2018 DROP TOWER CHALLENGE
Microgravity Expulsion from Water

https://spaceflightsystems.grc.nasa.gov/education-outreach/expulsion/

HOW-TO GUIDE

Challenge overview

What? Teams of grade 9-12 students are challenged to design and build objects that sink in water in normal gravity, but will be expelled as far as possible out of the water during free fall 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 2018 meeting of the American Society for Gravitational and Space Research (ASGSR).

Who? The design challenge is for students in grades 9-12, 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 DODEA schools for the children of U.S. military personnel. 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. It is envisioned that the selection will include ten teams local to the fall 2018 ASGSR conference site (for which the location and dates have yet to be announced) and ten more teams that are not local (e.g., more than 150 miles distant). However, only the top-performing teams will be invited to participate in the conference as explained in the next section.

How does a team participate?

There are four phases and ways in which a team can participate in the challenge:

1. prepare your proposal – *open to all eligible*
2. build your test object(s) – *if the team's proposed project is selected for testing*
3. analyze & document the results – *generally after the microgravity testing*
4. present at the 2018 ASGSR conference – *if invited to participate based on the challenge performance and submitted report*

Each phase is separated by a submission to NASA - respectively of the proposal, test object(s), and written report. 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 enable 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 2018 ASGSR conference (phase 4).

1. Prepare your proposal *now to Nov. 10*

1.1 Understand the challenge

While the goal of the challenge is to use hydrophobic properties to expel the objects from water under microgravity conditions, performance will be judged based on vertical displacement of the objects. The greater an object moves upward during the drop, the higher its score:

The score for an object equals the difference in heights between (1) its highest point just before the release of the drop package, i.e., in normal gravity, and (2) its highest point at any time during the free fall, i.e., in microgravity.

This holds whether the object tumbles or not during microgravity, where the measurement won't be based on a specific part of the object. Also note that the relative position of the object to the water is not a factor in the scoring, even though the general goal is to expel it from the water during free fall.

As in most competitions, the highest score is best and teams will be judged based on their most successful object, where they can submit up to three for testing:

A team's score equals the score of their top-performing object, i.e., the highest of their objects' scores.

Each test object must sink in water in normal gravity. Gravity causes objects that are more dense than water to sink to the water's bottom, but sedimentation is eliminated during microgravity and an object's interaction with the water then becomes governed by its surface properties.

The expulsion must result from hydrophobic surface of the object. 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. In free fall, objects with "water fearing" surfaces can be pushed from the water and the goal of this challenge is to cause them to move upward as far as possible during the drop.

The expulsion of a floating object in microgravity can be seen in a video at www.facebook.com/NASA.celere. It can also be down-loaded from the *Expulsion 2018* folder within the SEEC Microgravity section of Dennis Stocker's Google drive, where Stocker is one of the challenge staff and SEEC is the abbreviation for the Space Exploration Educators Conference. The video is courtesy of researchers at Oregon's Portland State University (PSU). As can be seen, the ball 'jumps' out of the water in microgravity. It must be emphasized that challenge's test objects must sink in the water in normal gravity, while the object in the video instead floats. Please know that the challenge staff will **not** share the hydrophobic treatment of the

ball in this video, as we are looking for participating teams to research and find their own approaches to the challenge rather than copy what was done in the video.

1.2 Design your test object(s)

Based on your research, design your test object(s) using the guidelines below to achieve the highest score as described in the previous section. Note that NASA will provide the rest of the experiment hardware including the three water containers in which your objects will be tested (with one object per container), the video camera, and lighting.

Number – Each selected team can submit up to three different objects for testing. This allows a team to compare test results, e.g., in the required report and - if invited - at the 2018 ASGSR conference. Of course, at least one test object must be proposed and - assuming selection - built and shipped to NASA for testing.

Materials – The objects must be fabricated from safe solid materials such as plastic or metal. Glass and similarly fragile materials are unacceptable. 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, such as foods, are generally not allowed, but organic materials such as wood, cork, cotton, wool, and leather are allowed exceptions.

Containers – Each object will be tested in its own container of water. The vessel's interior is a rectangular prism which is 210 mm tall and 63 mm across, where the cross-section is square. Three independent containers, each with an object in water, will normally be tested during a single drop operation. Each container will be filled with 120 ml of water and then a team's object is placed inside. The team must specify if a certain orientation is required, e.g., in a drawing.

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

Non-buoyant – Each object must sink in water to the bottom of the container in normal gravity or it will be rejected rather than tested in microgravity.

Movement – In microgravity conditions, objects may only rise because of their wetting characteristics and must not rise because of other reasons, for example, mechanical propulsion initiated during free fall.

1.3 Prepare and submit your proposal

Prepare your proposal using the entry form which will be made available online, including the *Expulsion 2018* folder within the SEEC Microgravity section of Dennis Stocker's Google drive. The proposal will include information about your team plus

descriptions and depictions of your test object(s). Each proposal shall 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. E-mail the proposal to Ed-DropTower@lists.nasa.gov **by no later than Nov. 10, 2017.** The proposals will be reviewed and selections will be announced via e-mail to all proposers by mid-December. Teams who've been selected for testing will continue to subsequent phases.

2. Build your test object(s) *mid-December to Feb. 10*

Assuming that your team's proposal is selected, build your test object(s) following the rules in the design section (1.2) of this guide. It is acceptable to change your design(s), e.g., based on research conducted after your proposal submission. But you are strongly encouraged to check with Ed-DropTower@lists.nasa.gov to ensure that the new design(s) 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, unless at the 2018 ASGSR conference.

Once they're ready, ship your test object(s), with appropriate care in packing, to the following address. The object(s) must **arrive at NASA by no later than February 10, 2018**.

Expulsion c/o Nancy R. Hall
NASA Glenn Research Center
21000 Brookpark Road, MS 77-7
Cleveland, OH 44135

Late objects will be disqualified from the competition!

3. Analyze & document the results *mid-December to May 1*

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 object(s) are built and the microgravity test conducted, your team can begin writing an introduction based on what you've learned in preparing your proposal. 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.

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 objects' motion during the drop tests, tentatively supplemented by still images taken from the video.

One option for analyzing the video results is through NASA's Spotlight software. However, the software is not currently supported and Spotlight-8 is not compatible with current versions of Microsoft Windows. So Spotlight-16 should be used if this option is taken, although many NASA researchers are now instead using ImageJ, which is freely available from the National Institute of Health (NIH). Meanwhile, the free Tracker software is shared by Open Source Physics as a tool for "physics teaching and student activities." The Tracker software has notably been used by some participants in past drop tower challenges.

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 cross-hairs 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, 2018.

4.0 present at the 2018 ASGSR conference *mid-May to fall 2018*

Based on their scores and written reports, some teams will be invited in mid-May to present their results in a student 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 October or November with the student day on a Saturday. Admission will be free on that day for a limited number of students who present their posters at the conference, as well as accompanying advisors and chaperones. The free admission does not include meals or participation in the evening banquet, although tickets could optionally 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. That anticipated travel

support is unlikely to cover the full cost of the trip, so teams would need to take action to address the likely shortfall. The travel support would likely be up to $500 per student presenting at the conference. It would be provided as a check at the conference and the funds could be used for any associated costs, including the cost for the adult travel. Receipts would not be necessary as it is not a reimbursement.

Awards will be presented to teams on the student day based on their posters and success with the challenge. The conference will also include opportunities for students to participate tour the exhibit hall, attend research presentations, and interact with microgravity researchers and other students.

Calendar

Now	open for proposals
Nov. 10, 2017	deadline for e-mail submission of proposals to NASA
Mid-December	teams selected for testing announced by NASA
Feb. 10, 2018	deadline for object(s) to arrive at NASA
Feb.-March	objects tested in NASA's 2.2 Second Drop Tower
May 1, 2018	written report due to NASA
Mid-May	teams selected for ASGSR participation announced by NASA
Fall 2018	annual ASGSR meeting

Key Rules

- **Proposals:** 5 maximum per organization (e.g., school), with 1 maximum per team
- **Team:** teams can be of any size, but each student can only be on one team
- **Density:** objects must sink in water (to the bottom) under normal gravity conditions
- **Number:** up to 3 objects per team
- **Size:** an object's longest dimension may be no more than 60 mm and no less than 5 mm
- **Prohibited materials:** fragile materials (e.g., glass), hazardous materials (e.g., that are corrosive, toxic, radioactive), 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 with water in a plastic jar and dropping the jar in front of a video camera to get a glimpse of what happens in microgravity. Just a 4-foot fall provides 0.5 seconds of microgravity, which 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**.**

Two+: Include two or three different objects for testing so that you can compare their test results. An added benefit is the increased probability of success with the challenge.

Timing is important: The drop duration is only 2.2 seconds. More importantly, late submissions to NASA, e.g., of the test objects, will disqualify teams from the competition. So don't wait until the deadlines to complete tasks.

FAQs (i.e., 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, where teams don't need to be affiliated with a school at all and can be formed from any group of youth in grades 9-12 including siblings, neighbors, and friends as a few examples. But note that preference in proposal selection will be given to teams over individual participants.

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: From the challenge website or the *Expulsion 2018* folder in the SEEC Microgravity section of Dennis Stocker's Google drive.

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: Are drawings required for the proposals?

A: Yes; each proposals must include both descriptions and drawing(s) of each test object(s). The drawing(s) must be 'pasted' into the proposal, so the proposal will consist 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.

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: Do we get our test object(s) back?
A: A team's objects will not be returned unless a team representative is at the ASGSR conference, so you may want to build extra copies to keep.

Q: Is the water used in the drop tests distilled, de-ionized, etc.?
A: No; there is nothing special about the water used in the drop tests. It is simply tap water at an ambient temperature.

Questions?

If you can't find the information you need at the challenge website, the *Expulsion 2018* folder in the SEEC Microgravity section of Dennis Stocker's Google drive, or www.facebook.com/NASA.celere, then e-mail Ed-DropTower@lists.nasa.gov.