MESA DAY CONTEST RULES 2025-2026

(FINAL)

Moon Base

LEVEL: Middle School (MS)

DIVISION(S): Grade 6 and Grades 7/8

COMPOSITION OF TEAM: 2-3 students per team

NUMBER OF TEAMS: Preliminary – Determined by your local MESA center
Regional – # of teams per division at the discretion of each region (Northern, Central, LA/Central Coast, and Southern)

SPONSORS: California State University, East Bay MESA College Prep Center
California State University, Long Beach MESA College Prep Center

OVERVIEW: Changes, if any, from "DRAFT" rules are highlighted in "yellow." In the future, space agencies from many nations are planning to return to the moon with plans to establish permanent research stations. As is obvious from the many craters on the moon visible from the Earth, meteor strikes are a relatively common occurrence with devastating results. Your task is to design a structure to house these new moon-based research activities that will protect the astronaut from meteor strikes. Students will design and construct an original structure using only recycled cardboard that can withstand the highest amount of impact, is lightweight, and meets the specific size requirements outlined below. **Participation logistics, limits, and competition facilities may vary by host site. Advisors and students are responsible for verifying this information with their local MESA center.** Students should take into consideration the transportation of projects; competition-ready projects must be transported safely to the competition site.

LAB REPORT: An **engineering lab report** is a required component of this competition that is meant to clearly demonstrate and illustrate evidence of the application of the Engineering Design Process in the MESA project. The purpose of the Engineering Lab Report is for students to better understand the process an engineer goes through in the creation of a project. MESA projects are not designed to be completed in a single class period or day, but to be the result of thoughtful research, planning, analysis, and evaluation. Keeping a lab report throughout the design process will help to keep a designer on track, using a logical progression of planning, in order to develop their project efficiently.

For the Engineering Lab Report, **electronic submission will be required**. Teams should use an electronic portal/application such as Google Docs to keep and

maintain a lab report. Access and permission to the lab report must then be given to MESA Day staff and judges OR lab report is submitted electronically (e.g., PDF file, WORD file) for review. **Please check with your local MESA center for the deadline and submission platform to submit your team's lab report for local and for regional events.** See "MESA Day 25-26 Engineering Lab Report Guidelines" at https://mesa.ucop.edu/.

MATERIALS:

For the structure, the only allowable material is deconstructed, post-consumer, not plastic coated, unpainted cardboard without seams with up to a maximum 5mm thickness.

- No other materials are allowed

The Host Center will provide the following during the competitions:

- Safety Goggles
- Scale for weighing the structures
- The Impact Testing Device for testing
- An empty 12-ounce standard soda can (with a height of 12.1 cm) for the Astronaut
- Paint (fingerpaint, bright colored, glow-in-the-dark, etc.)
- Step Stool
- As needed, a surface to protect the integrity of the floor may be used.
- Square Guide for centering "astronaut" (24 inch x 24 inch printout)
- Floor

GENERAL RULES:

1) The students' full name, grade level, school name, and MESA center must be clearly labeled on the structure. A 10% penalty in the score will be assessed for failing to properly label. Once the structure has been checked in, changes and alterations are not allowed.
2) Only recycled, deconstructed, post-consumer, not plastic coated, unpainted cardboard without seams (e.g., teams cannot submit a post-consumer box as is) with up to a maximum 5 mm thickness can be used to create the structure (polymers, wood, metal, ceramics, etc. are not allowed). Students are NOT allowed to create glued connections or laminates on the existing cardboard or mix substances (e.g., water) with the cardboard; however, cardboard can be layered.
    a) After the project has been tested, there will be a forensic inspection to ensure no additional materials are used on the internal structure and no individual piece of cardboard is thicker than 5 mm.
3) All joints or connections must be created with allowed materials; no glue, tape, or other external adhesive of any type can be used in any way or form. Carved, mortise, tenon, or other systems using exclusively cardboard are allowed.
4) The structure (including all parts - joints, connectors, etc.) MUST fit the following specifications. Note that the shapes and geometry of the Moon Base are up to the teams to determine as long as they meet the specifications (See Figure 1):
    a) Maximum linear length = 55 cm
    b) Maximum linear width = 55 cm
    c) Maximum linear height = 25 cm
    d) Minimum interior clearance = must fit a 20 cm radius half sphere in the center.
    e) Maximum Structure Weight = 800 grams

5) Structure must be **fully enclosed**, except the following:
   a) The entire structure must NOT have a base/floor.
   b) The structure must ONLY have two rectangular openings, to allow the "astronaut" to be seen by the audience and to allow the inspection of the structure with the following dimensions (see Figure 1):
      i) A height of between 9 to 11 cm
      ii) A MINIMUM width of 10cm to a MAXIMUM width of 20 cm
6) No material (e.g., paint, varnish, hairspray, etc.) may be applied to the structure, with the exception of the ink or pencil used to identify students' full name, grade level, school, and MESA center. Any tape that is on the post-consumer cardboard must be removed (e.g., tape on an Amazon box). Pre-existing markings and printings from manufacturing are acceptable (see Attachment A: Cardboard Examples).
7) Please remember that the purpose of this contest is to use creativity to build the best structure within the framework of the rules. The purpose is not to break the rules and see if you can get away with it.
8) The structure and lab report must be the original work of the students. Judges may ask questions to confirm provenance.
9) Digital media (e.g., photos, video recordings, etc.) will not be accepted for judging purposes. **All judging decisions are final.**

FIGURE 1

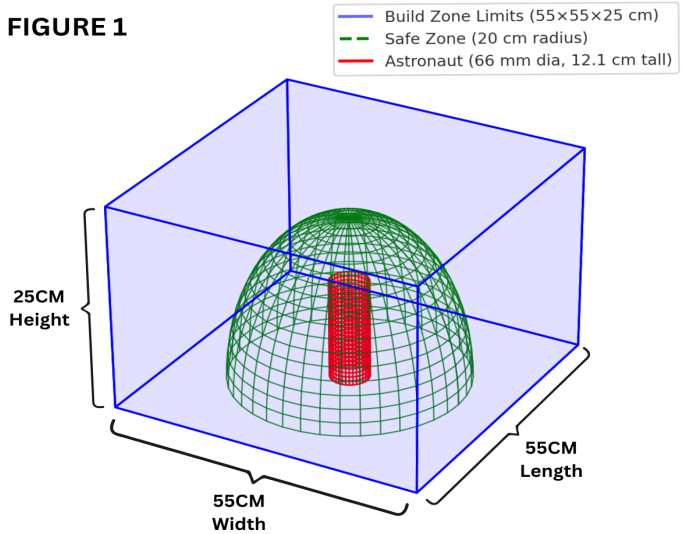
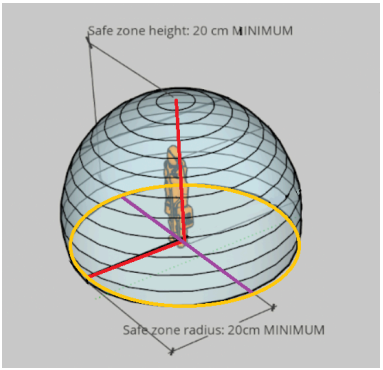
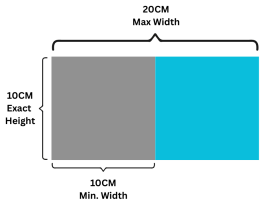


Figure 1.

Top: Demonstrates the maximum build dimensions for the moon base structure. Structures can be any shape as determined by the teams, but must fit within the 55 x 55 x 25 cm.





Bottom Left: Enlarged image of the minimum interior clearance of the 20 cm radius half-sphere "safe zone" (shown in green above) in which the astronaut (shown in red above) is placed.

Bottom Right: Demonstrates the shape and size of the 2 openings. **The height must be between 9 cm and 11 cm** (the image is NOT updated), and the width can range between a minimum of 10 cm (gray) and a maximum of 20 cm (gray+blue).

JUDGING:

1) Prior to load testing, the structure receives a specification check to determine whether it conforms to the weight, dimensions, and construction rules. An internal measurement device (see Figure 2 below) will be used to ensure that competing teams have left enough clearance inside of their structure to meet specifications.
2) The competing structure is weighed and its mass "m_s" is recorded in grams.
3) The structure will be centered on a flat, sound surface under the impact testing device (see Attachment B for details). A "crash test dummy astronaut" (i.e., an empty 12 ounce standard soda can) with a height of 12.1 cm will be centered in the interior space. After each test, the Moon Base and astronaut must be re-centered below the testing device.
    a) In setting up the competition, place the square guide on the ground to denote the center. Teams are responsible for placing their device as close to the center as possible.
4) A load with a mass "m_l" (in grams) will impact the structure, starting at an elevation of 50 cm, measured from the flat surface where both the structure and testing device are standing. After the impact, the judges will verify that the structure remains intact and did not touch the astronaut body (i.e., the empty 12 oz standard soda can). If the structure has touched the body of the astronaut or the hitchball breaks through the structure entirely, either will count as the point of failure because it did not protect the astronaut. The hitch ball (see Attachment C: Testing Device Construction Materials), used as the load, will need to be weighed ("m_l") prior to testing.
    a) The Host Center will provide a 12.1 cm tall "astronaut" made of an empty 12 ounce standard soda can. Bright-colored paint will be placed on the top of the "astronaut's head" to see if the structure hit the astronaut.
    b) A new can should be used for each team unless the can used in the previous trial was not touched by the Moon Base.
5) If the structure or impact weight/hitch ball did not touch the astronaut or break through the structure, the height of the impact will be increased by increments of 25 cm up to 200 cm (i.e., 75 cm, 100 cm, 125 cm, 150 cm, 175 cm and 200 cm). The impact height "H" (in cm) is the highest measured impact height that still protects the astronaut; the highest measured impact height is recorded.
    a) A structure that does not protect the astronaut at its initial impact height of 50 cm will be disqualified.
6) Disqualified structures are not eligible to place. However, they may be tested in private, time permitting.

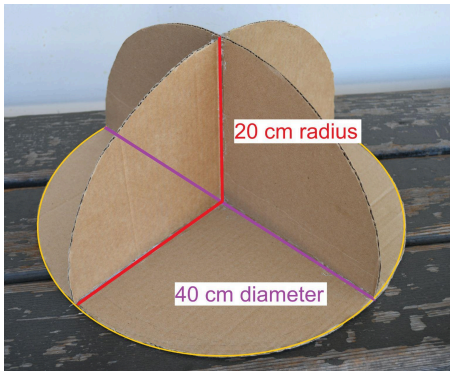


Fig 2. Internal measuring device

The "safe zone" internal measuring tool was created by Julian Peña, Lead Judge with the San Jose State University MESA Center. Images created by CSU Long Beach MESA Center.

SCORING:

1) The structures will be scored by their Impact-to-Mass Ratio, "I/M" calculated as:

   $I/M = m_l * g * (H * 10^{-2}) / m_s$

   Where: m_l is the mass of the hitch ball in grams; g is the gravity, 9.81 m/s^2; H is highest impact elevation in centimeters; and m_s is the mass of the competing structure in grams.

2) **Performance Points**
   a) Winning Performance (P_w) = team with the highest Impact-to-Mass Ratio from all teams in the same Division/Grade Level (receives 75 points)
   b) Team Performance (P_t) = team's Impact-to-Mass Ratio
   c) Team Performance Ratio = P_t divided by P_w
   d) **Team Performance Points = P_t / P_w x 75**
3) Final Team Score = (Team Performance Points - Penalties) + Engineering Lab Report Points

AWARDS:

- Teams who do not submit an Engineering Lab Report will NOT be eligible for any awards.
- Awards will be given per division: Grade 6 and Grades 7/8 (MS).
- Medals will be awarded for 1st, 2nd, and 3rd place based on the best Impact-to-Mass Ratio.
- Ribbons will be awarded for 1st, 2nd, and 3rd place based on Innovative Engineering Design Raking.
- Only teams that place in the Impact-to-Mass Ratio category will advance to Regional MESA Day; please check with your local MESA center to determine the number of teams that advance to Regional MESA Day.

ATTACHMENTS/APPENDIX:

- A: Cardboard Examples
- B: Impact Testing Device
- C: Testing Device Construction Materials
- D: Moon Base Specifications Checklist
- E: Inspection and Score Sheet for Moon Base

A: CARDBOARD EXAMPLES

Below are a few examples of commonly used cardboard.

1) ACCEPTABLE:

a. Pre-existing markings and printings from manufacturing (i.e. amazon, home depot, USPS, etc.)

2) NOT ACCEPTABLE:

a. Paperboard lined cardboard

b. Cardboard with tape or sticker labels (any tape that is on the post-consumer cardboard must be removed before using)

B: IMPACT TESTING DEVICE

This device has been designed in such a way that it can be safely built by the MESA students with teacher supervision. All materials are standard and can be found at the local hardware store. A tutorial video on how to build the testing device can be viewed here: https://www.youtube.com/watch?v=oXwbVM1Jupg

1) Materials (Note that the tester can be built using PVC pipe, but ABS is more impact resistant, easier to cut and glue, and is a more sustainable product):

ID	Qty	Item
(a)	2	2 inch ABS pipes (10 ft standard length)
(b)	2	2 inch ABS 90 degree Tee (NIBCO 2 in. ABS DWV All Hub Sanitary Tee)
(c)	2	2 inch ABS 90 degree short elbow (NIBCO 2 in. ABS DWV 90° Hub x Hub Vent Elbow)
(d)	1	2 inch ABS double Tee (NIBCO 2 in. ABS DWV All Hub Double Sanitary Tee)
(e)	5	2 inch ABS caps (NIBCO 2 in. ABS DWV Hub Cap)
(f)	1	ABS glue
(g)	1	Impact Weight
(h)	1	Metal pin or similar metal object
(i)	1	Rope
(j)	1	Stainless Steel M15 Single Pulley

2) Tools: hand saw, drill, sandpaper (or file), small level, step stool, and hot glue gun.

3) Construction process:

I. Cut eight 25 cm long pieces of 2 inch ABS pipe. Finish each cut with the sandpaper or file.
II. Build the apparatus feet (2 units) first by gluing two collinear pieces of ABS pipe (Item a) to the Tee. (Item b)
III. Build the horizontal beam of the apparatus by gluing two pieces of pipe (Item a) to the double Tee (Item d)
IV. Create the apparatus two columns by gluing one side of the 90 short elbows (Item c) to a piece of ABS pipe (Item a).
V. Create the apparatus frame by gluing the horizontal beam created in step (III) to the feet created in step (IV). Place this assembly on a flat surface and make sure all pipes are on the same horizontal plane.
VI. Install the apparatus feet from step (II) to the frame from step (V). Apply glue to the column in the frame and slowly slide each column into the tee at each apparatus foot. Always keep a level on top of the frame to ensure the beam on the frame is horizontal. (see Figure 2).
VII. Install the caps (Item e) at the ends of each apparatus foot.

Fig 2. Installation of the apparatus feet.

VIII. Cut the 2 inch pipe (Item a) at 7 feet and mount it on top of the double tee (Item d) at the center of the apparatus.

IX. Measure and mark this vertical pipe at an elevation of 50 cm measured from the horizontal surface where the apparatus is standing. Continue measuring and marking the pipe at 25 cm increments until reaching a final mark at an elevation equal to 200 cm. Repeat step 9 for the back side of the vertical pipe.

X. Drill holes where the markings were made to allow the pin to go through both sides of the pipe.

XI. Create the pulley system attachment by using a drill and a 3mm drill bit to drill a hole in the center of a 2" PVC cap. This is your center guide hole for the rope.

XII. Use sandpaper, a file, or countersink reamer to smooth the edges of the center guide hole to ensure that there are no burrs that may catch the rope as it is pulled through the hole in both directions.

XIII. Using the drill and same drill bit, drill 3 holes at the edge of the 2" cap in a straight line leading to the center hole. Once done, use a file, jewelry saw, or thin snips to cut out the remaining space between the three holes to create one single hole (around 9mm long by 3mm wide when done). This hole should be long enough to allow the shank of the pulley to fit through.

XIV. Using hot glue, JB Weld or another epoxy, glue the shank of the pulley to the cap by filling in the gaps left between the hole and the pulley's shank. Let sit for 24 hours to cure to ensure enough strength to support the weight of the hitch ball.

C: TESTING DEVICE CONSTRUCTION MATERIALS

Product	Qty.	Unit Price	Links for Purchase (these are only suggestions - you can purchase these items from other vendors)
4 oz. Medium Black ABS Cement	1	5.50	https://www.homedepot.com/p/Oatey-4-oz-Medium-Black-ABS-Cement-309993/100136815
2 in. ABS pipe (10 ft standard length)	2	17.96	https://www.homedepot.com/p/VPC-2-in-x-10-ft-ABS-Cell-Core-Pipe-29-210HD/309282467
2 in. ABS DWV All Hub Sanitary Tee	2	4.96	https://www.homedepot.com/p/Charlotte-Pipe-2-in-ABS-DWV-San-Tee-ABS004000800HD/313834693
2 in. ABS DWV All Hub Double Sanitary Tee	1	19.52	https://www.homedepot.com/p/NIBCO-2-in-ABS-DWV-All-Hub-Double-Sanitary-Tee-C5835HD2/100347018
2 in. ABS DWV 90-Degree Hub x Hub Vent Elbow	2	6.52	https://www.homedepot.com/p/NIBCO-2-in-ABS-DWV-90-Degree-Hub-x-Hub-Vent-Elbow-C5807VHD2/100344401
2 in. ABS DWV Cap	5	10.84	https://www.homedepot.com/p/NIBCO-2-in-ABS-DWV-Cap-C5817HD2/204697207
5/32 in. x 75 ft. Camouflage Diamond Braid Polypropylene Rope with Winder	1	5.53	https://www.homedepot.com/p/Everbilt-5-32-in-x-75-ft-Camouflage-Diamond-Braid-Polypropylene-Rope-with-Winder-72575/206094286
2,000 lb. 1 7/8 in. Ball Diameter, 3/4 in. Shank Diameter, 2 3/8 in. Shank Length Chrome Class III Trailer Hitch Ball	1	12.97	https://www.homedepot.com/p/TowSmart-Class-1-2-000-lb-1-7-8-in-Ball-Diameter-3-4-in-Shank-Diameter-2-3-8-in-Shank-Length-Chrome-Trailer-Hitch-Ball-717/206798800
304 Stainless Steel M15 Pulley (2-Pack)	1	6.99	2Pcs 304 Stainless Steel M15 Single Pulley Block, Wire Rope Hanging Wire Towing Wheel, with 2Pcs Spring Snap Hook: Amazon.com: Industrial & Scientific
10 in. Hack Saw with Plastic Handle	1	10.97	https://www.homedepot.com/p/Anvil-10-in-Hack-Saw-with-Plastic-Handle-12750/303858480
Pro Grade Precision 3-2/3 in. x 9 in. Faster Sanding Sheets 60 Grit Coarse (6-Pack)	1	6.68	https://www.homedepot.com/p/3M-Pro-Grade-Precision-3-2-3-in-x-9-in-Faster-Sanding-Sheets-60-Grit-Coarse-6-Pack-127060PGP-6/313353720
9 in. Torpedo Level	1	5.97	https://www.homedepot.com/p/Empire-9-in-Torpedo-Level-587-24/100653523

Note: It will be necessary to drill holes and have a pin to release the hitch ball. It is suggested to use a metal pin or similar metal object (e.g., screwdriver, t-handle hex key, etc.) that is easy to pull but strong enough to support the weight of the hitch ball.

D. MOON BASE SPECIFICATIONS CHECKLIST

This checklist is provided **ONLY** as a reference for teams to "pre-inspect" their Moon Base structures to ensure they meet the rules specifications. Teams may check-off each of the following items after comparing their competition-ready Moon Base structures with the rules. **This checklist will NOT be used by judges.**

- ☐ 2025-2026 rules are used.
- ☐ Engineering Lab Report is properly labeled with team members' full names, grade level, school name, and MESA center.
- ☐ Moon Base structure is properly labeled with team members' full names, grade level, school name, and MESA center.
- ☐ Only recycled, deconstructed, post-consumer, not plastic coated, unpainted cardboard is used.
- ☐ No glue, tape, or other external adhesives of any type are used.
- ☐ No individual piece of cardboard is thicker than 5 mm.
- ☐ The maximum linear length of the structure is not greater than 55 cm.
- ☐ The maximum linear width of the structure is not greater than 55 cm.
- ☐ The maximum linear height of the structure is not greater than 25 cm.
- ☐ The interior of the structure fits a 20 cm radius half sphere in the center (minimum interior clearance).

  Note: It is highly suggested that teams create their own internal measurement device to ensure that they build a structure that fits over it.
- ☐ The structure weighs 800 g or less.
- ☐ The structure is fully enclosed with the exception of the two rectangular openings and NO base/floor.
- ☐ Each of the two openings has a height of between 9 cm to 11 cm.
- ☐ Each of the two openings has a minimum width of 10 cm to maximum width of 20 cm.

E: INSPECTION AND SCORE SHEET FOR MOON BASE

Middle School – Grade 6 and Grades 7/8

Student Names: _____ Grade: 6 or 7/8 (circle one)

School: _____ MESA Center: _____

Section Below to be Completed by JUDGES

ENGINEERING LAB REPORT: ☐ Submitted ☐ Not Submitted (NOT eligible for any awards)

SPECIFICATION CHECK:

General Rules	YES	NO
Moon Base is labeled properly (students' full name, grade, school name, and MESA center)	No Penalty	-10%
Only recycled, deconstructed, post-consumer, not plastic coated, unpainted cardboard is used	PASS	DQ
No glue, tape, or other external adhesive of any type is used	PASS	DQ
Width of individual cardboard pieces is no thicker than 5 mm	PASS	DQ
Maximum linear length of the structure is not greater than 55 cm	PASS	DQ
Maximum linear width of the structure is not greater than 55 cm	PASS	DQ
Maximum linear height of the structure is not greater than 25 cm	PASS	DQ
Minimum interior clearance: Interior of structure fits a 20 cm radius half sphere in the center	PASS	DQ
Maximum structure weight is 800 g	PASS	DQ
Structure is fully enclosed with the exception of the two rectangular openings and no base/floor	PASS	DQ
Structure has two rectangular openings with a height of between 9 cm to 11 cm	PASS	DQ
Structure has two rectangular openings with a minimum width of 10 cm to maximum of 20 cm	PASS	DQ

Structure Weight (in grams): _____ **Innovative Engineering Design Ranking (1, 2, 3, etc.):** _____

TESTING RESULTS:

Mass of Hitch Ball (in grams)		Highest Impact Height (in centimeters)	

$I/M = m_l * g * (H * 10^{-2}) / m_s$

Where: m_l is the mass of the hitch ball in grams; g is the gravity, 9.81 m/s^2; H is highest impact height in centimeters; and m_s is the mass of the competing structure in grams.

Mass of Hitch Ball Multiplied by 9.81 (force of gravity)	Highest Impact Height multiplied by 10^{-2}	Multiply the result in column 1 to the result in column 2	Divide the result in column 3 by the weight of the Moon Base
Example: *Mass of hitch ball is 1154 g.* *1154 g x 9.81 m/s^2 = 11,320.74*	*Example:* *Highest Impact Height is 125 cm.* *125 cm x 10^{-2} = 1.25 m*	*Example:* *11,320.74 x 1.25 m* *= 14,150.925*	*Example:* *Structure weight is 231 g.* *14,150.95/231 g = 61.26*

FINAL TEAM SCORE:

Team Performance (team's I/M)	
Winning Performance (highest I/M from all teams in the same Division/Grade Level)	
Team Performance Ratio (Team Performance ÷ Winning Performance)	
Team Performance Points (Team Performance Ratio x 75)	
only if applicable - **Moon Base Labeling Penalty** (10%)	-
Engineering Lab Report Points (if lab report was not submitted, not eligible for any awards)	+
Final Team Score (Team Performance Points - Penalties) + Engineering Lab Report Points	