ENTRY FORM　　　Capillary Flow Challenge (CFC)

PARTICIPANT INFORMATION			
A	**Adult advisor name**	Dr. Al DeGennaro and Dr. David Whitbeck	
B	**Adult advisor e-mail address**	degennaro@gssm.k12.sc.us and whitbeck@gssm.k12.sc.us	
C	**School or organization**	Governer's School for Science and Math	
D	**City (or township, etc.)**	Hartsville	
E	**State (or territory)**	South Carolina	
F	**Student grade level(s)**	12th grade	
G	**Number of students in team**	3	
H	**Team name**	Snap-Crackle-Pop	
I	**Conference attendance:** If selected, will team representatives attend the ASGSR conference in Cleveland, Ohio on Saturday, October 29, 2016?		YES

EXPERIMENT INFORMATION *(use additional pages if necessary)*		
1	**Experiment name** *This should be your draft poster title for the ASGSR conference.*	Effect of nozzle tapering, tube height and material type on height of auto-ejected silicone oil droplets
2	**Brief description of droplet-launching device**	The droplet launching device is a nozzle that was optimized with respect to material type, amount of tapering, and nozzle height. The first way in which this nozzle was optimized was difference in free energies of the surfaces, consequently lowering the contact angle and increasing the portion of the silicone oil surface tension directed upward. We think this will maximize the upward force on the oil ("ThermoPore-Surface Energy & Capillary Forces, Part 4"). We needed a material that was very high energy compared to silicone oil, so we chose glass ("Contact Angle and Surface Tension of Some Solvents Used in Pharmaceuticals"). We found the water column acceleration as a function of tube height by a form of F=ma, shown below: $a = F/m = (\cos(\theta)\sigma 2\pi r)/(h\pi r^2\varrho)$ Where θ is the contact angle of the oil and glass, σ is surface tension of silicone oil, r is the radius of the tube, h is the height of the straight section of the tube, and ϱ is the density of silicone oil.

		("ThermoPore-Surface Energy & Capillary Forces, Part 4") From this, we graphed the displacement, velocity, acceleration, jerk, snap, and crackle as a function of time programmatically. We wanted to find the point at which increasing time in the tube had dramatic decreasing benefit on the increase in velocity in order to have a tube height that would shoot at a high ejection velocity but wouldn't be taller than it needed to be. This point was found where the slope of the velocity versus time graph decreased dramatically, at t= 0.4 seconds. We found the corresponding height from the displacement versus time graph, which was h= 5 cm meters. This is where we decided to cut off our nozzle, because after this point the benefit to adding more length decreases dramatically. This ending velocity is 0.16 m/s. The tapering of the nozzle was estimated by looking at previous studies on ejection height and nozzle tapering. In an experiment done by Taulatin High School, an optimal tapered diameter was found to be 2 mm for a tube radius of 9 mm to optimize ejection height ("Fluid Dynamics in Microgravity"). We decided to use this tapered radius to optimize the ejection velocity (and therefore ejection height) on the droplet and applied a tapering of 5 mm to 2 mm over 4 mm of nozzle height. We assume that the length of the nozzle is short enough that the ejection velocity is approximately equal to the velocity at the end of the straight part of the tube. The silicone oil travels through the tube for approximately 0.4 seconds (neglecting nozzle time) and that leaves 1.8 seconds for travel. With a velocity of 0.16 m/s, we expect it to travel 0.288 m in that time. Works Cited: Fluid Dynamics in Microgravity .:. Go Up. (n.d.). Retrieved August31,2016,from.http://tuhsphysics.ttsd.k12.or.us/Research/DIME06 /FinalPaper/index.htm Keller, A., Broje, V., & Setty, K. (2007). Effect of advancing velocity and fluid viscosity on the dynamic contact angle of petroleum hydrocarbons. Journal of Petroleum Science and Engineering, 58(1-2), 201-206. doi:10.1016/j.petrol.2006.12.002

		Mehrabian, H., & Feng, J. J. (2014, June 17). Auto-ejection of liquid drops from capillary tubes. J. Fluid Mech. Journal of Fluid Mechanics, 752, 670-692. doi:10.1017/jfm.2014.352 Phaechamud, T., & Savedkairop, C. (2012, Winter). Contact Angle and Surface Tension of Some Solvents Used in Pharmaceuticals. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 3(4), 513-529. Retrieved August 26, 2016, from Faculty of Pharmacy. R. (2009). ThermoPore-Surface Energy & Capillary Forces, Part 4.RetrievedAugust25,2016,from.https://www.youtube.com/watch?v=sLI_JKNYXVU Substrates and Adhesion – Know Your Surface. (n.d.). RetrievedAugust24,2016,from.http://solutions.3m.com/wps/portal/3M/en_US/Adhesives/Tapes/Support/Technical-News-Articles/?PC_Z7_U00M8B1A00NI60IDFIPS8T3HR2000000_assetId=1319246224870
3	**Analysis plan (optional)**	We will use AutoCAD and Inventor to design the test apparatus. Tracker, a program for analyzing videos for physics, will be used to measure the velocity and total displacement of the droplet. Error = (|(hypothesized-actual)|/actual)*100=percent error (all referring to ejection height) Success Criteria: successful ejection of droplet.
4	**Conceptual drawings** *Either paste them directly into the entry form (preferred) or attach them (e.g., in a doc, jpg, pdf, ppt format).*	Attached in email

Notes

- *Teams are required to have an adult advisor, such as a teacher, parent or guardian.*
- *The city and state should be that of the school or organization rather than the advisor or team members.*
- *CFC is open to teams in grades 9-12, whether of the same grade or mixed grades.*

After completion, this entry form must be …

1. **saved in either a doc or pdf format**
2. **named in the following format:**
   `CFC_<StateInitials>_<OrgAbbrev>_<AdvisorLastName>_<TeamInitials>`

where (a) an example is **`CFC_WI_MHS_Smith_ABC.doc`**
(b) and any attached drawings must be named in the same format

3. **e-mailed with any attached drawings to celere@lists.nasa.gov by no later than Oct 1, 2016.**

   IMPORTANT: Early submissions are strongly encouraged because selections will be made on an ongoing basis where the odds of acceptance will diminish with time. It is even possible that all selections could be made before the Oct. 1 deadline.

Questions?

See http://spaceflightsystems.grc.nasa.gov/CFC or e-mail celere@lists.nasa.gov.