MINES FORMULA JUNIOR DESIGN EVENT

OVERVIEW

The Society of Automotive Engineers (SAE) hosts a collegiate design series that challenges universities to design a ¾ formula racing car (FSAE). To show the skill of young engineers, teams will design a system of a Formula SAE car. Teams will apply leadership and 21st century skills in conjunction with the engineering design process to develop a solution to the design challenge given and judged by the Mines Formula SAE Race team.

ELIGIBILITY

Open to High school chapters. Two (2) teams of two to four (2-4) students per chapter.

ATTIRE

TSA competition attire is required.

PREPARATION

Prompt is located at the end of this document following the rubric.

Participants develop a solution for the prompt with design consideration of the criteria from the design solution portion of the official rating form.

Participants create a Documentation Portfolio based off the criteria from the Documentation Portfolio portion of the official rating form.

The documentation portfolio must be saved as a single, multi-page PDF document with the pages presented in the following order:

Title page with the event title, the conference state, the year, and the team ID number; one (1) page
Table of contents; pages as needed
Team Introduction; one (1) page

Following are all pages as needed

Design Fundamentals and Integration
Design Process and Selection
Final Design Explanation
Manufacturability Plan
Bill of Materials & Cost
Engineering drawings (ISO)

Participants will prepare for an interview to further explain the design process and solution. Additional materials to help explain design process during the interview are suggested but not required. Some examples follow.

Cad models
PowerPoint
Posterboard
Protype
Referenced documents
Project management documents

REGULATIONS AND REQUIREMENTS

Students will work to develop their leadership and 21st century skills in the process of preparing for and participating in this Colorado TSA competitive event. The development and application of those skills must be evident in their submission, demonstration, and/or communication pertaining to the entry.

PRELIMINARY ROUND

A. No more than two (2) team members report to the event area at the time and place stated in the conference program to check in:
   a. The portfolio in PDF format on two [2] USB flash drives
   b. Any additional materials for interview
B. Entries are evaluated by the judges with neither students nor advisors present.
C. Twelve (12) semifinalists are announced via the Colorado TSA website.

SEMIFINAL ROUND

A. Semifinalists report at the time and place stated in the conference program to sign up for an interview.
B. No more than two (2) team members pick up the team's additional materials for interview from the display area at the time and place stated in the conference program.
C. All team members from each semifinalist team will report at the assigned time and place for an interview to further explain their design decisions.
D. The top three (3) finalists are announced at the awards ceremony.
E. Ties will be broken by Engineering Drawings

EVALUATION

PRELIMINARY ROUND

A. The documentation portfolio

SEMIFINAL ROUND

A. The presentation/interview

Refer to the official rating form for more information.

STEM INTEGRATION

This event aligns with the STEM (Science, Technology, Engineering, and Mathematics) educational standards.

LEADERSHIP AND 21ST CENTURY SKILLS DEVELOPMENT

This event provides opportunity for students to build and develop leadership and 21st century skills including but not limited to:

- Communication
- Collaboration/Social Skills
- Initiative
- Problem Solving/Risk Taking
- Critical Thinking
- Perseverance/Grit
- Creativity
- Relationship Building/Teamwork
- Dependability/Integrity
- Flexibility/Adaptability

CAREERS RELATED TO THIS EVENT

This competition has connections to one (1) or more of the careers below:

- Automotive Engineering
- Aerospace Engineering
- Mechanical Engineering

Participant/Team ID# _____

Mines Formula Junior Design

2023 OFFICIAL RATING FORM

HIGH SCHOOL

Judges: Using minimal (1-4 points), adequate (5-8 points), or exemplary (9-10 points) performance levels as a guideline in the rating form, record the scores earned for the event criteria in the column spaces to the right. The X1 or X2 notation in the criteria column is a multiplier factor for determining the points earned. (Example: an "adequate" score of 7 for an X1 criterion = 7 points; an "adequate" score of 7 for an X2 criterion = 14 points.) A score of zero (0) is acceptable if the minimal performance for any criterion is not met.

Go/No Go Specifications

- Before judging the entry, ensure that the items below are present; indicate presence with a check mark in the box.
- If an item is missing, leave the box next to the item blank and place a check mark in the box labeled ENTRY NOT EVALUATED.
- If a check mark is placed in the ENTRY NOT EVALUATED box, the entry is not to be judged.

PDF of the digital portfolio was submitted

ENTRY NOT EVALUATED

DOCUMENTATION PORTFOLIO (100 points)				
CRITERIA	**Minimal performance**	**Adequate performance**	**Exemplary performance**	Record scores in the column spaces below.
	1-4 points	**5-8 points**	**9-10 points**	
Professionalism (X1)	Has no or little formatting, as if word docs were printed to PDF then combined.	Has good formatting but not consistent or hard to follow.	Easy to follow and consistent with clear sections.	
Design Fundamentals (X2)	No integration of system with the car was concerned. No design fundaments stated or parts missing.	Integration to the car is considered but not in depth. Design Fundamentals of all the parts are not consistent. Design Fundamentals of system is only a restatement of prompt.	Full integration to car is considered and stated. Design Fundamentals of all the parts are consistent and overall system fundamentals is explained well.	
Design Process (X3)	No or only some of the parts of the system are covered.	All parts are covered with details on design choice justifications.	Great detail of design decisions are presented in a logical way that ties together with design fundamentals.	
Final Design (X1)	Explanation is incomplete or a restatement of design process.	All parts are included in explanation in a logical easy to follow way.	Explanation ties back to design fundamentals and Design processes.	
Manufacturability Plan (X1)	Not all parts are covered, missing detail.	Each area is covered for all parts and easy to follow.	Completely covers the whole manufacturing process without missing steps for complete system.	
Bill of Materials (X1)	Missing parts completely or costs/weights.	All parts are listed and complete.	BOM is consistent with final listed cost and weight.	

Engineering Drawings (X1)	Missing parts or drawings are not complete.	All parts have drawings but not easy to read.	All drawings are easy to read with team drawing sheet.	
			DOCUMENTATION PORTFOLIO SUBTOTAL (100 points)	0

Rules violations (a deduction of 20% of the total possible points for the above sections) must be initialized by the judge, coordinator, and manager of the event. Record the deduction in the space to the right. Indicate the rule violated: _____	
PRELIMINARY SUBTOTAL (100 points)	0

SEMIFINAL INTERVIEW (70 points)				Record scores in the column spaces below.
CRITERIA	**Minimal performance**	**Adequate performance**	**Exemplary performance**	
	1-4 points	**5-8 points**	**9-10 points**	
Organization (X1)	Not prepared, spending lots of time looking though material.	Spent time talking about what they knew.	Had prepared interview material covered in a logical way.	
Knowledge (X3)	No one can answer the questions or explain.	Explanation cannot be expanded on or not in line with other design concepts	Able to elaborate past questions asked and reference back to design concepts	
Articulation (X1)	Unclear or lots of stuttering.	Clearly explains answers.	Comfortable with answer explaining clearing with no major gaps or pauses.	
Team Participation (X2)	Only 1 team member answers questions.	Only half of the team answers questions.	Every member has answered questions.	
			SEMIFINAL INTERVIEW SUBTOTAL (70 points)	0

Rules violations (a deduction of 20% of the total possible points for the above sections) must be initialized by the judge, coordinator, and manager of the event. Record the deduction in the space to the right. Indicate the rule violated: _____	
SEMIFINAL SUBTOTAL (70 points)	0

To arrive at the TOTAL score, add any subtotals and subtract rules violation points, as necessary. TOTAL (170 points)	0

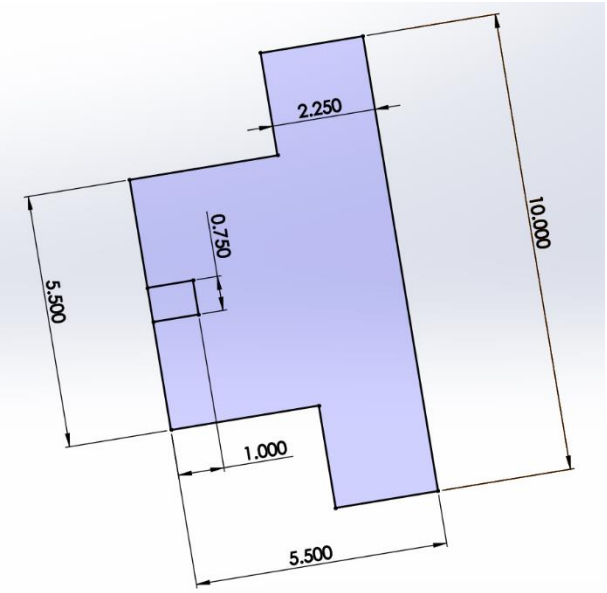
Mines Formula Junior Design Event Prompt (Steering Wheel)

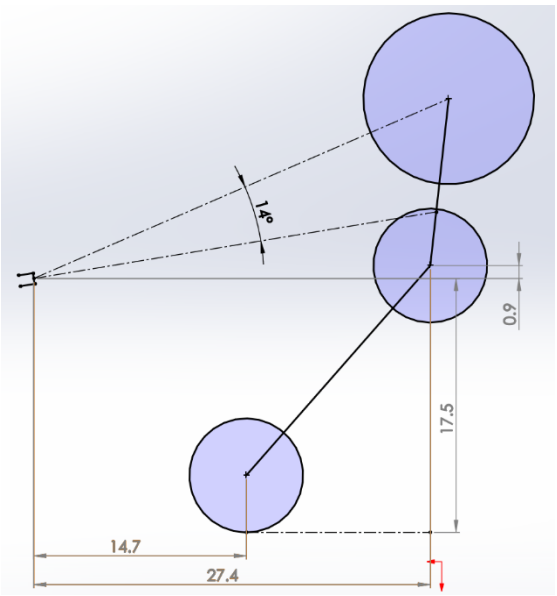
Design:

The system of the Formula SAE car that needs to be design is the steering wheel. The steering wheel system must attach to the steering column which is a 0.75-inch x 0.625-inch carbon fiber tube which delivers a force of 18Nm. Teams must comply with official SAE rules and car limitations as follows.

V.3.3 Steering Wheel

V.3.3.1 The Mechanical parts of the Steering Wheel system must exist in a volume defined by 5.5-inch diameter circle around the center of the steering column and 2 planes, one that is 5.5 inches forward of the 2nd that is 1 inch back of the front face of the steering column. Then another volume that is a 10-inch diameter circle around the center of the steering column and 2 planes, one being the same as the first plane from the first volume and the other a plane 2.25 inches back of that first plane. Side view shown below with driver position refenced from front face of steering column.





V.3.3.2 The Steering Wheel must be attached to the column with a quick disconnect.

V.3.3.3 The driver must be able to operate the quick disconnect while in the normal driving position with gloves on.

V.3.3.4 The Steering Wheel must have a continuous perimeter that is near circular or near oval.

The outer perimeter profile may have some straight sections, but no concave sections. “H”, “Figure 8”, or cutout wheels are not allowed.

The Formula SAE car also has a complete data acquisition system working over CAN bus which includes, live data steaming to the off-track support team, live engine tuning, driver communication to the off-track support team, launch control and electronic shifting. Please consider the potential integration of these systems with the driver and the potential advantages or disadvantages in a racing or testing scenario. The list of the sensors that the data acquisition systems monitors are as follows:

Suspension/ Vehicle dynamics	Powertrain/ Drivetrain
Suspension linkages forces (6 per conner) Suspension displacement roll (1 per axle) Suspension displacement heave (1 per axle) Accelerometer (1 per axle) Steering Angle Ride height (1 per conner) Wheel Speed (1 per wheel) Tire Temperature profile (1 per wheel) Tire Pressure (1 per wheel)	Current Gear Engine Speed Oil temperature (Before/After Oil Radiator) Water temperature (Before/After Water Radiator) Battery Voltage Fuel usage
Engine Data	Brakes Data
Throttle position Intake pressure Intake temperature O2 sensor data	Front Pressure Rear Pressure Disk temperature (1 per wheel)

Documentation: (Documentation Example follows)

Like the Formula SAE competition for universities, documentation is a huge part of design. To show case the understanding of your design rather than copying another design create a document of the following as you would as a part of a Formula SAE team. Please use Photos, Drawings, Diagrams do not write a wall of text like a textbook. Write it as if you were going to have to read it.

Design Fundamentals and Integration: How your team considered the other systems of the car and the basics of design.

Example: The Steering Column needs to be as light as possible while having as little compliance as possible to insure best driver feel of the car. The steering column will also be stressed between 240 degrees of rotation and connected at both ends to a steering wheel system and steering rack gear. This is a dynamic system that can be solved statically at max load using solid mechanics basics and material properties assumptions. Major design limitations are going to be integration with the other systems.

Design Process and Selection: Explain the different designs your team came up with and how.

Example: The load though the steering column is 18nm at a length of 2 feet. We found though driver testing that 0.5degs of compliance is negligible for driver feel and our target for compliance. Carbon Fiber has the highest stiffest to weight material we can work with, and a circle is the best shape for rigidity of a rotating object. Both shown in graphs and equations. Carbon Fiber cannot be welded so the options for attachment at ends are bolting and gluing. We looked at…… keep expanding on process.

Final Design Explanation: Why the final design was picked and what qualities make it the best solution.

Example: We chose a 0.75x0.625 carbon fiber tube purchased from rock west composites. We found that the strength of carbon fiber is high enough in purchased tubes to provide the rigidity needed with only an estimated 0.1 degree of compliance, which is below our target found from driver testing. Our tube size choice came from the integration between the steering wheel system and steering rack crossed with what we could

buy. Any smaller tube would not integrate well and the weight savings from creating a custom tube for optimal fiber ordination is minimal.

Manufacturability Plan: Explain how the system would be manufactured and assembled for a one-off Formula SAE car for racing. Please consider production time, skill and equipment needed.

Example: We plan to buy the tubes, cut them to length using a diamond blade hacksaw and finish them on a lathe before gluing the end to the steering rack gear. Proper air filtration will be needed for cutting of the carbon fiber with an entry level lathe operator. Basic sanding and glue can be done with an experienced carbon fiber manufacturing tech to insure proper bonding. Process should take less than 2 hour excluding glue cure time.

Bill of Materials & Cost: List every component in the system with weight, material, and estimated cost for a prototype, assume any labor time is a zero cost as your team would be producing the product in house. Example: CNC machining. Cost of running the machine is not needed, only the price of the raw material and one-off jigging is needed.

Example:

Steering Column	Carbon Fiber	0.12 Lbs	50 USD

Engineering drawings (ISO): Create readable drawings of every designed component in the system that was design. Fasteners and other purchased components are not needed in drawings.