Cargo Bottle Rocket
Event Specifications
MESA Day 2019

LEVEL:	Middle School/High School
NUMBER OF TEAMS:	One (1) team per school can participate at the MESA Day state competition. Three (3) teams can participate at MESA regional events.
TEAM MEMBERS:	Three (3) students to Five (5) students per team
OBJECTIVE:	To construct and launch a rocket made from one or more 2-liter plastic soda bottles, which will achieve the following objectives: 1) Deploy at apogee a capsule containing one grade A, large chicken egg that will allow the egg to return to the ground intact. 2) Egg capsule shall remain aloft for a maximum period of time Teams that incorporate Additive Manufacturing (3D Printing) as part of their design will receive a bonus. Students will also be required to submit their Engineering Design Notebooks (EDN) during specification check for review and scoring. Teams that do not have a notebook will receive a penalty.
MATERIALS:	Any materials that coincide with the design parameters may be used to build the rocket. Materials that could compromise the integrity of the *pressurized* 2- liter plastic bottle will not be allowed (e.g. hot glues, super glues, model cements). All materials are acceptable for the egg capsule, except metals. Judges reserve the right to reject designs that use materials that appear hazardous or may present safety issues, including but not limited to damage to facilities or injury to persons nearby. One launcher will be provided for each school. The Host Center will provide eggs during competition.

CAREER BACKGROUND:

Aerospace engineering focuses on the development of aircraft or spacecraft. Aerospace engineers may develop new technologies for use in aviation, defense systems, and space travel. They often specialize in areas such as aerodynamic fluid flow; structural design; guidance, navigation, and control; instrumentation and communication; robotics; and propulsion and combustion. https://www.bls.gov/ooh/architecture-and-engineering/aerospace-engineers.htm#tab-2-

For a career video on Aerospace Engineering, visit

https://www.careeronestop.org/videos/careeronestop-videos.aspx?videocode=17201100

DESIGN PARAMETERS

1. The bottle rocket may be made up of one or more 2-liter soda bottles. Substantial aluminum or metal parts are not allowed on the rocket. Small metallic parts, such as springs, machine screws, hinge pins, small escapement mechanisms, etc., will be allowed as long as they do not protrude dangerously. *Diameter of 2-liter pop bottle nozzle must be ≅ 2.5 cm in order to mate with the launcher seal.*
   a. If using more than one bottle, only one (1) bottle can be pressurized.
2. The egg capsule shall fit within the diameter of the of the 2-liter bottle(s).
3. Tail fins and the nose cone assembly may extend beyond the diameter of the 2-liter bottle(s).
4. No pre-made kits or commercially finished products may be used. Additive manufactured parts, designed and printed by the team, are not considered pre-made kits or commercially finished parts. Teams should have complete details of the design, including basic measurements used in construction, in their EDNs to support evaluation.
5. Maximum launching pressure for the rockets shall be 50 pounds per square inch gauge (PSIG). Teams may select any launch pressure up to 50 PSIG.
6. The source of energy is limited to a water/pressure combination. Alternate sources of energy to increase or maintain the altitude of the rocket will not be allowed. Powered rotors will not be allowed. Springs or rubber bands or small, lightweight escapement mechanisms may be used to help deploy the capsule.
7. Rocket booster (pressurized 2-liter bottle) shall separate from the egg capsule during flight. Remainder of rocket <u>may</u> separate from the egg capsule.
8. Egg capsules shall employ a mechanism to ensure a safe return of the egg to the ground. Commercially made mechanisms (i.e. parachutes) will not be allowed.
9. Teams may use any launch angle between 70 and 90 degrees. Students will be responsible for determining the launch angle.
10. Design should be constructed sturdy and durable enough to withstand a minimal amount of movement (i.e. table movement, judges handling).
11. Bonus points will be awarded for using Additive Manufacturing (3D Printing) as part of the design.
12. Rockets and launchers shall have the team name (school name) or team member's names marked on the exterior for identification.

MINIMUM SAFETY EQUIPMENT:

1. All team members participating in the launch shall wear plastic hard hats and goggles.
2. Team members shall remain at least 2 meters from launcher during launch.
3. Teams should bring their own safety equipment. A set of hard hats and goggles will be available at the event if needed.

SPECIFICATION CHECK:

1. During specification check, teams will check in to the competition area and submit their launcher, rocket, and Engineering Design Notebook (EDN) for impounding.
   - Essential components or scored components of the EDN are listed in a rubric on the reverse side of the score sheet.
2. Immediately upon submission for competition, each launcher and rocket receives a specification check to determine whether it conforms to dimensions, materials, and construction rules. Rockets will be checked for potential damage that may cause loss of structural integrity of pressurized bottle. Any launcher or rocket which fails the specification check will be given a performance score of zero. Teams may still receive points for the EDN and Additive Manufacturing.
3. Judges **may disqualify** any entry if, in their opinion, the testing of the rocket might create a safety hazard for spectators, team members, or property (i.e. sharp edges).
4. Devices (launcher and rocket) must be in testing condition prior to device inspection. Students must demonstrate:
   a that rocket can be successfully secured to launcher, and
   b that the trigger mechanism is in working order.
   If devices are disqualified during inspection check, design changes will not be allowed. Only devices passing inspection will be allowed to launch.
5. Repairs are allowed, replacement parts and materials only, and all repairs must be done in the impound area under supervision of a judge. The addition or exchange of parts that, in the opinion of the judge, would alter the design or function of the launcher or rocket is NOT allowed. No tools or supplies will be available at the event. Teams should bring any repair tools and repair materials with them.
6. All repair materials to be used during the competition must be impounded with the device. Tools may be kept by the team and need not be impounded.
7. After clearing specification check, all launchers and rockets will be impounded until testing.

TESTING CONDITIONS

1. At least two team members are required to be present during testing.
2. Testing will be done on a 4 foot x 4 foot plywood launch pad placed on grass
3. Testing will be done with the team's own launcher.
4. Teams must have a trigger that is activated from a distance of at least 2 meters.
5. Teams are not allowed to hold down the launcher but may add weight to ensure launcher does not move during launch.
6. Weights will be provided by MESA on the day of competition to secure launcher.
7. Two judges will record the time of the flight.
8. Timing will be recorded to the nearest 10th of a second.

JUDGING:

1. Teams (including launchers and rockets) must be ready for competition when called or forfeit that launch. Some leeway will be given to teams participating in multiple events at the discretion of the lead judge.
2. Teams shall be given one (1) launch.
3. All team members participating in the launch shall wear at least the minimum safety equipment prior to starting launch set-up until launching is complete. If any team member fails to wear the minimum safety equipment, the team will receive a zero performance score.

4. Before launch, teams will be allowed to load their egg capsule and fill the rocket with the amount of water desired. Water and eggs will be supplied by the Host Center.
5. Teams will be allotted 5 minutes to prepare their launch. This includes the time required to fill the rocket with water before the first launch attempt. If a launch attempt is aborted due to a leak or for any other reason, the team still must remedy the situation, refill their rocket with water, and complete their launch within the 5-minute time limit. Only one (1) launch per team will be allowed.
6. The team member responsible for operation of the device shall indicate to the judge that the devices are in the "ready-to-operate" condition and the desired launch pressure. The judges will operate the air compressor to apply the requested launch pressure to the rocket.
7. Judges will give the launch order and students may pull the trigger. Timing will begin at the first movement of the rocket.
8. The launch will be timed until the egg capsule stops its vertical movement (i.e. touches ground or is stopped by an obstruction) or reaches ground level.
9. A judge will retrieve and inspect the egg capsule. Any obvious signs of egg breakage including cracks or indentations will be considered non-survival of impact.
10. The performance score (average time of flight) will be reduced by 50% if any of the following occurs:
    a The rocket fails to deploy the capsule
    b The capsule becomes lost or cannot be retrieved
    c The egg does not survive impact
11. Teams may claim their rockets after the competition is officially over. All rockets will be disposed of, if not reclaimed.

SCORING CRITERIA

1. The final score will be based on a combination of the Performance Score (P), the Notebook score (N), and the Additive Manufacturing bonus (A).
2. The performance score (P) will be determined by the average of the two (2) times recorded by two (2) time keepers.
3. The performance score (P) will be reduced by 50% if any of the following occurs:
    a. The rocket fails to deploy the capsule
    b. The capsule becomes lost or cannot be retrieved
    c. The egg does not survive impact
4. Engineering Design Notebook score (5 point maximum)
5. Additive Manufacturing Bonus (5 points)

Cargo Bottle Rocket
Score Sheet
MESA Day 2019

School:_____

Student Names:_____

_____

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Specification Check

1.	Rocket is designed to deploy an egg capsule?	Yes	No
2.	Capsule fits within the diameter of the 2-liter bottle	Yes	No
3.	Energy is limited to the water/pressure combination?	Yes	No
4.	Rocket has one (1) pressurized 2-liter bottle?	Yes	No
5.	Integrity of pressurized 2-liter bottle appears intact?	Yes	No
6.	Rocket & Launcher marked with team and/or team member's name?	Yes	No
7.	Rocket is safe to use?	Yes	No
8.	Launcher is in working order and safe to use?	Yes	No
9.	**If team fails specification check, they are disqualified (except during regional events)**	**PASS**	**FAIL**
10.	Team has submitted an Engineering Design Notebook*?	Yes	No
11.	Team used Additive manufacturing (3D Printed parts)? 5 point bonus	Yes	No

Testing

1.	Did the capsule deploy?	Yes	No
2.	Was the capsule retrieved?	Yes	No
3.	Did the egg survive?	Yes	No

If the answer to any of these is no, the performance score is reduced by 50%.

TIMER #1+:_____(seconds)

TIMER #2+:_____(seconds) +Measure to the nearest tenth of a second

Engineering Design Notebook Score*:_____
*(5 points max, 5 point penalty if missing notebook)

Additive Manufacturing Bonus? YES (5 points) NO (0 Points)

Lead Judge Signature:_____ Student Signature:_____

Judge Comments:

Rubric for Engineering Design Notebooks (EDN)

EDN Goals	3	2	1	0
1. Explore				
1.1 Problem Statement. Accurately describes, in your words, the design objective (includes success criteria, constraints constants and variables)	**Specific** description of problem, success criteria, constraints, variables and constants	Basic...	Weak...	No...
1.2 Depth of Free exploration. Prior knowledge, brainstorming & hands-on exploration documented.	**Numerous** examples of brainstorming and hands-on exploration observations.	Regular...	Few...	No...
1.3 Research in Design: Research ideas about your design that might be useful. Record information using different sources (e.g. books, websites, interviews from experts).	**Clear** analysis of other design pros/cons.	Basic...	Scant...	No...
2. Design				
2.1 Design Plan. Includes reasoning on your design choices (materials used, modifications, etc.). Use data from past trials, research and design considerations.	**Clear** reasons given (based on data or research) for each design choice.	Basic...	Scant...	No...
2.3 Design sketching and/or photos. Prior & during build, team sketches, 2-D or 3-D perspective drawings.	**Numerous** representations of each design iteration.	Regular...	Scant...	No...
3. Test				
3.1 Observation. Data & written observations (tables, graphs, labeled drawings, etc.).	**Numerous** presentation of quantitative & qualitative data, graphs & charts follow design progression.	Regular...	Scant...	No...
3.2 Reflection/Analysis. Assesses pros and cons of design/materials, testing procedure, etc. Apply test results and analysis to pose a theory, recommend and argue for a next step, or draw an insightful conclusion. Restate the purpose in your conclusion.	**Detailed** reflection shows how design considerations and logic flowing from research, test analysis, etc.	Basic...	Scant...	No...
4. EDN Organization				
4.1 Structured. Includes Table of Contents with key elements. Elements of EDN can be used to answer judges questions easily	**Clear** organization utilizes defined sections.	Basic...	Minimal...	No...
4.2 Labeled. Clearly labeled with School and Team Members names.			Yes	No
Column Totals (for selected categories)				
			Subtotal (out of 25)	
			Modifier	Subtotal ÷ 5
			Score (out of 5)	

Comments/Suggestions: