



energy | innovation | sustainability | engineering | design

RULES FOR THE 2018 HUMAN POWERED VEHICLE CHALLENGE



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I. General Information

A) Objective

To provide an opportunity for engineering students to demonstrate application of sound engineering principles toward the development of practical, efficient, sustainable, and fast human-powered vehicles.

B) Superiority of Rules

These rules have been established by the ASME's Human Powered Vehicle Challenge (HPVC) Committee. Should any conflict arise between these rules and those of the ASME, the ASME rules shall dominate. Should any conflict arise between these rules and other information regarding the ASME HPVC, whether generated by the ASME or any other organization, these rules shall dominate.

C) Location

Locations of all competitions can be found on the official HPVC website. Teams wishing to participate should consult the HPVC website, ASME HPVC Community on Facebook, and HPVC Questions Forum.

Official HPVC Website: <https://community.asme.org/hpvc/default.aspx>

Official Rules and Forms: <https://community.asme.org/hpvc/m/default.aspx>

HPVC Facebook Community: <http://www.facebook.com/ASMEHPVC>

HPVC Question Forum: <https://groups.google.com/forum/#!forum/asmehpvc>

D) Schedule Summary & Host Information

The ASME HPVC website shall specify all the important dates and contact information for the relevant competition.

E) Competition Summary

The competition shall include four events: a design event, a speed event, a technology innovation event, and an endurance event. Scores from each event are totaled to obtain the overall score to determine the winner.

F) On-Site Schedule

On-site registration begins on the first day (generally on Friday morning) of the competition. All teams must register in person before the end of the registration period.

II. General Rules of Competition

A) *Minimum Number of Vehicles to Compete*

There is no requirement for a minimum number of vehicles. However, should the number of vehicles entered be more than one but less than four, the number of awards granted for overall placement in that event shall be one less than the number of competing vehicles.

To be eligible for the overall 1st, 2nd, or 3rd place winner, a vehicle must compete and score in all 5 events: design, innovation, male speed, female speed, and endurance.

In the endurance event, a vehicle must complete at least 10 kilometers in order to meet this requirement.

B) *Events of the Competition*

- Design Event: Teams are scored on their application of sound engineering principles and practices toward a vehicle design. This event includes a written report, a technical presentation, performance safety video and static judging of their HPV.
- Innovation Event: Teams are scored on the design and demonstration of a technical innovation related to their vehicle.
- Men's and Women's Speed Event: Teams are scored on the speed of their vehicles, either in a flying start 100 meter sprint or a head-to-head drag race from a standing start. The ASME HPVC Committee will announce which event will be held well in advance of the competition. Separate scores for men and women are recorded for this event.
- Endurance Event: Teams are scored on speed, practicality, performance and reliability of their vehicles in a road race format with urban transportation obstacles and challenges.

C) *Modification of Vehicles*

Modifications to the vehicle are allowed between events, as long as safety is not compromised. Vehicles must retain their main frame and general drivetrain configuration. Any vehicle deemed to have undergone changes in excess of this allowance will be permitted to compete if it does not present a safety risk; however, any scores achieved will not be credited to the original entry. Vehicles in which the basis of design involves changes to the main frame or drive train configuration for various racing events must submit a request for a waiver prior to the report due date.

D) *Aerodynamic Devices*

Vehicles may include components, devices, or systems engineered specifically to reduce aerodynamic drag. Front fairings, tail sections, full fairings and other such devices are encouraged. The effectiveness of aerodynamic devices must be substantiated in the design report in order to receive credit for the design scores regarding aerodynamics.

Make-shift devices which are unrepresentative of the design, are crudely crafted, and/or present a clear safety concern will be prohibited, and must be removed prior to racing unless previously granted a waiver by the Head Judge. Fairing configurations may be changed between events in accordance with Section II.C provided that all safety requirements, including the seat belt and Rollover Protection System (RPS) rules, are not compromised by the change of configuration.

E) *Vehicle Number and Logos*

ASME will assign each vehicle a number. The number "1" will be assigned to the overall winner from the prior year's competition. All other numbers will be assigned by ASME. At its discretion, ASME may consider requests for specific vehicle numbers, but no zero or triple digit numbers will be allowed.

Decals – ASME will provide two adhesive decals to each team during the on-site registration process. Each decal will display the assigned vehicle number as well as the ASME logo. Each vehicle shall provide sufficient space on either side for these stickers. This space may include fairings, cargo containers, or surfaces especially designed for this purpose. The decals shall be no larger than 35 cm wide x 30 cm high. If one or both of the ASME decals are lost, obscured, or difficult to see from either side of the vehicle, the vehicle shall be removed from the competition until they are restored. If a vehicle number is obscured during an endurance race, any laps run without a visible number will not be counted.

School Name – All vehicles should display their school name or initials on each side of the vehicle in characters at least 10 cm high in a color that contrasts with the background.

F) *Fairness of Competition*

All participating teams will be assured an equal opportunity and a fair competition. Any participating team that, in the reasoned opinion of the judges, seeks to exert an unfair advantage over other competitors will be subject to a penalty in performance points or disqualification from the competition.

G) *Protests*

Protests must be announced to a member of the judging staff either at the time of the incident or within a 15 minute period following the announcement of results of the event. Following the announcement of the intent to protest, a written protest (see Section XVI Appendix 4: Protest Form) must be presented within 30 minutes unless otherwise allowed by the Head Judge. Oral protests will not be recognized.

Protests must be specific in nature and must include a factual account of the event being protested and the specific rules infraction, or the perceived error in the scoring of an event. ASME HPVC Protests Form may be used to file a protest. This form is available in the appendix of these rules. Protests will be examined and resolved by the judges at their earliest convenience during the competition. Their decision will be final and without further appeal.

H) *Event Scoring*

Scoring for each event and the overall scores will be based on a points system. The team with the most points wins the event.

I) *Energy Storage Devices*

Vehicles may employ the use of energy storage devices for purposes of accelerating and improving performance of their HPVs, but by no means are they required. If energy storage is used, energy must be stored after the race has begun with human power as the sole external source of energy.

Prior to each race, each team must demonstrate that their storage device has zero propulsive energy stored.

Energy storage devices are permitted in the Technology Innovation event, and all energy storage devices should be compatible with the spirit of the competition with respect to energy conservation and environmental stewardship.

During the safety inspection, the team must be prepared to discuss the safety of the storage device, especially during a high-speed incident. Teams whose vehicles present an unacceptable risk in the perception of the judges will not be allowed to utilize the energy storage device in the competition.

Stored energy used to power non-motive systems (does not impart momentum to the vehicle) is allowed and may be stored prior to the beginning of the race.

Combustion engines are excluded from the competition.

J) *Report and Video Publication*

After the completion of the events for a particular HPVC all team's Design reports, Innovation reports and Innovation presentation videos will be published to a shared site.

If a team does not want their design and/or innovation reports and/or presentations posted publically, the team must submit a request, in writing, to the event Head Judge no later than the report due date. The request must convincingly outline the grounds (such as active NDAs, or submission for intellectual property) for which the request is being made, and teams must be prepared to present an alternative submission omitting any specific sections in question. Requests will be granted or denied by the judging committee, and their decision will be final and without appeal.

K) *Design & Innovation Feedback*

In an effort to help teams learn from their experience, the judging staff will be providing feedback on each team's performance in the Design and Innovation events.

During the evaluation of the Design and Innovation reports and live/video presentations the judges will take note of specific areas where teams may be able to most improve their scores. Judges will be looking for things like areas that may be missing key details, where teams missed the mark with information provided or just generally in what areas team can improve the most. Feedback provided will be constructive and actionable so that teams will walk away with a better understanding of the scores they received and how they can improve their skills further.

The means in which feedback will be provided will either be written (method 1) or in person during the event (method 2) as outlined below. Due to scheduling constraints, the specific method will be selected in advance for each competition and posted to the website when available.

Feedback Method 1-

All written feedback will be collected in a standard format and delivered to the team captain after the conclusion of the competition.

Feedback Method 2-

To deliver the feedback, teams will be assigned a time slot during the race weekend where they will meet with one of the judges for a 10 minute discussion. During this time, the judge will review the feedback collected and will be available to answer any questions the team may have. It is important to note that at this time the scores for the Design and Innovation events will be finalized so there will be no opportunity to modify any scores, this time will be for improvement feedback only.

Note: No action is required from teams to receive feedback outlined here, this section is simply included in the rules as informational

L) *Readiness to Compete*

Teams must show up ready to compete and repair facilities will only be provided if the host school offers. The host is not responsible for assistance with vehicle repairs. All vehicles must arrive at the competition ready to ride and pass safety inspection.

III. **Safety**

A) *General*

The safety of participants, spectators, and the general public will override all other considerations during the competition. The judges will consider the safety features of the competition courses, as well as those of the competing vehicles, in permitting each event of the competition to begin or continue. Any event of the competition may be delayed, terminated prematurely, or canceled if the Head Judge, in consultation with ASME and the Judging Team, determines that such action is necessary in the interest of safety.

B) *Performance Safety Requirements*

Each vehicle must demonstrate that it can come to a stop from a speed of 25 km/hr in a distance of 6.0 m (19.7 ft), can turn within an 8.0 m radius (26.2 ft), and demonstrate stability by traveling for 30 m (98.4 ft) in a straight line at a speed of 5 to 8 km/hr (fast paced walking speed).

C) *Minimum Braking System Requirement*

Each vehicle must have a braking system with properly designed brakes on the front most wheel of the vehicle at a minimum. If multiple forward wheels are employed (such as in a tadpole trike or quad bicycle design) each wheel must have its own brake. Simply put, vehicles must at least have front brakes.

Even though teams may employ front brakes outlined here teams are still responsible to conduct adequate testing to ensure that the vehicle can pass the stopping performance test outlined in the performance safety requirements.

D) *Rollover Protection System*

All vehicles must include a rollover protection system (RPS) that protects all drivers in the vehicle in the event of an accident. Functionally, the RPS must:

- Absorb sufficient energy in a severe accident to minimize risk of injury
- Prevent significant body contact with the ground in the event of a fall (vehicle resting on its side) or rollover (vehicle inverted)
- Provide adequate abrasion resistance to protect against sliding across the ground. This is particularly important around the rider's arms and legs. Adequate guarding must be included.

The RPS must allow for a load path supporting the driver and retaining them from being ejected from the HPV in the event of a crash. This load path will be defined from the ground (impact point), to the outside of the vehicle body, through the structural RPS, through the safety harness, to the driver's body (center of gravity). A thorough RPS design includes the structural fortitude of not only the roll bar/frame, but also a rigidly mounted and structurally sound seat and properly affixed safety harness. In the RPS analysis teams must document the load path from rider to ground to receive full points.

In order to demonstrate the effectiveness of the RPS in protecting body contact from the ground, teams may be required, during safety check, to lay their vehicle on its side as well as invert it fully with the largest rider inside. Once laying on its side and inverted the rider must not make contact with the ground and if safety is compromised vehicle modifications will be required or vehicle will not be allowed to race.

In addition, the RPS shall meet the top and side load requirements described below.

- 1) **RPS Load Cases:** The RPS system shall be evaluated based on two specific load cases – a top load representing an accident involving an inverted vehicle and a side load representing a vehicle fallen on its side. **In all cases the applied load shall be reacted by constraints at the seatbelt attachment points;** simulating the reaction force exerted by the rider in a crash.

- (a) Top Load: A load of 2670 N per driver/stoker shall be applied to the top of the roll bar(s), directed downward and aft (towards the rear of the vehicle) at an angle of 12° from the vertical, and the reactant force must be applied to the seat belt, seat, or roll bar attachment point and not the bottom of the roll bar (unless the bottom is the attachment point). Note that there may be one roll bar for the driver and another roll bar for the stoker which will result in each RPS having an applied load of 2670 N, or the driver and stoker can both be protected by a single roll bar which will result in the RPS having an applied load of 5340 N.

The roll bar is acceptable if 1) there is no indication of permanent deformation, fracture, or delamination on either the roll bar or the vehicle frame, 2) the maximum elastic deformation is less than 5.1 cm and shall not deform such that contact with the driver's helmet, head or body will occur.

- (b) Side Load: A load of 1330 N per driver/stoker shall be applied horizontally to the side of the roll bar at shoulder height, and the reactant force must be applied to the seat belt, seat, or roll bar attachment point and not the other side of the roll bar. Note that there may be one roll bar for the driver and another roll bar for the stoker which will result in

each RPS having an applied load of 1330 N, or the driver and stoker can both be protected by a single roll bar which will result in the RPS having an applied load of 2670 N.

The roll bar is acceptable if 1) there is no indication of permanent deformation, fracture or delamination on either the roll bar or the vehicle frame, 2) the maximum elastic deformation is less than 3.8 cm and shall not deform such that contact with driver's helmet, head occurs.

- 2) RPS Attachment The RPS must be structurally attached and braced to the vehicle frame or fairing and, with the vehicle in the upright position, must extend above the helmeted head(s) of the driver(s) such that no part of any driver will touch the ground in a rollover or fall over condition. The RPS may be incorporated into the fairing, providing that that part of the fairing is used in all events. Teams must demonstrate that the RPS meets both functional requirements and loading requirements. See Figure 1

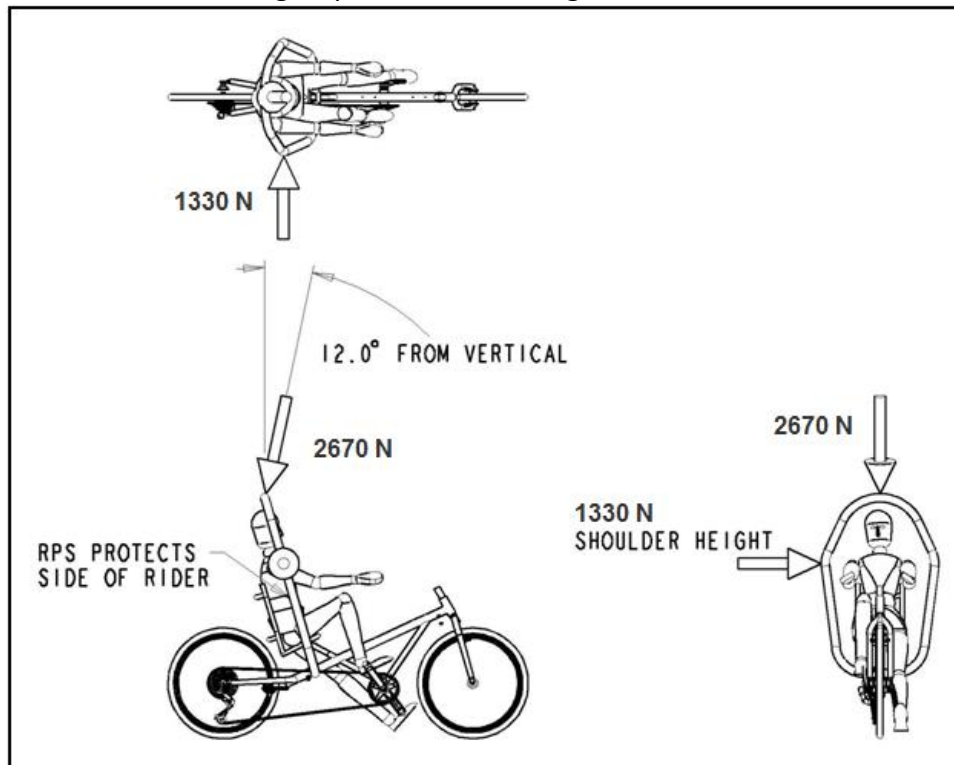


Figure 1: Example of Proper RPS Design and Side and Top Load Case Applications (Note: Loads shown should not be applied concurrently in analysis and/or testing)

E) *Safety Harness*

All drivers of all vehicles in all events will be secured to their vehicle by safety belts and, where feasible, shoulder harnesses at all times that the vehicle is in motion. Commercially available seat belts and harnesses designed for automotive, aviation or racing applications will generally be accepted without test data for the straps and buckles. Test data for attachment points may still be required at the time of the safety inspection. Seat belts should be adjusted as firmly as possible, consistent with comfort, to provide the protection for which they have been designed. A slack belt will greatly reduce the protection afforded to the wearer.

The safety harnesses must be attached to the RPS or a structural member in the RPS and may not be attached to the seat unless it is structurally integrated into the RPS.

- 1) Custom Fabricated Harnesses If the harness is custom fabricated by the team or a commercial entity not in the business of producing harnesses or webbing products designed for use in life supporting application (i.e. climbing, racing, automotive), significant test data will be required, as defined below.
 - Hand stitching of webbing is not acceptable under any situation. Machine stitching will be acceptable with supporting test data.
 - Webbing connections secured with a properly tied water knot will be accepted without test data.
 - The minimum acceptable width for harness webbing is 25mm.
 - 2) Testing requirements for non-commercially produced harnesses
 - Tensile test samples of a stitched joint must be prepared in an identical manner to the intended production method including: Base webbing material, thread, stitching pattern and quantity.
 - Tensile tests performed on a minimum of 5 samples must show a 95% statistical confidence of an ultimate strength in excess of 3340 N.
 - 3) Testing requirements for off application buckles
 - Off application is defined as a buckle designed for anything other than a life supporting applications (automotive, aviation, climbing, etc.). Other buckles designed for life supporting applications will be accepted without testing documentation.
 - Plastic buckles of any type are not permitted.
 - Tensile tests performed on a minimum of 5 samples must show a 95% statistical confidence of an ultimate strength in excess of 3340 N.
- F) *Exemptions* Any team may request an exemption from rule **Section III.D** and/or **Section III.E** using the Section XVII Appendix 5: HPVC Safety Exemption Request Form. The request must be based on the safety of the driver or general public, and must be submitted in writing to the Head Judge no later than the Entry Date. The request must convincingly argue that safety is enhanced by omitting the safety harness and/or the RPS. Waivers will generally not be granted for fully faired vehicles, recumbent vehicles, or vehicles with three wheels. Requests for waivers will be granted or denied by the judging committee, and their decision will be final and without appeal. Without a waiver granted by the judging team, teams without the RPS and/or safety harness will not be able to compete in any racing event.
- G) *Vehicle Hazards* All surfaces of the vehicle—both on the exterior and in the interior in the region of the driver(s) and in the access area—must be free from sharp edges and protrusions, open tube ends, screws protruding more than three threads, and other hazards. All drivetrain components, steering components, and wheels must be fitted with appropriate guards if within reach of the rider and must be designed and constructed so that they will not injure the rider in the event of an accident.

H) *Clothing and Protective Equipment* All participants must wear fully enclosed shoes (entire foot is covered), appropriate clothing and properly fitting helmets with fastened straps that meet CPSC Safety Standard for bicycle helmets (16 CFR Part 1203) or equivalent while:

- Warming up or orienting themselves on any event course,
- Riding in the Sprint or Drag Race, Endurance Event, and safety check, and
- Riding any competing vehicle or other human powered vehicle on or in close proximity to an event course.

Note that this requirement applies to all participants riding any HPV or bicycle, including personal vehicles.

I) *Required Safety Test of Energy Storage Devices*

Vehicles that utilize energy storage devices shall specifically address the safety of the device or system in the design report and during the safety inspection. In particular, safety in the event of a high-speed accident shall be addressed. Teams whose vehicles present an unacceptable risk in the perception of the judges will not be allowed to utilize the energy storage device in the competition.

J) *Safety Certification*

Participating teams must certify (HPVC Safety Certification) that:

- The design and construction of their respective vehicles have been carried out with due consideration of occupant and bystander safety.
- The specified safety tests will have been completed before arrival at the competition.
- All drivers and stokers will have had no less than 30 minutes of riding experience in their vehicle prior to the competition. Each team shall present a ride log at registration that clearly indicates the operator's name, date, duration in hours and minutes, and location for each ride or vehicle test used to satisfy the safety certification requirement.

K) *Safety Inspection and Demonstration*

A competition official shall oversee tests of each vehicle's ability to meet the braking, turning and forward motion requirements. Each vehicle shall be visually inspected by the judges to ensure that no hazards exist that are likely to cause harm to the driver, passengers, competitors or spectators. Potential hazards include but are not limited to defects or play in the steering system, sharp edges, protruding bolts, open tube ends, and pinch points. In addition, the vehicle must provide the driver with a forward-facing field of view of at least 180° wide.

The rollover protection system must appear substantial and correctly installed. The tallest driver on the team must sit in the vehicle with safety harness locked and demonstrate the roll bar assembly extends beyond the driver's helmeted head and shoulders.

The safety check will take place during the scheduled safety inspection time block. No vehicle will be allowed to participate in any race unless it has successfully completed the safety check. It is expected that teams evaluate the safety of their vehicles **before** they arrive for the safety inspection. This includes the mitigation of all safety hazards (Section III.G) as well as performance safety requirements (Section III.B). All teams will be granted at least one attempt at a successful safety evaluation, but any team that fails the safety inspection may make a request to the safety judge for a re-inspection at a later time. Such re-inspection will be granted at the sole discretion

of the safety judge based on available time. If the re-inspection occurs after the designated inspection time block for that team, the team may be assessed a design score penalty up to 10%. Note: if time does not permit a team to complete their safety inspection they will not be allowed to race until a re-inspection time has been scheduled and the inspection has been completed successfully.

L) *Performance Safety Video*

One week before the race teams will submit a short video (maximum 2 minutes) showing their HPVs completing the three performance safety requirement tests (Section III.B). This video can be very brief as it must only show the vehicle completing the tests, or if the tests cannot be completed successfully, teams must briefly explain how they will modify their vehicles to pass by the date of the race. To conduct the tests a crude test set up and a visual estimate for vehicle speed will be acceptable.

The video will be submitted to an official ASME HPVC database (a link will be posted to the competition website to submit the video file) for review by the judging team. Video files must be less than 500MB and in mp4 format

M) *Modifications Affecting Safety*

Modifications to vehicles between events of the competition must not compromise the safety of the vehicle. If the competition officials determine that any modification has reduced the safety of the design to an unacceptable level, the vehicle will be disqualified from the affected event of the competition.

N) *Disqualification of Unsafe Vehicles*

The competition officials reserve the right to remove, from the competition, any vehicle that is judged to be unsafe by any metric. Riders must always be in control of their vehicles. Loss of control of a HPV such that it poses an immediate safety risk to the rider, spectators, or any other person(s) may constitute immediate suspension barring said vehicle or specific riders from further racing of the HPV in that event and subsequent events. This determination will be made by the Head Judge, in consultation with the Judging Team and ASME staff, and will be final. This includes consideration of a vehicle's perceived performance under prevailing weather conditions.

Petitions for a disqualified vehicle or rider to be reinstated into the competition can be made on the grounds that safety concerns have been corrected, or on a rider-by-rider qualification that will be conducted to prove that he or she can handle the vehicle to the satisfaction of the judging team. The considerations to reinstate removed vehicles or riders will be made by the judging team if sufficient time is available and will not be made if it impedes the function of the judging staff during an ongoing event. There is no guarantee that a disqualified vehicle or rider will be reinstated and all decisions by the judging team will be final.

O) *Fouls and Penalties- Speed and Endurance Events*

The competition officials reserve the right to remove, from the competition, any vehicle that is judged to be unsafe by any metric. Riders must always be in control of their vehicles. Loss of control of a HPV such that it poses an immediate safety risk to the rider, spectators, or any other person(s) may constitute immediate suspension barring said vehicle or specific riders from further

rating of the HPV in that event and subsequent events. This determination will be made by the Head Judge, in consultation with the Judging Team and ASME staff, and will be final. This includes consideration of a vehicle's perceived performance under prevailing weather conditions.

Petitions for a disqualified vehicle or rider to be reinstated into the competition can be made on the grounds that safety concerns have been corrected, or on a rider-by-rider qualification that will be conducted to prove that he or she can handle the vehicle to the satisfaction of the judging team. The considerations to reinstate removed vehicles or riders will be made by the judging team if sufficient time is available and will not be made if it impedes the function of the judging staff during an ongoing event. There is no guarantee that a disqualified vehicle or rider will be reinstated and all decisions by the judging team will be final.

IV. Entry and Registration

A) *Team Eligibility*

Entry in the Human Powered Vehicle Challenge is open to teams from any college or university with an engineering program.

B) *Team Member Eligibility and Certification*

All members of the respective school's team must be enrolled as full-time students in an engineering program of study at that school. Any individual that is currently a full-time student in an engineering program of study, enrolled for the next upcoming semester/quarter, or has been enrolled for the previous semester/quarter, but graduated no earlier than six months prior to the competition date, is eligible to fully participate in the ASME HPVC.

All team members must be registered individually for the competition before the deadline and provide their names, ASME membership numbers (if available), and academic majors.

In addition to registration, drivers must also submit a ride log electronically before the posted deadline to be eligible to compete. Only those individuals thus identified will be allowed to participate as vehicle drivers at any time during the competition. **No driver shall compete in multiple entries in any single racing event.**

C) *Verification of Team Rosters*

ASME may, at its discretion, submit a copy of any team's roster of drivers to the respective school's registrar's office for verification of enrollment and academic major.

D) *Vehicle Design, Analysis, and Construction*

The research, analysis, and design of all vehicles entered by a school must be performed solely by current students at that school. All student team members shall be listed on the team's certified roster. Construction of the vehicle may include the assistance of outside vendors where the required capabilities exceed those available at the school.

E) *Driver Requirement Exceptions*

All racing events require that teams have at least one complete crew of each gender. Significant penalties are incurred for teams that do not meet this requirement, as described in the rules for each event. An exception to the eligibility rule may be granted to allow drivers to compete for a

school other than that in which they are enrolled, as described below. No other exceptions will be allowed.

If a participating school's roster cannot support at least one complete crew of each gender, that school may request the voluntary participation of one or more drivers from volunteers in attendance provided that the volunteer 1) meets all eligibility requirements from rule IV B and 2) will not participate in the same event for any other team. The requester must submit a written request for a waiver of the rules for this purpose to the Head Judge for approval prior to the start of the applicable event. Scores derived in this manner will be credited to the requester.

F) *Submittal of Final Entries*

Final entries must be received by the published entry date and must include the following:

- A completed entry form (with online registration)
- The registration fees (with online registration)
- Identification and certification of eligibility of team members (with online registration)
- A signed certification of vehicle safety (with online registration)
- If required, a Safety Exemption Request (HPVC Safety Exemption Request Form [Appendix 5])
- An acknowledgment of understanding of the rules, or requests for clarification or variance (with online registration)
- A description of the vehicle (submitted online with Design and Innovation reports)
- A top level 3-view engineering drawing of the vehicle (Attached to Design report)

G) *Late Entries*

At its sole discretion, ASME may consider entries received after the entry date.

H) *Entry fees*

The entry fees for the competition may differ depending on site. The specific fees will be outlined on the competition website.

I) *Refund of Entry Fees*

If an entry is not accepted, all fees will be returned. If a school requests a cancellation of an entry and refund of the entry fee before the registration deadline, a full refund, less the non-refundable processing fee, will normally be made. No refunds of registration fees will normally be made after the registration deadline.

ASME may decline to refund any or all entry fees in the case of (1) cancellation of the competition for reasons beyond its own control, (2) non-receipt of the full entry fee by the final entry deadline, or (3) submittal of an entry by an ineligible school.

J) *Notification of Acceptance*

Notification of acceptance of registration will be sent within one week of receipt of the final Entry Date.

K) *Competition Information*

The following information, or a URL for a website that contains this information, shall be provided to each approved:

- A vehicle number
- List of deadlines
- On-site registration location and time
- A map showing the location of the various events
- A schedule of events
- Location and time for the Design event
- A course map for the Sprint or the Drag Race event, as appropriate
- A course map for the Endurance event

L) *On-Site Registration*

All competitors must register on-site with ASME staff before participating in the competition. Registration location and time shall be provided to teams at the time of acceptance, or on the competition website.

During the on-site registration process teams may:

- Request changes in the team roster for verification
- Receive identification for each team driver (arm stamp, wrist bracelet, etc.)
- Receive two decals to display their assigned vehicle numbers and ASME logo
- Receive a final schedule, including times, locations and other event information.

M) *Late registration*

Late registration will only be possible if prior arrangements have been made with ASME, at least one week in advance of the competition start date.

V. Design Event

A) *Objective*

To demonstrate the effective application of established principles and practices of design engineering to the development of the team's vehicle.

B) *Description*

The Design Event includes four parts:

1. Design report submitted in advance of the competition
2. Safety video submitted to the Judging Team (See III.L Performance Safety Video)
3. Design presentation to the Judging Team during static inspection (See V.I Presentations)
4. Safety and static inspection by Judging Team

Failure to submit a design report will result in non-evaluation of a team's design presentation during static judging. If a team fails to complete any part of the design event, their vehicle will be judged as a non-participant. This condition will not affect the vehicle's participation in the other events, provided that the vehicle successfully completes the safety inspection.

C) *Design Report*

The report should concisely describe the vehicle design and document the design, analysis, and testing processes and results. The report should have the character of a professional engineering report and should be organized as described in Section V.D.

Reports should emphasize clarity both in presentation and in the statement of results and conclusions. Photographs and drawings are encouraged where beneficial in documenting unique features of the design.

The design report must clearly display the vehicle number on the cover page.

Design reports shall use 12 point Calibri font, single line spacing within paragraphs and double line spacing between paragraphs. Major headers shall be 14 point Calibri Bold, left justified. Margins shall be 1 inch top, bottom, left, and right. All figures and tables shall include a caption in 10 point Calibri italic font. Avoid watermarks and graphics that obscure text legibility.

Report writers should note that bulk is not a desirable feature; therefore, reports have a **26 page maximum limit**. (The limit includes the following sections: Design, Analysis, Testing and Conclusion. Required ASME Report Cover Page & Vehicle Description, the 3-view drawing, the abstract, and references will not be included in the page count. Penalties will be levied for exceeding the page limit (See Section V. M). Additionally, judges will not consider any page beyond the 26th.

A copy of the judges score sheet is included in Appendix 2 of these rules. Teams are strongly encouraged to carefully read the score sheet prior to writing the design report.

Teams are expected to comply with ASME's Code of Ethics in the creation of their reports.

D) *Design Report Organization* The design report shall be organized as follows:

- | | | |
|------|---|--|
| I. | ASME Report Cover Page & Vehicle Description Form | No page number |
| II. | Title Page | No page number |
| III. | 3-View Drawing of Vehicle | No page number |
| IV. | Abstract | Page i |
| V. | Table of Contents | Page ii |
| VI. | Design | Page 1, First page that counts towards limit. |
| | a. Objective | |
| | b. Background | |
| | c. Prior Work | |
| | d. Design Specifications | |
| | e. Concept Development and Selection Methods | |
| | f. Innovation | |
| VII. | Analysis | |
| | a. RPS Analyses | |
| | b. Structural Analyses | |
| | c. Aerodynamic Analyses | |

- d. Cost Analyses
 - e. Other Analyses
- VIII. Testing
 - a. Developmental Testing
- IX. Conclusion
 - a. Comparison – Design goals, analysis, and testing
 - b. Evaluation
 - c. Recommendations **Last numbered page, Last page that counts towards limit.**
- X. References

E) *Design Report Content*

Content of each section should be in accordance with the design report score sheet (see Appendix 2).

- a. ASME Report Cover Page & Vehicle Description Form The first page should be the completed ASME Report Cover Page & Vehicle Description Form, available in the appendix of these rules
- b. Title Page The title page should include the report title, vehicle number (assigned by ASME), names of team members including contact information for two designated team members, and the name and contact information of faculty advisor.
- c. 3-View Drawing of Vehicle Include a drawing of the complete vehicle with at least front, top, and side projections. Key dimensions such as wheelbase, track, overall length and overall width should be included. Drawings to follow ASME Y14.5 and related standards such as ASME Y14.24 and ASME Y14.3
- d. Abstract The abstract should give a clear summary of the objectives, scope, and results of the vehicle design. It should be limited to no more than 300 words.
- e. Design The Design section should include an overall description of the vehicle with appropriate background information, design objectives, design criteria, and design alternatives that were considered. It should clearly demonstrate that established design methodologies, including structured design methods and engineering principles, were effectively used during the vehicle design process. Sub-sections include:

Objectives Clearly state the objectives and design mission of the vehicle

Background Include supporting research and review of prior art. Provide background information to justify your objectives, mission, design approaches, and design concepts. Background research should include specific information found/used to aid in design and development of the HPVC, but should not include your team's general competition history. Appropriate background research can include information found on HPV development, aerodynamics, HPV standards (such as ISO or Federal), competitive vehicles, etc. Cite references as appropriate.

Prior Work Clearly document any design, fabrication, or testing that was not completed in the current academic year. If teams reuse work from previous years and it is not listed here teams will be assessed a penalty for reusing content.

Design Specifications Provide the design specifications for the vehicle. Tables and bullets may be used. Also provide rationale or justification for the specifications as appropriate. Document methods (such as QFD) used to develop the specifications.

Concept Development and Selection Methods Document the use of established concept development and selection tools such as the Pugh's Concept Selection Technique, etc.

Innovation Describe aspects of the vehicle design that are particularly innovative.

Description Describe the final vehicle design, making generous use of drawings and figures. Describe how the vehicle can be practically used, what environmental conditions (weather, etc.) were addressed and how components and systems were selected or designed to meet the stated objectives.

- f. Analysis The analysis section summarizes the engineering evaluation of the vehicle's performance and structural viability as related to the design criteria outlined in the description. **For each analysis documented, the objective, modeling method & assumptions, results, and conclusions should be clearly indicated.** Conclusions should describe how the results were used to improve the vehicle, i.e. what changes were made as a result of the analysis.

Each sub-section should include a table summarizing all analyses completed in that section. The summary should include objectives, methods, and results. In addition, provide selected examples of specific analyses in sufficient depth to allow judges to evaluate the technical correctness of the analysis. The analysis section should include the following sub-sections.

RPS Analyses Document the structural analysis of the rollover and side protection system. This section must convincingly demonstrate that the RPS is fully compliant with Section III.D of these rules in order to obtain full points.

Structural Analyses Document structural analyses conducted on the frame or mechanical components. Specify objectives, load cases, methods, and results. FEA is an appropriate tool, but not the only tool, used for structural analyses.

Aerodynamic Analyses Document aerodynamic analyses, including drag estimates, conducted on fairings, aerodynamic devices, or other components. CFD is an appropriate tool for aerodynamic analyses.

Cost Analysis Provide a tabulated cost analysis of the HPV. The cost analysis should include capital investment, tooling, parts and materials, and 3rd party labor costs, but not student labor costs.

Other Analyses Document other analyses conducted during the design process, including power/speed modeling, vehicle handling, stability, steering, suspension kinematics & dynamics, optimizations, etc.

- g. Testing The testing section documents physical tests and/or experiments conducted to develop or verify the design. **For each test, the objectives, methods, results, statistical analysis of data, conclusions, design modifications, and comparisons to product design specifications should be clearly described to acquire full points.** Test results should be compared with design specifications and analytical predictions and should document design changes/validations driven by said results. Sufficient examples should be included to demonstrate the extent to which physical testing was used during the design process. This section should include the following sub-section:

Developmental Testing Document physical testing conducted to develop or optimize the vehicle design. This testing is usually done early in the design phase to aid in the design process. Include objective, methods, results, and conclusions. Examples of developmental testing include, but are not limited to testing weld quality, composite materials, RPS mock up, and prototype sub systems.

RPS and Performance Testing results will be presented with safety information at the live presentation during the static judging and **not in the design report.**

- h. Conclusions Demonstrate that the design team completed a substantive evaluation of the vehicle design. This section should include the following subsections:

Comparison Use a table to compare the vehicle design specifications with analytical performance predictions and experimental results. Were design objectives met?

Evaluation Describe how the final vehicle was evaluated with respect to the objectives and design specifications.

Recommendations Document any recommendations for future work on the vehicle, including but not limited to modifications and improvements.

F) *Prior Work*

Design credit will only be given for work done during the current academic year. The report should clearly indicate if the documented design work is for a new vehicle design or improvements to a previous design. To be considered a new design, the vehicle must be substantially different from previous or additional entries (in the event a school is submitting multiple entireties into a single competition) by that team or school. A substantially different vehicle has a significantly different objective, or has a significantly different design solution. It is acceptable to advance and refine the design of an existing vehicle, but the new developments must be clearly differentiated from prior work. In the event that the design is not a completely new design, the report must clearly identify which features of the design are new and what new analyses, tests, etc., were performed to verify the design changes. Scoring is based solely on the current year's work and design points will not be awarded for design work done in previous academic years.

Unoriginal content, including content generated from other teams or previous years and not cited, may be assessed a penalty for plagiarism.

G) *Design Report Submittal*

The design report must be submitted electronically to ASME no later than the report due date. The report due date is normally 45 days prior to the competition and will be announced by ASME well in advance. See the competition website for dates and instructions specific to each competition.

H) *Late Reports*

Design reports will be accepted up to 25 days past the published Report Date, subject to a 4% penalty per day the report is late. Teams that do not submit reports within 25 days after the Report Date will not be eligible for participation in the design event.

I) *Design Presentation*

- a. Objective The design presentation gives teams an opportunity to provide RPS & performance testing results and any updates following the design report.
- b. Description During the design presentation teams are to **present their RPS & performance testing results, safety analysis** and any design updates since the submission of the design report. The presentation will take place during the static judging of the vehicle and should be accompanied by supporting material and visuals of testing results (See V.I.g). As the judges walk around they will visit each team individually, but other teams are encouraged to watch as many presentations as they would like.
- c. Time Limit Design presentations will have a maximum time limit of 6 minutes followed by a maximum of 3 minutes of questions from the judges.
- d. Content & Scoring Presentations will be scored by the same judges whom scored the submitted design reports. Teams will present their RPS & Performance Testing results as well as their safety design and hazard analysis. Any additional information which is typically included in a technical presentation, such as the general design of the vehicle must be omitted. Only information regarding the testing and safety of the vehicle will be scored.

Note: Scores for all other sections of the design report will not be updated during the presentation so it will benefit teams to focus specifically on testing and safety

e. Testing

RPS Testing Physical testing of the RPS system should be documented and presented, including test set up, results and conclusions. This includes the testing of the entire RPS and not just the roll bar. Teams must treat the entire system from the rider to the ground as the RPS to achieve full points; including the seat, safety harness, attachment hardware and roll bar.

Performance Testing Document physical testing done to verify vehicle performance. This testing must be conducted on the final version of the HPV or a prototype with similar

properties of the system being tested. Document and present your objectives, methods, results and conclusions. Examples of performance testing include, but are not limited to, testing final vehicle performance capabilities, final frame geometry on prototype frame and aerodynamic testing on finished fairing.

- f. Safety Teams are to conduct an analysis of potential hazards and how the team addressed safety of the 1) vehicle occupants, 2) bystanders and 3) vehicle builders during the construction of the vehicle (i.e. shop safety).

Features, components and systems designed to mitigate hazards should be described. Of particular interest is how established engineering principles were used to design safety systems. Teams must also address how their design protects the rider's head and appendages such that they do not contact the ground in the event of a crash where the vehicle falls over or inverts.

Teams are required to have at least one additional safety feature of their choosing which improves the safety of their specific vehicle design/configuration. The need, quality and perceived performance of the execution of this safety feature will be evaluated to determine points awarded.

At the time of safety inspection teams must have a functioning bell/horn, headlight, taillight, side reflectors and rearview mirror(s) in order to achieve points for safety accessories.

- g. Supporting Material and Visuals Supporting material is encouraged; acceptable media includes posters, photographs, charts and other visuals. Live videos, photographs, data, and other digital visual media will be allowed, but teams are required to bring their own devices to display the information and electrical power may not be provided. Test data should be tabulated in the supporting material clearly outlining the results and conclusions of the test.

J) *Static Judging*

During the design presentation and prior to the start of the safety inspection vehicles will be statically inspected. Vehicles will be visually inspected based upon the following items:

- Physical characteristics
- Design features
- Safety features
- Consistency with report
- Safety
- Aesthetics

K) *Vehicle Display*

A designated time block will be set aside for a required public static display of the competing vehicles. At least one team member must be present with the vehicle at all times. During the static display time, it is expected that other participants, spectators and the competition officials will tour the display area. The judges may also review the display and inspect the design features of any vehicles for which a design report was not received.

L) *Design Scoring*

Design scoring is based on the extent to which established engineering design principles were applied in the design process and the effectiveness of the design practices used. Scores will also reflect the effectiveness of the report and presentation in communicating the design process and solution. Design teams must address each of the specified topics in order to receive a score for that topic. Design scoring for all vehicles shall be as follows:

Subject Area	Points
General	5
Design	15
Analysis	25
Testing	25
Safety	20
Aesthetics	10
Total	100

M) *Design Score Penalties*

In addition to those previously described, penalties may be imposed by the Judging Team for failures to comply with the rules of the Design Event. Penalties will be assessed according to the following table in cases where an unfair advantage might have been gained or the Judges' ability to evaluate a design has been compromised.

Rules Infraction	Maximum Penalty
Report content largely non-original	Event Disqualification
Late report submittal	4% per day
Late for Static Judging or Safety Check	10%
Late submittal of performance safety video	0.5% per day (Maximum of 12.5%)
Performance safety video over time limit	5%
Over Page Limit ("non-participant" at 26 pgs over)	3% Per Page
Report does not conform to required outline	10%
ASME Report Cover Page & Vehicle Description	
Form missing from 1 st page or incomplete	5%

N) *Overall Design Scoring*

The judges will compile the design scores including any penalties on a total points basis. The event score is given by

$$\text{Points} = \left(\frac{\text{Team Design Score}}{\text{Maximum Possible Design Score}} \right) \times \text{Maximum Event Points}$$

Where the Maximum Possible Design Score is the maximum points possible according to the Judge's Score Sheet, and the Maximum Event Points are given in Section X.

VI. Innovation Event

A) Objective

- 1) To encourage innovation that advances the state of the art in human powered vehicles
- 2) To provide teams an opportunity to demonstrate significant technological innovations

B) Description

The Innovation Event includes two parts:

1. Innovation report submitted in advance of the competition
2. Innovation video submitted two weeks in advance of the competition (See VI.E Presentation)

This event provides teams an opportunity to present a documented functional demonstration of a key innovative feature of the design that advances the technology of human powered vehicles. The innovation may be related to vehicle systems, performance, manufacturing methods, safety or other vehicle areas. Though vehicles may implement as many innovative features on their vehicles as they chose, **only one innovation may be selected to be scored in the innovation event.** Innovation is a process and cannot be executed with a single iteration therefore teams will be awarded significant points for the process of developing their innovation including prototyping and documenting their learnings. An overall score multiplier will be granted based the novelty and difficulty/depth of the innovation challenge. Teams provide a detailed description of their innovation in their innovation report which is to be submitted concurrently with the design report. The innovation will be scored on design, concept evaluation (prototyping), learning, and execution.

C) Definition of Innovation

- 1) Innovation is the introduction of a previously unknown, unusual, or unfamiliar product, process, material or method, or the alteration of an established product, process, material or method by introducing new elements, forms or processes
- 2) Innovations related to any aspect of human-powered vehicles are encouraged, including vehicle performance, manufacturing & materials, human physiology, safety, and ergonomics

D) Report

Teams shall submit an Innovation Report. The Innovation Report is due on the same date as the Design Report, but should be submitted separately as a standalone document. (Note: This report will not count toward the page limit for the Design Event.) A copy of the judges score sheet is included in Appendix 3 of these rules. Teams are strongly encouraged to carefully read the score sheet prior to writing the design report. The report should be no more than 3 pages in length, but must include a title slide and should contain the following sections:

- 1) ASME Report Cover Page & Vehicle Description Form No page number
- 2) Title Page No page number
- 3) **Design First page that counts towards page limit**
 - (a) New Idea (score multiplier) - Students must provide clear evidence that they have developed a truly innovative and new idea. This can be bolstered by a high level of difficulty/depth of the innovation, and conversely trivial/banal innovations will not earn a high multiplier.

- (i) Previous examples of a high level of difficulty or depth in innovations include some typical designs like manufacturing methods for improving material properties in composite layups, active safety features (such as airbags), or alternative storage (such as ultra-capacitor) regenerative braking energy storage.
 - (ii) Examples of a low level of difficulty or depth in innovations include some typical designs like a solar powered USB charger, a tool storage solution, or an integrated GPS or communication system.
- (b) Need- Describe the need addressed by this innovation. Why is it significant?
- (c) Advancing the Art of HPVs- Students must clearly show that the innovation has benefits, which can be performance, ergonomics, cost, environmental, social, etc.
- (d) Technology and Concept Feasibility Study- Students must clearly demonstrate that the innovation is feasible, and does not require a violation of the laws of physics or the use of an unavailable process or material. Students must also show that the proposed embodiment of the design is feasible. In other words, the concept will work?
- 4) Concept Evaluation- **Note: To achieve points a prototype must be constructed before constructing the final version of the innovation. A small scale test, materials testing, subsystem test, or full sized prototype are all acceptable to meet this requirement, but a purely analytical/theoretical analysis will not be accepted.**
 - (a) Prototype Functionality Evaluation- Does the prototype do what was intended? This is not an evaluation of how well it performs, but a validation of the design concept.
 - (b) Benefit Study- Students must provide data to show how effectively the prototype achieved the anticipated benefits in question 3.c
 - (c) Unanticipated Benefits- Students must provide data to show how effectively the prototype achieved unanticipated benefits. Often the proposed benefits are not as important as unanticipated benefits.
- 5) Learnings
 - (a) Failures- Students should document what did not work -- concepts that turned out to be infeasible (why?), prototypes that did not work (why?), and unanticipated difficulties.
 - (b) Learning from Failure- Students should document how failures were used as stepping stones to subsequent successes.
 - (c) Negative Aspects of the Design- Students should clearly identify and if possible quantify unanticipated negative aspects -- increased cost, regulatory restrictions, negative environmental aspects, etc. **Last page that counts towards page limit**
- 6) References- List all references and patents cited in the literature review

E) *Innovation Video Presentation*

- a. Objective Teams will produce a short video showcasing the final functioning version of their innovation presented in the innovation report
- b. Description Two weeks before the event, teams will submit a video that supplements their innovation report. This is an opportunity to demonstrate the functionality of each team's final innovation prototype and any evaluation & learnings that have been found since the submission of their innovation report
- c. Time Limit The innovation video presentation is limited to 3 minutes in length including introduction, demonstration, discussion and closing remarks

- d. Content & Scoring Videos will be scored by the same judges whom scored the submitted innovation reports. Teams will showcase any changes and learnings, but most importantly teams will demonstrate the efficacy of their final prototype by which the judging team will be able to evaluate its performance. Innovation video and report are scored together in the same rubric
- e. Formatting & Evidence Teams may dictate the method/structure of which the demonstration and results data is conveyed in the video, but at a minimum teams must show an unobstructed and unedited view of the innovation functioning to its best ability
- f. Video Submission & Publication The Innovation video presentation will be submitted to an official ASME HPVC database (a link will be posted to the competition website to submit the video file) for review by the judging team. Following the same protocol as the written reports, after completion of the event videos will be made public for the betterment of the HPVC as a whole. Video files must be less than 500MB and in mp4 format

F) *Innovation Score Penalties*

In addition to those previously described, penalties may be imposed by the Judging Team for failures to comply with the rules of the Innovation Event. Penalties will be assessed according to the following table in cases where an unfair advantage might have been gained or the Judges' ability to evaluate a design has been compromised.

Rules Infraction	Maximum Penalty
Report content largely non-original	Event Disqualification
Late report submittal	4% per day
Late video submittal	1% per day (Maximum of 25%)
Over Page Limit (3 pgs)	3% Per Page
Video over time limit (3 minutes)	10%
Report does not conform to required outline	10%
ASME Report Cover Page & Vehicle Description	
Form missing from 1 st page or incomplete	5%

G) *Scoring*

Teams will be scored out of 28 possible base points and an overall score multiplier, based on the following criteria:

- 1) Points are awarded based on the following three areas
 - (a) Multiplier 1x to 2x multiplier
 - (b) Design 7 points
 - (c) Concept Evaluation 8 points
 - (d) Learnings 7 points
 - (e) Execution 6 points

Scoring breakdowns are detailed in the innovation score sheet document which can be found in Appendix 3 of these rules

- 2) Score in the Innovation Event is the total points earned divided by the total possible points, expressed as a percentage:

Team Raw Score = Team Innovation Multiplier * \sum Team Points Earned

$$\text{Points} = \left(\frac{\text{Team Raw Score}}{\text{Maximum Possible Raw Score}} \right) \times \text{Maximum Event Points}$$

Where the Maximum Possible Raw Score is the maximum points possible according to the Judge's Score Sheet, and the Maximum Event Points are given in Section X.

VII. Speed Event (Sprint or Drag Race)

The competition will include either a sprint or a drag race format. The type of race will be determined and announced well in advance of the competition at the discretion of the Judging Team and host school. Separate speed events are held for men and women.

Please note, during the speed event **no outside assistance may be given to the driver(s) of any HPV.**

A) *Sprint Race*

a. *Objective*

To provide teams the opportunity to demonstrate the top speed of their vehicles.

b. *Description*

The Sprint Event is an individual, timed event with a flying start to achieve top speed on a closed course. Each team shall include multiple drivers with separate scoring categories for both genders. The male and female sprint races shall be run concurrently.

c. *Sprint Course Description*

The course will consist of a straight, smooth, and level (less than 1% slope over entire course) paved surface of suitable width and clear of obstacles, pits, cracks, or potholes. The timed portion of the course shall be 100 meters in length, preceded by a 400 to 600 meter "run-up" section and followed by a "run-down" section at least 200 meters in length. Where possible, the length of the "run-up" should be maximized.

The beginning of the run-up shall be marked by a starting line. All vehicles in line for a run shall remain in a marked staging area until directed by the start line official to move to the starting line. The course will include a separate route for returning vehicles from the "run down" end of the course to the starting area.

While the course should be designed to completely avoid collision hazards, this may not be possible in all cases. Hay bales or equivalent cushioning material will be used to protect vehicles and drivers from collision with any fixed obstacles located adjacent to the course. Such cushioning shall reflect proper safety design with due consideration to the estimated speed of passing vehicles and their direction along the course.

The course shall be clearly marked to indicate the following points:

- Staging area
- Starting line
- Release line
- 300 meters to time trap
- 200 meters to time trap
- 100 meters to time trap
- 50 meters to time trap
- Beginning of time trap
- End of time trap
- End of course

As an alternative venue, a velodrome may be utilized to hold the sprint race. No distance markings will be used in the event of a velodrome race, but the 400 to 600 meter "run-up", 100 meter time trap, and 200 meter "run-down" lengths will be maintained when possible. Timing equipment and the starting line will be limited to the flat straight portions of the velodrome when possible.

d. Timing Area

The timing and scoring area, located at the end of the speed trap, will be off limits to spectators and all others except the competition officials and the event timing staff.

e. Tally Board

Vehicle speeds and standings shall be posted in a timely manner on a "tally board" or display for the benefit of competitors. The "tally board" will be separated from the timing area.

f. Drivers' Meeting

All drivers who will participate in the Sprint Event must attend the mandatory Drivers' Meeting at approximately 45 minutes prior to the scheduled start of the race. The meeting will clarify operating procedures and signals and will identify course features, hazards, and landmarks.

By the time of the meeting all team equipment, vehicles and other required items should be in place and clear of the track. Any team that is not represented at this meeting will normally not be permitted to participate in the event; in cases of unavoidable absence, the team may file an appeal with the Judging Team, whose decision regarding participation will be final.

g. Starting Order

The first round of sprint attempts will be assigned at random. Subsequent starts will be on a "first ready, first started" basis. Place holding in line is prohibited: a team is not considered ready unless both driver and vehicle are present and prepared to race. Teams will be notified of their staging order prior to the start.

h. Line Position Forfeiture

Each successive vehicle will have 15 seconds to begin a sprint attempt after the start line official has determined that the course is ready and safe for the event to proceed. If a vehicle is not ready

within the 15-second period, the vehicle must stand aside for others that are ready to proceed. In extreme cases, the vehicle will forfeit the run and must re-enter at the end of the line.

i. Start Assistance

Assistance is not permitted. The rider must be completely self-sufficient from the beginning of the run until the vehicle crosses the finish line. As always, assistance is permitted in the event of an emergency, but once assistance is given the run is forfeit.

j. Number of Attempts

During the Sprint Event, each vehicle will be allowed to make as many runs as time and conditions permit and all vehicles will be provided an equal opportunity to compete.

Although all competitors will have an equal opportunity to compete, there will be no assurance of an equal number of runs for all vehicles. Teams may take advantage of every opportunity to maximize their number of runs, or selectively pass opportunities. Such strategies should consider that foregone opportunities may not be regained.

Teams will be notified of race time remaining at 30 minutes, 15 minutes, and 5 minutes until the end of the race time. No team may make a run after the official end of race time.

k. Interruption and Termination

The Sprint Event will normally run continuously. However, circumstances such as equipment failures, an emergency or hazardous weather or wind conditions may require a delay or premature termination of the event. Delays or terminations will be determined by the Head Judge with the help of the judging team and the Competition Director.

l. Scoring

The Sprint Event is scored separately for each gender. Thus each vehicle will have two sprint scores: one for male drivers and one for female drivers.

The point score for each vehicle is based on the winning time for the event, that is, the fastest time of any vehicle in the event. Points are awarded based on the following formula:

$$\text{Points} = \frac{t_{\text{Winner}}}{t} \times (\text{Maximum Event Points})$$

Where t_{Winner} is the time of the winning vehicle, t is the fastest time of the event for a particular vehicle, and the Maximum Event Points is the point value for the event, specified in Section X.

B) Drag Race

a. Objective

To provide teams the opportunity to demonstrate the speed and reliability of their vehicles in a tournament format.

b. Description

The Drag Event is a tournament style race where two vehicles compete at a time from a standing start to be the first to cross a set finish line.

c. Duration and Timing

The Drag Event ends when both the Men's and Women's events are complete and champions have been determined.

Every effort will be made to run the event as quickly as possible. This includes starting sequential heats as soon as the course is clear and lining up upcoming competing pairs of teams as early as possible. An exception will be made for teams which need to race back to back during the quarterfinals or semifinals. If a team needs to race back to back a 10 minute rest period will be granted between the end of the previous race and the beginning of the following heat.

d. Drag Course Description

The drag race course shall consist of a paved level course typically between 350 to 450 meters (1148.3 to 1476.4 ft) in length. The course shall be at least six (6) meters (19.7 ft) wide at all locations. The surface shall be smooth and free of potholes, cracks, and debris. Curves are permitted on the course, which may be a closed loop (although a closed loop is not required).

The course immediately following the start and immediately preceding the finish line shall be straight, unless separate and equal length lanes are provided for each vehicle. If the course is not a closed loop there shall be a return path to the staging area.

The course may either be one shared course for both teams or a mirrored "rally track" style course where teams will turn in opposite mirrored directions. A head to head finish will still be prioritized with this configuration, but teams may diverge during the race with each team limited to their individual path. Each path will be as close to an exact mirror as possible with the layout, number of turns, turn radius, etc. being exactly the same. Where possible number of cones, signage, and other details will also be mirrored exactly.

e. Timing Area

The timing and scoring area shall be off limits to competitors, spectators, and all others except competition officials and the event timing staff.

f. Tally Board

If the race venue can support it, race results shall be posted on a tally board or computer monitor throughout the race. Results should be updated after each individual race, and should indicate the winners' and losers' brackets and race times.

g. Drivers' Meeting

All drivers who will participate in the Drag Race Event must attend the mandatory drivers' meeting for that event. The drivers' meeting shall take place approximately 45 minutes prior to the scheduled start of the race. The meeting will clarify operating procedures and signals and will identify course features, hazards, and landmarks.

Any team that is not represented at this meeting will normally not be permitted to participate in the event; in cases of unavoidable absence, the team may file an appeal with the Judging Team, whose decision regarding participation will be final.

h. Race Description

The Drag Race Event allows two teams at a time to race each other side by side from stationary at a starting line to a predetermined finish line.

The Drag Race Event is gender specific. Each driver shall compete against drivers of the same gender. Separate scores shall be kept for male and female drivers.

The drag race consists of two phases: qualifying and a double-elimination tournament drag race. All vehicles shall compete in the qualifying race. The vehicles with the fastest qualifying times shall compete in the drag tournament.

i. Qualifying Race

The event shall begin with the female driver qualifying race. After all female drivers have completed the qualifying race, the male qualifying race shall commence. In both male and female races, vehicles shall start in the order of vehicle number.

The maximum number of vehicles racing in each heat shall be at the discretion of the Head Judge, and will depend on the nature of the course and the available timing equipment (typically two). Each vehicle shall be timed separately. Qualifying race place is based on finish times.

j. Brackets and Seeding

The top 16 vehicles from the qualifying race will advance to the elimination rounds in each gender. If there are less than 16 vehicles, then the tournament shall consist of 8 vehicles. If the venue and time window allow more than 16 vehicles may be able to compete in the tournament, and the exact number of teams will be announced during the drivers' meeting.

After the first round of eliminations, the event is split into two brackets: the winner's bracket and the loser's bracket. At the end of each round, the losers in the winner's bracket move into the loser's bracket. The losers of the loser's bracket are eliminated from the competition. The championship race determines the winner of the event. In the event that neither championship contestant has two losses after the round, an extra race will determine the winner.

Seeding shall be based on qualifying time. That is, the first race shall take place between the vehicles with the first and last qualifying times, the second race between the second and next to last qualifying places, and so on.

Tournament seeding and sequencing may be modified by the Head Judge to account for event-specific circumstances.

k. Drag Race

All races in the drag tournament shall be between two vehicles. Vehicles will be instructed at the starting line of the race by a flagman. When both competitors indicate they are ready the flagman

will start the race by waving the flag. No verbal command is required therefore the drivers must be able to clearly see the flagman. There will be a finish line judge (if not a closed loop) who will determine the winner of the race.

Following the completion of the race, competitors must return to the staging area for succeeding elimination rounds. Once there, teams will be instructed by the staging area coordinator.

Event and race sequencing will be determined by the Head Judge and announced at the drivers' meeting.

Disabled vehicles at the start or during the race will have no more than 20 seconds to make repairs or they will forfeit the race. Disabled vehicles must clear the course as rapidly as possible.

l. Race Forfeiture

Vehicles must be in line and ready to start in turn. If a vehicle is not ready to start at their turn, they forfeit the race and either move to the loser's bracket or are eliminated from the race. If a vehicle is unable to start within 20 seconds of the start signal it must forfeit the race. Forfeiture in the qualifying race makes the vehicle ineligible to compete in the drag tournament.

m. Start Assistance

Assistance is not permitted. The rider must be completely self-sufficient from the beginning of the heat until the vehicle crosses the finish line. As always, assistance is permitted in the event of an emergency, but once assistance is given the run is forfeit.

n. Interruption and Termination

The Drag Race Event will normally run continuously. However, circumstances such as equipment failures, an emergency, hazardous weather, or wind conditions may require a delay. Delays or terminations will be determined by the Head Judge with the help of the Judging Team and the Competition Director. The Drag Race Event will end with the completion of the championship rounds for both genders.

o. Scoring

Scores for teams eliminated in the tournament shall be determined by the round in which the vehicle was eliminated. The place order for all remaining vehicles shall be determined by qualifying speed. Separate scores shall be maintained for each gender.

Scoring for teams that qualify in the tournament depends on the round in which they are eliminated from the tournament. See the table below for the example score breakdown for the tournament.

Table 1: Drag Tournament Scoring for 16 Teams

	Elimination Match							
Eliminated in Round:	Champion						20	12
		31			26	24	19	11
		30	29	28	25	23	18	10
							17	9
Place	1	2	3	4	5	7	9	13
Points	12.5	11.6	10.8	9.9	9.1	8.2	7.4	6.5

Teams that do not qualify for the tournament will be scored based on time obtained in the qualifying round, in accordance with the following formulas:

$$\text{Points} = \frac{t_{\text{Fastest Non-Qualifying Time}}}{t} \times (6.0 \text{ Points})$$

C) Fouls and Penalties

Fouls and penalties for the speed event are described in the general fouls and penalties Section IX

VIII. Endurance Event

A) Objective

To provide teams the ability to demonstrate the functionality, agility, utility and durability of their vehicles.

B) Description

The Endurance Event is a 2.5 hour, timed relay race with multiple laps around a closed course. Each team shall include multiple drivers **and both genders**.

C) Endurance Course

The Endurance Event shall take place on a closed-loop course at least 1.5 kilometers in length.

- The course shall be continuously paved with occasional patches of rough pavement or gravel typical of a public roadway.
- The course shall include turns in both directions and straight sections designed to demonstrate the advantage of the vehicles' aerodynamic features.
- Up and down grades shall be included if possible, with maximum grades on the course to not exceed 5 % uphill or 7% downhill. The maximum vertical distance climbed in one lap shall not exceed 30 meters.
- The course shall include a paved section with no obstacles that is at least 1.0 kilometers long.
- Individual laps should be approximately two (2) kilometers in length, again to the extent that the event site permits; in no case, however, may the lap length be less than 1.5 kilometer.

D) Start

The start of the race will be an unassisted LeMans style start

- (a) *Start Area* The start area shall accommodate a LeMans style start that includes a broad, straight section immediately preceding the start line. This area shall be wide enough to ensure a safe start. The start area will include a designated driver start area at least ten meters away from the vehicles parked in preparation for the start.
- (b) *Start Process* Start of the Endurance Event shall begin with all vehicles parked diagonally on one or both sides of the race course. Drivers will be positioned at least ten meters from their vehicle with a parcel of groceries positioned in front of the driver or adjacent to the vehicle. At the start signal, all drivers shall pick up the parcel, run to their vehicles, enter and buckle in, and then take off.
- (c) *Cargo* Start will include the pick-up and stowage of a grocery parcel that must be carried until the first grocery stop.
- (d) *Starting Order* Vehicles shall start each endurance race in the order of finish for the women's sprint or women's drag race. **Vehicles with no women's sprint or drag race score shall be placed at the end of the starting line-up.**
- (e) *Starting Driver* The starting driver may be of either gender and is subject to the minimum, maximum and single ride limits (See VIII). In other words, teams may start the race with their fastest driver regardless of gender.
- (f) *Mechanical Malfunctions at Start* Any vehicle that requires mechanical assistance at the time of the start must forfeit its starting position and safely exit to the side of the course; it may rejoin the event at the rear of the field of competitors when ready. Repair work that interferes with the safe and orderly start of an event may result in a penalty against the responsible team.
- (g) *Caution* Drivers shall use caution during the start to avoid accidents.

E) Pits

The course layout must include pit work areas, including safe entry and exit; room for the starting line-up; and a straight run of at least 100 meters between the starting line and the first turn.

- (a) *Pit Location* The pit area shall be located in an area adjacent to the course and shall begin not less than 30 meters and not more than 50 meters after the finish line. The pit area shall be located after, but in relatively close proximity to the start line.
- (b) *Pit Crews* Due to space limitations, no more than eight crew members (excluding drivers) will be allowed in the pit area for each team. Crew members may not be in another team's pit area without permission.
- (c) *Pit Stalls* Prior to the drivers' meeting, teams shall locate their pit stall. All equipment must be placed in the selected pit area prior to the drivers' meeting. During the race, all work in the pit area must take place within the selected pit stall and not in the pit lane. A typical pit stall is 2.6m x 4.9m in dimensions, but may vary as venues allow. (Failure to observe this rule will result in black flag penalties as described in VII Q.)
- (d) *Right of Way in the Pit Area* Competing vehicles have the right of way on the course and in the pit areas at all times during an event. Vehicles entering the pit area from the course shall have the right-of way over those returning from the pits to the course. Interfering with a competing vehicle in any way may result in a penalty assessment against the responsible team.

F) Start Assistance

No assistance shall be provided to any driver except in the pit area (except in emergencies). This includes, but is not limited to, picking up or launching a fallen vehicle, helping to steady a vehicle, helping the driver to remove a fallen or inoperable vehicle from the course (except in emergencies), giving water to a driver, picking up dropped parcel items, etc. The penalty for receiving assistance will be 500 meters deducted from the total race distance for each occurrence.

In the event that assistance is provided to a vehicle after a fall or accident, if the condition of the rider is questionable a judge or course marshal may hold the vehicle for 60 seconds in lieu of the 500 meter penalty. During the 60 second wait, the judge or marshal shall ascertain that the driver is mentally and physical prepared to continue the race.

Note: This rule does not prohibit team members or spectators from checking on the condition of the rider after an accident. If necessary, assistance may be provided to extract an injured or disabled driver or move a disabled vehicle off the course, but may be subject to the 60 second vehicle hold or 500 meter penalty.

G) General Obstacles

Course obstacles shall include:

- 1) A speed bump typical of a city street speed control device; speedbump added to course will have maximum height no more than 5cm (1.97"), but speed bumps of typical size already present on course (e.g. permanent asphalt speedbump) may go over this specification.
- 2) A stop sign, requiring a vehicle to come to a complete stop until signaled to proceed by the stop sign judge.
- 3) A tight hairpin turn of approximately 180 degrees with a maximum radius that does not exceed 8 meters (26.2 ft). Double hairpin turns are acceptable and encouraged if facilities permit.
- 4) A slalom section consisting of a series of tight turns as shown in Figure 2. Knocking a tennis ball off of a cone constitutes failure of the obstacle.
 - a. Passing is permitted in the slalom, but due to increased safety concerns (e.g. potential for instability, tight spaces, tight turns, etc.) passing must be done with the upmost caution and will be penalized heavily if an unsafe pass is made. Teams must make certain that there is clear room to pass and also alert the team being passed with the use of a horn or bell.
- 5) A section of rumble strip which will simulate a washboard road or cobblestone street. This will likely be constructed of 1.9cm x 8.9cm (1"x4") boards lying flat running perpendicular to the track on 66cm (26") centers and will be wide enough for two lanes of traffic through the obstacle.
- 6) Quick turn. As teams approach the quick turn they will be funneled into a single lane 3m (9ft 10") wide. Then each rider will be signaled to turn into a right lane or left lane by the quick turn judge when they reach the opening of the lane change delta. Teams will have to switch to the signaled lane within the 3.5m (11ft 6") length of the delta. If teams cannot make the lane change a center 3m (9ft 10") wide lane will be provided to allow for vehicles to continue on straight, but taking this lane or knocking down any cones constitutes a failure of the obstacle. Figure 3 shows the quick turn obstacle.

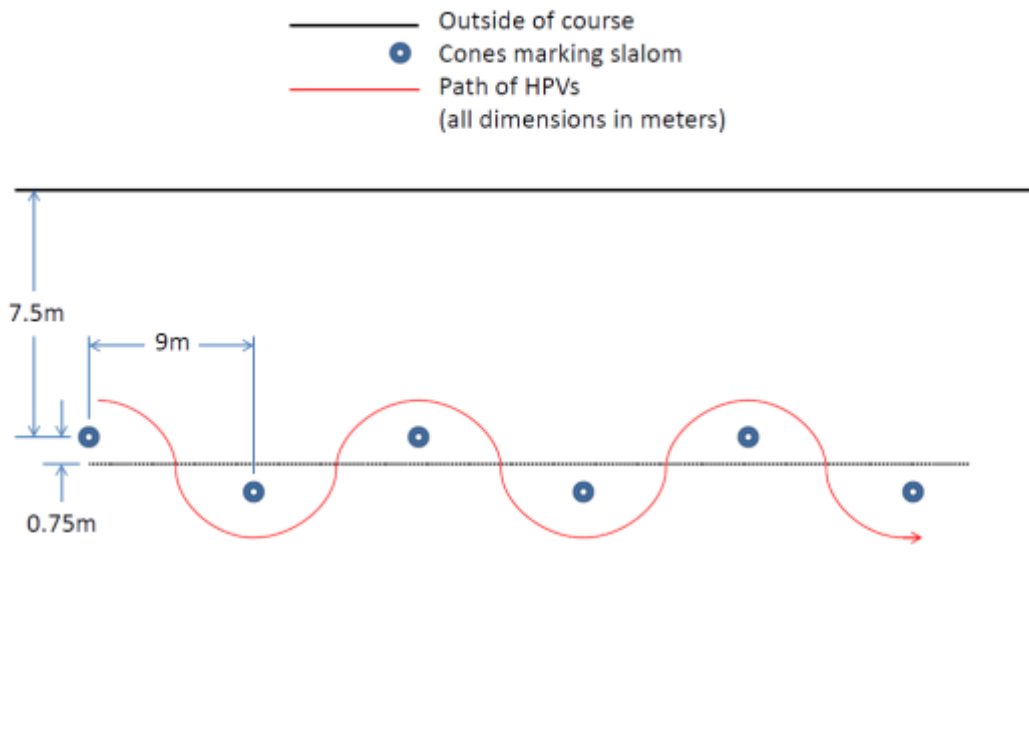


Figure 2: Slalom course (Note: actual layout subject to limitations of venue)

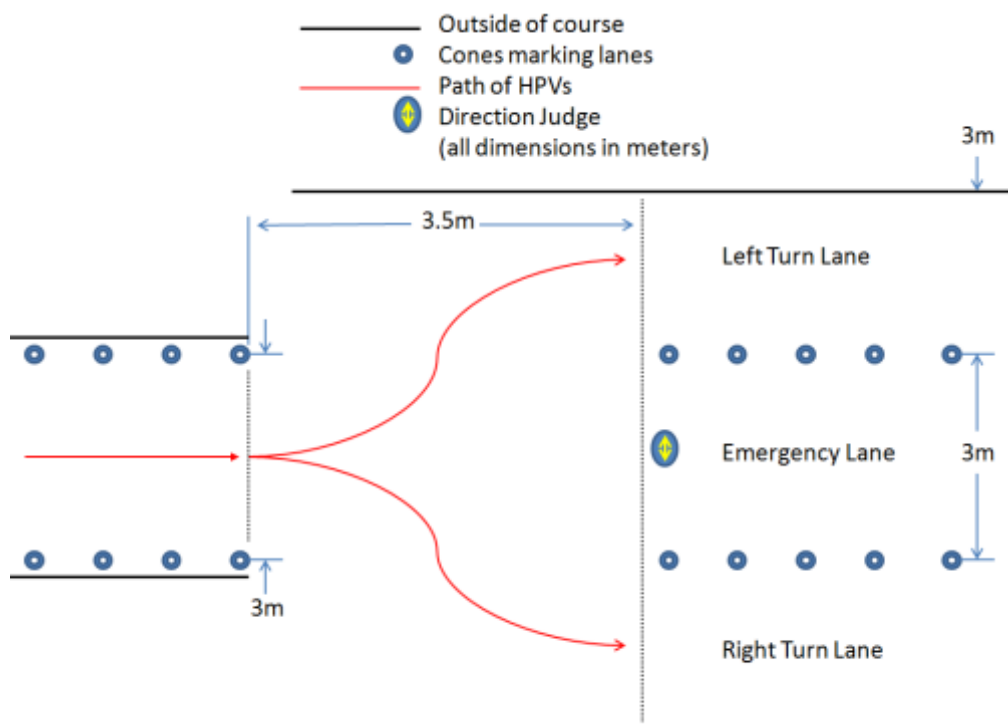


Figure 3: Quick turn obstacle (Note: actual layout subject to limitations of venue)

If possible all obstacles shall be located on the course such that at least one continuous kilometer is obstacle-free, but obstacles will be spread out enough to reduce traffic in and around obstacles if possible. Please note that actual obstacles used at the competitions may differ from described above due to venue limitations.

H) Venue Specific Challenges

Additional challenges and obstacles may be implemented at specific venues to challenge teams to develop further in the areas of practicality and robustness. Each host, in conjunction with the ASME judging staff, will select which specific challenges will be implemented; 1 to 3 venue specific challenges will be chosen for each HPVC. *Some challenges will not be announced until as late as the drivers meeting immediately before the race, but other challenges, which require substantial design accommodations, will be announced well ahead of time to allow for adequate preparation.*

1) Hillclimb- Low Grade (<5%)

A low grade hillclimbing challenge will be included as a portion of the full endurance lap and teams must complete the obstacle on every lap. Teams will be notified of the hill and approximate grade during the riders meeting.

2) Hillclimb- Steep Grade ($\geq 5\%$)

A steeper grade hillclimbing challenge will be an independent obstacle from a standard endurance lap. On a lap where a team elects to perform a hillclimb challenge; teams will proceed around the course as usual until they approach the entrance to the hillclimb obstacle. Teams will then enter the approach chute, gradually slow to a stop at the hillclimb start line and then proceed up the incline. Teams will continue upwards, reach the apex indicated by a marker, descend in a slow and controlled manner (walking speed), and finally come to a complete stop at the base of the hill before rejoining the course.

Teams must complete one hillclimb for every 5 total completed laps (rounding down). Only one hillclimb may be completed per lap, but hillclimb laps may be completed back to back, or spread out at team's discretion. For each team at least two different riders must complete a hillclimb challenge.

Teams that cannot climb the incline in the traditional manner in which they operate their vehicle may push their vehicle up the hill, assuming that they follow all other competition rules to complete the challenge. No outside assistance is allowed in making upward or downward progress on the hill.

Teams will be notified of the Steep Hillclimb challenge and approximate grade no later than 90 days prior to the event.

3) Low Light Endurance Challenge

The endurance race may be held in the evening or early morning at such a time that natural light is limited or nonexistent. Depending on the venue, artificial lighting such as street lights may or may not be present. This challenge is specifically intended to emphasize the lighting and visibility design needs for practical human powered transportation.

- a) This is a strictly additive challenge and all other rules and challenges of the endurance event are still valid
- b) All vehicles will be **required** to run a 300 lumen or greater white headlight and a 10 lumen or greater red taillight

- c) Safety judging will include special emphasis on lighting and visibility. Failure to meet safety, visibility, or lighting requirements during safety judging will disqualify a team from the low light endurance event.
- d) Vehicles may be pulled from the event if for any reason they are deemed unsafe for the low light conditions. This includes the loss of a headlight or taillight.
- e) The low light endurance challenge will be announced no later than 90 days prior to the event

4) *Weighted Trailer Challenge*

The trailer challenge will be an **optional challenge** that teams may elect to complete on a single lap of their endurance race. Teams will be required to stop, connect a weighted trailer, and complete a full lap. The bonus assessed will be based on the amount of weight elected to tow.

All teams intending to attempt the weighted trailer challenge must design onto their vehicle a trailer mount ring. The mounting ring shall be mounted horizontally and located at the rearmost location of their vehicle 350mm above the ground. The ring must measure 2 inch ID and 1/4" gauge such as ring 3564T26 offered on McMaster-Carr. The event hosts will provide a trailer that attaches to the trailer mounting ring. The unloaded trailer will have a mass of approximately 11.5kg (25.4lbm) and teams can elect to add up to 45.2kg (100lbm) in increments of 11.3kg (25lbm).

If a team decides to complete the weighted trailer pull lap they will proceed around the course as usual until reaching the trailer installation area. Teams will enter the queue, decelerate, and stop at the line specified on the ground. The vehicle operator will then exit the vehicle, indicate to the judges how much desired additional weight will be added, retrieve the weighted trailer and attached it to their vehicle to be towed around the following lap. Upon successfully hitching their vehicle to the trailer, operators can ingress and proceed around the lap as normal. After completion of the single lap and arrival at the trailer installation area, drivers will exit the vehicle, unhitch the trailer and place it back in its station. The driver can then ingress and rejoin the race as normal. If teams cannot complete the weighted lap they are responsible to return the trailer to the trailer installation area as quickly as possible by any means possible; this includes the aid of additional team members. Teams that attempt the challenge, but do not return the trailer in a reasonable time (approximately 3 times an average lap time) will be penalized.

Once teams successfully return with the weighted trailer the judges will determine the appropriate bonus. Bonus reward laps will be added on to each team's total distance at the end of the race and be calculated as follows:

$$\text{Rewarded Additional Laps} = 2 * \frac{\text{total weight of trailer towed (kg)}}{\text{maximum weight of trailer}}$$

$$\text{maximum weight of trailer} = \text{weight of unloaded trailer} + 45.2(\text{kg})$$

Only a limited number of teams will be able to perform the weighted trailer challenge at a time therefore delays due to a waiting queue are possible. Teams are encouraged to plan their attempt accordingly.

The weighted trailer challenge will be announced no later than 90 days prior to the event

5) *Lock Security Challenge*

Human powered vehicle theft is one of the greatest concerns of many individuals who chose this mode of transportation. Teams are tasked to develop vehicle security solutions to be entered into the HPVC vehicle security challenge.

In the vehicle security challenge teams will be required to secure their vehicle within a specified area. The thieves “judges” will not be able to observe the teams during the securing of their vehicle. However, a neutral monitor will closely study the teams as they secure the vehicle, including recording the time it takes for each team to set their security measures. Once the vehicle is secure, the judges will have three minutes to defeat each team’s security measures and remove the vehicle from the specified area. If the judges cannot remove the vehicle within three minutes, full points will be awarded.

The security challenge area will contain a bike rack or secure pole, specific dimensions will not be specified to encourage teams to develop solutions that work with a range of commonly supplied bike racks or standard service/utility poles. The bike rack or pole will contain “fixed” structural tubes no larger than 3” in diameter. Teams are not mandated to utilize this structure.

The set up time is defined as follows: Once the first team member passes into the secure vehicle area the time will start and the driver(s) will have 75 seconds to secure their HPV. Teams will only be allowed one team member to set their security measures for single rider vehicles, and two team members for tandem vehicles.

The judges will only be allowed to cause irreparable damage to security components that attach the vehicle to the supplied bike rack or pole. Teams should be aware in advance that any item looping around the bike rack will be subject to the common bike theft tools listed below.

Once the driver has completed securing the HPV or the 75 seconds has expired, judges will be allowed access to the following tools in the following order:

- 0 seconds - Wire cutters
- 30 seconds - Hacksaw
- 1 min - Bolt cutters & car jack
- 1 min 30 seconds - Drill
- 2 min - Angle grinder

Judges will be able to enter the vehicle if security measures allow them to do so. Once inside the vehicle, judges will be able to use basic tools on hardware only. To reiterate, judges will not be able to manipulate any piece of the vehicle that is not a security lock,

chain, cable, nut, bolt, screw, etc. Care will be taken to maintain the state of every aspect of a team's vehicle and respect their hard work.

During the removal process it is entirely possible that a team's lock will be damaged beyond operation, but not completely removed from the vehicle. In order to ensure that teams can continue the race under this circumstance teams are highly encouraged to secure the lock to a removable portion of their HPV or include a quick release on the lock which can be opened quickly. If a quick release is utilized it must be as far away from the bike rack or security pole as possible and may not interfere with the judge attempting to break the lock. The ideal place for the quick release would be inside or imbedded in the HPV.

Points will be awarded in the form of additional completed laps for time spent by the judges trying to defeat the security measures. Additional laps will be calculated by the following:

$$\text{Rewarded Additional Laps} = 1 + 2 * \frac{\text{time to remove HPV from security area (s)}}{180}$$

The lock security challenge is to be completed only once for each vehicle during the endurance race. Teams must carry their security system with their vehicle through the entire endurance race. Only two teams will likely be able to perform the security challenge at a time therefore delays due to a waiting queue are possible. Teams are encouraged to plan their stop accordingly. If a team does not complete the security lock challenge for any reason during the endurance event no reward laps will be awarded. Teams that have not begun securing their vehicles by the time the 2.5 hour endurance clock has expired will not be allowed to attempt the lock security challenge.

The lock security challenge will be announced no later than 90 days prior to the event

6) *Parcel Pickup and Delivery*

A parcel pickup and delivery station shall be provided on the course. Each team is required to deliver or pick up a parcel five times during the race. At least two drivers must make a pickup or delivery. Teams start the race with a parcel. At the first parcel stop, the initial parcel is deposited with a parcel clerk who will record the time and vehicle number. Subsequently, parcels are alternatively picked up or dropped off. After dropping the parcel on the fifth stop, the parcel pickup/delivery requirement will be met. Teams may choose when to stop, and stops are permitted throughout the event. Note that delays due to a waiting queue are possible. Teams are encouraged to plan stops accordingly. Failure to complete five stops with at least two drivers shall result in a one lap penalty for each missed stop. If all five stops are made by the same driver the team will be penalized one lap. Damage to parcels will be assessed at the completion of the five drop offs and appropriate penalties will be made at that time (See IX).

When entering the parcel pickup area, vehicles must park in designated parking spots. These spots will be oriented perpendicular to the direction of the course. Drivers must fully dismount their vehicle, retrieve and secure the parcel, and re-mount their vehicle. The

orientation of the parking spot will require vehicles to either back into or out of the spot. Note that, as always during the endurance race, drivers are allowed to push their vehicle. Vehicle entry/exit may not be undertaken in active traffic.

The parcel will be a standard sized 38x33x20 cm (15”h x 13”w x 8”d) reusable grocery bag containing items determined by the host school (mass not to exceed 5.5 kg).

The parcel pickup and delivery challenge will be announced no later than 90 days prior to the event.

I) Lap Counting Process

Laps will be counted by the Judging Team and an Assistant Lap Counter provided by each team.

- (a) The Judging Team will record laps of all teams in sequence as the official record of the race.
- (b) *Assistant Lap Counters* Each competing team must provide one assistant lap counter as a scoring assistant to count and record laps. This record will serve as a back-up to correlate the official lap count. Lap counters will be provided with a lap counting sheet to record:
 - (i) The time-of-day each lap is completed using time from their own watch; counters need not be synchronized between teams and/or judges
 - (ii) The driver's gender and identity**
 - (iii) The times of driver changes
 - (iv) Any other substantive data

No score will be tabulated for any team that does not provide an assistant lap counter.

J) Driver/Stoker Requirements

- (a) Minimum distance for any driver: the number of laps nearest 5km or 30 minutes (whichever occurs first).
- (b) Maximum distance for any driver: the number of laps nearest 20 km.
- (c) Each team must have **at least one driver of each gender**.
- (d) A team may include any number of drivers as long as the distance-per-driver requirements are met.
- (e) All laps by an individual driver must be continuous – that is, all drivers must complete their laps in sequence, uninterrupted by any other driver, and may not ride in that event further.
- (f) A driver's distance or time may be cut short due to injury, vehicle disablement, or end of scheduled race time. There will be no penalty as a result of scheduled race ending prior to present occupant's completion of minimum distance. Otherwise the Head Judge must rule that the driver is indeed unable to continue in order to avoid penalty.
- (g) All laps not completed to these requirements will be subject to the lap requirement violation penalty
- (h) For multi-driver (i.e. tandem) vehicles, the minimum distance also applies to same-gender crews. At least one male-only crew and one female-only crew must complete the minimum distance. After that mixed-gender crews are permitted and each individual driver must complete minimum distance. If a multi-rider vehicle is operated by a single team member that will count as the minimum laps for their gender.

K) Judging Area

The lap counting and judging area will be adjacent to the start/finish area. It will be off limits to everyone except competition officials and the assistant lap counters.

L) Drivers' Meeting

All drivers who will participate in the Endurance Event must attend the mandatory Drivers' Meeting for that event. Drivers' meetings will take place approximately 45 minutes prior to the scheduled start of the race. The meeting will clarify operating procedures and signals and will identify course features, hazards, and landmarks.

Any team that is not represented at this meeting will normally not be permitted to participate in the event; in cases of unavoidable absence, the team may file an appeal with the Judging Team, whose decision regarding participation will be final.

M) Course Practice

The road course will be opened by the Head Judge for practice and will remain open at his/her sole discretion. All vehicles practicing on the course must be operated in the intended direction of the course and in a safe manner and with extreme caution, particularly when entering the pit area or any other areas congested with participants, officials, or spectators.

All drivers operating a vehicle on or adjacent to the course, on competing vehicles or otherwise must wear helmets meeting the approved standards for the competition.

N) Signals

Flags will be used by competition officials as follows:

Flag Color	Usage
Green	Start event
Red	Stop event
Yellow	Proceed with caution, beware of hazards, no passing without sufficient passing lane
Black	Proceed directly to pits: problem with vehicle, rule infringement, or penalty assessment
White	Less than 10 minutes remaining in the race
Black/white	Event completed, proceed to pit area

Each Course Marshal will be supplied with a yellow flag with which to signal caution in the event of an accident. During a yellow caution flag passing will be allowed when sufficient space is available to pass, but under no circumstances will unsportsmanlike conduct, cutting off another HPV, or contacting another HPV be permitted, and violating this rule will result in a conduct violation.

All other flags will be held in the judging area. As described, a green flag will signal that the event is underway, the black flag is used to indicate that a HPV is to go directly to the pits on their next lap, the white flag indicates 10 minutes left in race time, and the checkered flag indicates the end of the race. A red flag displayed at the race start will indicate that a restart is necessary, and all

vehicles should proceed by their most direct path to the starting area. A red during the event requires that all vehicles stop at the earliest safe opportunity. At the end of the race a 'clean up vehicle' will display a red flag to indicate that the race has ended and is not to be overtaken. The vehicles should then return to the pit area as the course will then be closed.

O) Disabled Vehicles

The first concern following any accident is the safety of the driver. Once it has been determined that the driver is not injured, disabled vehicles must be removed from the course as soon as possible. In the event of an injury, no person should take any action that might increase the risk associated with the injury. In the case of injury, only on-site paramedics, ambulance workers or licensed medical professionals should tend to the injured.

Disabled vehicles must be removed from the course at the nearest safe exit; drivers may not move disabled vehicles along the course other than to reach a point of removal. Disabled vehicles may be returned to the pit area by the driver and/or team members by safely removing the vehicle from the course and wheeling or carrying it to the pit area.

Course workers will assist with the removal of vehicles from the course, as necessary in the interest of safety. Primary responsibility, however, remains with the respective team. Non-emergency blockage of the course by a disabled vehicle may result in the assessment of a penalty.

Traffic will be controlled in the area of a disabled vehicle by the Course Marshals or by other competition officials, who will oversee the clearing of the course and signal the resumption of normal competition.

Disabled vehicles that have been removed from the course and repaired must re-enter the course either at the point of removal or at some point that it had passed between that point and the starting line on that same lap. That is, no vehicle will advance its position on the course as the result of a disablement. Re-entering vehicles must yield the right-of-way to vehicles on the course.

P) Fouls and Penalties

Fouls and penalties for the endurance event are described in the general fouls and penalties Section IX.

Q) Interruptions

The Endurance Event will normally run continuously. However, obstruction of the course, an emergency, hazardous weather, or other conditions may require a delay or premature termination of the event. The need for—and extent of—any such delay or termination will be evaluated by the Judging Team, with the Head Judge making the final determination.

If the event is interrupted and a restart is required, the restart order will recreate, as nearly as possible, the order of vehicles at the time of the interruption.

R) Termination

The endurance event shall be run for 2.5 hours. At that time, all vehicles still in the competition will be permitted to finish the lap they are currently on. A "sweep" vehicle will enter the course

and complete one lap. The sweep vehicle shall not pass any operable competing vehicles on the course, nor shall any competing vehicles pass the sweep vehicle. At the completion of the lap by the sweep vehicle, the event will be declared complete.

When the official race clock reads elapsed time of 2:20, the white flag shall be placed on prominent display near the judge's area, and will remain there until a race time of 2:30. At that time, the white flag shall be replaced with the black and white checkered flag.

S) *Scoring*

Vehicle rank in the endurance event is based on average speed minus penalties. The formula for average speed is:

$$V_{average} = \frac{(Number\ of\ Laps\ Completed - Lap\ Penalties) \times (Lap\ Length) - (Distance\ Penalties)}{(Finish\ Time + Time\ Penalties)}$$

Points are awarded based on each individual vehicle's average speed compared to the fastest average speed.

$$Points = \frac{V_{average}}{V_{maximum\ average}} \times Maximum\ Event\ Points$$

Where the Maximum Event Points is the point value for the event, specified in Section X.

IX. **General Fouls and Penalties**

Throughout the competition the Head Judge and the Judging Team will determine whether a foul has occurred and the extent of any assessed penalty (which may include disqualification from an event or from the competition). The responsible team will be notified as soon as possible of an infraction and any resultant penalty by the Judging Team.

Penalties for fouls (including but not limited to examples below) will be assessed as follows:

- **Equipment violations**

- Penalty

- Require a pit stop to remedy the violation

- Example

- Failure to meet equipment requirements, including the proper display of vehicle numbers

- **Safety violations**

- Penalty

- Sprint- Require a pit stop to remedy the violation and speed/time for that run rejected
 - Drag- Require a pit stop to remedy the violation and up to 5% penalty in final event score
 - Endurance- Require a pit stop to remedy the violation and subtraction of one or more laps from the team's total lap count

- Example

- Such as entering the course without a proper helmet or seat belt

- **Lap requirement violations**
 - Penalty
 - Deduction of one lap for each improper lap
 - Example
 - Failure to meet minimum or maximum driver lap requirements
 - This includes **not meeting the minimum number of single gender laps**. For each lap missed, one lap will be subtracted from the total number completed
- **Illegal start assistance on course**
 - Penalties
 - Sprint- speed/time for that run rejected
 - Drag- Up to 25% penalty in final event score
 - Endurance- Deduction of 500 meters from total distance
- **Conduct violations:**
 - Penalty
 - Sprint- speed/time for that run rejected
 - Drag- Up to 25% penalty in final event score
 - Endurance
 - *First violation:* A minimum of a 15-second delay in the pit area. No work may be performed and no driver changes may be made during this stop.
 - *Second violation:* A minimum of a 60-second delay, with the same stipulations as above.
 - *Third violation:* Disqualification from the event
 - Example- Conduct violations include but are not limited to
 - Obstruction of a vehicle by a competing team or by a spectator
 - Foul driving, whether intentional or unintentional
 - Including an unsuccessful or dangerous pass in the slalom
 - **Poor sportsmanship** or an activity that fosters unfair competition
- **Failure to complete an obstacle:**
 - Penalty
 - Deduction of 500 meters from total distance per infraction
 - OR repeat the failed obstacle
 - Example
 - Failure to stop at stop sign, complete the slalom, hairpin turn, quick turn, improper entry or exit of HPV at parcel stop, knocking any tennis balls off of cones, etc.
- **Damaging or loss of parcel:**
 - Penalty
 - Deduction of a maximum of 1,500 meters from total distance depending on severity of damage

Violations and penalties will be at the sole discretion of the Head Judge and the Judging Team. Penalty appeals may be filed in accordance with specified protest procedures.

Drafting is expressly permitted as long as there is no interference with other vehicles.

X. Overall Scoring

Overall Score Scores from Design Event, Innovation Event, Speed Event and Endurance Event will be combined to determine the overall standing of the competition.

The formula for combining the scores is:

$$\text{Overall Score} = \sum \text{Event Scores}$$

The maximum event points are:

Competition Event	Maximum Points
Design Event	30
Innovation Event	20
Male Speed Event	12.5
Female Speed Event	12.5
Endurance Event	25
Total Score	100

In the case of a tie in the overall point count, the order of finish in the Design Event will determine the overall finish for all vehicles.

XI. Announcement of Results and Awards

A) Announcement of Results

The judges will post the results of each event of the competition as soon as possible after the completion of the respective event and validation of the collected data.

B) Presentation of Awards

The awards presentation will be held after the completion of the competition's final event.

C) Competition Awards

Competition awards shall be given as follows:

Overall 1st Place:	Trophy and cash prize
Overall 2nd Place:	Trophy and cash prize
Overall 3rd Place:	Trophy and cash prize
Design Event	1 st + cash prize, 2 nd and 3 rd place trophies
Men's Speed Event	1 st + cash prize, 2 nd and 3 rd place trophies
Women's Speed Event	1 st + cash prize, 2 nd and 3 rd place trophies
Innovation Event	1 st + cash prize, 2 nd and 3 rd place trophies
Endurance Event	1 st + cash prize, 2 nd and 3 rd place trophies

Cash prize amounts will be posted on the event website.

Overall winner must participate, complete minimum requirements and score points in all events to be eligible for monetary awards.

Minimum requirements are valid non-zero scores in the Design Event, Male Speed Event, Female Speed Event, Innovation Event and Endurance Event.

D) Other Awards

Reoccurring Awards- Teams will be recognized for significant achievements during the course of the competition and the winners will be selected by teams voting. Voting will take place virtually during the final day of the competition and must be completed by the end of the final race. The details for the means of voting will be announced at the final drivers meeting. These awards include but are not limited to the following:

Sportsmanship	Special Achievement
Team Spirit	Perseverance

Additional awards may be suggested or provided by the judges, host, the teams involved or others. Such awards are encouraged in the spirit of the competition; however all such awards must be approved by the ASME Judging Team prior to the event.

Additional special awards may be given out by the ASME team to recognize notable or humorous activity and promote the good natured spirit of the competition. These awards will often be very specific to each competition and judges will accept nominations for special awards.

E) Review and Modification of Results

If an error or discrepancy is determined in the final results, it will be addressed by the judging team as quickly as possible. To assure scoring accuracy is maintained, the judging team will expedite every effort to resolve errors and reserves the right to review the results for up to 48 hours after the official awards ceremony to ensure all scores are accurate and final.

XII. Clarification and Modification of Rules

A) Clarification and Modification of the Rules

These rules may be modified by the Competition Judges as necessary to maintain the competition as a challenging and rewarding experience for engineering students. No changes by any party shall be made without the written consent of the Global Chief Judge. Questions or recommended changes should be referred to the Event Head Judge.

B) Global Chief Judge and Head Judges

The Global Chief Judge and Head Judges of the ASME Human Powered Vehicle Challenge serve a three year term and together maintain the competition rules.

The Global Chief Judge: Chris Wlezien, Chicago, IL

The North America East Coast Head Judge: Brian Jones

The North America East Coast Head Judge Elect: Jeremy Mikesell

The North America West Coast Head Judge: Will Hilgenberg

The North America West Coast Head Judge Elect: Peter Aumann

The Asia Pacific Head Judge: Aaron Williams

C) Questions and Comments About the Rules

Questions about the rules may be posted on the HPVC forum here:

<https://groups.google.com/forum/#!forum/asme-hpvc>

XIII. Appendix 1 Registration and Documentation Submittal

The following documentation is required for registration and participation in the ASME Human Powered Vehicle Challenge. The required materials should be submitted to the parties indicated in accordance with the schedule as noted.

For reference, the following lead times establish the deadlines:

Entry Date	8 weeks before Registration Date
Report Date	45 days before Registration Date
Innovation Video Date	2 weeks before Registration Date
Performance Safety Video Date	1 week before Registration Date
Safety Ride Log	1 week before Registration Date
Registration Date	The initial day of competition (on-site)

Document	Notes	Date Due
Entry Registration	Online	Entry Date
Certification of Eligibility	Part of Online Registration	Entry Date
Safety Certification	Part of Online Registration	Entry Date
Safety Ride Log	Submitted online before arrival at event	1 week before competition
Acknowledgment of Rules	Part of Online Registration	Entry date
Design Reports	Electronic submission via website	Report Date
Performance Safety Video	Electronic submission via website	1 week before competition
Innovation Reports	Electronic submission via website	Report Date
Innovation Video	Electronic submission via website	2 weeks before competition
Vehicle Description	Required information about vehicle submitted online with Design and Innovation reports	Report Date
Protests (Section XVI. Appendix 4)	Submit to Head Judge only if required	In accordance with II.G
Safety Exemption Request (Section XVII. Appendix 5)	Submit only if an exemption is requested and submit to Head Judge	10 Days Following Entry Date
Evaluation	Form provided by ASME at the end of the competition	End of competition

Please refer to the ASME HPVC website for dates, registrations fees, and registration instructions.

<https://community.asme.org/hpvc/default.aspx>


XIV. Appendix 2 Design Event Judge's Score Sheet

2018 HPVC Design Scoring Criteria		
Design Report Evaluation		100
General		
1	Form &	5
2	Title Page	1
3	3-View Drawing	1.5
4	Abstract	1.5
Design		15
1	New Design	2
2	Design Methodology	1
	Design Objective	1
	Background research	1
	Prior Work	1
	Organizational Timeline	1
	Design Criteria/PDS	1
	Alternatives and Evaluation	1
	Structured Design Methods	2
	Description	1
3	Discretionary Points	4
Analysis		25
1	Rollover/Side Protection System	1
	Top Load Modeling	1
	Top Load Results	2
	Side Load Modeling	1
	Side Load Results	2
2	Structural Analytical Calculations	1
	Objectives	1
	Analysis Case Definitions	1
	Modeling	1
	Results	2
	Design Modifications	1
3	Aerodynamics	1
	Aero Device Incorporated	1
	Alternatives Evaluated	1
	Chosen Design Substantiated	1
4	Cost Analysis	2
5	Other Analyses	1
	Objectives	1
	Analysis Case Definitions	1
	Results	1
	Design Modifications	1
6	Discretionary Points	4
Testing		25
1	Rollover/Side Protection System	1
	Top Load Testing Setup	1
	Top Load Testing Results	2
	Side Load Testing Setup	1
	Side Load Testing Results	2
2	Developmental Testing	1
	Objective & Methodology	1
	Results and Discussion	1
	Statistical Analysis	1
	Conclusions	1
	Design Modifications	1
	Comparison with PDS and Analysis	1
	Comprehensiveness	1
3	Performance Testing	1
	Objective & Methodology	1
	Results and Discussion	1
	Statistical Analysis	1
	Conclusions	1
	Design Modifications	1
	Comparison with PDS and Analysis	1
	Comprehensiveness	1
4	Discretionary Points	5
Safety		20
1	Rollover/Side Protection System	1.5
	Installation & Design	1.5
	Consistent with RPS rule	1.5
	Prevents bodily contact with ground	1
2	Safety Harness	2
3	Steering System	1.5
4	Braking System	1.5
5	Sharp Edges, Protrusions, Pinch Points	2
6	Other Hazards	1
7	Rider's Field of View	1
8	Safety Accessories	1
	Bell/Horn	1
	Taillight	1
	Headlight	0.5
	Side reflectors	0.5
	Rear view mirrors	0.5
9	Additional Safety Features	1.5
10	Discretionary Points	2
Aesthetics		10
	Overall impression of vehicle	3
	Quality of craftsmanship	3
	Quality of custom parts	2
	Quality of Frame/Fairing Finish	2

XV. Appendix 3 Innovation Event Judge's Score Sheet

2018 HPVC Innovation Scoring Criteria						
	Item	Question	Points	Discussion	Notes	Evaluation based on
Innovation Multiplier	1	Is the proposed innovation a new idea?	1x to 2x multiplier	Students must provide clear evidence that they have developed a truly innovative and new idea. This can be bolstered by a high level of difficulty/depth of the innovation, and conversely trivial/banal innovations will not earn a high multiplier.	List/discussion of similar patents, summary of literature review, and/or patent applications by teams are sufficient. Reused innovations are not acceptable and points are only awarded in the first year a team submits a specific design. Ignorance of an existing design does not warrant allocation of points if the judging team does not feel the innovation is not a new idea.	Report
	2	What is the need for the proposed innovation?	2	Students must document the target market and need of their specific innovation	All innovations solve problems for specific needs. Please list the embodiment of the need and how this innovation solves the problem.	Report
Design	3	Does the proposed innovation benefit or advance the state of the art of human-powered vehicles?	2	Students must clearly show that the innovation has benefits, which can be performance, ergonomics, cost, environmental, social, etc.	This can be applicable in the HPVC or to mainstream human powered vehicles.	Report
	4	Is the innovation possible with existing or proposed technology and is this specific proposed execution feasible?	3	Students must clearly demonstrate that the innovation is does not require a violation of the laws of physics or the use of an unavailable process or material. Students must also show that the proposed embodiment of the design is feasible. In other words, the concept will work?		Report
Concept Evaluation	5	Is the prototype functional?	3	Does the prototype do what was intended? This is not an evaluation of how well it performs, but a validation of the design concept.	Early prototypes will often show more learning opportunities while subsequent prototypes (or iterative improvements to one prototype) will often better confirm functionality.	Report and Innovation Video
	6	Are the proposed benefits of the concept realized?	3	Students must provide data to show how effectively the prototype achieved the anticipated benefits in question 3.	This can be executed by testing a mock up, prototype, or even a full scale version.	Report and Innovation Video
	7	Are there any unanticipated benefits?	2	Students must provide data to show how effectively the prototype achieved unanticipated benefits. Often the proposed benefits are not as important as unanticipated benefits.	Often times during the innovation process unanticipated benefits outweigh the original goals of the design and advance the state of the art significantly.	Report and Innovation Video
Learnings	8	What failures were experienced?	2	Students should document what did not work -- concepts that turned out to be infeasible (why?), prototypes that did not work (why?), and unanticipated difficulties.	Read Henry Petroski to get an idea of how important failures are in innovation.	Report and Innovation Video
	9	What was learned from the failures?	3	Students should document how failures were used as stepping stones to subsequent successes.	Most innovations are built on what is learned by failures. In fact, more is learned from failures than from successes.	Report and Innovation Video
	10	What are the unanticipated negative aspects of the design?	2	Students should clearly identify and if possible quantify unanticipated negative aspects -- increased cost, regulatory restrictions, negative environmental aspects, etc.	Even though benefits are realized, the innovation may not have full value because of some unanticipated negatives.	Report and Innovation Video
Execution	11	How well does the concept function based on the quality of the design?	3	Students should demonstrate how well the concept performs based on the quality of the design and the quality of physical execution	Well executed designs that function as intended shall receive maximum points, whereas poorly executed concepts with low craftsmanship that do not function shall receive low points.	Innovation Video
	12	Does the quality of execution reinforce the benefit(s) of the innovation?	3	Students must show that the physical execution of the design allows for or exceeds the intended benefits of the innovation	If the execution of the concept performs up to or beyond the intended level described in the benefits, full points should be awarded. If explicit metrics for measuring the quality of execution are not available the judges will assess points at their discretion.	Innovation Video

XVI. Appendix 4: Protest Form

 http://go.asme.org/HPVC	PROTESTS Form Human Powered Vehicle Challenge Competition Location: _____ Competition Date: _____
<p>*** This is <u>NOT</u> a required form. It may be used <u>only if</u> a team is filing a protest during an event *** Additional details can be found in the Rules, Section II.G. ***</p>	

Protests

Protests may be made in accordance with the rules of the ASME Human Powered Vehicle Challenge. This protest format may be used or not used at the discretion of the team or individual presenting the protest. If this format is not used, the information outlined herein should be included in whatever format is used.

Any intent to protest must be announced within 15 minutes of the causative action, and the written protest must be submitted within 30 minutes of this announcement. Oral protests will not be honored.

Date: _____ Protesting Team's Vehicle No. _____

Protesting School: _____

Other Vehicle(s) Involved (if applies): _____

Event during which protested action occurred: _____


Nature of protest (e.g., rule violation, error in scoring, etc.) _____

Description of incident/statement of protest (may be entered or continued on separate page)

This image shows a single sheet of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Judges Action:

XVII. Appendix 5: Safety Exemption Request Form

 <p>http://go.asme.org/HPVC</p>	<p>Requested Exemptions to the Safety Certification Human Powered Vehicle Challenge</p> <p>Competition Location: _____</p> <p>Competition Date: _____</p>
--	--

***** This is NOT a required form. It is to be used only if a registrant/team is requesting an exemption to the safety certification *****

Any request for exemptions from specific safety requirements must be submitted in writing using this form to the competition Head Judge at hpvcasme@gmail.com

NOTE: You have up to 10 days following your vehicle/team registration for this submission

Which HPVC Event are you inquiring about: _____

School: _____

Vehicle/Team Name: _____

Vehicle Number (if applicable): _____

Requestor's Name/Team Captain's _____

I request the following exceptions to the safety certification, and I have included a brief justification for that/those request(s):

[illegible]

XVIII. Appendix 6: ASME Report Cover Page & Vehicle Description Form



<http://go.asme.org/HPVC>

ASME Report Cover Page & Vehicle Description Form

Human Powered Vehicle Challenge

Competition Location: _____

Competition Date: _____

This required document for all teams is to be incorporated in to your Design & Innovation Reports. Please Observe Your Due Dates; see the ASME HPVC for due dates.

Vehicle Description

School name: _____

Vehicle name: _____

Vehicle number _____

Vehicle configuration

Upright _____

Semi-recumbent _____

Prone _____

Other (specify) _____

Frame material _____

Fairing material(s) _____

Number of wheels _____

Vehicle Dimensions (*please use m, m³, kg*)

Length _____

Width _____

Height _____

Wheelbase _____

Weight Distribution Front _____

Rear _____

Total Weight _____

Wheel Size Front _____

Rear _____

Frontal area _____

Steering Front _____ Rear _____

Braking Front _____ Rear _____ Both _____

Estimated Cd _____

Vehicle history (e.g., has it competed before? where? when?) _____
