

The MESA Machine: Ball Launch

- LEVEL:** Grades 6 and 7/8
- TYPE OF CONTEST:** Team
- COMPOSITION OF TEAM:** 2-3 students per team
- NUMBER OF TEAMS:** Preliminary – As determined by your local MESA Center
Regional – 1 for 6th Grade; 1 for 7th/8th Grade per Center
- SPONSOR:** Ben Louie, Associate Director, USC MSP
- OVERVIEW:** Students will design and construct a complex machine that utilizes three to six different sequential and dependent actions from three different energy/simple machine categories that will ultimately launch a vinyl kick ball the farthest distance in the least amount of time. Students must design their machine to be transported by bus or car. **Participation logistics, limits, and competition facilities may vary by host site. Advisors and students are responsible for verifying this information with their center director.**

An Engineering Lab Book is a required component of this competition. The purpose of the Engineering Lab Book is for students to follow more closely the practices of an engineer in the completion of their MESA Day projects. The Engineering Lab Book will encourage students to take a purposeful and sustained approach to building their devices. 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. The lab book should provide a daily and constant written record of the thought and insight a team is putting into their project, from initial ideas to the final completed project.

- MATERIALS:** For the complex machine, all materials are legal with the exception of remote control devices (i.e., wireless), hazardous materials, or unsafe energy.

For the Engineering Lab Book, three format options are available for submittal; please check with your local center director for the format required for your preliminary event. **Electronic submissions will be required at the Regional/State level.**

Electronic Lab Book

Teams use an electronic portal/application such as Google Docs to keep and maintain lab book. Access to such a lab book is then given to MESA Day staff

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and judges OR lab book is submitted electronically (e.g. PDF file) for review.

Printed/Written Pages

Teams record their lab book entries by hand or typed through a program like Microsoft Word. Printed/handwritten loose leaf pages are then submitted (pages must all be well organized and clipped/stapled together).

Standard Lab Book

Teams use a standard notebook (composition books, spiral notebooks, subject notebooks, etc.). The lab book page size must be equivalent or greater than that of a composition book page (approx. 9.75" length x 7.5" width). Pocket sized books, post it notes, flashcards, etc. cannot not be used.

The Host Center will provide the following:

- 2-inch vinyl kick ball/hacky sack weighing between 25 – 35 grams
- Safety goggles

GENERAL RULES:

- 1) The students' full name, school name, grade and MESA Center must be clearly labeled on the machine. A 10% penalty in the score will be assessed for failing to properly label.
- 2) All parts of the complex machine must fit into a 75 cm by 75 cm by 75 cm cube (i.e., the *Machine Launch Zone*). No parts, including moving parts such as marbles and levers, may extend outside of the *Machine Launch Zone* at any time during inspection or during competition, except the parts for the single operation to initiate the machine in Rule 3.
- 3) The machine must be initiated by a single operation (e.g., pull a string, flick a switch, cut a string, push a button, etc.) provided by the team. The single operation **MUST** be performed outside of the *Safety Zone* and the *Distance Zones* (see Attachments/Appendix).
- 4) No human power may be used to add potential or kinetic energy for the entire operation of the machine, including initiation.
- 5) The complex machine must incorporate between three (3) to six (6) actions that are sequential and dependent upon the previous action. Each of the three to six actions **MUST** use one of the following listed categories of energy/simple machines:
 - a. Categories of energy/simple machines, **which MUST be safe and not cause personal injury or damage to host facilities**, are LIMITED to the following:
 - i. Gravity (e.g., free fall, ramps, etc.)
 - ii. Springs or rubber bands (e.g., tension springs, bungee cords, torsional springs, mousetrap, etc.)
 - iii. Levers or pulleys (e.g., seesaw, bottle opener, tongs, fixed pulley, movable pulley, compound pulley, etc.)
 - iv. Electronics (e.g., DC motors, circuit boards, generators, sensors, etc.) – electrical power will NOT be provided
 - b. Three (3) different categories of energy/simple machines listed above **MUST** be used.
 - c. Sequential and dependent actions must use a different category of energy/simple machines (e.g., a free fall using gravity to a ramp using gravity will be counted as one action).
 - d. Use of energy/simple machines not listed will NOT be counted as actions or categories of energy/simple machines.
 - e. The action to initiate the machine does NOT count as one of the three (3) to six (6) actions.
 - f. The sequence of actions must end with an action that launches the vinyl kick ball.

- 6) The complex machine must be able to load the host supplied vinyl kick ball prior to the initiation of the machine. No alterations to the vinyl kick ball are allowed.
- 7) The complex machine must launch the vinyl kick ball within 60 seconds of the initiation.
- 8) The complex machine must have moving parts visible at all times once it is initiated to verify actions and categories of energy/simple machines (see Rule 5).
- 9) All construction materials are acceptable, with the exception of remote control devices (i.e., wireless), explosives, caustic chemicals, or other hazardous materials that may cause personal injury or damage to host facilities.
- 10) The Engineering Lab Book must be properly labeled with names, school, center, grade and must contain and cover the following sections with each section tabbed/labeled:
 - a. Identify the Problem (at least 2 sentences for each question below)
 - i. State what is the challenge being worked on?
 - ii. What are the limits/constraints?
 - iii. How do you think you can solve it?
 - b. Explore
 - i. Find out what others have done (research). Clearly list at least 5 sources (web pages, books, etc.). Identify (cite) and describe them.
 - c. Design
 - i. Brainstorm ideas (at least 3 ideas) and record them. Each idea should be represented by a sketch or drawing.
 - ii. Select one idea and create a plan (at least 5 sentences) to build a prototype from. Generate a list of materials for your prototype.
 - d. Create
 - i. Using your plan, build your prototype; describe the building of prototype (at least 5 sentences). Include a picture of the actual project prototype.
 - e. Try It Out
 - i. Test your idea/prototype. Attempt at least 3 trials/attempts of your test. Measure the results of your test (e.g., distance, time, potential energy, kinetic energy).
 - ii. Provide evidence of the use and application of at least 2 appropriate mathematical concepts in your tests. Sample concepts may include calculating the speed of your vinyl kickball by using $d = rt$ or the potential energy for an action using gravity as the category of energy/simple machines by using $PE = mgh$.
 - f. Make It Better
 - Describe how you can make the project better and what modifications you will be making (at least 5 ways you can improve project). Build and prepare competition ready project. Include a picture.

JUDGING:

- 1) Machines will be checked for specifications and weighed prior to the start of the competition. Modifications and repairs are allowed during the competition; however, the team must provide all parts, materials, and supplies.
- 2) Each machine must be ready when called or the team will forfeit that launch.
- 3) Each machine will be allowed two (2) non-consecutive launches.
- 4) Each team will be given up to 90 seconds to prepare the machine, load vinyl kick ball, and verify to the judge the three to six actions and the three different categories of energy/simple machines.
- 5) One team member will be responsible for the initiation of the machine; entire body, including hands and fingers, of member must be outside of the *Safety Zone* (this is to ensure the safety of the student). The designated member will indicate to the judge the machine is ready to launch. The team member must wait until the judge gives the "START" order.

- 6) Judge will record the following:
 - a. Time will be measured from the initiation of machine (i.e., “START” order) to the time the machine launches the vinyl kick ball to the nearest 00.01 seconds.
 - b. Distance will be determined from the *Launch Line* to the point where the vinyl kick ball initially lands inside or outside of the *Distance Zones*. See Attachments/Appendix for competition area specifications.
 - i. If any part of the vinyl kick ball lands on a line separating the *Distance Zones*, the team will receive the lesser of points.
- 7) If the machine does not launch the vinyl kick ball within 60 seconds of the initiation of the machine, the judge will declare a mistrial; the team will receive a “Team Score” of zero (0) for that launch.
- 8) Team members may not touch or interfere with the machine once the initiation has been triggered.
- 9) The order of the competition will be randomly selected.
- 10) All team members and spectators must stand outside of the *Safety Zone* and the *Distance Zones* during each launch. Only judges are allowed inside *Safety and Distance Zones*.

SCORING:

- 1) Machine points
 - a. 10 points for each sequential and dependent action. (maximum of 60 points)
- 2) Distance points
 - a. Outside Distance Zones 1 and 2 and two-meter length of Distance Zone 3 = 0
 - b. Inside Distance Zone 1 = 5
 - c. Inside Distance Zone 2 = 10
 - d. Inside or beyond Distance Zone 3 = 20
- 3) Time points
 - a. 1 to 20.99 seconds = 20
 - b. 21 to 40.99 seconds = 10
 - c. 41 to 60 seconds = 5
- 4) Team Score = machine points + distance points + time points
- 5) The best team score of the two launches will be used.
- 6) Engineering Lab Book deduction: 20% of best team score for an incomplete lab book or 50% of best team score for a missing lab book (see Engineering Lab Book Requirement Rubric).
- 7) **Tie Breaker:** if there is a tie among Final Team Scores, the lightest machine will be the winner.

AWARDS:

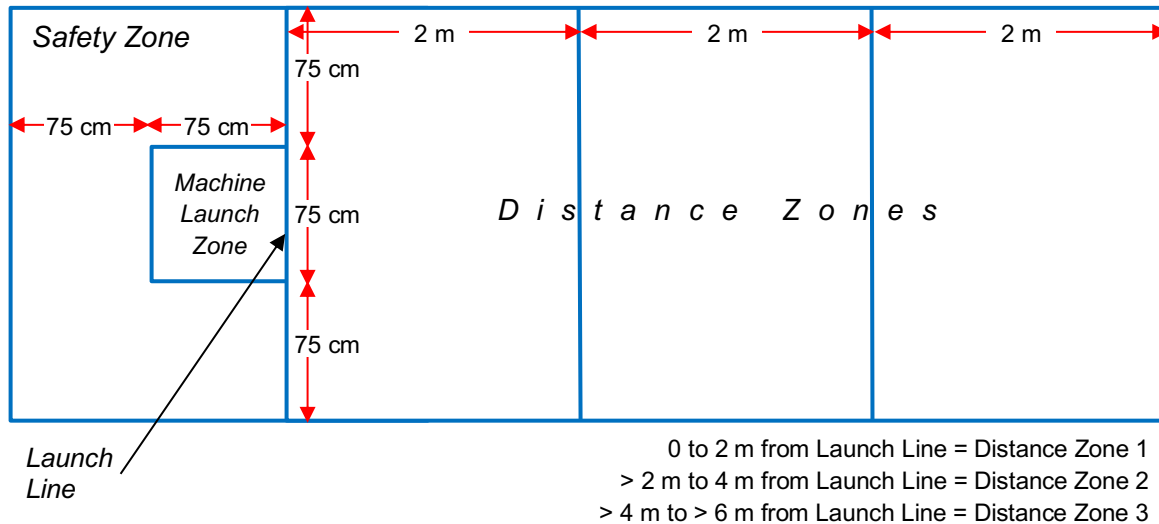
- Awards will be given per grade level: 6th grade and 7th/8th grade.
- Medals will be awarded for 1st, 2nd and 3rd place based on greatest team score.
- Ribbons will be awarded for Innovative Engineering Design.
- Only 1st place teams placing in the team score category will advance to Regional/State MESA Day.

ATTACHMENTS/APPENDIX:

- Competition Area Specifications
- Recommended Equipment
- Inspection & Score Sheet for The MESA Machine
- Engineering Lab Book Requirement Rubric

Competition Area Specifications:

- *Machine Launch Zone* is 75 cm by 75 cm and centered along a 2.25 m wide *Distance Zones*.
- *Safety Zone* is 1.5 m by 2.25 m and centered along the width of the *Machine Launch Zone*.
- *Distance Zones* is 6 m long by 2.25 m wide.



Recommended Equipment

- Scale to weight machines
- 2-inch vinyl kick balls/hacky sacks weighing between 25 – 35 grams
- Scale to weigh vinyl kick balls/hacky sacks
- Measuring tape (metric)
- Blue painters tape to outline the *Machine Launch Zone*, *Safety Zone*, and *Distance Zones*
- 1 stop watch to record launch time
- 3 safety goggles (required)

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INSPECTION AND SCORE SHEET FOR THE MESA MACHINE
Middle School – Grades 6 and 7/8

Copies of this inspection and score sheet will be provided by the MESA Day Host Center.

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

School: _____ MESA Center: _____

List three to six actions of machine

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

List corresponding category of energy used (see Rule 5)

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

Section below to be completed by Judges

INSPECTION LIST:	YES	NO
All parts of machine fit into 75 cm x 75 cm x 75 cm	<input type="checkbox"/>	<input type="checkbox"/>
Machine is initiated by a single operation performed outside of <i>Safety</i> and <i>Distance Zones</i>	<input type="checkbox"/>	<input type="checkbox"/>
Machine incorporates three (3) to six (6) actions (see Rule 5)	<input type="checkbox"/>	<input type="checkbox"/>
Three (3) different categories of energy/simple machines used	<input type="checkbox"/>	<input type="checkbox"/>
Machine able to load vinyl kick ball prior to the initiation of machine	<input type="checkbox"/>	<input type="checkbox"/>
No remote control machines, hazardous materials, or unsafe energy are used	<input type="checkbox"/>	<input type="checkbox"/>
Machine labeled properly (students' full name, school name, grade and MESA Center)	<input type="checkbox"/>	<input type="checkbox"/>

Weight: _____ **Innovative Engineering Design (ranking – 1, 2, 3, etc.):** _____

LAUNCH 1					
Machine		Distance (DZ = Distance Zone)		Time	
# of actions <i>(see Rule 5 – max. of 6)</i>		DZ 1 = 5	Outside DZs = 0	1-20.99 sec = 20	
	x 10	DZ 2 = 10	<i>(see Scoring 2)</i>	21-40.99 sec = 10	
Points		DZ 3 = 20		41-60 sec = 5	> 60 s = mistrial
+ Points		+ Points		+ Points	

Mistrial (reason): _____ **TEAM SCORE:** = _____

LAUNCH 1					
Machine		Distance (DZ = Distance Zone)		Time	
# of actions <i>(see Rule 5 – max. of 6)</i>		DZ 1 = 5	Outside DZs = 0	1-20.99 sec = 20	
	x 10	DZ 2 = 10	<i>(see Scoring 2)</i>	21-40.99 sec = 10	
Points		DZ 3 = 20		41-60 sec = 5	> 60 s = mistrial
+ Points		+ Points		+ Points	

Mistrial (reason): _____ **TEAM SCORE:** = _____

Best of two launch Team Scores.... _____

Machine Labeling Penalty (10%).... - _____

Engineering Lab Book Penalty (20% or 50%).... - _____

Final Team Score (best of two launches) _____

ENGINEERING LAB BOOK REQUIREMENT RUBRIC

Please use this rubric to assess lab book entries. An **incomplete** lab book (i.e., missing 1 to 2 specified criteria) will lead to a 20% deduction from the total project score. A **missing** lab book (i.e., not submitted OR missing 3 or more specified criteria) will lead to a 50% deduction from the total project score and will make team ineligible to place.

Criteria		YES	NO
	Is the lab book properly labeled? <i>(Names, Grades, School, MESA Center)</i>		
1	Identify the Need (at least 2 sentences for each) <i>State what is the challenge being worked on? What are the limits/constraints? How do you think you can solve it.</i>		
2	Explore <i>Conducting research (listing 5 cited/referenced sources), gathering materials, try using materials</i>		
3	Design <i>Brainstorming ideas (at least 3 iterations) each represented by a picture, sketch or drawing. Creating a plan for selected idea (at least 5 sentences). A list of materials for the prototype.</i>		
4	Create <i>Building a prototype. Describing the building of the prototype (at least 5 sentences). Including a final picture of the project.</i>		
5	Try it Out <i>Testing idea/prototype. Attempting at least 3 trials/attempts. Measuring each trial result (by specific performance criteria like distance traveled, time, etc.). Providing evidence of the use and application of at least 2 appropriate</i>		
6	Make Better <i>Evaluate results. List at least five ways project can be improved</i>		
	TOTAL		
	Lab Book Complete (mark with X)		

Is this considered an **incomplete** lab book – missing 1 or 2 criteria listed?..... **NO** **YES** (-20%)

Is this considered a **missing** lab book – missing 3 or more criteria listed? **NO** **YES** (-50%)