

Prosthetic Arm

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

OVERVIEW: Students will design, construct, and operate a simulated prosthetic arm that can grab, stack, and release plastic cups into a pyramid in the fastest time. **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 notebook is a required component of this competition. The purpose of the Engineering Notebook is for students to closely follow the practices of an engineer in the completion of their MESA Day project. The Engineering Notebook 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 notebook should provide a written record of the thought and insight that a student put into their project, from initial ideas to the final completed project.

MATERIALS: For the device, all materials are legal with the exception of hazardous materials. There are no cost limitations; however, awards will be given to the most innovative designs utilizing low-cost materials.

For the Engineering Notebook, any standard notebook, including but not limited to spiral and subject notebooks and composition books may be used. Notebook page size must be equivalent or greater than that of a composition book page (approx. 9.75" length x 7.5" width). Pocket sized notebooks, post it notes, flashcards, etc. cannot be used. Computer generated notebooks and/or pages are allowed.

The Host Center will provide the following:

- 21 – First Street 16 ounce plastic cold cups from Smart & Final or equivalent

GENERAL RULES:

- 1) The students' full name, school name, grade and MESA Center must be clearly labeled on the device. A 10% penalty in the score will be assessed for failing to properly label.
- 2) The device must have at least two artificial fingers. These fingers:
 - a. MUST open and close. At least two fingers are required to move.
 - b. MUST grab, stack, and release the plastic cup into a pyramid. Team member may NOT use any other part of the prosthesis or parts of his/her own hand, wrist or arm to grab and release the plastic cup.
- 3) The device must NOT be controlled or operated by either of the team member's fingers, hands, or wrists.
- 4) In order to simulate an amputated arm, participating team member must have his/her wrist, hand, and fingers immobilized during the competition. The team will determine own method for immobilization.
- 5) The device (i.e. artificial fingers) may only grab, stack, and release ONE plastic cup at a time.
 - a. A plastic cup that is dropped on the table or floor, knocked over, knocked off the pyramid, etc. must be grabbed by the artificial fingers before attempting to replace it onto the pyramid.
- 6) During the trial, the team member may use his/her encumbered hand to hold and move the original pre-stack of cups, but the bottom must remain in contact with the table at all times.
- 7) The engineering notebook must contain the following sections with each section tabbed/labeled:
 - a. Proper Labeling
 - i. Proper labeling is required of each notebook. Students must have group member names, grades, school and MESA center on the inside cover of their MESA Engineering Notebooks.
 - b. Project Introduction
 - i. A one page introduction for the project. Students can write about why they chose the project that they are worked on and what challenges they expect to run into with this project. They may also briefly describe the project criteria and constraints. This introduction should be honest and genuine.
 - ii. A half page description of two (2) medical reasons that a patient might need a prosthetic arm. Only one reason can be a type of trauma or injury. For each reason, provide a simple description of the physiological process that lead to the need for the prosthetic arm.
 - c. Daily Entries
 - i. At least ten daily entries will be required. Each entry must have the date of entry and be at least half a page long. They should answer the following questions:
 - What did you work on/discuss today?
 - What was the result of your work?
 - What do you need to do during your next meeting?
 - d. Anatomy/Project Sketches
 - i. Notebook must contain at least two distinct project sketches that should be placed towards the back or end of the completed notebook pages. One sketch should be of the anatomy of the human arm and the other sketch of the final device. These sketches MUST be hand-drawn or student's original computer-generated. Additional sketches can be included to indicate a progression in the thinking and design of the device, and be detailed. Sketches must be no smaller than one page, and can either be drawn on the notebook page directly or attached.

- ii. BOTH the sketch of the anatomy of the human arm AND the sketch of the final device should include the following eight required and correctly labeled structures:
- Radius/Ulna
 - Flexor Carpi Ulnaris
 - Radiocarpal Joint
 - Carpus
 - Carpometacarpal Joint
 - Metacarpus
 - Phalanges
 - Tendons

e. Materials Table

- i. Notebook must contain a materials table. Table should list all materials utilized for the above eight required structures.

Sample Materials Table

Structure	Material
Radius/Ulna	Mailing Tube
Flexor Carpi Ulnaris	Bungee cord
Radiocarpal Joint	Hinge

f. Applied Mathematics

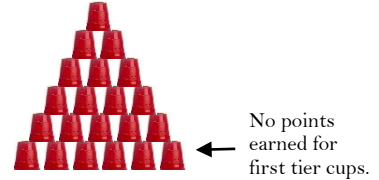
- i. Notebook must contain evidence of two (2) applied mathematics principles as it pertains to the project. This section must include the calculations for both the following:
- Calculate how much work is done by the artificial fingers in grabbing an object.
 - Calculate the total time it takes to open and close the artificial fingers; must use and demonstrate applied mathematics to calculate since the actual time will vary based on tolerances in manufacturing, changes in power levels, wear and tear, and other factors. (Hint: the distance traveled between the tips of the artificial fingers is an arc.)

JUDGING:

- 1) Devices will be checked for specifications prior to the start of the competition. If devices are disqualified during the specification check, design changes will not be allowed.
- 2) Repairs are only allowed with duplicate parts and materials.
- 3) Each device will be allowed two (2) non-consecutive trials.
- 4) At the beginning of each trial, team member must demonstrate immobilization (see Rule 4).
- 5) Each device must be ready when called or team will forfeit that trial.
- 6) Each team will be given up to 60 seconds to prepare, attach, and demonstrate prosthetic arm, and to place the pre-stack of 21 plastic cups facing down anywhere on the table (i.e. the lips of the cup facing down). If at the end of the 60 seconds the team is not ready, the trial will be declared a mistrial and this process will be repeated for the second trial.
- 7) The judge will give the start order and begin the timer.
- 8) The team member will enter the *Working Area* and will have a maximum of 1 minute (60 seconds) to grab, stack, and release the plastic cups into the tallest pyramid. The judge will notify the team when 30 seconds, 20 seconds, and 10 seconds remain.
- 9) The judge will stop the timer when the last plastic cup has been placed onto the pyramid. Or, the judge will call "time" after one minute has passed.
 - a. The judge will record the time needed to complete the trial.
 - b. The judge will count the number cups successfully stacked on the second tier or higher (i.e. cups still stacked at the end of the trial).

SCORING:

- 1) Team points-to-time ratio = total points divided by trial time in seconds (00.00)
 - a. 20 points awarded for each plastic cup on the second tier or higher; plastic cups on the first tier will NOT earn points (maximum of 15 cups x 20 = 300 points)
 - b. Time needed to complete trial (maximum of 60.00 seconds)
- 2) Maximum of 4 points awarded for two sketches and materials table
- 3) Final Score = best points-to-time ratio plus (+) sketches/table points
 - a. The best points-to-time ratio of the two trials will be used
- 4) A deduction of 20% of the final score will be assessed for a missing or incomplete engineering notebook.

**AWARDS:**

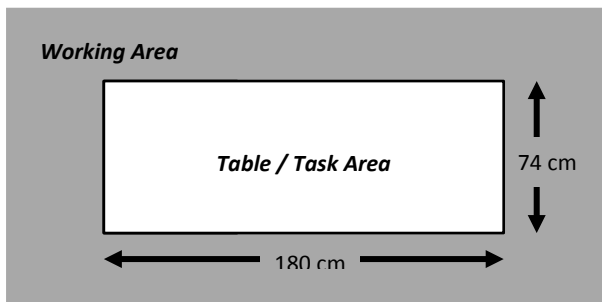
- Medals will be awarded for 1st, 2nd and 3rd place based on the greatest Grand Total Score.
- Ribbons will be awarded for Innovative Engineering Design utilizing low-cost materials.
- Only teams placing in the Total Score category will advance to Regional MESA Day.

ATTACHMENTS/APPENDIX:

- Competition Area Specifications
- Equipment
- Inspection & Score Sheet for Prosthetic Arm
- Engineering Notebook Requirement Rubric

Competition Area Specifications

- A standard six foot table with approximate dimensions of 180 cm (L) x 74 cm (W) x 75 cm (H).



- A perimeter of approximately one (1) meter around the table will be marked with tape. Only the team member actively participating during the trial will be permitted in this *Working Area*.

Equipment

- 21 pre-stacked First Street 16 ounce plastic cold cups from Smart & Final or equivalent (recommend additional plastic cold cups as replacements)
- Standard six foot table
- Measuring tape
- Masking tape to outline the *Working Area*
- 1 stop watch to record trial time



INSPECTION AND SCORE SHEET FOR PROSTHETIC ARM

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: _____

Section below to be completed by Judges

INSPECTION LIST:	YES	NO
Device includes at least two artificial fingers that open and close (at least 2 fingers are required to move)...	<input type="checkbox"/>	<input type="checkbox"/>
Fingers grab and release cups	<input type="checkbox"/>	<input type="checkbox"/>
Device not controlled by fingers, hands, or wrists of either hand	<input type="checkbox"/>	<input type="checkbox"/>
Team has demonstrated immobilization of the fingers, hand, and wrist	<input type="checkbox"/>	<input type="checkbox"/>
Device labeled properly (students' full name, school name, grade and MESA Center)	<input type="checkbox"/>	<input type="checkbox"/>

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

SKETCHES AND MATERIALS TABLE

Structure	Material Listed 0.1 points	Sketch of Arm Anatomy		Sketch of Final Device		Sub Total
		Present 0.1 points	Correctly Labeled 0.1 points	Present 0.1 points	Correctly Labeled 0.1 points	
Radius/Ulna						
Flexor Carpi Ulnaris						
Radiocarpal Joint						
Carpus						
Carpometacarpal Joint						
Metacarpus						
Phalanges						
Tendons						
TOTAL (maximum 4 points)						

TRIAL 1 # of cups: _____ x 20 = (count *ONLY* cups on second tier or higher)

Trial Time (00.00 seconds): Cup Pts/Time Ratio: _____

Mistrial (reason): _____

TRIAL 2 # of cups: _____ x 20 = (count *ONLY* cups on second tier or higher)

Trial Time (00.00 seconds): Cup Pts/Time Ratio: _____

Mistrial (reason): _____

Final Score (best of two trials + Sketches/Materials Table Points) _____

Device Labeling Penalty (10% of Final Score) - _____

Engineering Notebook Penalty (20% of Final Score) - _____

GRAND TOTAL SCORE _____

MESA DAY 2017-2018

Engineering Notebook Requirement Rubric

Please use this rubric to assess notebook entries. An incomplete or missing notebook will lead to a 20% deduction from the total team score.

Criteria		YES	NO
1	Is the notebook properly labeled? <i>(Names, Grades, School, MESA Center)</i>		
2	Does the notebook contain a one page introduction to the project <u>AND</u> a half page description of two (2) medical reasons that a patient might need a prosthetic arm with simple description of physiological process? <i>(On the first page of the notebook)</i>		
3	Are there at least 10 dated entries in the notebook?		
4	Is each entry at least half a page long?		
5	Are there at least two distinct project sketches included? <i>(Sketches do NOT need to be of the anatomy of the human arm or of the final device since these sketches are scored independent of this engineering notebook.)</i>		
6	Is there a materials table? <i>(Materials table does NOT need to be accurate or complete since this is scored independent of this engineering notebook.)</i>		
7	Is there evidence of the following two (2) applied mathematics principles? <ul style="list-style-type: none"> - Calculate how much work is done by the artificial fingers in grabbing an object. - Calculate the total time it takes to open and close the artificial fingers; must use and demonstrate applied mathematics to calculate. (Hint: the distance traveled between the tips of the artificial fingers is an arc.) 		
TOTAL			

Does the notebook meet the requirement? (circle one) **YES** **NO**
Notebooks must meet ALL criteria to fulfill this requirement