2023 DROP TOWER CHALLENGE
Diving into Experimental Research (DIVER)

https://www1.grc.nasa.gov/space/education-outreach/drop-tower-competition/current-drop-tower-challenges/2023-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, hydrophobic (water-fearing) and hydrophilic (water-loving) surfaces or coatings can have additional effects which are more pronounced in microgravity.

What?

Teams of grade 8-12 students are challenged to design and build simple devices which in normal gravity will float in water, but which will submerge as far as possible 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 2023 meeting of the American Society for Gravitational and Space Research (ASGSR).

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. **With the exception of DODEA schools, this challenge is not open to participants outside of the United States, regardless of citizenship!** Students are free to get help from adults, for example, in building their test objects. An organization (e.g., school, science center, 4-H club, Scout troop) may submit no more than five proposals, where it is envisioned that no more than two will be selected from a single organization.

Selection?

After proposal evaluation, NASA anticipates selecting up to 20 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.

Table of Contents

A. THINGS TO KNOW

Calendar

2022	***Now!!!***	***Preparation of proposal***
	Nov. 13, 11:59 PM	Deadline (in your time zone) to e-mail proposal(s) to NASA
	Early December	NASA announces teams selected for testing
2023	Jan.-February	Preparation of test objects
	Feb. 13	Deadline for the arrival of test objects at NASA
	Feb.-March	Testing in NASA's 2.2 Second Drop Tower
	April	Analysis and report writing
	May 1, 11:59 PM	Deadline (in your time zone) to e-mail final report(s) to NASA
	Mid-May	NASA announces teams selected for ASGSR participation
	Fall 2023	Annual ASGSR meeting (probably in early November)

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 citizenship.
- **Proposals:** No more than 5 proposals will be accepted per organization (e.g., school, science center, 4-H club, Scout troop), and no more than one proposal will be accepted from a team.

- **Team:** Teams can be of any size, but a maximum of four students per team will be invited to the ASGSR meeting. Each student can only be on one team. Each team is required to have an adult advisor, who may advise multiple teams.
- **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:** An object's longest dimension (e.g., length or diameter) may be no more than 60 mm and no less than 5 mm.
- **Prohibited materials:** hazardous materials (e.g., that are corrosive, toxic, radioactive), fragile materials (e.g., glass), materials or coatings that dissolve in or react with water, small creatures (whether dead or alive), most biological materials.

Hints

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**.**

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.

Timing is important: Late submissions to NASA of the test objects will disqualify teams from the competition. Late final reports will disqualify teams from being selected to participate in the ASGSR conference, so don't wait until the deadlines to complete tasks.

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 analysis (as revealed in the final report)
3. Team's final report

Failure to submit a final report by the deadline will disqualify a team from being selected for ASGSR participation regardless of their test performance!

B. WHAT TO DO

There are four phases to participating in the challenge:

1. Prepare your proposal – *open to all eligible*
2. Develop & self-test your test object(s) – *if the team's proposed project is selected for testing*
3. Analyze & document the results – *generally after the NASA microgravity testing, but some draft text can be written during the second phase*

4. Present at the 2023 ASGSR conference – *if invited to participate based on the challenge performance and submitted final report*

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 2023 ASGSR conference (phase 4).

1. Prepare your proposal

1.1 Understand the challenge

The goal is to design and build objects which will float in normal gravity but submerge as far as possible because of their wetting characteristics during free fall (i.e., microgravity conditions).

Scoring: An object's score will be calculated based on the maximum vertical distance travelled downward during free fall.

Capillary action occurs when the attraction between the liquid and the surface (adhesion) is stronger than the liquid's attraction to itself (cohesion). The adhesion/cohesion balance affects how liquids interact with a surface, including that of a floating test object, and can cause the liquid to move, for example when the force of gravity seems to disappear. The geometry of the surface, including both the shape and dimensions, can influence the resulting motion.

A surface's properties can also affect liquid interactions, where their influence can be particularly strong in microgravity. Surfaces can be either hydrophobic or hydrophilic, that is 'water fearing' or 'water loving.' 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 a diving object

Watch the YouTube video, Ping Pong Ball On Water, which shows an experiment created by a middle school team for a previous drop tower competition. The DIVER challenge goal is for student teams to create objects that will float under normal-gravity conditions but dive into the water during microgravity conditions.

When an object floats on water in normal gravity, it is because gravity pulls more forcefully on the water than the less dense object. However, in microgravity, the interaction between the object and the water is governed by the wettability (or contact angle) of the object by the water. Thus, to submerge the object for this challenge, it is necessary for your objects to be less dense than water but have highly wetting surfaces. Note that the objects must float in water in normal gravity, or they will not be accepted for testing.

1.3 Develop your test object concepts

Based on your research, design your own object(s) that will submerge 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.

Number - Each selected team can 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 2023 ASGSR conference. Of course, at least one test object must be proposed and assuming selection built and shipped to NASA for testing.

Materials – The diving objects must be fabricated from safe solid materials such as plastic or metal. Water-soluble materials and coatings are prohibited, as are materials and coatings which chemically react with water. For safety, corrosive, toxic, and radioactive materials are prohibited. Other hazards such as sharp edges, compressed gases, batteries, and lasers are not allowed. 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 wood, cork, cotton, leather, and wool are allowed exceptions.

Containers – Each diving 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 from left to right and front to back (i.e., where the cross-section is square). Three containers with objects will be tested in a single drop.

Size – The longest dimension of each test object shall be no more than 60 mm and no less than 5 mm.

Buoyant – Each test object shall float in water while in normal gravity or it will be rejected from testing.

Diving – Objects may only dive because of their wetting characteristics and must not dive because of other reasons, e.g., mechanical propulsion initiated during free fall, etc.

1.4 Prepare and submit your proposal

Prepare your proposal using the entry form, shown in Appendix B, which is available online as a stand-alone document. The proposal shall include information about your team plus descriptions and depictions of your test object(s). It must be written in English and consist of a single file, in either doc or pdf formats, into which all figures must be 'pasted.' The file must be less than 10 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. 13, 2022. 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 object(s)

Assuming that your team is selected for participation in the testing, build your test object(s) 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. 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. Note that 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 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.

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 box, each object should be packaged individually. An object's indivdual 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.**

Ship the objects to the following address, where they must **arrive at NASA by no later than February 13, 2023**.

DIVER 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!

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 object(s) 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 object(s) 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.

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.

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) and not a full address. This is where you should be recognized for your work!

3.2 Analyze results

NASA's goal is to electronically provide the test data to each team within two weeks of their tests and by at least April 1, with objects tested in the order received at NASA.
For each test, the data will consist of a video filmed at 30 frames per second showing the water motion during the drop tests, potentially 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 the droplet motion. 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 written in English.

4. Present at the 2023 ASGSR Conference

Based on their performance in the drop testing, 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.

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. It is expected that admission will be free or at a nominal cost on that day for the invited students presenting at the conference as well as accompanying advisors and chaperones. The student-day admission does not include meals or participation in the evening banquet, although tickets may be purchased for the latter.

It is tentatively expected that financial support will be made available to help invited non-local teams travel to the conference for this purpose. The travel support will likely be up to $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.

Additional awards will be presented based on the poster presentations. The conference will also include opportunities for students to tour the exhibit hall, attend research presentations, and interact with microgravity researchers and other students.

Testing in the 2.2 Second Drop Tower.

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 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. Note that preference in proposal selection will be given to teams over individual participants.

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. Students from other schools outside of the USA are not eligible, even if they are U.S. citizens.

Q: Does the number of objects proposed affect the odds of selection?
A: Preference will be given to plans with two or more objects because their results can be compared. Keep in mind that each team is limited to a maximum of three test objects.

Q: Where do we get the entry form?
A: Online, at the 2023 Drop Tower Challenge webpage.

Q: What file formats are acceptable for the proposals?
A: The proposals must be submitted as either doc or pdf files. Teams submitting their proposals in other file formats risk rejection.

Q: Can proposals or reports be submitted in a language other than English?
A: No.

Q: Are drawings required for the proposals?
A: Yes; your proposal must include descriptions and drawing(s) of each test object(s). 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.

Q: What is the maximum file size for the proposals?
A: Each proposal's file must be less than 10 MB or it will not be deliverable to the challenge staff.

Q: Can we build test object(s) using a 3-D printer?
A: Yes.

Q: Can we simply buy test object(s)?
A: Yes.

Q: Will we get our test object(s) back?
A: No.

Q: Is the water used in the drop tests distilled, de-ionized, etc.?
A: It is simply tap water at room temperature.

Q: Can a team submit more than one proposal?
A: No, and a student can only be a member of one team so a student cannot be part of more than one proposal. However, your organization (e.g., school, Scout troop, club, etc.) can have as many as 5 teams submit proposals.

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.

View from the eighth floor as technicians ready the drag shield assembly.

APPENDIX A – Suggested Internet Links

2023 DIVER Challenge

https://www1.grc.nasa.gov/space/education-outreach/drop-tower-competition/current-drop-tower-challenges/2023-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

What is Microgravity?
www.nasa.gov/centers/glenn/shuttlestation/station/microgex.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

Hydrophobic Surfaces
http://soft-matter.seas.harvard.edu/index.php/Hydrophobic_Surfaces

Ping Pong Ball on Water (video)
www.youtube.com/watch?v=wOqYCt-n2ts

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

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/

APPENDIX B – Entry Form

The form can be downloaded from the 2023 Drop Tower Challenge webpage.

2023 Drop Tower Challenge: DIVER **ENTRY FORM** 17 June 2022

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)**	

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 be that of the school/organization/group rather than that of the advisor or student participants.

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

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, including any coatings**	
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 sink the furthest?” are inappropriately vague.

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

5 To the best of your ability, list the materials from which the devices are planned to be made including any coatings.

7 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 (e.g., below), where attaching them as separate files is unacceptable. The drawings must show the planned dimensions of each device. **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 10 MB.

SUBMISSION

This entry form must …

1. be completed in English,
2. include drawing(s) of the device(s) with dimensions labeled as described above,
3. be submitted in either a .doc or .pdf format,
4. be named DIVER23_<StateAbbrev>_<OrgAbbrev>_<AdvisorLastName>_<EntryAbbreviation>, where an example is DIVER23_WV_GWHS_Smith_Team1,

   The abbreviations for eligible states, territories, etc. is provided below for reference. The entry abbreviation can be the team name (if short) or initials or some other short designator which will distinguish between multiple entries from the same advisor.
5. be less than 10 MB in size (where, in contrast, there is no limit to the number of pages), and
6. be e-mailed to Ed-DropTower@lists.nasa.gov by no later than November 13, 2022.

The adult advisor should either be cc'd with the submission e-mail or personally submit it on behalf of the team. An organization (e.g., school) may submit no more than 5 entries. Each entry should be e-mailed individually.

QUESTIONS

If you still have questions after checking the …

(1) entry form,
(2) DIVER guide, and
(3) website, i.e., https://www1.grc.nasa.gov/space/education-outreach/drop-tower-competition/

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

STATE 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**				