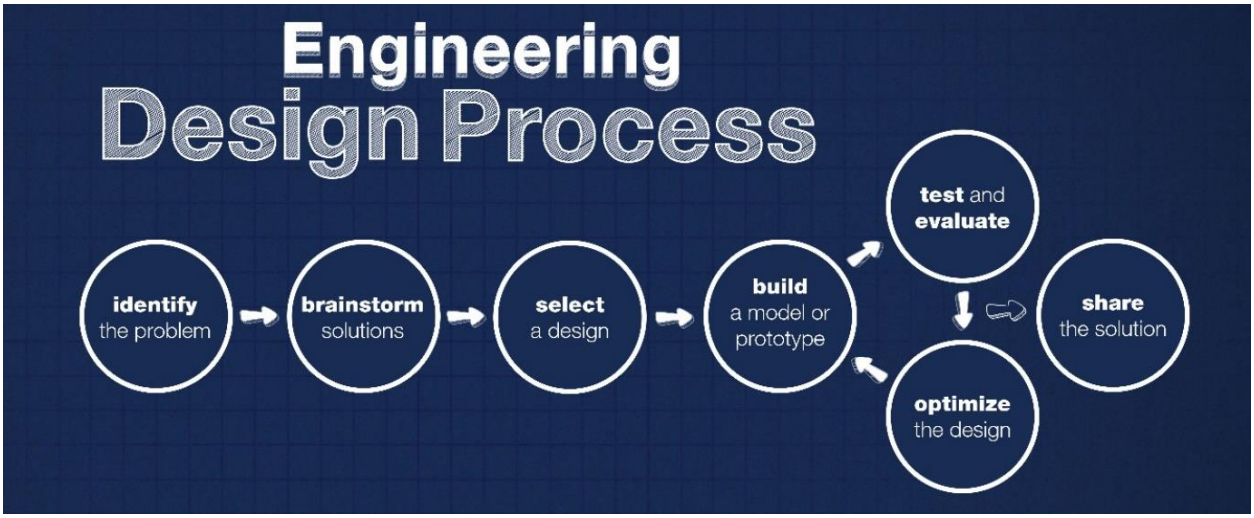
# 2024 DROP TOWER CHALLENGE
# *Microgravity Expulsion from Water*

https://www1.grc.nasa.gov/space/education-outreach/drop-tower-competition/current-drop-tower-challenges/2024-drop-tower-challenge/

# Guide with Instructions
## Challenge overview
### Why?
Future space exploration requires a better understanding of fluid behavior in microgravity because of the cooling, life support, propellant, and other spacecraft systems which include liquids. Especially in the apparent absence of gravity, the shape and nature of a surface can affect how liquids interact with it, for example within a channel or container. Furthermore, hydrophilic (water-loving) and hydrophobic (water-fearing) surfaces or coatings can have additional effects which are more pronounced in microgravity.

While it is hoped that you will learn about both fluid physics and microgravity research, you can more importantly learn about the engineering design process and scientific method, moving from a problem statement, to hypotheses, the design and preparation of your experiment, testing & analysis – ideally repeatedly with the refinement of your design – and finally reporting.




And while the challenge wasn't developed to specifically address any practical issues or applications, your approach to the challenge may inspire NASA to address microgravity fluid management in a new way.

Participation in a nationwide NASA design challenge might be worth noting in your applications for college, etc. Regardless, it is hoped that the challenge will inspire you to pursue a career in STEM (Science, Technology, Engineering, and Mathematics), perhaps even at NASA.

## What?

Teams of grade 8-12 students are challenged to design and build simple devices that will float in water in normal gravity and will be expelled as far as possible from the water because of wetting characteristics when they experience apparent weightlessness, i.e., microgravity, in NASA's 2.2 Second Drop Tower. NASA will invite the top-performing teams to present their results in a student poster session at the 2024 meeting of the American Society for Gravitational and Space Research (ASGSR).

**Testing in the 2.2 Second Drop Tower.**

## Who?

The design challenge is for students in grades 8-12, where teams will be favored over individuals in selection. The program is limited to students from the United States, but citizenship is not required. It is open to all fifty states, the District of Columbia, Puerto Rico, American Samoa, Guam, the Northern Mariana Islands, the U.S. Virgin Islands, and all Department of Defense Education Activity (DoDEA) schools for the children of U.S. military personnel. **Except for DoDEA schools, this challenge is not open to participants outside of the United States, regardless of citizenship!**

Students may get guidance from adults, for example, in building their test objects, but are expected to lead the project, prepare the report, and do most of the work. An organization (e.g., school, science center, 4-H club, Scout troop) may submit no more than two proposals, where it is envisioned that no more than one will be selected from a single organization.

## Where?

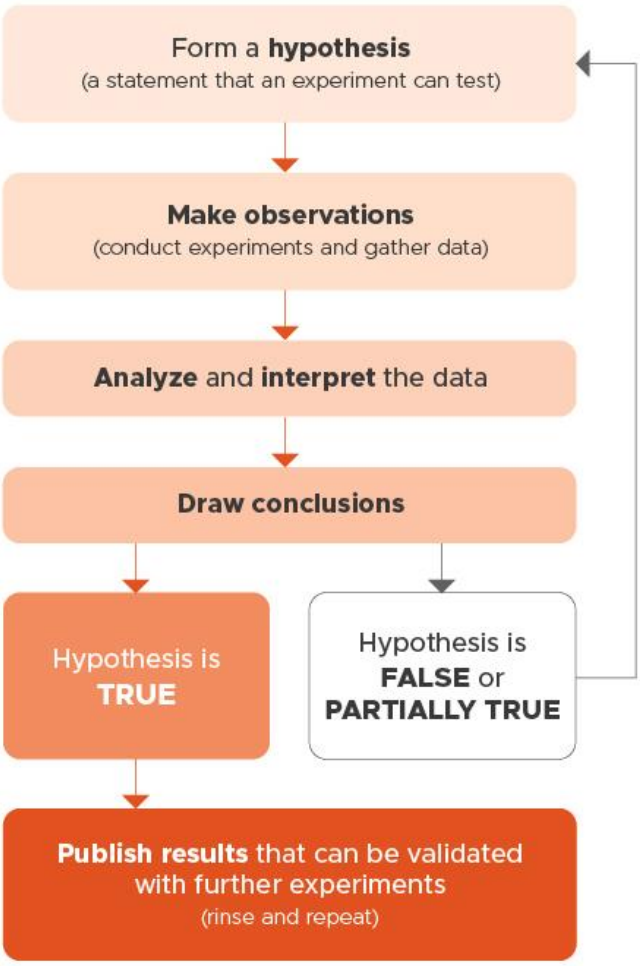
Participation is remote, where participants do not travel to NASA for the testing. An exception is for those teams invited to present their results at the 2024 ASGSR meeting, but the location will not be announced until Nov. 2023.

## Cost?

There is no cost to participate in the challenge other than for (1) the preparation of the test objects, (2) the shipment of the test objects to NASA, and (3) travel costs for those invited to present their results at the ASGSR meeting. Regarding the latter, it is expected that ASGSR will provide $500 in travel support for each invited non-local student who present their results at the conference.

## Selection?

After proposal evaluation, NASA anticipates selecting up to 30 teams to build objects to be tested in the 2.2 Second Drop Tower at the NASA Glenn Research Center in Cleveland, Ohio. Only a few top-performing teams will be invited to participate in the ASGSR conference.




**Scientific Method.**

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# A. THINGS TO KNOW

## Calendar

| | | |
|---|---|---|
| **2023** | ***Now!!!*** | ***Preparation of proposal*** |
| | **► Nov. 1, 11:59 PM** | Deadline (in your time zone) to e-mail your team's proposal to NASA |
| | Early December | NASA announces teams selected for testing |
| **2024** | Jan.-February | Preparation of test objects |
| | **Jan. 15** | Deadline for updated list of materials in the objects and updated drawings & dimensions |
| | **► Feb. 15** | Deadline for the **arrival** of test objects at NASA |
| | Feb.-March | Testing in NASA's 2.2 Second Drop Tower |
| | Late March | NASA provides access to the drop results |
| | April | Analysis and report writing |
| | **► May 1, 11:59 PM** | Deadline (in your time zone) to e-mail your team's final report to NASA |
| | Mid-May | NASA announces teams selected for ASGSR participation |
| | Fall (probably in Nov. or late October) | Annual ASGSR meeting |

**Failure to meet any of the key deadlines will disqualify a team from being selected for ASGSR participation, if not more!**

# Key Rules

- **Eligibility**
  - The challenge is open to grades 8-12 in the United States including all fifty states, the District of Columbia, Puerto Rico, American Samoa, Guam, the Northern Mariana Islands, the U.S. Virgin Islands, and all DoDEA schools for the children of U.S. military personnel.
  - Except for DoDEA schools, those outside of the United States are not eligible regardless of their citizenship.
- **Team**
  - Each team is required to have an adult advisor, who may advise more than one team.
  - Each student may only be on one team.
  - Teams can be of any size, but a maximum of four students per team will be invited to the ASGSR meeting.
- **Proposals**
  - A team can only submit one proposal.
  - If an organization (e.g., school, science center, 4-H club, Scout troop) has more than 2 teams, it must choose no more than 2 proposals to submit to NASA.
- **Number**
  - Each team may include up to 3 test objects in their proposal and if selected for testing may submit up to 3 objects for that purpose.
- **Size**
  - A test object's longest dimension, including diagonal(s), may be no more than 60 mm and no less than 5 mm.
- **Buoyant**
  - Each test object must float in water in normal gravity.
- **Prohibited materials, components, etc.**
  - Hazardous materials that are corrosive, toxic, radioactive, etc.
  - Chemical reactions, compressed gases, sharp edges
  - Electrical components such as batteries, lasers, motors, etc.
  - Fragile materials such as glass, thin plastic, etc.
  - Materials or coatings that are liquid when shipped to NASA
  - Materials or coatings that dissolve in or react with water, e.g., antacid tablets
  - Parts, materials, or coatings that separate (intentionally or otherwise) from the test objects
    - *For example, the release of ballast during the drop is not allowed.*
  - Small creatures, whether dead or alive, and most biological materials other than cork, cotton, leather, wood, and wool
- **Deadlines**
  - Late submission of the proposals, test objects, and/or final reports will disqualify teams from the competition.

# Hints

## Follow the rules and instructions!!!

**Control and variables:** You should ideally have two or three different objects for testing so that you can compare the performance of each object in your report - and poster too if you are selected for ASGSR meeting participation. An added benefit is the increased probability of success with the challenge.

**Conduct your own microgravity trials:** Consider putting trial objects in a plastic jar with water which is mounted in a box with a video camera and dropping the box to get a glimpse of what happens in microgravity. Just a 4-foot fall provides a half second of microgravity; that can provide a hint of what will happen in the 79-foot fall in NASA's 2.2 Second Drop Tower. For inspiration on conducting your own drop research, check out the Fire in Free Fall video by Physics Girl Dianna Cowern (*who is sadly now disabled by long COVID*). You may change the designs of your test objects after your proposal is submitted, but the rules must still be followed.

**Timing is critical:** Late submissions to NASA of your proposal, test objects, or final report will each disqualify your team from the competition. Don't wait until the deadlines to complete tasks!

**Communication:** When contacting the challenge staff, please e-mail Ed-DropTower@lists.nasa.gov rather than individual staff members to avoid the chance of e-mailing someone who is vacationing, sick, etc. and not checking their e-mail.

# Selection Criteria for ASGSR Meeting Participation

Teams will be evaluated based on the following:

1. Performance during testing in the 2.2 Second Drop Tower
2. Team's approach to the challenge, e.g., application of the engineering design process and scientific method (as revealed in their proposal and final report)
3. Team's analysis (as revealed in their final report)
4. Team's final report
5. On-time submission of the proposal, test objects, and final report

Narrative feedback about your team's performance will be provided upon request, where it might help you learn how to do better in subsequent challenges.

# B. WHAT TO DO

There are four phases of participation in the challenge:

1. Prepare your proposal – *open to all eligible*
2. Build your test objects – *open to all teams selected by NASA for testing*
3. Analyze & document your results – *generally after the NASA microgravity testing, but some draft text can be written during the second phase*

4. Present at the 2024 ASGSR conference – *open to those teams invited by NASA based on the selection criteria above*

Each phase is separated by a submission to NASA and subsequent phases rely on the earlier ones for continued participation. The proposal is used to determine whether a team will continue to phase 2, and the objects must be submitted for testing to have results to analyze and write about in phase 3. Finally, the test performance and written report will both be used to determine which teams are invited to present their results in the student poster session at the 2024 ASGSR conference (phase 4).

# 1. Prepare your proposal

## 1.1 Understand the challenge

The goal is to design and build objects that will float in normal gravity and will be expelled as far as possible from the water because of wetting characteristics during free fall (i.e., microgravity conditions) in NASA's 2.2 Second Drop Tower and not because of mechanical means, such as released ballast.

**Scoring:** An object's score will be calculated based on the maximum vertical distance travelled upward during free fall. In evaluating a team's test performance, only their top-scoring object is considered. To be clear, if a team has multiple test objects, the scores are not added or averaged. But having multiple objects increases the odds of a high score and allows for the comparison of results in the final report.

**Adhesion & cohesion:** The balance between the attraction of the liquid and a surface (adhesion) and the liquid's attraction to itself (cohesion) affects how liquids interact with a surface, including that of a floating test object. The adhesion/cohesion balance can cause the floating object and liquid to move when the force of gravity seems to disappear. The geometry of the surface(s), including both the shape and dimensions, can also influence the resulting motion.

**Water loving & fearing:** A surface's properties can affect liquid interactions, where their influence can be particularly strong in microgravity. Surfaces can be either hydrophilic or hydrophobic, that is 'water loving' or 'water fearing.' As an extreme example, the leaves of the Lotus flower have a superhydrophobic surface where researchers are working to mimic the 'Lotus effect.'

## 1.2 Watch video of an expelled object

Watch the *Water and Ping Pong Ball* video on the challenge's web page. The ball floats on water in normal gravity because gravity pulls more forcefully on the water than the less dense ball. While the ball is much denser than air, surface properties were used to cause the ball to be expelled from the water in the apparent absence of gravity.

Given the challenge, NASA will not share how the surface of the Ping-Pong ball was treated to cause it to be expelled in this video! The challenge staff will not help teams succeed, except in broad ways such as explaining the rules and instructions.

## 1.3 Develop your test object concepts

Based on your research, design your own objects that will be expelled during the free fall. Note that NASA will provide the rest of the experiment hardware including three containers (each holding water and a test object), the video camera, and lighting.

**Wetting:** NASA will not advise your team on whether your test objects should be hydrophilic (water-loving) and hydrophobic (water-fearing).

**Buoyant:** Each test object shall float in water while in normal gravity or it will not be tested in microgravity!

**Expulsion:** Objects must be expelled because of their wetting characteristics and not for other reasons, such as the release of ballast during free fall.

**Number:** Each selected team can propose and submit up to three different objects for testing. Using multiple objects allows a team to compare test results, for example in the required report and - if invited - at the 2024 ASGSR conference. Of course, at least one test object must be proposed and assuming selection built and shipped to NASA for testing.

**Containers:** Each test object will be tested in its own container of water, where the interior is a rectangular prism which is 210 mm (8.25 in) tall and 63 mm (2.4 in) across with a square cross-section. Three containers with objects will be tested in a single drop.


**Containers with objects from a different challenge being loaded into the drop rig.**


**Containers with objects from a different challenge mounted in the drop rig.**

**Materials:** The test objects must be fabricated from safe solid materials such as plastic or metal. Please avoid the use of fragile materials such as glass, thin plastic, etc. in your devices. Verify the ruggedness of your test objects because they must survive shipping to and handling at NASA.

**Safety:** Corrosive, toxic, and radioactive materials are prohibited. Other hazards such as compressed gases and sharp edges are also not allowed.

**Biology:** Small creatures (such as insects) are not allowed, whether they are dead or alive. Other biological samples are generally not allowed, but materials such as cork, cotton, leather, wood, and wool are allowed exceptions.

**Chemistry:** Chemical reactions are prohibited, so avoid materials and coatings that react with water (such as antacid tablets).

**Electricity:** Electrical components such as batteries, lasers, motors, etc. are not allowed, but wire is an allowed exception.

**Liquids:** While liquids can be used in creating your test objects, the devices must be dry and contain no liquids when they are shipped to NASA.

**Insoluble:** Materials, including coatings, must not dissolve in water.

**Separation:** Test objects may not include parts, materials, or coatings that separate – intentionally or otherwise – in the water. As examples, (1) the separation of ballast is not allowed, (2) the water must not become cloudy or discolored, and (3) the water's adhesion to (and thus wetting of) the container must not be affected by contamination from the test object. **Objects causing such outcomes will receive zero in test performance scoring regardless of the motion of the test object.**

**Drop testing:** We normally drop your test objects twice, unless there is an operational issue leading us to conduct additional drop(s). Your test objects will typically be in the water for roughly 10 minutes prior to the first drop test and for 30 minutes or more before the second drop test. That is just one reason why it is important that the materials, including any applied coatings, do not dissolve in water, etc.

**Object Orientation:** While our intent is to place objects in the water in your preferred orientation (if any) prior to each drop, we do not guarantee their orientation during the microgravity tests. The test hardware will be jostled as it is lifted to the top of the tower and prepared for the drops. You are encouraged to verify that your objects will float in your preferred orientations through your own testing.

### 1.4 Prepare and submit your proposal

Prepare your proposal using the entry form, shown in Appendix C, which is available online as a stand-alone document. The proposal shall include information about your team plus descriptions and depictions of your test objects. It must be written in English and consist of a single file, in a pdf format, into which all figures must be 'pasted.' The file must be less than 9 MB in size or it will not be received by the challenge staff.

E-mail the proposal to Ed-DropTower@lists.nasa.gov by no later than Nov. 1, 2023. More precisely, your proposal must be e-mailed to NASA before midnight (at least 11:59 PM) in your local time zone. The proposals will be reviewed, and selections will be announced via e-mail to all proposers by at least mid-December. Teams who've been selected for testing may continue to the next phase.

## 2. Build your test objects

Assuming that your team is selected for participation in the testing, build your test objects following the rules in the design section (1.3) of this guide. Make sure to review the key rules and hints as you design your test object.

**Changes:** It is acceptable to change your designs, e.g., based on research conducted after your proposal submission. However, you are encouraged to check with Ed-DropTower@lists.nasa.gov to ensure that the new designs are acceptable. Given the deadline for the arrival of your devices at NASA, you should strive to finalize your designs in January.

**Materials, dimensions, and drawings update:** Each team will be asked to e-mail our staff by Jan. 15 at ed-droptower@lists.nasa.gov with an updated list of all materials used in your test objects. In that list, clearly identify any materials that were not listed in your initial proposal. In addition, if there are any changes to the dimensions or designs, updated drawings need to be submitted. The update will be requested in early January to ensure that safety requirements will be met during drop testing at NASA.

**Extra test objects:** You may want to make extra copies of your test objects to keep because the objects sent to NASA won't be returned. For example, you could display them at your school or perhaps even at the ASGSR conference.

**It is highly recommended that you conduct your own microgravity trials:** Consider putting trial objects with water in a plastic jar and dropping the jar with a video camera to get a glimpse of what happens in microgravity. Just a 4-foot fall provides a half second of microgravity, which can hint at what will happen in the 79-foot fall in NASA's 2.2 Second Drop Tower. For inspiration on conducting your own drop research, check out the Fire in Free Fall video by Physics Girl Dianna Cowern**.** You can also contact Ed-DropTower@lists.nasa.gov for guidance on how to conduct your own drop tests.

**Liquids:** When shipped to NASA, all test objects must be dry and not contain liquid. But your team can use liquids, including coatings, in preparing your test objects. The devices, including any coatings, just need to be dry when they are shipped.

**Coatings:** Coatings must be applied by your teams before they are shipped to NASA. Coatings – and more generally all test object materials – must not (1) dissolve in water, (2) react with water, or (3) detach from your test objects in water.

**Packaging:** Once your objects are ready, package them to prevent breakage during shipping and injury to challenge staff. Although a team's objects should be shipped together in one package, each object should be packaged individually. An object's individual package can be as simple as a resealable plastic bag, but the package must be labeled (e.g., with a permanent marker) with the organization name, team or experiment name, and the object number or other identifier. An advisor with multiple teams may ship their objects together to NASA, making such labeling even more important. Note that the shipment of more than three test objects by a team is unacceptable even if more than three different test objects were built. Three is the 'magic' number and **each team must choose no more than three objects to ship to NASA.**

**Object orientation:** Your shipment must include printed drawing(s) of each test object with down arrow(s) to indicate their preferred orientation in the water. If there is a no preferred orientation for your objects, then please indicate that on a piece of paper packaged with the objects.

**Shipping:** Ship the objects and drawings to the following address, where they must **arrive at NASA by no later than February 15, 2024**.

Expulsion c/o Tyler Hatch - DESK
NASA Glenn Research Center
21000 Brookpark Road, Bldg. 77, Rm. 110
Cleveland, OH 44135

**Late objects will be disqualified from the competition!**

**View within the 2.2 Second Drop Tower as technicians prepare for a drop test.**

# 3. Analyze and document your results

## 3.1 Draft written report

Report writing can and ideally should begin after your team's proposal has been selected for testing. Even before your test objects are completed and the microgravity test conducted, your team can begin writing an introduction based on what you've learned in preparing your proposal and from any preliminary tests performed by your team. References can also be documented. You can also draft the section describing your experiment (i.e., attempt at the challenge), once the design of your test objects has been finalized. But of course, you'll need to wait until the tests have been conducted to write the results, discussion, and conclusions. Furthermore, the abstract should be the last section of your paper to be written.

**Guidance:** While Expulsion is a design challenge in which you must apply engineering skills, the written report should be prepared as a scientific paper. There is no required format for the written report, but it is suggested that teams generally follow the guidance found in "A Guide to Writing a Scientific Paper: A Focus on High School Through Graduate Level Student Research" by Renee A. Hesselbach et al.

**Example papers:** While the referenced paper provides guidelines, example papers can be seen, for example, in the digital repository for the meetings of the International Conference on Environmental Systems (ICES). Those papers aren't directly relevant to the design challenge but instead address life support and related spaceflight topics. You're encouraged to review a few scientific papers, whether from there or elsewhere, to get an idea of how you might prepare your report.

**Authors:** While student names should not be included in your proposal, they should be included in your written report and on the poster if your team is invited to present at the ASGSR meeting. Similarly, identify your organization and where it is located, but just the city and state (for example) but not the full address. This is where you should be recognized for your work!

**Audience:** The report should be written for readers who don't know anything about the Expulsion challenge, microgravity, and wetting phenomena (e.g., hydrophilic and hydrophobic surfaces).

## 3.2 Analyze results

NASA's goal is to electronically provide the test data to all teams by at least April 1, so if you don't receive access to your results by then, contact Ed-DropTower@lists.nasa.gov.

For each test, the data will consist of a video filmed at 30 frames per second showing what happened during the drop tests, possibly supplemented by still images taken from the video.

Tracker, which is shared by Open Source Physics as a tool for "physics teaching and student activities," is a suggested way to make measurements of motion in the tests. The Tracker software has notably been used by some participants in past drop tower challenges. As an alternate, many of NASA's microgravity researchers use ImageJ (from the National Institute of Health) or its 'batteries included' version called Fiji, which are both freely available for making such measurements.

Position measurements can also be made with simple graphic software that continually reveals the position of the cursor. Simply load an image, move the cursor to each desired position and write down their values (i.e., by hand). Repeat with successive video frames to track positions as a function of time. Microsoft Paint is an example of such software, where it reveals the position of the crosshairs in the bottom left of the window (in pixels and relative to the image).

Measurements can also be made manually by taping a transparent overlay to your computer monitor and marking the positions using a permanent marker. You can make measurements for multiple images (i.e., times) using the same transparency, where it may be helpful to mark each position with the image number (or time).

Please understand that these are just suggestions and are not meant to indicate endorsements by NASA or the federal government.

## 3.3 Complete and submit written report

Using the results from the testing, complete your written report (e.g., as described in section 3.1) and e-mail it to Ed-DropTower@lists.nasa.gov by no later than May 1, 2023, more specifically by midnight in your local time zone. Note that the report must be no more 9 MB, written in English, and submitted in a pdf format.

# 4. Present at the 2024 ASGSR Conference

Based on their performance in the drop testing, application of the engineering design process and scientific method, analysis, and written reports, some teams will be invited in mid-May to present their results in a student poster session at this annual meeting. All participating teams will be contacted by e-mail about the selections.

**When and where?** The meeting dates and location have not yet been announced, but it is expected that the conference will be held in early November (or perhaps late October) with the student day on a Saturday.

**Cost:** It is expected that there will be a nominal registration fee, such as $25/each, for the invited students presenting at the conference as well as accompanying advisors, parents, and/or chaperones. Except for continental breakfast(s), the admission does not include meals, but tickets may be purchased for the Saturday evening banquet. The special admission includes participation in the student day and tentatively the preceding day, but probably not the full conference.

**Travel support:** It is envisioned that financial support will be provided to help invited non-local teams travel to the conference. The expected travel support is $500 per invited student presenting at the conference. Given that the travel expenses could exceed that support, teams coming to the conference will need to take action to address the likely shortfall. Furthermore, the financial travel support will not be provided in advance. Instead, it will probably be provided as a check at the conference.

**Poster:** The posters are pinned up on vertical boards and are typically no more than 48" wide and 48" tall, but the size specifications for the 2024 meeting are not yet known. The posters are almost always printed in a single piece (where software such as PowerPoint allows for custom sizes) and brought rolled up in a tube. To be clear, there will not be tables for the poster session so you should not have a tri-fold display board as might be used at a school science fair. There are many online resources with recommendations for creating and presenting scientific posters, where these are a few examples:

- 10 simple rules for designing a scientific poster
- Conference presentations: Lead the poster parade
- Creating Anthropology Conference Posters: A Guide for Beginners
- Designing conference posters
- How to Create a Research Poster
- How to make an academic poster
- Poster Perfect
- Ten Simple Rules for a Good Poster Presentation

ASGSR awards will be presented based on the poster presentations, where other students will be presenting on projects other the drop tower challenge. So, this is another opportunity to do your best!

**Activities:** The conference will include opportunities for students to tour the exhibit hall, attend research presentations, and interact with other students, the challenge staff, and various microgravity researchers.

# APPENDIX A – FAQs: Frequently Asked Questions

**Q: How are microgravity conditions created?**
**A:** During its fall in NASA's 2.2 Second Drop Tower, each object behaves as if there is no gravity, just as if it were in orbit on the International Space Station (ISS). Our sensation of gravity and weight comes from a resistance to its pull, for example because of the floor preventing us from falling. If we are freely falling (e.g., after jumping off a diving board), we feel weightless, and free-fall is the basis for many amusement-park rides. This occurs because all objects fall at the same acceleration unless acted upon by another force. As one result, the astronauts and the ISS fall together (around the Earth) such that the astronauts float within the space station. This happens even though the space station is so close to the Earth that the gravity is only about 10% less than that at the Earth's surface.

**Q: Can students be on more than one team?**
**A: No.**

**Q: Can a team submit more than one proposal?**
**A: No.** Your organization (e.g., school, club, Scout troop, etc.), however, can have multiple teams but it may submit at most 2 proposals to NASA. A school, for example, could select the top 2 proposals to submit to NASA for evaluation.

**Q: Can home schools participate?**
**A: Yes**; teams don't need to be affiliated with a school and can be formed from any group of youth in grades 8-12 including siblings, neighbors, and friends as a few examples.

**Q: Can teams from countries other than the United States participate?**
**A: No**, unless your team is from a DoDEA school for the children of U.S. military personnel. All other students from outside of the USA are not eligible, even if they are U.S. citizens.

**Q: Where do we get the entry form?**
**A:** Online, at the 2024 Drop Tower Challenge webpage.

**Q: Can proposals or reports be submitted in a language other than English?**
**A: No!** They will be rejected, where the challenge staff doesn't have the language skills or resources to appropriately address the challenge in other languages.

**Q: Are drawings required for the proposals?**
**A: Yes**; your proposal must include descriptions and drawing(s) of each test object. They can be drawn by hand, with standard software (e.g., PowerPoint), or using Computer Aided Design (CAD). The drawing(s) must be 'pasted' into the proposal, so that the proposal consists of a single file. Drawing(s) of each object must (1) identify its maximum dimension when accounting for diagonal(s) and (2) include a down arrow indicating the preferred orientation, if any, of the test object in the water.

**Q: What file formats are acceptable for the proposals and final reports?**
**A:** Your proposal and final report must be both submitted as a pdf file. Teams submitting those documents in another file format risk rejection.

**Q: What is the maximum file size for the proposals and final reports?**
**A:** Each proposal's file must be less than 9 MB or it will not be deliverable to the challenge staff.

**Q: Does the number of objects proposed affect the odds of selection?**
**A: Yes**; preference will be given to plans with two or more objects because their results can be compared. But each team is limited to a maximum of three test objects.

**Q: Can we build test objects using a 3-D printer?**
**A: Yes.**

**Q: Can we simply buy test objects?**
**A: Yes.**

**Q: Will we get our test objects back?**
**A: No.**

**Q: Will NASA help us with ideas for our proposal?**
**A: No.**

**Q: Will NASA provide guidance for our test objects if we are selected to participate in the microgravity testing?**
**A: No,** except for reminders, clarifications, etc. about the rules and instructions. Otherwise, the challenge staff won't help teams succeed. The competition isn't over until the winners are invited to present their results at the ASGSR meeting.

**Q: Will NASA provide guidance on conducting our own preliminary drop tests?**
**A: Yes.**

**Questions?**
If you can't find the information you need in this guide or at the challenge website, then e-mail Ed-DropTower@lists.nasa.gov.

# APPENDIX B – Suggested Internet Links

## 2024 Expulsion challenge

https://www1.grc.nasa.gov/space/education-outreach/drop-tower-competition/current-drop-tower-challenges/2024-drop-tower-challenge/

## Microgravity & drop testing

2.2 Second Drop tower
https://www1.grc.nasa.gov/facilities/drop/

Fire in Free Fall (video)
https://www.youtube.com/watch?v=VAA_dNq_-8c

Microgravity (video)
https://www.youtube.com/watch?v=GSLwvtF4Zo0

What is Microgravity?
https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-microgravity-58.html

## Surfaces & more

Capillarity – Measuring Surface Tension
https://www.teachengineering.org/lessons/view/duk_surfacetensionunit_less2

Capillary Action and Water
https://www.usgs.gov/special-topics/water-science-school/science/capillary-action-and-water

Explained: Hydrophobic and Hydrophilic
https://news.mit.edu/2013/hydrophobic-and-hydrophilic-explained-0716

Fundamentals of Surface Tension/Wettability
http://web.mit.edu/nnf/education/wettability/index1.html

Superhydrophobic surfaces
www.lawrencehallofscience.org/sites/default/files/pdfs/college_resources/modules/Superhydrophobic/Superhydrophobic_Surfaces.pdf

Superhydrophobicity – The Lotus Effect
https://www.teachengineering.org/lessons/view/duk_surfacetensionunit_less4

Surface Tension Basics
https://www.teachengineering.org/lessons/view/duk_surfacetensionunit_less1

Water and Ping Pong Ball - Microgravity Experiment (video)
https://www.youtube.com/watch?v=hI8fg_d67fU

Wetting and Contact Angle
https://www.teachengineering.org/lessons/view/duk_surfacetensionunit_less3

## Analysis software

Fiji
https://fiji.sc/

ImageJ
https://imagej.nih.gov/ij/

Tracker
http://physlets.org/tracker/

## A Guide to Writing a Scientific Research Paper

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3528086/pdf/zeb.2012.0743.pdf

# APPENDIX C – Entry Form

The form can be downloaded from the 2024 Drop Tower Challenge webpage.

**This entry form must be completed in English; the use of other languages is unacceptable.**

| PARTICIPANT INFORMATION | | |
|---|---|---|
| **A** | **Adult advisor name** | |
| **B** | **Adult advisor e-mail address** | |
| **C** | **School/organization/group** | |
| **D** | **City (or township, etc.)** | |
| **E** | **State or territory (etc.)** | |
| **F** | **Student grade level(s) [8 9 10 11 12]** | |
| **G** | **Number of students on the team** | |
| **H** | **Team name (if any)** | |
| **I** | **How did you learn of the challenge?** | |

**Notes**

A All teams are required to have an adult advisor, such as a teacher, group leader, parent, or guardian.

D-E The city and state (etc.) should normally be that of the school/organization/group rather than that of the advisor or student participants. However, if the group is informal, e.g., a family or group of friends, then use the advisor's city and state (etc.).

F The Expulsion challenge is open to team members in grades 8-12, where selection preference will go to teams over individuals. Multi-grade teams, as might be found in a club or family, are acceptable.

H The optional team name can, but doesn't need to, match that of your school mascot, etc.

| EXPERIMENT INFORMATION | | |
|---|---|---|
| **1** | **Experiment name** | |
| **2** | **Research question** | |
| **3** | **Hypothesis (optional)** | |
| **4** | **Number of devices (max 3)** | |
| **5** | **Materials from which the device(s) will be fabricated, incl. any coatings, etc.** | |
| **6** | **Device dimensions** | |
| **7** | **How do the devices differ?** | |
| **8** | **How are the devices the same?** | |
| **9** | **Analysis plan (optional)** | |

**Notes**

2 The research question should be specific to the device(s), for example the differences between them. Generic research questions, such as "which device will be expelled the furthest from the water?" are inappropriately vague.

4 The experiment should include two or three devices to allow the comparison of results.

5 Based on current plans, to the best of your ability, list the materials from which the devices are to be made including any coatings, adhesives, fasteners, etc.

9 A brief description of an analysis plan is optional and will not be used in the selection process.

## DRAWINGS

Drawing(s) of the devices are required. They must be pasted into this entry form (below and/or on subsequent blank pages), where attaching them as separate file(s) is unacceptable. The drawings must show the planned dimension(s) of each device. They must also include down arrow(s) to indicate their preferred orientation in the water. **Please note that that some jostling will occur as the drop package is transported to the top of the drop tower, so you may want to account for that in your device design.**

The drawings can be (1) drawn by hand and scanned or photographed, or (2) they can be created on the computer, e.g., using a drawing program such as MS PowerPoint. Computer-Aided Design (CAD) drawings are acceptable but are not required. But again, it must be emphasized that the drawing(s) must be embedded in this entry form file.

Note that there is no limit to the number of drawings and pages that may be included in the entry, but the resulting entry form file must be less than 9 MB and must be submitted by email. Some servers will not send emails larger than 9 MB.

## KEY RULES CHECKLIST **(See the flyer and especially guide for more details and rules.)**

- □ Participants must be grade 8-12 students in the United States (incl. territories) or DoDEA schools.
- □ A student may only be on 1 team.
- □ Teams can be of any size, but a maximum of four students per team will be invited to the ASGSR meeting.
- □ A team may only submit 1 entry.
- □ An organization (e.g., school) may submit no more than 2 entries.
- □ Each team may include up to 3 test objects in their proposal.
- □ An object's longest dimension, when including diagonal(s), must be ≥5 mm and ≤60 mm.
- □ Objects must float in water in normal gravity.

## SUBMISSION CHECKLIST

**This entry form must …**

- □ be in English, where use of other languages is unacceptable
- □ include drawing(s) of each device in which:
  - □ each device is identified by name, number, etc.
  - □ the maximum dimension of each device is clearly labeled
  - □ down arrow(s) indicate the preferred orientation of the object in the water
- □ be submitted in a .pdf format (where all other formats are unacceptable)
- □ be named XPLSN24_<StateAbbrev>_<OrgAbbrev>_<AdvisorLastName>_<TeamAbbrev>_entry, where an acceptable example is XPLSN24_WV_GWHS_Smith_Team1_entry,
  *The abbreviations for eligible states, territories, etc. are provided on the next page for reference. The team abbreviation can be the team's name (if short) or initials or some other short designator. If an organization submits two entries (the maximum allowed), the team abbreviations must be different.*
- □ be less than 9 MB in size (where, in contrast, there is no limit to the number of pages)
- □ be e-mailed to Ed-DropTower@lists.nasa.gov no later than Nov. 1, 2023, 11:59 pm (your local time)
  *The adult advisor should either be cc'd with the submission e-mail or personally submit it on behalf of the team. If two entries are submitted by the same advisor, they must be e-mailed separately.*

## QUESTIONS

If you still have questions after checking the following:

(1) entry form
(2) guide
(3) website (~~where the address is also shown below as a footnote~~)

then e-mail the Expulsion challenge staff at Ed-DropTower@lists.nasa.gov.

## STATE, ETC. ABBREVIATIONS

| US State | Abbrv | US State | Abbrv | US State | Abbrv | US Territory | Abbrv |
|---|---|---|---|---|---|---|---|
| Alabama | **AL** | Louisiana | **LA** | Ohio | **OH** | American Samoa | **AS** |
| Alaska | **AK** | Maine | **ME** | Oklahoma | **OK** | District of Columbia | **DC** |
| Arizona | **AZ** | Maryland | **MD** | Oregon | **OR** | Guam | **GU** |
| Arkansas | **AR** | Massachusetts | **MA** | Pennsylvania | **PA** | Northern Mariana Islands | **MP** |
| California | **CA** | Michigan | **MI** | Rhode Island | **RI** | Puerto Rico | **PR** |
| Colorado | **CO** | Minnesota | **MN** | South Carolina | **SC** | U.S. Virgin Islands | **VI** |
| Connecticut | **CT** | Mississippi | **MS** | South Dakota | **SD** | DODEA schools | **DOD** |
| Delaware | **DE** | Missouri | **MO** | Tennessee | **TN** | | |
| Florida | **FL** | Montana | **MT** | Texas | **TX** | | |
| Georgia | **GA** | Nebraska | **NE** | Utah | **UT** | | |
| Hawaii | **HI** | Nevada | **NV** | Vermont | **VT** | | |
| Idaho | **ID** | New Hampshire | **NH** | Virginia | **VA** | | |
| Illinois | **IL** | New Jersey | **NJ** | Washington | **WA** | | |
| Indiana | **IN** | New Mexico | **NM** | West Virginia | **WV** | | |
| Iowa | **IA** | New York | **NY** | Wisconsin | **WI** | | |
| Kansas | **KS** | North Carolina | **NC** | Wyoming | **WY** | | |
| Kentucky | **KY** | North Dakota | **ND** | | | | |