



## 2022 NFPA Fluid Power Vehicle Challenge

# Overview, Rules and Awards

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NFPA  
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Foundation

### Important Dates and Deadlines

Registration: ASAP  
Kick-off webinar: September 29 (Recorded)  
VEST, Inc. Q&A Session (optional): October 15  
Prepare Resumes and Profiles: October 27  
Networking Mixer: November 5  
VEST, Inc. Q&A Session (optional): November 12  
Component Orders: December 1  
Dates related to the Competitions TBD in 2022

## **INTRODUCTION**

The NFPA Fluid Power Vehicle Challenge is a unique engineering design and build competition that embeds in the capstone design course at participating universities. It strives to promote original thinking in a competitive setting by combining two technology platforms that are not normally associated with one another—human-powered vehicles and fluid power.

The first, as exemplified by the bicycle, is recognized as extremely efficient in terms of input vs. output. The second presents more of a challenge in terms of efficiency, especially at low speeds. A fluid powered vehicle, then, presents undergraduate engineers with a familiar yet challenging platform for change. By combining this unlikely pair, the Vehicle Challenge hopes to create an environment that results in uncommon connections and breakthroughs, while supporting learning and the growth of fluid power industry knowledge.

The Vehicle Challenge supports the education of next generation engineers by exposing them to the design challenges associated with a fluid powered vehicle, and teaching them the value of fluid power components, circuits, and systems. In addition, the program provides these students with first-hand experience in working as an engineering team on a timeline to design, simulate, build, test, qualify, and compete with their concepts. Added benefits for the industry that supports this program through its donations to the NFPA Education and Technology Foundation include the potential development of new breakthrough technologies for motion control and the identification of high-performing students to hire into the fluid power industry.

### **Program Objectives**

1. Stimulate education in fluid power components, circuits, and systems, incorporating them into a systems engineering experience.
2. Provide students with experience in real world engineering under a strict timeline of designing, simulating, ordering, building, testing, and demonstrating their designs.
3. Stimulate innovative thinking for designing and testing potential new fluid power technologies or concepts integrated into a vehicle platform.
4. Provide an industry recruitment opportunity for high potential engineering seniors by engaging directly with practitioners in the fluid power industry.

### **Overview**

The Vehicle Challenge is based on the Chainless Challenge program, pioneered, and managed by Parker Hannifin from 2004 through 2016. The first program under the Vehicle Challenge name was held in 2017.

Teams from universities that have previously participated in the program, are required to make significant changes from designs of previous years. This experimentation has resulted in vehicle designs

that have varied from one, two, three, and four-wheels, upright and recumbent, using hydraulic and pneumatic components.

The Vehicle Challenge encourages universities to participate in the context of their senior capstone design courses, but student teams in other configurations are welcome. Either way, students are required to design and build the drive system for their vehicles, as well as participate in the Final Competition Event. They can utilize either off-the-shelf components provided by the program's official suppliers, from other suppliers and resources, or design their own.

The Vehicle Challenge will expand to two separate competition sites this year, ensuring that more students and universities can participate, and more industry representatives can connect with students. The Final Competition Events will include judging criteria for a straight sprint race, an efficiency challenge, and an endurance challenge. In addition, teams will present on their design process and decisions, and demonstrate the safe function of their vehicles.

1. Danfoss Power Solutions will host one event at their facility in Iowa in April 2021.
2. Norgren, a part of IMI plc, will host the other event at their facility in Colorado in April 2021.
3. Both site locations will have the same competition elements.
4. Specific details about traveling and attending each competition site will be provided after the Midway Reviews are complete.
5. Each team will be assigned a location based on their geographic location and their universities finals testing dates.

The Final Competition Events will be conducted over a two-day period at a location hosted by donors to the NFPA Education and Technology Foundation. Travel funds are provided by the program to offset the transportation and accommodations costs of the participants. Cash awards are given to the winning teams in several specified categories.

This document, and others, will define the requirements of the design of the human-assisted, fluid powered vehicle, provide the design review timeline, describe the Final Competition Event and rules, and special award categories.

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## PROJECT OVERVIEW

### Design Team

One team per university will be funded through the program.

1. Team members may have participated in previous year(s).

2. Six total team members, including university faculty advisor will be eligible to receive travel funds to the Final Competition Event.
3. Participants can be undergraduate and/or graduate students.

### Vehicle Requirements

**All vehicles must abide by the following technical requirements and must be approved through the Verification Review process to be cleared for safety and usability at the Final Competition Event.**

1. Vehicle propulsion must be accomplished through hydraulics with human power serving as the prime mover in the system. No internal combustion, or electric drive motor. Gears, chains, or belts are allowed in order to transfer power to the fluid power pump/compressor, but a fluid link (oil) is required between the pump and the motor.
2. It is **not** required to use pneumatics on the vehicle.
3. Use of stored energy for electronics and pneumatics will be for control purposes only and not for propulsion of the vehicle.
4. Vehicle designs must include an energy storage device.
5. Gas pre-charging systems will be available at Final Event location. The total accumulator pressure including the fluid and/or nitrogen gas charge cannot exceed the safe working limits of the storage device and system components. A safe limit rating must be maintained on the fluid power components and plumbing (manufacturers rating).
6. One pressure indicator is *recommended* to be in front of the motor but where it can safely be read to determine the normal peddling pressure and for proper charging of the accumulator.
7. All pressure indicators are subject to judges verifying their accuracy with the use of a diagnostic test point supplied by either Iowa Fluid Power or SunSource.
8. A second pressure indicator is required to be between the accumulator port and any other valve in the system.
9. The maximum total volume of all accumulator/s is one gallon or 3.7854 liters.
10. There is no requirement for the method of switching between the circuits, i.e., electronic, or manual but the circuitry must be designed to include direct propulsion and regenerative braking.
11. Vehicles must use fluids furnished by the competition.
12. Vehicle design must be for a single rider. The rider must be able to enter, exit, start and stop the vehicle unassisted.
13. Style of vehicle design is open. There are no requirements for the number of wheels or for either a standard, recumbent, or multi-wheel drive.
14. Maximum weight of the vehicle is 210 pounds without rider.
15. All components on the competition bike need to stay on for all races.
16. Each bike will be weighed in advance of the event races. The initial weigh in is the weight that will be used for all the races. 1% of your score for each pound over 210 lbs. will be deducted from each of the 3 event races.

### Safety & Rules

1. All designs must comply with safety policies.
2. Maximum pressure in any part of the system cannot exceed 3000 psi.
3. Active Leak: An active leak is when a droplet forms and drips off a surface.

4. Residual oil left on components in hard to clean areas is acceptable, but an active leak, such as when a droplet forms and drips off the surface, is not.
5. There is a zero-tolerance for active leaks in the system. If there is an active leak, teams will have the option repair it, but must be able to completely stop the active leak before their time to compete.
6. All vehicles must be reviewed by the judges and the Technical Liaison prior to operation.
7. If vehicles have an unfixable design flaw related to safety the result is elimination from event race(s) where that design element(s) is required.
8. If vehicles have a design flaw, teams will have the option to repair it to be readmitted to the event races, pending review by judges and the Technical Liaison.
9. All vehicles must have multiple, fully active, independent brakes that provide a failsafe braking condition. Brakes should be able to hold the vehicle at a stop under the full charge of the accumulator.
10. If shipping to the final event, vehicles are to be void of hydraulic fluid pressure and no more than 50 PSI of gas charge. Vehicles are to be shipped at least 10 days before the event. Vehicles can weigh no more than 210 pounds. Instructions will be provided.
11. Each rider must wear a helmet. The helmet must comply with a nationally recognized standards organization. All bicycle helmets must carry a CPSC sticker. The burden of proof of meeting this guideline will rest with the participant.
12. Guards are required to protect the rider from moving components, where deemed necessary for safety reasons.
13. Vehicles will be eliminated from the event races for any of the following reasons:
  - a. Insufficient braking capability
  - b. Lack of stability
  - c. Poor visibility
  - d. Dangerous protrusions
  - e. Unsafe design features
14. During the competition, any participant demonstrating unsportsmanlike conduct will be disqualified from the Challenge and forfeit any and all awards. Driving under the influence is automatic elimination. Same rules apply as driving a motor vehicle on the highway.
15. Any safety concerns not covered in this document will be evaluated and addressed at the discretion of judges and Technical Liaison.

## **SCHEMATICS**

“VEST, Inc. is offering Vehicle Challenge participants an extended free trial to use their software product, NetSkeme®, to design their hydraulic schematics. NetSkeme Hydraulic is certified for Google Chrome and Mozilla Firefox browsers where schematics can be saved in industry-standard file formats (e.g. DWG, DXF, PDF). Interested student teams are welcome to register for a trial of NetSkeme by following the instructions outlined in the VEST, Inc. Services Information document on the [Vehicle Challenge website](#). Student teams are not required to use NetSkeme® Hydraulic to design their schematics. Note: Regardless of how they are produced, all schematics must be reviewed by your mentor or Ernie Parker prior to ordering components.”

## COMPONENTS

Iowa Fluid Power and SunSource are sponsoring up to \$4,000 worth of products for each team. Teams can select from either or both provided lists of products to best meet their needs, recognizing that the sponsorship value associated with each product is not necessarily the market price for such item. Iowa Fluid Power and SunSource both furnished separate lists of fluid power components that will work well with most vehicle designs, including pumps, motors, accumulators, valves, pressure gauges, hose assemblies, fittings, etc. Additionally, one custom manifold will be provided per team, if desired.

1. Components are offered for consideration in experimental projects. It is up to the student/group/university to review the technical data for each part to ensure it meets the needs of the application.
2. Manifolds are valued at \$300 but will not be deducted from your total donation allocation amount.
3. Reservoirs will need to have adequate sealing and venting capability. There is zero tolerance for active leaks in the system.
4. No pipe thread except for low pressure (<150 PSI/10 bar) circuits. No black or galvanized pipe. If no other option, National Pipe Thread Fuel (NPTF), can be used only for small instrumentation ports. There is a zero tolerance for active leaks.
5. If teams assemble their own tubes, flare lock seals are recommended to put between the flare and the fitting, if flared fittings are used.
6. When tubing is used, teams will be required to report what the proper wall thickness is for each line when asked by the Technical Liaison or judges. Be prepared to report this during the Design and Specification Midway Review and at the Final Competition.
7. Teams cannot make their own hoses.
8. Only hose assemblies will be provided.
9. Teams may order hose assemblies from another reputable hose and fitting supplier that can ensure that the final hose assembly meets all relevant specifications.
10. Purchasing hose and hose ends separately is not possible and could result in elimination from the competition.
11. The deadline to order hoses will be March 1<sup>st</sup>.
12. Other components offered by Iowa Fluid Power and SunSource must be ordered on or before December 1<sup>st</sup>.
13. Teams should use provided component lists from Iowa Fluid Power and SunSource to plan for adequate delivery time for building and testing prototypes.
14. Teams are welcome to purchase components from other reputable suppliers, resources or design their own, at their own expense.
15. Each component list has specific ordering details and instructions, please read them carefully.
16. Component lists can be found on the Vehicle Challenge website.
17. One 5-gallon pail of hydraulic fluid will be shipped to each university.
18. It is expected that teams will bring necessary tools and equipment to the final competition.

## BEST USE OF PNEUMATICS, Sponsored by Norgren

The challenge is to incorporate pneumatics on to the vehicle to assist in the function of the vehicle. This is not required, but teams are encouraged to explore pneumatic applications. The use of pneumatics will be evaluated and scored by the Industry Judges. The judges will evaluate based on creativity, efficiency,

and safety. The winning team from both competition sites will be awarded \$1,000 each. Funds will be distributed directly to team participants.

Rules:

1. Safety is the highest priority. Designs will be evaluated for safety by the industry judges and unsafe use of pneumatics will not be allowed in the competition.
2. The standard available shop air pressure ranges between 110-120. This is what will be available at each competition site.
3. Using the frame as a conduit for the pneumatic plumbing/air supply must be reviewed by Ernie Parker and/or the team's mentor.
4. Each team can use either a small electric compressor or pneumatic reservoir to create or store pneumatic pressure.
5. The maximum pressure in the reservoir is limited to 150 but the system should be operated at 100 PSI or less for safety.
6. If an air reservoir is used, it can be recharged before each challenge event to the maximum allowable pressure.
7. Each team will be able to order up to \$500 of pneumatic components to help complete their pneumatic circuits.
8. Refer to that component list on the Vehicle Challenge website.
9. Norgren can supply components of other sizes/options upon request.
10. Teams are encouraged to view the educational webinar covering the use of pneumatics and possible applications that is posted on the Vehicle Challenge website. Note: pneumatic parking brake applications will not be eligible for award.
11. The deadline to order pneumatic components will be **January 31**.

### **BEST USE OF ELECTRONICS, Sponsored by Iowa Fluid Power**

The challenge is to incorporate industry grade electronics on to the vehicle to assist in the function of the vehicle. This is not required, but teams are encouraged to explore industry electronic applications. The use of electronics will be evaluated and scored by the Industry Judges. The judges will evaluate based on the team's ability to display a safe, innovative application that enhances the design of the vehicle. The winning team from both competition sites will be awarded \$1,000 each. Funds will be distributed directly to team participants.

1. To be considered for award, teams must display a safe, innovative application that enhances the design of the vehicle. Funds will be distributed directly to team participants.
2. Teams are encouraged to view the educational webinar covering the use of electronics and possible applications that is posted on the Vehicle Challenge website.

### **MANIFOLDS**

Manifolds are widely used in the fluid power industry. They reduce leaks, pressure drop, and the amount of plumbing required for the application. That is why NFPA members are partnering to offer one custom manifold per team each program year. Each offering has its advantages depending on team's goals for the project and desired educational experience. Plus, each offering allows for students to

interact with industry to complete their manifold design. **NOTE:** Because all manifold offerings require interaction and collaboration from industry partners the initial submission may be reviewed for accuracy, safety, availability, and may require additional communication from the team. **Teams choosing to include a manifold in their design should be prepared to check email and provide timely responses to questions from NFPA members to ensure that the manifold will meet original design intentions, and that it will be machined and delivered on-time.**

1. In all cases, the circuit development and product selection will be the responsibility of the team.
2. Specific instructions will be provided for each offering.
3. Teams should review their respective files posted on the [Vehicle Challenge website](#) for more information and consider the below paragraphs as high-level descriptions to help you understand the differences between the offerings and select the option that is best for the team.
4. The deadline to place orders for each offering will be December 1.

### **Iowa Fluid Power (IFP)**

Through their partner Sun Hydraulics, IFP is offering custom hydraulic manifolds using Sun Hydraulic's QuickDesign™ tool. This is a web-based CAD program that allows students to create a schematic, select components, and set basic design constraints before submitting for auto-design of the manifold layout. Some software training is required to ensure the accuracy of the manifold design. Teams will collaborate with their mentor and Ernie Parker to have their schematic and BOM reviewed prior to placing the order, and they will work with IFP's designated team with QuickDesign specific questions, and final manifold design considerations before it is sent to Sun Hydraulics for machining.

1. [Here is the link to the QuickDesign software training.](#)

### **SunSource**

Through their partner Source Fluid Power, SunSource is offering custom hydraulic manifolds. Teams will collaborate with their mentor and Ernie Parker to have their schematic and BOM reviewed prior to placing their initial order to SunSource staff. Teams will work with SunSource's designated team to set basic design constraints and a manifold layout will be provided to the team by SunSource for final approval before it is sent to Source Fluid Power for machining.

### **VEST, Inc.**

Through their product offerings, MDTools® and ManifoldEdge™ and their respective distribution and manufacturing partners, SunSource and Source Fluid Power, VEST, Inc. is offering participating teams the software tools to design their own layout for their custom hydraulic manifold. Teams will still collaborate with their mentor and Ernie Parker to have their schematic and BOM reviewed prior to submission to SunSource staff. Next, the student team designs/verifies the manifold layout to their specification using MDTools. Note that MDTools is available to teams with licensed Autodesk Inventor or Dassault System's Solidworks CAD products. Teams will then upload/share their completed design with stakeholders (team members, mentor/Ernie Parker/SunSource staff) for review, feedback, and final approval from SunSource within ManifoldEdge before it is sent to Source Fluid Power for machining.

1. If teams choose this option, they are expected to make that commitment by October 29.
2. A timeline will need to be followed and software training should be completed no later than November 8 to ensure that the manifold will be machined and delivered on time. Refer to VEST Inc.'s file on the [Vehicle Challenge website](#) for more complete details.

## **PROGRAM CADENCE**

The Vehicle Challenge will be divided into five phases.

### **Phase 1 – Kickoff | September – October**

#### Activities

1. University Student Teams confirm participation and register.
2. Supporting documents provided by Program Manager.
3. Student Teams attend a Kick-Off Webinar lead by Program Manager.
4. Student Team checks-in with Technical Liaison and their industry mentor so they can assist teams in identifying project objectives and setting a plan.
5. Universities receive stipend payments from NFPA for support of Student Team activities.

### **Phase 2 – Design and Specification Midway Review | October – December**

#### Activities

1. Coinciding with the university's senior capstone design course, students gain knowledge in fluid power components, circuits, and systems, and their use in controlling force and motion.
2. Students view educational webinars offered by Technical Liaison and Program Sponsors, along with data sheets and instructions for ordering components.
3. Student Team creates initial design and mechanical drawings to illustrate the fluid power control circuits that will be created for the vehicle.
4. Student Team simulates design and performs dynamic, fluid flow, expected performance, and other relevant analyses on it.
5. Program Manager schedules and conducts a Design and Specification Midway Review Webinar where the Student Team presents their project objectives and design specifications to the Program Manager, Technical Liaison, Industry Judges, and other volunteers. Program Manager coordinates scoring of the presentations.
6. Universities receive stipend payments from NFPA for support of Student Team activities.
7. Student Team must check-in with their industry mentor and Technical Liaison to have their schematic reviewed, discuss component selection.
8. Student Team chooses and orders components to use on their vehicle.
9. Teams may supplement new components with equipment from previous years.
10. Student Team attends the Networking Mixer.

### **Phase 3 – Build and Test | December – March**

#### Activities

1. Student Team receives ordered components.
2. Student Team begins to construct vehicle prototypes.

3. Student Team checks-in with their industry mentor to discuss assembly and other questions.
4. Student Team tests and adjusts their vehicle.

#### **Phase 4 – Verification Review | March**

##### Activities

1. Student Team checks-in with their industry mentor to discuss final adjustments and any questions.
2. Student Team submits video of vehicle in operation to Program Manager and Technical Liaison.
3. Program Manager confirms entry into Final Competition Event and sends specific instructions for vehicle shipping and Student Team travel and accommodations.
4. Student Team prepares final presentation of design project and vehicle operation and sends to Program Manager no later than seven days prior to departing for Competition Event.

#### **Phase 5 – Final Competition Event | March- April**

##### Before the Event Activities- March

1. Student Team builds transport crate (if shipping)
2. Student Team arranges vehicle shipping.
3. Student Team makes travel and accommodation arrangements.

##### Day 1: Travel Day

1. All team members, advisors, travel to the Final Competition Event
2. Evening event to welcome and introduce teams to mentors, judges, and program sponsors

##### Day 2: Prep and Presentation

1. Morning
  - a. Student Team unpacks vehicle and ensures system integrity and readiness to operate under the guidance of the Program Manager, Technical Liaison and Final Event staff.
  - b. Other participants and guests arrive for the first round of afternoon presentations combined with design review sessions.
2. Afternoon, Early Evening
  - a. Student Team presentations combined with design review sessions begin, conclude prior to reception and dinner
  - b. Networking reception and dinner.

##### Day 3: Final Competition

1. Morning
  - a. Student Teams, advisors, marshals, program managers, and judges arrive to Event site
  - b. The second round of afternoon presentations combined with design review sessions begin.
  - c. Student Teams participate in the sprint race, the efficiency challenge, and the endurance challenge.
  - d. Vehicles are judged for the determination of several awards.
  - e. Student Team repacks vehicle and arranges for shipping or transport back to university.
2. Afternoon, Early Evening

- a. Final scores are tabulated
- b. Networking reception and award ceremony for all attendees.

#### Day 4: Travel Day

1. All team members, advisors travel back to universities

### **CONSIDERATIONS: Midway Review & Final Presentation**

#### **Design and Specification Midway Review**

The Design and Specification Midway Review prepared and presented by Student Team will be evaluated and scored by the Industry Judges. Refer to the FPVC Scoring Rubric for detailed information on the assessment criteria. A presentation outline and template will be provided. All presentations submitted throughout the FPVC will be posted on the website after the Final Competition. Teams will be evaluated on:

1. Design objectives
2. Vehicle design
3. Fluid power circuit designs
4. Selection of hardware
5. Results and incorporation of analyses (e.g., finite element analysis)
6. Stage of prototype built to date

Midway Review PowerPoint slides are required to be submitted two days in advance of their scheduled presentation. For teams from returning universities, we expect new and innovative designs from you. You will need to describe changes from previous year's vehicle at your Midway Review. At the beginning of the Midway Review presentation, teams will need to specify if they are building from scratch or if they are leveraging last year's work product as a base to build upon. Teams that are using last year's work are required to make significant circuit changes, demonstrate their original thought, and their understanding of the work completed in specified criteria areas. Refer to the FPVC assessment Rubric for details.

#### **Proof of Working Vehicle**

It is required that teams demonstrate your vehicle is in working condition by submitting a YouTube video link, indicating your intent to participate in final event. The footage must:

1. Confirm that the vehicle is safe and operational with a team member riding it at least ½ a block or better.
2. Verify stored energy working off the accumulator.
3. Confirm the use of pressure indicators and test point.

#### **Final Presentation**

The final presentation must be received by the Program Manager no later than seven days before the final event. Consider this to be the final submission. Teams will not be able to modify or resubmit their presentation after the deadline. The final presentations will be posted on the NFPA website for review after the Final Competition. These final presentations shall be submitted in electronic PPT format.

Teams are welcome to include videos in their presentations. A YouTube link of any video(s) must be included in the speaker notes. A presentation outline and template will be provided. Final presentations will be given at the final event and evaluated and scored by the Industry Judges. Refer to the FPVC Scoring Rubric for more information on the assessment criteria. Teams will be evaluated on:

1. Summary of Midway presentation. **This will be limited to 2 slides and no more than 5 minutes.**
  - a. Design objectives
  - b. Vehicle design
  - c. Fluid power circuit design
  - d. Selection of hardware
  - e. Results and incorporation of analyses (e.g., finite element analysis)
2. Vehicle construction
3. Vehicle testing and improvements
4. Final vehicle brought to competition
5. Lessons learned and conclusions

### **Industry Mentorship & Networking Mixer**

NFPA will be assigning an industry mentor to each team to coach and check in with them throughout the year. Student teams are required to contact their mentor at least four times about things like their vehicle design, reviewing the team's schematics, component selection, assembly and testing and final adjustments before the final competition. This can be done through visits/conference calls/webinars/sending videos – whatever works best. **Student teams will be required to submit a brief summary of each meeting or discussion.** One point for each summary submission for a total of four points will be added to the team's final score. Take advantage of your mentor's expertise and ask questions!

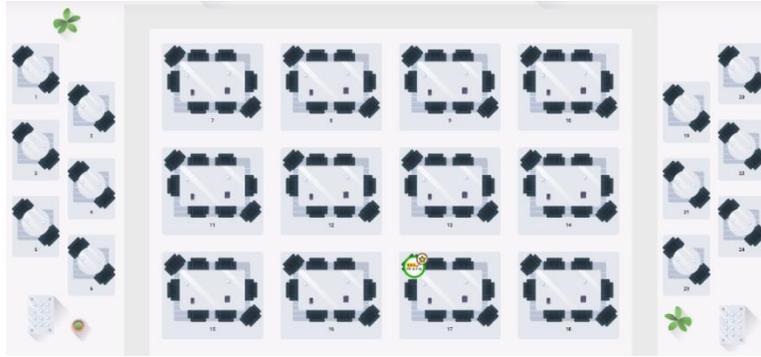
The purpose of the mentorship program is to help teams stay on track by having someone from industry to contact if they have questions or difficulties. **Your mentor and the Technical Liaison are required to review your schematic prior to ordering components or applying for a manifold.** Additional contact with mentors will be spread out over the course of the year:

1. After the Kick-off Call and before ordering components (Oct/Nov)
2. After ordering components and before the Midway Review (Nov/Dec)
3. After the Midway Review when your building and adjusting. (Jan/Feb)
4. Before submitting the Proof Working Vehicle (Feb/Mar)

Feel free to contact your mentor and the Technical Liaison more than four times. We would like to avoid the four calls to your mentor from happening in the month before the competition. **Successful teams set a regular meeting schedule with their mentor and don't hesitate to ask questions.**

### **Networking Mixer**

This will be an engaging, two-hour session in a ballroom-inspired seating arrangement pictured below. Like speed meetings, this event will allow HR/ Outreach representatives to exclusively connect with up to 6 to 8 students at a time in segmented Zoom breakout rooms. Industry representatives can discuss career opportunities, and students will have a chance to ask questions of their mentors and sponsors.



Participating companies will be asked to upload information about their companies in advance so that students can visit the “Meet Industry Representatives” page on the Vehicle Challenge website before the mixer to learn more about them. Students are encouraged to request individual meetings with representatives during this time. As shown above smaller virtual tables for one-on-one conversations will be available. We highly recommend advisors attending this event and getting to know industry representatives as they can be a source of employment for other students at your university. Student resumes will be sent to industry representatives in advance, so students and advisors are required to register and/or encouraged to update their resumes or profiles on the Vehicle Challenge website by **October 27**.

### Final Competition

1. Will include a safety inspection, design assessment, sprint race, efficiency challenge, endurance challenge and presentation. Each team starts with storage device void of hydraulic fluid. Maximum 10 minutes allowed to manually pressurize the storage device.
2. The pre-charge of the accumulator may not exceed 50 PSI if the vehicle is being shipped. The Technical Liaison and Judges will gas charge the accumulator to the safe, desired pre-charge pressure.
3. No mechanical, hydraulic, or pneumatic failures are allowed due to poor design or application of components. Vehicle failures during the Sprint Race and Efficiency Challenge will result in elimination.
4. Reservoirs, components, and plumbing must meet reasonable industry standards. No duct tape or other examples of insufficient workmanship. There is zero tolerance for active leaks in the system.
5. Be sure to include two pressure indicators (1) at the outlet of the accumulator with the test port and (2) before the hydraulic motor.
6. The manufacturer’s size and rating of the accumulator must be easy to read. If air is used, the size of the receiver and pressure must be known.
7. All course competitions will begin with a standing start.
8. The vehicle system configuration does not need to remain the same for all races. However, all components must remain in place. Teams may modify the configuration as long as there is no loss of oil during the change-over, other than a few drops.

9. Teams that need to make repairs will have that option only until their specified race start time. No additional grace period will be provided.
10. All repairs need to be done in the designated “shop area,” not in the field or on the racetrack.
11. The event race schedule is final unless teams agree to swap start times on their own. Judges and program staff will not make accommodations.
12. Drivers must maintain a safe speed and adhere to all instructions from the course marshals. Failure to comply will result in penalties, disqualification of event races or elimination.
13. The decisions of the judging panel are final. This includes tie breaking decisions. All ties will be broken based on adherence to the design criteria and performance.

### **Sprint Race**

*This event will demonstrate the ability of the vehicle to move a distance where the weight of the vehicle is proportional to the human propulsion.*

1. Maximum pressure in any part of the system cannot exceed 3000 psi.
2. Heats of multiple bikes at a time on a 400-600 ft course.
3. Standing start, one rider on vehicle, no pushing.
4. Each team is allowed up to two attempts and must use the same rider in both attempts.
5. Best time for places 1st, 2nd, and 3rd.
6. Timing in Minutes: seconds: tenths of seconds: hundredths of seconds.

### **Efficiency Challenge**

*This event will demonstrate the ability of the vehicle to effectively store and most efficiently use the smallest amount of stored energy to propel the unassisted vehicle the greatest distance proportional to the vehicle's weight.*

1. Maximum pressure in any part of the system cannot exceed 3000 psi.
2. The vehicle that goes the farthest is NOT necessarily the most efficient. Similarly, the most stored energy does not automatically indicate the winner either.
3. The vehicle must travel a minimum distance of 100 ft. Braking is not required. Vehicle will go as far as it can before coming to a complete stop.
4. The vehicle, designated rider, and safety gear will be weighed in advance of the event.
5. Each team is allowed up to two attempts and must use the same rider in both attempts.
6. Standing start, one rider on vehicle. There can be no assistance in making the machine move on its own. No windshields or wiggling of handlebars is allowed. Rider must remain on the vehicle for the entire event. If a foot touches the ground, this distance will be measured from the starting point.
7. Rider will not be allowed to operate the pedals or any other mechanical input device from the start of the event until the vehicle comes to rest. Braking is allowed for energy recovery, but not required.
8. 10 minutes will be allotted to charge the accumulator. No prior charging will be allowed. All charging will be human powered only.
9. The vehicle's pre-charge pressure used in the calculation below will be the pre-charge that is requested by the team and deployed by approved Technical Liaison only.
10. The volume of the storage device used in the calculation will be as stated on the vessel by the manufacturer (Pressure storage devices manufactured other than by Iowa Fluid Power or SunSource must be approved by the Technical Liaison).
11. The winner will be the determined by the following parameters and equation:

- Column B = gas pre-charge pressure in pounds per square inch (PSI) (Note: The minimum accumulator gas pre-charge pressure during filling will be 100 PSI)
  - Column C = Maximum system pressure that the accumulator is charged to.
  - Column D= Volume of the accumulator (Maximum 231 in<sup>3</sup>).
  - Column E = weight of the vehicle and rider in pounds.
  - Column F = total distance traveled from starting point in feet.
  - Refer to the Excel spreadsheet for the scoring ratio.
12. This calculation is an efficiency ratio and will provide an objective measurement to judge vehicle/system efficiency. It quantifies the winning vehicle as providing the most work with the smallest amount of stored energy.
  13. In the simplest terms, the vehicle that completes the challenge with the least amount of energy per pound of weight, wins.

### **Endurance Challenge**

*This event will demonstrate the reliability, safety, replicability, and durability of the fluid power system design and assembly.*

1. Maximum pressure in any part of the system cannot exceed 3000 psi.
2. Two bikes leave every two minutes.
3. The course may consist of laps in a slalom fashion. Maximum time to complete will be 20 minutes. Specific course will be determined and communicated prior to the Competition Event.
4. No hydraulic pressure in accumulators in advance of the race.
5. To test the regenerative braking circuits of the vehicles, the course will require at least one stop and restart of the vehicle after a minimum of 2000 feet.
6. The clock will stop upon the rider's complete stop in a designated area, riders must travel the greatest distance possible before they can start peddling to verify their regenerative braking ability. Once the rider pedals again, the clock will restart.
7. One rider on vehicle, no pushing. Two-wheeled riders can use their feet to stabilize themselves and push off to start. No second contact with the ground. Three-wheeled riders can have one push using their hands on the wheels. Riders with other vehicle configurations will need to consult judges on-site.
8. Teams are allowed up to two drivers, as an option, although not a requirement to complete the course.
9. The complete stop and driver changes will only be allowed in a designated area. For safety, the vehicle will come to a complete stop to change drivers, no pushing.
10. Riders that cannot complete the minimum distance of 2000 feet in 20 minutes will be disqualified.
11. If the vehicle breaks down during the Endurance Challenge, it must be moved to a safe distance from the track. The team will have 15 minutes to repair. The clock is not stopped for repairs.
12. The winner will be the determined by:
  - Furthest distance traveled in 20 minutes 1st, 2nd, and 3rd.
  - And furthest distance traveled demonstrating the regen circuit 1st, 2nd, and 3rd.

## PROCEDURES FOR STIPENDS, TRAVEL and AWARD PAYMENTS

Detailed below are the procedures for stipend payments, prize awards issued, and requests for reimbursement for travel expenses incurred to participate in the Fluid Power Vehicle Challenge and attend the Final Competition.

### For Payments Made to Universities:

University advisors are required to submit a W9 in the initial team registration form. No payments will be made prior to receiving the W9.

### Stipend Payments

Universities receive stipend payments from NFPA in support of Student Team activities. Three separate stipends will be disbursed upon completion of:

1. Kick-Off Webinar
2. Design and Specification Midway Review
3. Final Presentation

Teams that participate for the first time receive a \$1,500 stipend for the Kick-off Webinar, only. All stipends are restricted for use by current and future team participants for supplies and activities directly related to the NFPA Fluid Power Vehicle Challenge. The Final Presentation stipend payment may be lumped into any prize awards issued to the university at the Final Competition.

\*Steel toe shoes will be required for all attendees at the final competition. Advisors and students are welcome to use stipends for this purpose if they do not have them.

### Travel and Other Expense Reimbursement

For travel and qualifying expenses related to the final competition event, NFPA will reimburse up to a total of \$5,000 directly to universities for one faculty advisor and up to five students, participating in the final competition event. Advisors or university faculty will be required to submit the [Travel Reimbursement Form](#) in excel format and one PDF file of all receipts and supporting documents to Stephanie at [sscaccianoce@nfpa.com](mailto:sscaccianoce@nfpa.com) **no later than 30 days after the Final Competition event**. NFPA reserves the right to deny reimbursement if expenses are unrelated to the final competition or not a qualified expense. Receipts are required for every expense item, no exceptions. *If travel creates a personal or institutional financial hardship, please inform Stephanie, NFPA Workforce Program Manager.*

### Qualifying Reimbursable Expenses:

1. Team Accommodations at the hotel that NFPA designates.
2. Team Transportation
  - a. Airfare (coach/ economy flights only)
  - b. Auto rental
  - c. Trailer rental
  - d. Vehicle shipment to and from the final competition (as needed)
    - i. NFPA will reimburse for ground shipping only. Any expedited shipping will be the responsibility of the university.
  - e. Personal vehicle mileage
3. Travel Related Expenses
  - a. Meals not provided by NFPA or Vehicle Challenge event host.

- b. Taxi, Uber, Lyft, Tollways, Parking, etc.
- c. Other qualifying expenses as determined by NFPA.

### **Reimbursement Considerations**

1. Receipts are required for every expense. Receipts should include sufficient information to establish the amount, date, place, and the essential character of the expenditure.
2. The cost of a rented vehicle and/ or trailer and related fuel expenses will be reimbursed with receipts.
3. Mileage will not be reimbursed on a rented vehicle.
4. IRS mileage rate as of the final competition date will be used for reimbursement. This rate covers gas, wear and tear and other expenses.
5. Refer to [IRS.gov](https://www.irs.gov) for current rates.
6. To and from travel destinations must be written on receipts for Taxi, Uber, Lyft, etc.
7. NFPA recognizes that some universities use per diem and do not require receipts. NFPA does not honor any per diem and requires receipts for all meals. This excludes meals purchased when a meal is already provided by NFPA or the Vehicle Challenge event host.
8. NFPA travel reimbursement and award forms must be used. NFPA will not accept other documents.
9. Personal items such as toiletries and clothes are not allowable expenses.
10. Additional parts for bikes are not allowable expenses. Stipends can be used for that purpose.
11. Do not modify the travel reimbursement or award forms.
12. NFPA will not accept partial submissions. Payments for awards and reimbursement will not be processed until NFPA has received all supporting documentation. Any submissions received after the deadline will not be reimbursed.
13. Check with NFPA before incurring any expense if you are unsure if it will qualify for reimbursement.

### **AWARDS**

The Judging Committee determines final award winners based on a number of factors, including the overall assessment of (1) the Design and Specification Midway Review, (2) the competition results, (3) final presentations, (4) Interaction with Industry Mentors, (5) Points obtained from attending industry presentations. The decisions of the judging panel are final.

#### **Universities**

The Final Presentation stipend payment may be combined into one check with any prize awards issued to the university at the Final Competition. Awards will be issued to the university unless otherwise specified below.

#### **Individual Team Participants**

Based on the decisions of the Judging Committee, awards will be issued to individual team members as outlined in the awards section below. Recipients should consult a tax professional about reporting awards.

1. Advisors are required to identify the recipient(s) of the prize award(s) and how much is to be issued to each by filling out the [Award Recipient Form](#). This must be submitted to NFPA no later than 30 days after the final competition event.
2. Each recipient is required to submit documentation to collect payment from NFPA in the form of a W-9 for U.S. Citizens or a W-8BEN for non-U.S. Citizens. Forms can be found here, on [IRS.gov](#).
3. All checks issued to individual team participants will be mailed to the address listed on the W-9 or W-8BEN.

## CASH PRIZES

AWARD	PRIZE	CONSIDERATIONS
Overall Champion 1 <sup>st</sup> place 2 <sup>nd</sup> place 3 <sup>rd</sup> Place	\$3,000 \$2,000 \$1,000	First place overall champion will not be eligible to win more than one of the following: sprint race, endurance, or efficiency challenges. Funds will be distributed directly to team participants.
Best Presentations	\$1,000	Midway review score to be included in evaluating winning presentation. Funds will be distributed directly to team participants.
Sprint Race	\$1,000	Top three scores to be considered for placement. Final 1st place will be determined by a number of factors, including Overall Champion.
Efficiency Challenge	\$1,000	Top three scores to be considered for placement. Final 1st place will be determined by a number of factors, including Overall Champion.
Endurance Challenge	\$1,000	Top three scores to be considered for placement. Final 1st place will be determined by a number of factors, including Overall Champion.
Best Use of Pneumatics, Sponsored by Norgren	\$1,000	To be considered for award, teams must display creativity, efficiency, and safety. Funds will be distributed directly to team participants.
Best Use of Electronics, Sponsored by Iowa Fluid Power	\$1,000	To be considered for award, teams must display a safe, innovative application that enhances the design of the vehicle. Funds will be distributed directly to team participants.
Best Design	\$500	To be considered for award, teams must display innovation, uniqueness, and originality of the design.
Safety Award	\$500	To be considered for award, teams must take sufficient steps to construct a safe and reliable vehicle
Best Workmanship	\$500	Best degree of skill, expertise, and quality in vehicle.
Best Teamwork	\$500	Best attitude and cohesiveness of team.
13 Awards	\$15,000	

## **FLUID POWER CLUBS**

NFPA has launched a Fluid Power Club program for university students. NFPA will provide an annual stipend of up to \$2,000 to support club activities. Consider starting a club at your university to engage students in projects related to the Vehicle Challenge. Even for students who are not able to attend the final competition, it is a great opportunity for them to participate in fluid power education and get connected to industry professionals.

## **CAREERS IN FLUID POWER**

Because hydraulics and pneumatics are used everywhere, it means that there is always a need for people to work in the fluid power industry. Companies throughout the US, and the world, need people who are properly trained in fluid power technology.

Good-paying jobs are available in all kinds of markets: aerospace, agriculture, automation, construction, energy, entertainment, forestry, food processing, lawn and garden, marine, material handling, medical devices, mining, oil and gas, packaging, transportation and more...

If you want to become an engineer, or even work in sales, there is a career waiting for you in fluid power. Learn more by talking with the NFPA Industry Mentors and Judges at the Final Competition. These individuals work for companies that are looking to hire. You can also visit the [NFPA Careers Website](#) for more information.

## **International Fluid Power Society**

NFPA works with the International Fluid Power Society (IFPS) to strengthen and advance professional careers in the fluid power workforce through its work in education, training, and certification. Learn more by visiting [IFPS](#).