Judge Training

Contest Overview

The Engineering Machine Design Contest is an opportunity for students to design and build a complex machine using everyday objects with the guidance of a coach. The completed machine will use multiple steps to complete a simple task. Teams compete in a regional contest with the opportunity to advance to the Engineering Machine Design Championship.

Program Objectives

There are three simple and clear objectives that guide the development and growth of this program.

1. Provide a low-cost or affordable experience for students.
2. Inspire an interest in engineering and related career pathways.
3. Equip students with skills that will help prepare them for future careers.

Contest Theme

Each year a competition theme is chosen to guide the machine build and allow for whimsical creativity to flourish. Students are able to explore science, technology, engineering, and mathematics (STEM) principles while having fun in a collaborative environment. The theme for 2023 is Transforming Space Technology Into Orbit.

Creating awareness and connection to real-world challenges is an important aspect of the Engineering Machine Design Contest. Each year's theme is chosen in consideration with current topics and aligned to the National Academy of Engineering Grand Engineering Challenges.

Although teams are not required to design a machine related directly to any of the grand challenges, they are encouraged to use the Engineering Grand Challenge as an inspiration point and connection to real-world problems.

Teams and Machines

Example Machines and Team Presentations

Teams compete in either the Senior (9th-12th) or Junior (5th-8th) Division. There can be three to twelve students on a team.

Below are two examples of Senior Division machines.

Machine Example #1

Visit this link to watch the video: https://youtu.be/AAwuZM2MBJQ

Machine Example #2

Visit this link to watch the video: https://youtu.be/RvYETxLQgvk

Judging Roles

During the contest, judges work in Judging Groups to evaluate the teams and their machines. Each judging group consists of a **Lead Judge**, a **Technical Judge**, and one or more **General Judges**.

The following judge descriptions are guidelines. Each Regional Contest may define their judge roles differently.

Lead 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. In some instances, the Lead Judge may also take on the role of the Technical Judge.

Technical Judge

The Technical Judge is responsible for evaluating Machine Specifications and Run Penalties and while the other judges score teams on Machine Design and Operation. In most situations, the Technical Judge will NOT score Team Journals or Team Presentations. Their primary responsibility is to focus on ensuring machines meet specifications as outlined in the handbook and assess penalties that occur during machine runs.

General Judge

A General Judge is responsible for judging the Team Journals, Team Presentations, and Machine Design and Operation.

Judging Criteria

Teams are judged on three primary components:

1. Team Journal
2. Team Presentation
3. Machine Design & Operation

Contest Handbook

The Official Handbook for the Engineering Machine Design Contest can be downloaded below or viewed on the website. The next section of this training will cover the contest score sheets and pertinent rules.

View Handbook

Team Journal

Each team captures their design process and development of their machine in a Team Journal. Judges will evaluate the Team Journal prior to contest day or the morning of the contest.

The Team Journal should 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 (including materials used for all Chemical and Electrical Components)
8. Written Reflections of Entire Process – Team and/or Individual
9. Document Word Count (2,500 Word Max.)
10. Bibliography (Not included in word count)

Examples

Below are examples of Team Journals from a Junior Division team and a Senior Division team. (Note – these examples are from before the 2,500-word count maximum requirement was added.)

Team Journal Example #1 | Senior Division

New Berlin High School – Example Team Journal – 2023

Year: 2022

Team 1 | Eleva-Strum Engineers

E-S-Engineering-Journal

Team 2 | 6 Pheonixes

Engineering-Journal-6-Phoenixes

Team Journal Example #2 | Junior Division

Team 1 | Blessed Maria Saints

Journal_Jr_Blessed-Maria-Saints

Team 2 | Milk Science

Journal_Junior-Division_Milk-Science

Team Presentation

During the contest, teams will give a Team Presentation to the judges prior to their machine run. 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) (Sr. Div.) / STEM Processes (Jr. Div.)
5. Relevant Technical Details
6. Challenge(s) Faced

Machine Design and Operation

Machine Size

The maximum allowed machine size is 5 foot by 5 foot by 5 foot. It is important to note that the size of the machine DOES NOT depict success of the machine. Smaller machines are equally successful as larger machines.

Steps

Senior Division machines are required to have 15-20 steps and Junior Division machines are required to have 10-15 steps.

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. The Team Journal will also include a numbered list of the machine steps with a description of each step.

Below is an example of how machine steps might be labeled.

Recycled Material

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.

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.

Advanced Components

Senior Division teams are required to incorporate each of the four Advanced Components into the design of their machine. Junior Division teams are NOT required to incorporate Advanced Components but are encouraged to incorporate at least two Advanced Components. Junior teams should not be penalized for not incorporating any Advanced Components.

The Advanced Components are:

1. CHEMICAL REACTION | 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.

   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.

Chemical reactions should be safe and simple. The most common reactions use baking soda, vinegar, cornstarch, borax, hydrogen peroxide, sugar, flour, or other common substances.

2. ELECTRICAL | 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 are not permitted.
3. MECHANICAL | 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.
4. FLUID POWER | A fluid power component is one that uses fluids to move something in order to complete a task.
   Hydraulics is 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.
5. Fluid power should not be confused with hydropower which uses power derived from moving water.

Judge's Questions

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.) Judges should consider asking questions that will help them appropriately score the team such as:

1. What was the most difficult thing about working in a team?
2. How did you decide on your machine theme?
3. Can you tell us more about how you utilized the Engineering Design Process?
4. Can you elaborate on some of the scientific principles you used in your machine?

Judges should refrain from asking questions not related to the scoring of the team, such as questions about their age/grade, year participating in the program, and so on.

Examples

Below are examples of Team Presentations from two Junior Division teams.

2022 Example Machines

Chatfield High School, 2022 |Around the World in 20 Steps

2021 Example Machines

[Chatfield High School, 2021 |Trains, Planes, and Incline Planes]

[Southland High School, 2021 |Mort's New York Tour]

Scoring System

Score Sheet Overview

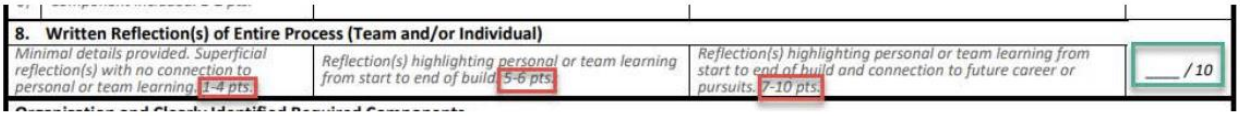
There are three general score sheets and one technical score sheet. The **Lead Judge** and **General Judges** will need to be familiar with the following score sheets:

1. Team Journal Score Sheet
2. Team Presentation Score Sheet
3. Machine Design and Operation Score Sheet

The **Technical Judge** will need to be familiar with the Machine Specification and Run Penalties Score Sheet.

Rubric Based Score Sheets

The score sheets are set up in a rubric template to provide guidance on how to score in each specific category. In the example below, when scoring the Written Reflection(s) in the Team Journal, a judge would refer to the three score descriptions.



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

Additionally, from the example above, the total points allowed per category are shown in the green box. The total points allowed per category vary by score sheet and category.

Team Journal

Team Journal Score Sheet

Generally, the Team Journal is scored prior to the Contest Day or the morning of the contest before the Preliminary Round. The Team Journal is scored on the following nine categories with a maximum score of 50 points.

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

7. Written or Visual Documentation of the Incorporation of Advanced Components (Sr. Div.) / STEM Processes (Jr. Div.) (5 pts.)
8. Written Reflection(s) of Entire Process (Team and/or Individual) (10 pts.)
9. Organization and Clearly Identified Required Components (including Bibliography) (5 pts.)

There is a 10 point penalty for Team Journals with more than 2,500 words.

View the score sheet here

Team Presentation

Team Presentation Score Sheet

The Team Presentation is scored on the following eight categories with a maximum score of 50 points:

1. Introduction of Team Members and Machine (5 pts.)
2. Machine Storyline and Theme (5 pts.)
3. Use of Engineering Design Process (5 pts.)
4. Integration of Advanced Components (Sr. Div.) / STEM Processes (Jr. Div.) (5 pts.)
5. Relevant Technical Details (5 pts.)
6. Challenge(s) Faced (5 pts.)
7. Teamwork (10 pts.)
8. Overall Presentation and Handling of Questions (10 pts.)

Time Penalties

Up to 5 Minutes = No Penalty

More than 5 Minutes and Up to 6 Minutes = 5 Point Penalty

6 Minutes = 10 Point Penalty and Cut Off

View the scoresheet here

Machine Design and Operation

Machine Design and Operation Score Sheet

The Machine Design and Operation is scored on the following eight categories with a maximum score of 150 points:

1. Engineering Design (20 pts.)
2. Use of Building Materials (20 pts.)
3. Innovation and Creativity (20 pts.)
4. Integration of Advanced Components (Sr. Div.) / STEM Processes (Jr. Div.) (20 pts.)
5. Machine Complexity (20 pts.)
6. Step Sequence (20 pts.)
7. Completion of Task (15 pts.)
8. Integration of Theme (15 pts.)

View the score sheet here

Machine Specifications and Penalties

Machine Specifications and Penalties Score Sheet

The Machine Specifications and Run Penalties are ONLY scored by the Technical Judge. This score sheet is split into three categories:

1. Machine Specification Penalties
2. Machine Run Penalties
3. Disqualifications

View the scoresheet here

When entering penalties in the CompetitionSuite Tabulation Program (introduced in the next section), Technical Judges will enter the number of specific penalty occurrences and not the actual point deduction. The tabulation program will calculate the correct deduction based on the number of occurrences entered by the Technical Judge.