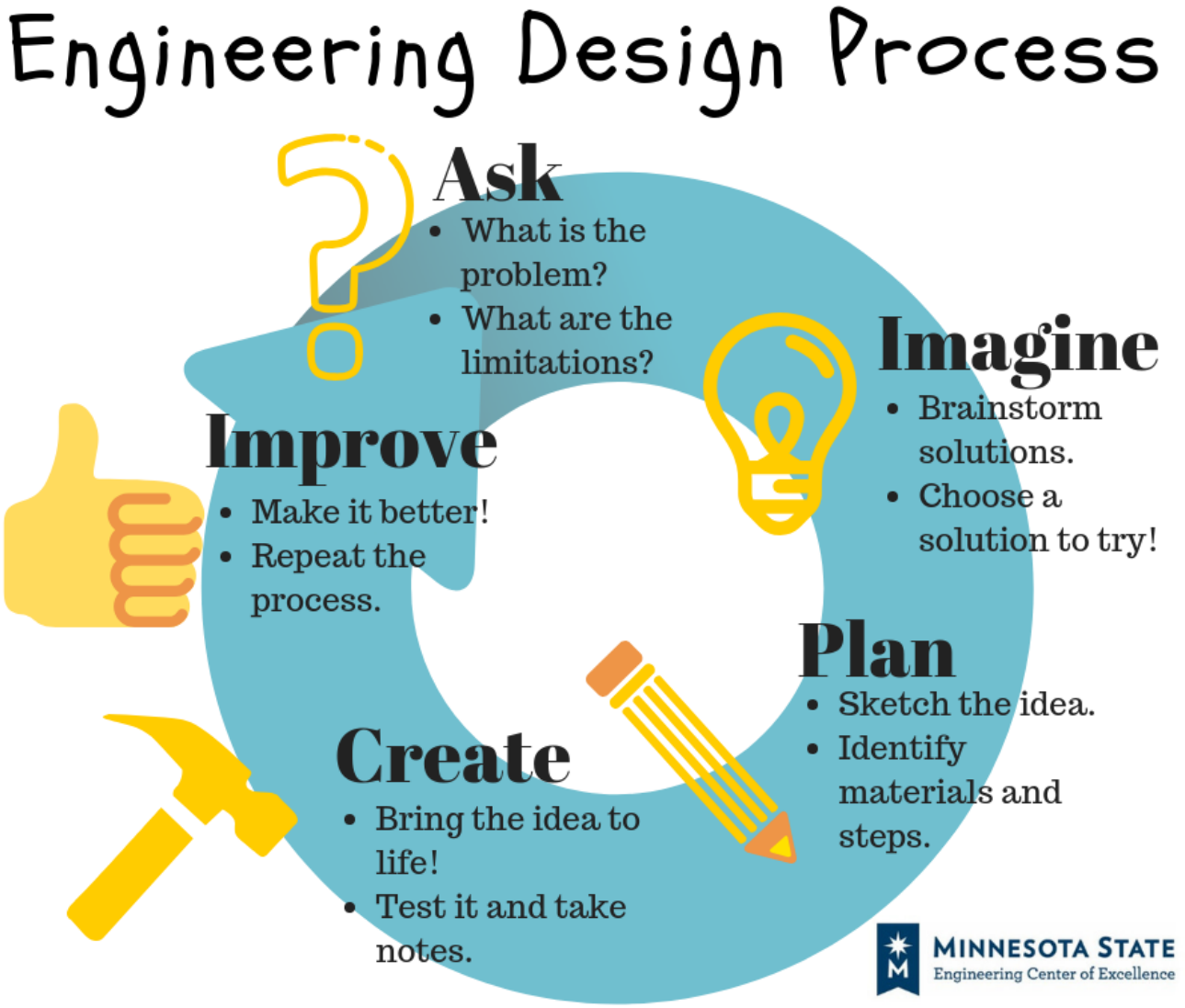
"**Everything but the Kitchen Sink**" (A design and machine that includes extensive use of household items.)

Team: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

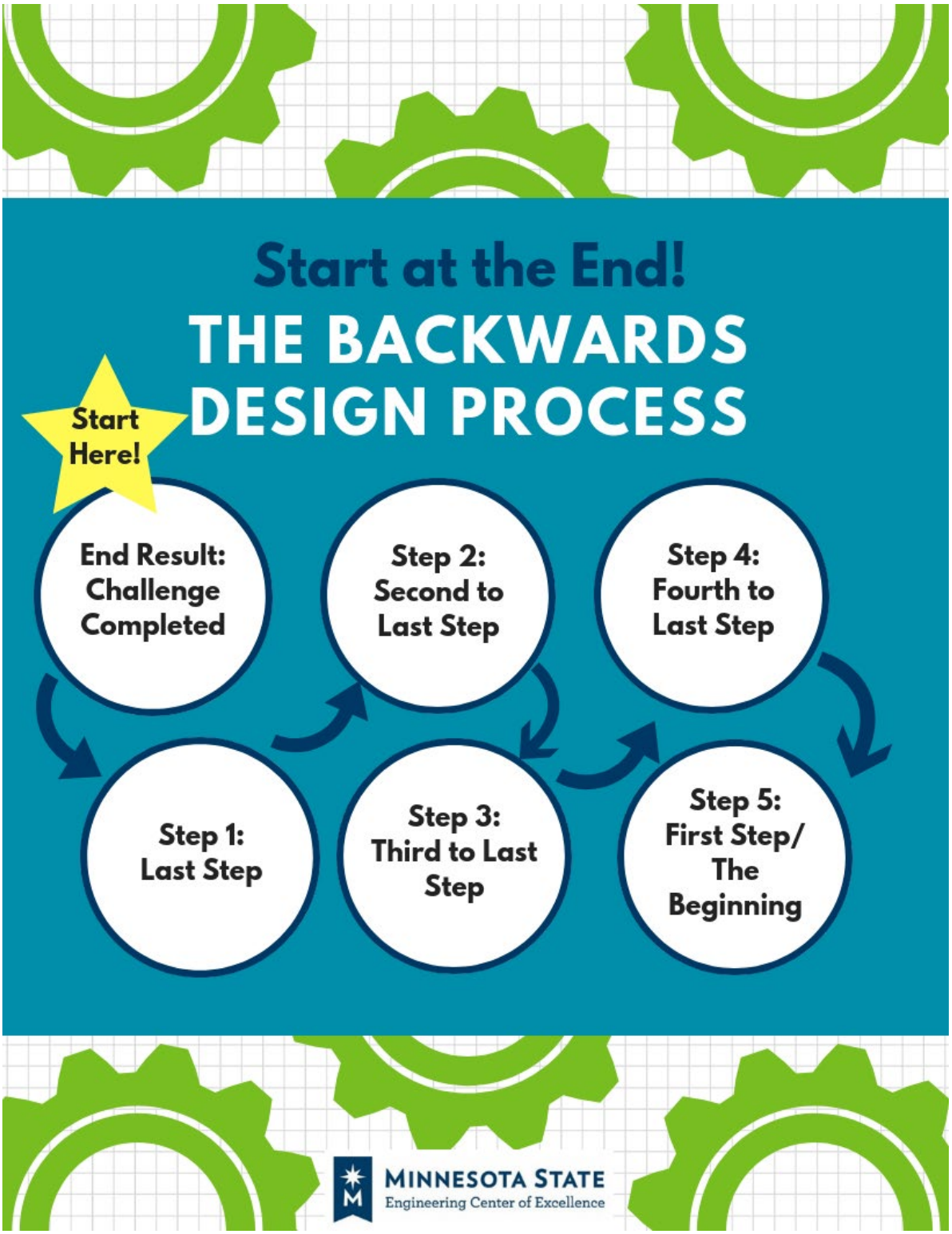
"**Wonderful Wacky**" (A design and machine that has a humorous/entertaining appeal.)

Team: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Please return to registration table by 11:00 A.M. Thank you!


Engineering Design Process
Ask
What is the problem?
What are the limitations?
Imagine
Brainstorm solutions.
Choose a solution to try!
Plan
Sketch the idea.
Identify materials and steps.
Create
Bring the idea to life!
Test it and take notes.
Improve
Make it better!
Repeat the process.
MINNESOTA STATE
Engineering Center of Excellence

Backward Design Process



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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.*