

## The MESA Machine: Ball Launch

<b>LEVEL:</b>	Grades 9/10 and 11/12
<b>TYPE OF CONTEST:</b>	Team
<b>COMPOSITION OF TEAM:</b>	2-3 students per team
<b>NUMBER OF TEAMS:</b>	Preliminary – As determined by your local MESA Center Regional – 1 for 9 <sup>th</sup> /10 <sup>th</sup> Grade; 1 for 11 <sup>th</sup> /12 <sup>th</sup> Grade per Center
<b>SPONSOR:</b>	Ben Louie, Associate Director, USC MSP

**OVERVIEW:** Students will design and construct a complex machine that utilizes four to eight different sequential and dependent actions from four different energy/simple machine categories that will ultimately launch a vinyl kick ball to land the closest distance to a target in the greatest amount of time. Students must design their complex 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 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 50 cm by 50 cm by 50 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 complex 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* (see Attachments/Appendix).
- 4) No human power may be used to add potential or kinetic energy for the entire operation of the complex machine, including initiation.
- 5) The complex machine must incorporate between four (4) to eight (8) actions that are sequential and dependent upon the previous action. Each of the four to eight 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
    - v. Pressurized fluids (such as air or water)
  - b. Four (4) 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 four (4) to eight (8) 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 machines (i.e., wireless), explosives, caustic chemicals, or other hazardous materials that may cause personal injury or damage to host facilities.
- 10) Lab books are meant to clearly demonstrate and illustrate evidence of the application of the Engineering Design Process in the MESA project.

The Engineering Lab Book must be properly labeled (names, school, center, grade level, etc.) and contain and cover the following sections using the template provided:

1. **IDENTIFY THE PROBLEM** (at least 2 sentences for each question below)  
State what is the challenge being worked on? What are the limits/constraints? How do you think you can solve it?
2. **EXPLORE**  
Find out what others have done (research). Clearly list at least 5 sources (web pages, books, etc.). Identify (cite) and describe them.
3. **DESIGN**  
Brainstorm ideas (at least 3 ideas) and record them. Each idea should be represented by a sketch or drawing. Select one idea and create a plan (at least 5 sentences) to build a prototype from. Generate a list of materials for your prototype.
4. **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.
5. **TRY IT OUT**  
Test your idea/prototype. Attempt at least 3 trials/attempts of your test. Measure the results of your test (e.g., accuracy, time, kinetic energy, potential energy). Provide evidence of the use and application of at least 2 appropriate mathematical concepts in your tests. Sample concepts may include calculating kinetic energy for an action using gravity, potential energy for an action using springs/rubber bands, or mechanical energy for an action using levers/pulley.
6. **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) \* Devices will be checked for specifications prior to the start of the competition. Teams that are deemed disqualified after this initial check will still have an opportunity to compete under ALL of the following conditions:
  - a. Accept an automatic “Mistrial” and therefore no score for Launch #1.
  - b. Make repairs/modifications as necessary to bring the device to proper specifications and be ready to compete when called for Launch #2.
  - c. Make repairs/modifications only in the designated area as indicated by the judges.
  - d. Failure to adhere to any of a, b, or c will result in the disqualification being upheld.
- 2) \*Teams that aren’t disqualified but wish to make repairs and modifications may do so, but they **MUST** be ready to compete when called for Launch #1.

- 3) Modifications and repairs are allowed during the competition; however, the team must provide all parts, materials, and supplies.
- 4) Each machine must be ready when called or the team will forfeit that launch.
- 5) Each machine will be allowed two (2) non-consecutive launches.
- 6) Each team will be given up to 90 seconds to prepare the machine, load vinyl kick ball, and verify to the judge the four to eight actions and the four different categories of energy/simple machines.
- 7) 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 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.
- 8) 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. Accuracy will be determined at the point of initial impact of the vinyl kick ball inside or outside of the *Target Zones*. See Attachments/Appendix for competition area specifications.
    - i. If any part of the vinyl kick ball lands on a line separating the *Target Zones*, the team will receive the lesser of points.
- 9) 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.
- 10) Team members may not touch or interfere with the machine once the initiation has been triggered.
- 11) The order of the competition will be randomly selected.
- 12) All team members and spectators must stand outside of the *Safety Zone* during each launch. Only judges are allowed inside the *Safety Zone*.

### SCORING:

- 1) Machine points
  - a. 10 points for each sequential and dependent action. (maximum of 80 points)
- 2) Accuracy points
  - a. Inside Target Zone 1 = 25
  - b. Inside Target Zone 2 = 15
  - c. Inside Target Zone 3 = 5
  - d. Outside of *Target Zones* = 0
- 3) Time points
  - a. 1 to 20.99 seconds = 5
  - b. 21 to 40.99 seconds = 15
  - c. 41 to 60 seconds = 25
- 4) Team Score = machine points + accuracy 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: 9<sup>th</sup>/10<sup>th</sup> grade and 11<sup>th</sup>/12<sup>th</sup> grade.
- Medals will be awarded for 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> place based on greatest team score.
- Ribbons will be awarded for Innovative Engineering Design.

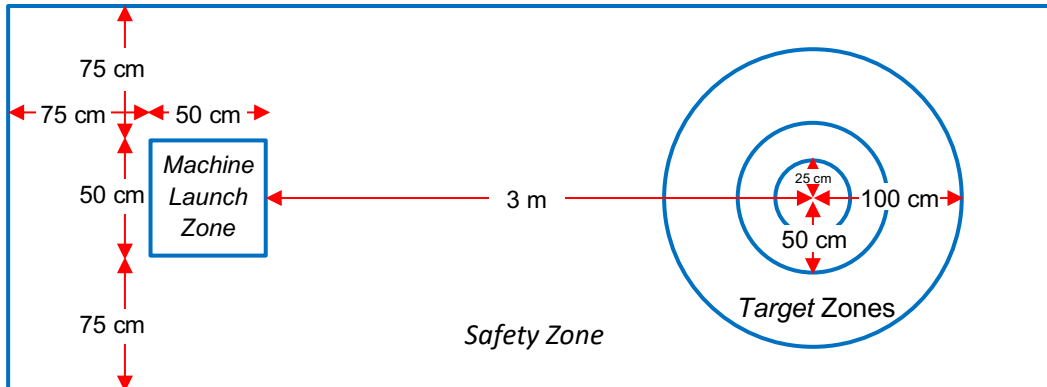
- Only 1<sup>st</sup> place teams placing in the team score category will advance to Regional/State MESA Day.

**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 50 cm by 50 cm.
- *Target Zones* are three concentric circles with a center point/target that is 3 meters from and centered to the *Machine Launch Zone*.
- The *Safety Zone* is 2 meters by 6 meters.



0 to 25 cm from target = Target Zone 1  
> 25 cm to 50 cm from target = Target Zone 2  
> 50 cm to 100 cm from target = Target Zone 3

### **Recommended Equipment**

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

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**INSPECTION AND SCORE SHEET FOR THE MESA MACHINE**  
**High School – Grades 9/10 and 11/12**

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

Student Names: \_\_\_\_\_ Grade: **9/10** or **11/12** (circle one)  
 School: \_\_\_\_\_ MESA Center: \_\_\_\_\_

**List four to eight actions of machine**

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_
7. \_\_\_\_\_
8. \_\_\_\_\_

**List corresponding category of energy used (see Rule 5)**

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_
7. \_\_\_\_\_
8. \_\_\_\_\_

**Section below to be completed by Judges**

INSPECTION LIST:	YES	NO
All parts of machine fit into 50 cm x 50 cm x 50 cm .....	<input type="checkbox"/>	<input type="checkbox"/>
Complex machine is initiated by a single operation performed outside of <i>Safety Zone</i> .....	<input type="checkbox"/>	<input type="checkbox"/>
Machine incorporates four (4) to eight (8) actions (see Rule 5) .....	<input type="checkbox"/>	<input type="checkbox"/>
Four (4) different categories of energy/simple machines used .....	<input type="checkbox"/>	<input type="checkbox"/>
Complex machine able to load vinyl kick ball prior to the initiation of machine .....	<input type="checkbox"/>	<input type="checkbox"/>
No remote control devices, 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		Accuracy (TZ = Target Zone)		Time	
# of actions (see Rule 5 – max. of 8)		TZ 1 = 25	Outside TZs = 0	1-20.99 sec = 5	
	x 10	TZ 2 = 15		21-40.99 sec = 15	> 60 s = mistrial
TZ 3 = 5		41-60 sec = 25			
Points		+ Points		+ Points	

Mistrial (reason): \_\_\_\_\_ **TEAM SCORE:** \_\_\_\_\_

LAUNCH 2					
Machine		Accuracy (TZ = Target Zone)		Time	
# of actions (see Rule 5 – max. of 8)		TZ 1 = 25	Outside TZs = 0	1-20.99 sec = 5	
	x 10	TZ 2 = 15		21-40.99 sec = 15	> 60 s = mistrial
TZ 3 = 5		41-60 sec = 25			
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	<b>Identify the Need</b> (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	<b>Explore</b> <i>Conducting research (listing 5 cited/referenced sources), gathering materials, try using materials</i>		
3	<b>Design</b> <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	<b>Create</b> <i>Building a prototype. Describing the building of the prototype (at least 5 sentences). Including a final picture of the project.</i>		
5	<b>Try it Out</b> <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 mathematical concepts in the tests.</i>		
6	<b>Make Better</b> <i>Evaluate results. List at least five ways project can be improved</i>		
	<b>TOTAL</b>		
	<b>Lab Book Complete</b> (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%)