CAPILLARY FLOW CHALLENGE (CFC)

https://spaceflightsystems.grc.nasa.gov/cfc/

HOW-TO GUIDE

www.asgsr.org www.nasa.gov

Challenge overview

- **What?** Teams of grade 9-12 students are challenged to design and build simple devices that use capillary action (only) to eject droplets of silicone oil as far as possible while they fall down 2.2 Second Drop Tower at the NASA Glenn Research Center in Cleveland, Ohio. Selected teams will compete in the challenge and are encouraged to present their results to microgravity researchers at a conference in Cleveland on Sat., October 29, 2016.
- **Who?** The design challenge is for students in grades 9-12, where teams will be favored over individuals in selection. Youth are free to get help from adults, for example in building their experiment hardware. It is anticipated that about ten proposals will be selected from teams local to Cleveland, OH (e.g., within a few hour drive) and about ten proposals will be selected from non-local teams. An organization (e.g., school, science center, 4H 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.
- **When?** Now!!! Proposals can be submitted at any time up to October 1, but selections will be made on an ongoing basis so the odds of acceptance will diminish with time. It is even possible that all selections may be made before the Oct. 1 deadline. Teams can check www.facebook.com/NASA.celere or contact celere@lists.nasa.gov for updates on the submission and selection status. The testing will be conducted intermittently until mid-October, where the student-built experiment hardware should be sent to NASA when ready but it must arrive at NASA by no later than Friday, October 7. Experiments will be conducted during the next available drop opportunity following their arrival at NASA.

How does a team participate?

- **Engineering**
  - **Watch the video** - Watch the YouTube video on *Spontaneous Capillarity-Driven Droplet Ejection* – created by researchers at Oregon's Portland State University (PSU) - to learn about the microgravity ejection of the droplets through capillary action.
  - **Design & build droplet launchers** – Next, design your own device(s) that launch droplets of low-viscosity silicone oil using capillary action (only) during the free fall. Note that NASA will provide the rest of the experiment hardware including the housing that will hold the fluid and a bracket that will secure your capillary devices.
    - **Number** - Participating teams can submit up to four devices for testing, where having two or more different devices allows for a comparison of results.
    - **Materials** – While it is not required, it can be very useful for later analysis if the device is transparent, e.g., made of clear plastic or glass – which are both acceptable materials. The PSU team, led by Prof. Mark Weislogel, has sometimes created capillaries from polystyrene test tubes (normally used for centrifuging) where they sanded down the tips and expanded the resulting hole with a drill bit. Metals and ceramics are also acceptable materials, but porous materials such as paper, cardboard, wood, etc. are not allowed. Furthermore, the droplet-launching

devices must not include liquids or hazards such as compressed gases, batteries, lasers, or radioactive materials.

- **Size** - Each device must be no more than 150 mm tall. The bottom will be submerged in oil up to a depth of ~35 mm, so the device should be at least 40 mm tall to eject droplets. Each device should have a cross section of no more than 20 mm - i.e., it should be at most 20 mm across. As an important hint, please note that smaller inner dimensions can enable shorter ejection times. In the time-sequence below showing microgravity droplet ejection (provided by the PSU researchers), the inner diameter of the glass tubes was 5.8 mm and the outlet holes were 3.52, 2.62, and 1.1 mm in diameter from left to right. Similarly, capillary channels are cut in acrylic that is 3 mm thick in the NASA/PSU student challenge, CELERE.

- **E-mail proposal** to celere@lists.nasa.gov including the conceptual designs of your droplet launchers using the entry form available on the CFC website. Proposals should be submitted as soon as possible and must be submitted by **no later than Oct. 1**.
- **Build your droplet launchers**, where you might want to make extra copies to keep because the devices sent to NASA won't be returned - unless at the ASGSR conference.
- **Ship droplet launchers** - With appropriate care, pack and ship your droplet launchers so that they arrive at the following address by **no later than Oct. 7**.

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

Analysis & reporting

- **Analyze results** - NASA will record and electronically provide teams with the video of their droplet launchers being tested in the 2.2 Second Drop Tower. Note that the provided video may include other teams' devices because up to 4 devices can be dropped at once. But each team should focus their analysis on the performance of their own creations.
- **Prepare poster, presentation, and/or report** to share the results with NASA researchers, parents, and others.

ASGSR conference

- **Present poster** – Participating teams are strongly encouraged to present a poster about their research in a student session at the annual meeting of the American Society for Gravitational and Space Research (ASGSR) in Cleveland, OH on Sat., October 29, 2016. Admission will be free on that day for a limited number of students, plus teachers/advisors and chaperones, who present their posters at the conference. Note that the free admission doesn't include meals, e.g., participation in the evening banquet. Some limited travel support will be made available to non-local teams who present their results at the meeting. Awards will be presented to teams on that day based on the posters and success with the challenge.
- **Other student activities** – The conference will also include opportunities for students to participate in a design challenge, tour the exhibit hall, attend research presentations, and interact with microgravity researchers and other students.

Calendar

- ***Now*** open for proposals
- **Sat., Oct. 1** deadline for proposals (but it might be too late for selection)
- **Fri., Oct. 7** deadline for devices to be delivered to NASA
- **Sat., Oct. 29** student day at the ASGSR conference

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 a single team
- **Number:** up to 4 devices per team
- **Size:** 40-150 mm device height, 20 mm maximum device cross-section
- **Prohibited materials:** porous materials (e.g., paper, cardboard, wood), liquids, compressed gas, batteries, lasers, radioactive materials

Hints

- **Submit soon:** Selections will be made on an ongoing basis, where it is possible that all selections will be made before the Oct. 1 proposal deadline. Therefore, proposals should be submitted as soon as they are ready to improve the odds of selection.
- **Two+:** Design and submit 2-4 different devices for testing so that you can compare their results.
- **Stay small:** The drop duration is only 2.2 seconds and smaller inner dimensions can enable shorter ejection times.
- **Transparent:** While devices do not need to be transparent (or translucent), the use of such a material can allow for observation of the oil's movement within the device and thus facilitate analysis of the device's performance.

Selected FAQs

Q: How are microgravity conditions created?
A: Through free fall. During its fall in NASA's 2.2 Second Drop Tower, each device behaves as if there is no gravity, just as if it were in orbit on the International Space Station.

Q: What is a conceptual drawing?
A: A conceptual drawing could be called a sketch. The drawing should show the approximate size and shape of each device and indicate the planned materials. They can be drawn by hand, with standard software (e.g., PowerPoint), or using Computer Aided Design (CAD).

Q: Does the number of devices proposal affect the odds of selection?
A: Preference will be given to plans with two or more devices because their results can be compared.

Q: Where do we get the entry form?
A: From the challenge website.

Q: Can we build the capillary device using a 3-D printer?
A: Yes, but a surface printed with a 3-D printer may not be smooth enough for efficient capillary flow.

Q: Do we get our experiment back?
A: Capillary devices will not be returned unless at the ASGSR conference, so you may want to build extra copies to keep.

Questions?

Check the challenge website or send an e-mail to celere@lists.nasa.gov.