2025 NFPA Fluid Power Vehicle Challenge

Overview, Rules, and Awards

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Important Dates and Deadlines
Registration: ASAP
Kick-off webinar: September 26 (Recorded)
Prepare Resumes and Profiles: October 25
Networking Mixer: November 1
Component Orders: December 1
Competition Dates: April 9-11, April 23-25, and April 30 – May 2

NFPA Education and Technology Foundation

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. Students are expected to participate for the duration of the program and attend 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 Final Competition Events will include a sprint race, an efficiency race, an endurance race and a regenerative braking demonstration. In addition, teams will present their design process and decisions, and demonstrate the safe function of their vehicles.

1. IMI plc will host one event at their facility in Illinois: April 9-11, 2025.
2. Danfoss Power Solutions will host one event at their facility in Iowa: April 23-25, 2025.
3. IFP Motion Solutions Inc. will host one event at their facility in Iowa: April 30- May 2, 2024.
4. Each site location will have the same competition elements.
5. Specific details about attendance and traveling to each competition site will be provided after the Midway Reviews are complete.
6. Each team will be assigned a location based on their geographic location and their university's final exams testing dates.

The Final Competition Events will be conducted over a three-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 outline the rules and special award categories.

Contents

PROJECT OVERVIEW

Student Design Team

One team per university will be funded through the program.

1. Team members may have participated in previous year(s).
2. Eight total team members including at least one faculty advisor will be eligible to travel and 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.
    a. No internal combustion, or electric drive motor.
    b. 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. 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. A safe limit rating must be maintained on the fluid power components and plumbing (manufacturers rating).
6. Two pressure indicators are required. Gauges should be mounted where they can be safely read by the rider.
    a. A pressure indicator and test point are required to be at the outlet port of the accumulator.
    b. A pressure indicator and test point are required to be in place on the supply side of the hydraulic motor.
7. All pressure indicators are subject to judges' verification of accuracy with the use of a diagnostic test point supplied by either IFP Motion Solutions Inc. or SunSource. The maximum total volume of oil and nitrogen of all accumulator/s is one gallon or 3.7854 liters.
    a. No additional reservoirs or air tanks for the purpose of storing energy for propulsion are permitted.
8. Circuitry must be designed to include direct propulsion and regenerative braking.
    a. Teams must include an indicator that allows judges to observe the engagement of the regenerative braking circuit during the Regenerative Braking Demonstration.
9. There is no requirement for the method of switching between the circuits, i.e., electronic, pneumatic, or manual.
10. Vehicles must use fluids furnished by the competition.
11. Vehicle design must be for a single rider.
    a. The rider must be able to enter, exit, start and stop the vehicle unassisted.

12. 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.
13. The maximum weight of the vehicle is 210 pounds without a rider. Each vehicle will be weighed in advance of the event races. The initial weight at 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.
14. All components on the competition bike need to stay on for all races.
15. Reservoirs, components, and plumbing must meet reasonable industry standards.
    a. No duct tape or other examples of insufficient workmanship.
16. Windshields are not permitted.

Safety & Rules

1. All designs must comply with safety policies.
2. Maximum pressure in any part of the system cannot exceed 3000 psi.
3. **There is a zero-tolerance for active leaks in the system.** If there is an active leak, teams will have the option to repair it, but must be able to completely stop the active leak before their time to compete.
    a. An active leak is defined as when a droplet forms and drips off a surface.
    b. 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.
4. All vehicles must be reviewed by the judges and a Technical Liaison prior to operation.
5. 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.
    a. 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 a Technical Liaison.
6. All vehicles must have multiple, fully active, independent brakes that provide a fail-safe braking condition.
    a. Teams must equip their vehicle with at least two independently actuated friction brakes (e.g., rim brakes, disc brakes). Vehicles with only one wheel require only one brake.
    b. Each brake must operate on different wheels or axles.
    c. Hydraulic circuits (e.g., regenerative braking) do not count as one of the required brakes.
    d. Brakes should be able to hold the vehicle at a stop under the full charge of the accumulator.
7. If shipping to the final event, vehicles are to be void of hydraulic fluid pressure and have no more than 50 PSI of gas charge.
    a. Vehicles will likely be required to ship at least 10 days before the event. Teams should plan accordingly. Instructions will be provided.
8. 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.
9. Guards are required to protect the rider from moving components.
    a. Chain guards are required.
10. 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
11. During the competition, any participant demonstrating unsportsmanlike conduct will be disqualified from the competition and forfeit all awards.
    a. Driving under the influence is automatic elimination. Same rules apply as driving a motor vehicle on the highway.
12. Any safety concerns not covered in this document will be evaluated and addressed at the discretion of judges and Technical Liaison.

SCHEMATICS

All schematics must be reviewed by your mentor or Technical Liaison prior to ordering components. Designing a circuit and ordering components is an iterative process. Changes may be made that require your attention. Be prepared to check for and respond to emails from Program Sponsors promptly. Consider watching the Schematics Webinar before drafting your schematic. Additional resources include the IFPS Fluid Power Handbook and Symbology Guide and the Hydraulic Circuit Color Coding Guide which can be found on the FPVC website.

COMPONENTS

Applied Fluid Power, IFP Motion Solutions Inc., and SunSource are sponsoring up to $5,000 worth of products for each team. Teams can select from any or all of the 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 an item. Applied Fluid Power, IFP, and SunSource have 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 team to review the technical data for each part to ensure it meets the needs of the application.
    a. Each component list has specific ordering details and instructions; please read them carefully.
    b. Component lists can be found on the Vehicle Challenge website.
    c. Teams are welcome to purchase components from other reputable suppliers, resources or design their own, at their own expense.
    d. Teams should use the provided component lists from Applied Fluid Power, IFP, and SunSource and submit their order by **the December 1st deadline**.
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.
    a. No black or galvanized pipe.
    b. If no other option, National Pipe Thread Fuel (NPTF), can be used only for small instrumentation ports.

    c. 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. 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.
    a. Be prepared to report this during the Design and Specification Midway Review and at the Final Competition.
6. Teams cannot make their own hoses.
    a. Hoses may be reused or purchased on the private market. Stipend funds may be used for hoses.
    b. Teams are responsible for identifying reputable hose and fitting suppliers.
    c. Please contact NFPA if this causes a financial hardship or if the team is unable to find a hose supplier.
    d. Teams may order hose assemblies from a reputable hose and fitting supplier that can ensure that the final hose assembly meets all relevant specifications.
    e. Purchasing hose and hose ends separately is prohibited and could result in elimination from the competition.
7. One 5-gallon pail of hydraulic fluid will be shipped to each university.
8. Gas pre-charging systems will be available at the Final Competition locations.
9. Teams are expected to bring the necessary tools and equipment to the final competition.
10. When installing piston pump and piston motors, be sure to fill the cases with clean oil before turning the pump or motor.
11. **All Components offered by Applied Fluid Power, IFP and SunSource must be ordered by December 1st.**

BEST USE OF PNEUMATICS, Sponsored by IMI plc

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 PSI. 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 the technical liaison 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 PSI 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 competition 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 the component list on the Vehicle Challenge website.
9. IMI can supply components of other sizes/options upon request.
10. Teams are encouraged to view the educational webinar entitled "IMI, Use of Pneumatics and Applications" covering the use of pneumatics and possible applications that is posted on the Vehicle Challenge website.
11. Pneumatic parking brake applications will not be eligible for this award.
12. Email Jared Amundson at jared.amundson@imi-precision.com to place a pneumatics order.
13. The deadline to order pneumatic components is **January 31**.

BEST USE OF ELECTRONICS, Sponsored by IFP Motion Solutions Inc.

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 the 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 entitled "IFP Motion Solutions, Use of Electronics" 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 the team's goals for the project and desired educational experience. Plus, each offering allows 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 regularly 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 manifolds is **December 1**.

Applied Fluid Power

In partnership with our integrated business units, Applied Fluid Power is offering a custom manifold solution. Teams will collaborate with their mentor and technical liaison to have their schematic and BOM reviewed prior to placing their initial order with Applied Fluid Power. As required, teams will work with Applied Fluid Power and/ or technical liaisons to align on basic design outcomes; a manifold layout will be provided to the FPVC team by Applied Fluid Power for final production approval.

IFP Motion Solutions Inc. (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 technical liaison to have their schematic and Bill of Materials (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 technical liaison 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.

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 are provided by the Program Manager.
3. Student Teams attend a Kick-Off Webinar lead by the Program Manager.
4. Student Teams watch Safety Video in Education Webinars on FPVC website.
5. Student Team schedules first meeting with assigned industry mentor and establishes meeting plan.
6. 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 the 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 for both direct drive and regenerative braking 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 upon completion of Midway Review for support of Student Team activities.
7. Student Team must check-in with their industry mentor and Technical Liaison to have their schematic approved and review component selection.
8. Student Team chooses and orders components to use on their vehicle by December 1.
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 provides crate dimensions and weight to program manager to arrange shipping.
3. Student Team makes travel and accommodation arrangements.

Tuesday: Travel Day

1. Team members, advisors, travel to the Final Competition Event.

Wednesday: Assembly Day

2. Teams drop off competition vehicles (if not shipping) and complete vehicle assembly.
3. Evening event to welcome and introduce teams to mentors, judges, and program sponsors.

Thursday: Prep, Presentation and Races (weather dependent/subject to change)

1. Morning
    a. Student Team unpacks complete vehicle assembly and pre-race safety inspection
    b. Final Presentations combined with Vehicle Design Review and Safety Inspections are judged by the technical liaison and judges.
2. Afternoon, Early Evening
    a. Competition races and regenerative braking demonstration.
    b. Networking reception and dinner.

Friday: Roundtable Discussion and Award Ceremony (weather dependent/subject to change)

1. Morning
    a. Roundtable discussion on vehicle performance.
    b. Tour of facilities or networking opportunity.
    c. Student Team repacks vehicle for shipping or transport back to university.
2. Afternoon
    a. Networking award ceremony and lunch. Team members and advisors travel back to universities if possible.

Saturday: Travel Day

1. Additional travel back to universities.

CONSIDERATIONS: Midway Review & Final Presentation

Design and Specification Midway Review

The Design and Specification Midway Review prepared and presented by the Student Team will be evaluated and scored by the Industry Judges. Refer to the FPVC Assessment Rubric for detailed information on the assessment criteria. A presentation outline and template will be provided. Teams will be evaluated on:

1. Design objectives and lessons learned from investigating previous designs
2. Vehicle design
3. Fluid power circuit designs showing both direct drive and regenerative braking
4. Selection of hardware
5. Calculations and analyses
6. Stage of prototype built to date
7. Identification of reputable hose supplier

Teams must submit their Midway Review PowerPoint slides two days before their scheduled Midway Review. For teams from returning universities, we expect new and innovative designs from you. You will need to describe changes from the 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

Teams must demonstrate their vehicle is in working condition by submitting a YouTube video link, indicating their intent to participate in the 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 & Design Review

The final presentation must be received by the Program Manager no later than seven days before the final event. 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 Assessment Rubric for more information on the assessment criteria. Teams will be evaluated on progress made between Midway Review and Final Presentation:

1. Vehicle construction
2. Vehicle testing and improvements
3. Final vehicle brought to competition
4. Demonstration and understanding of regenerative braking
5. Lessons learned
6. Demonstration of understanding of design choices

Industry Mentorship & Networking Mixer

NFPA will assign 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 report of each meeting or discussion that summarizes challenges identified and lessons learned. The mentor summaries must be written by the students.** 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 to assist teams in identifying project objectives and setting a plan before ordering components (Oct/Nov)
2. Before the Midway Review to review schematics and component orders (Nov)
3. After the Midway Review when you're 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. **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 Zoom meeting with breakout rooms assigned to NFPA member companies. Students will be able to move between breakout rooms to talk with HR/ Outreach representatives about career opportunities and ask questions of their mentors and sponsors. Additional breakout rooms will be available for one-on-one conversations.

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. 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 are required to register and update their resumes or profiles on the Vehicle Challenge website. **The deadline to submit resumes is October 25.**

Final Competition

1. Will include a safety inspection, design assessment, sprint race, efficiency race, endurance race, regenerative braking demonstration and final 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.
    a. The Technical Liaison 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, Efficiency Race, and Endurance Race will result in elimination from that race.
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. 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.
6. All course competitions will begin with a standing start.
7. Teams are encouraged to wear university-branded tee shirts or polo shirts during the competition. Stipend funds can be used to purchase these shirts if needed.

8. 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.
9. 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.
10. Teams that need to make repairs will have that option only until their specified race start time. No additional grace period will be provided.
11. All repairs need to be done in the designated "shop area," not in the field or on the racetrack.
12. The event race schedule is final unless teams agree to swap start times on their own. Judges and program staff will not make accommodations.
13. 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 from the competition.
14. **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

The goal of this event is to move a distance as fast as possible from a standing start using Stored Hydraulic Energy and/or Rider Power.

1. Riders are allotted 10 minutes just before the sprint race to store hydraulic energy in their accumulator (charge the accumulator). The accumulator cannot have any hydraulic charge before this period.
2. Maximum pressure in any part of the system cannot exceed 3000 psi.
3. Heats of multiple bikes at a time on a 400-600 ft course.
4. Standing start, one rider on vehicle, no pushing.
5. Each team is allowed up to two attempts and must use the same rider in both attempts.
6. Maximum time allowed per attempt is three minutes.
7. Best time for places 1st, 2nd, and 3rd.
8. Timing in Minutes: seconds: tenths of seconds: hundredths of seconds.

Efficiency Race

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 IFP 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^3).
    - 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 Race

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. Vehicles leave roughly every minute.
3. The vehicle must travel a minimum distance of 2000 ft. Braking is not required.
4. Teams are allowed to switch drivers, as an option, although not a requirement to complete the course.
5. 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 or running start.
6. No external charging is permitted. Students are encouraged to use regenerative energy.
7. The course may consist of laps in a slalom fashion. Maximum time to complete will be 15 minutes. Specific course will be determined and communicated prior to the Competition Event.
8. No hydraulic pressure in accumulators in advance of the race.
9. Riders that cannot complete the minimum distance of 2000 feet in 15 minutes will be disqualified.
10. If the vehicle breaks down during the Endurance Race, it must be moved to a safe distance from the track. The clock is not stopped for repairs.
11. The winner will be the determined by:
    - Furthest distance traveled in 15 minutes 1st, 2nd, and 3rd.

Regenerative Braking Demonstration

This event will demonstrate the potential of stored energy and the regenerative braking capabilities of the fluid power system design.

A demonstrated regenerative braking circuit is defined as the vehicle slowing down due to pressure being forced into the accumulator using the inertia of the bike as the power source to produce that pressure (or energy). This can come from either a motor being used as a pump or a separate pump.

1. Maximum pressure in any part of the system cannot exceed 3000 psi.
2. Only one rider permitted for the duration of the demonstration.
3. No fluid pressure in accumulators in advance of the demonstration.
4. Maximum time to complete will be 5 minutes.
5. Each team will be assigned an industry judge at the competition site to observe their demonstration. Each team is allowed up to two attempts and must use the same rider in both attempts.
6. Teams must include an indicator that allows judges to observe the engagement of the regenerative braking circuit during the Regenerative Braking Demonstration.
7. Depending on the location, the course will be between 100 and 200 feet. The course may consist of laps in a slalom fashion.
8. No weight can be added to or removed from the vehicle during the demonstration.
9. Including a regenerative braking circuit and completion of the demonstration will result in earning 3 points towards final score.
10. To test the regenerative braking circuits of the vehicles, the course will require at least one stop to go into regenerative mode to recover energy and use only regenerative energy to restart and propel the vehicle for at least 10 feet.
11. Riders can only build pressure while they are braking to recover as much energy as possible as they actively advance. Pedaling is not permitted at or after the vehicle comes to a stop.
12. The accumulator can only be charged from kinetic energy, not from external sources.
13. One rider on vehicle, no pushing. Two-wheeled riders can use their feet to stabilize themselves and push off once to start. No second contact with the ground until the vehicle stops. 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. This rule applies to the beginning of the race and after the vehicle comes to a stop.

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. Completed student registrations and Kick-Off Webinar - $1000
2. Design and Specification Midway Review - $1000
3. Inclusion of Regenerative Braking Circuit in Final Presentation - $1000

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 combined with 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 seven 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 the program manager **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. **Itemized receipts are required for every expense item, no exceptions**. *If travel creates a personal or institutional financial hardship, please inform the 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 Rules

1. **Receipts are required for every expense**.
    a. Receipts should be itemized and include sufficient information to establish the amount of each item, date, place, tax, and the essential character of the expenditure.
    b. If applicable, any tips not included in the total should be written on the receipt.
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.
    a. IRS mileage rate as of the final competition date will be used for reimbursement. This rate covers gas, wear and tear and other expenses. Refer to IRS.gov for current rates.
4. To and from travel destinations must be written on receipts for taxis, Uber, Lyft, etc.

5. **NFPA recognizes that some universities use per diem and do not require receipts.**
    a. **NFPA does not honor any per diem and requires receipts for all meals.**
    b. **NFPA will not reimburse meals purchased when a meal is already provided by NFPA or the Vehicle Challenge event host.**
6. NFPA travel reimbursement and award forms must be used. NFPA will not accept other documents.
    a. Do not modify the travel reimbursement or award forms.
7. Personal items such as toiletries and clothes are not allowable expenses.
8. The purchase of alcohol will not be reimbursed.
9. Additional parts for vehicles and the purchase of crates for shipping are not reimbursable expenses. Stipends can be used for that purpose.
10. NFPA will not accept partial submissions.
11. Payments for awards and reimbursement will not be processed until NFPA has received all supporting documentation.
12. Any submissions received after the deadline may not be reimbursed.
13. Check with NFPA before incurring any expense if you are unsure if it will qualify for reimbursement.

Universities

The Final Presentation stipend payment may be combined 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 Receipt Form. This must be submitted to NFPA no later than 30 days after the final competition event.
2. All checks issued to individual team participants will be mailed to the address listed on the registration form.
3. Individual team participants may be required to submit a W-9 or W-8BEN to receive their award.

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, and (4) Mentor Summary Submissions. The decisions of the judging panel are final.

AWARD	PRIZE	CONSIDERATIONS
Grand Champion 1st place 2nd place 3rd Place		Top scores in each category will determine recognition for teams finishing in first, second, and third place. Funds will be distributed to their universities.

Midway Review Presentation Award	$1,000	Top score will be considered for placement based on the work completed leading up to the Midway Review Presentation. Funds will be distributed directly to team participants.
Final Presentation and Design Review Award	$1,000	Top score will be considered for placement based on the work completed between the Midway Review Presentation and the Final Competition Event. Funds will be distributed directly to team participants
Sprint Race	1st: $750 2nd: $500 3rd: $250	Prize money will be awarded to teams finishing in first, second, and third place. Funds will be distributed to their universities.
Efficiency Race	1st: $750 2nd: $500 3rd: $250	Prize money will be awarded to teams finishing in first, second, and third place. Funds will be distributed to their universities.
Endurance Race	1st: $750 2nd: $500 3rd: $250	Prize money will be awarded to teams finishing in first, second, and third place. Funds will be distributed to their universities.
Best Use of Pneumatics, Sponsored by Norgren	$1,000	To be considered for the award, teams must display creativity, efficiency, and safety. Funds will be distributed directly to team participants.
Best Use of Electronics, Sponsored by IFP Motion Solutions	$1,000	To be considered for the award, teams must display a safe, innovative application that enhances the design of the vehicle. Funds will be distributed directly to team participants.
Judges' Choice: Design	$1,000	To be considered for the award, teams must display innovation, uniqueness, and originality of the design. Funds will be distributed directly to team participants.
Judges' Choice: Safety	$1,000	To be considered for the award, teams must take sufficient steps to construct a safe, lightweight and reliable vehicle. Funds will be distributed directly to team participants.
Judges' Choice: Workmanship	$1,000	To be considered for the award, the degree of skill, expertise, and quality of workmanship must be evident in the vehicle. Funds will be distributed directly to team participants.
Judges' Choice: Teamwork	$1,000	To be considered for the award, the team must display a positive attitude and cohesiveness of the team. Funds will be distributed directly to team participants.
12 Awards	$12,500	

SCORING

The Grand Champion will be determined by the top point-getters in the following areas:

- Midway Review

- Final Presentation and Vehicle Design Review
- The three Final Competition races (Sprint, Endurance, Efficiency)
- Regenerative Braking Demonstration
- Completing mentor meeting summaries

The Midway Review and Final Presentation & Vehicle Design Review are scored on various objectives with a 1-5 rating (1 being Poor and 5 being Excellent). The overall top possible score for both review areas combined is 15. We will take an average of all the judges' scores, on the questions, for the midway review, and final presentation/vehicle design review.

Completion of the Regenerative Braking Demonstration will be worth 3 points. Teams that cannot complete the demonstration will not be awarded any points.

The Final Competition races are scored as follows:

- 1st place = 3 points
- 2nd Place = 2 points
- 3rd Place = 1 point

Teams can earn up to 4 points for submitting summaries of interactions with the teams' mentors.
In total, teams can earn up to 19 points for participation in the program, plus up to 9 points for their performance in the races, and 3 points for their Regenerative Braking Demonstration.

A total of 31 points may be earned.

The Safety, Design, Workmanship, Teamwork, Best Use of Pneumatics, and Best Use of Electronics awards are not scored and are decided on by the judges.

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 fluid power projects. A list of suggested activities is available at NFPAFoundation.com. This is a great opportunity for all students to participate in fluid power education and connect with 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 Foundation 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.