

Biomedical Engineering – Prosthetic Arm DEMONSTRATION EVENT

- LEVEL:** Grades 11 and 12
- TYPE OF CONTEST:** Individual / Team
- COMPOSITION OF TEAMS:** 1 - 2 students per team
- NUMBER OF TEAMS:** 3 teams per Center
- SPONSOR:** Ben Louie, Associate Director, USC MSP Center
- OVERVIEW:** Students will design and build an original prosthetic arm to grab, lift, and pour a 50 ml graduated cylinder filled with 50 ml of sand into a standard coffee mug.
- MATERIALS:** Any materials, except those that might cause injury, may be used by the student(s), taking into consideration cost and weight efficiency.
- The following materials will be provided by the host center:
- 50 ml plastic graduated cylinder (with permanently molded graduations – 26 mm / 1 in diameter and 200 mm / 7.87 in height)
 - 50 ml of sand
 - Standard coffee mug

RULES:

1. Both the display and model should be clearly labeled with student name(s), school and center. *If display or model is not clearly labeled with student name(s), school and center, a 6.5 point penalty will be deducted from the grand total score.*
2. The model **MUST** perform three tasks: grab, lift, and pour the 50 ml graduated cylinder with 50 ml of sand.
3. Any materials may be used in the construction of the prosthetic arm model, except those that might cause injury. **Robotic arm kits, hydraulic/pneumatic robot arm kits, and any other kits are NOT allowed**; however, parts from kits are allowed. Note that maximum points will be awarded to designs that have the lowest cost to construct and the lowest weight.

4. The prosthetic arm model **MUST** be operated by the push of button(s), a pull of string(s), a push or pull of syringe(s), etc. Students may NOT perform the actual function of grabbing, lifting, or pouring (e.g. students may not grab or lift graduated cylinder with a pair of tongs, or pour the sand/turn graduated cylinder by rotating a tube with hands).
5. The entire base of the model **MUST** fit within the *Model Zone*, a 1.5 foot square. Any part of the model that may be in contact with the table **MUST** be within the *Model Zone*. (See *Attachment A: Competition Setup*)
6. The display should meet minimum and maximum size requirements. (See *JUDGING # 1a*)
7. The display should be freestanding. The display should include the following:
 - a) A synopsis of the project of 200 to 250 words should be attached to the front of the display. (See *JUDGING # 1b*)
 - b) A scaled plan rendering of the prosthetic arm should be attached to the front of the display. The rendering should include a three-view drawing depicting the model designed and built that includes dimensions. Photographs are not allowed in place of a scaled drawing. (See *JUDGING # 1c*)
 - c) A materials table should be attached to the front of the display. The materials table should include a detailed listing of all materials used with a cost breakdown for each material used in the prosthetic arm and how each material was acquired. (See *JUDGING # 1d*)
8. The model **MUST** be competition-ready when turned in for inspection. No modifications to the model are allowed after it is submitted to the judges for inspection. The display should be submitted for judging at the same time the model is turned in.

JUDGING:

The competition will be judged in two components. Judges will receive the “Score Sheet for Biomedical Engineering – Prosthetic Arm” from the MESA Day Host Center.

Component I: Display and Prosthetic Arm Model

1. Points will be awarded for each of the following: **(10 points maximum)**
 - a. The display including the stand and all of its components fits into a space that is 3 feet high by 3 feet wide by 2 feet deep. The display is freestanding at the time of judging. **(up to 1 point)**
 - b. A brief synopsis of the project, 200 to 250 words, should be on the front of the display. The synopsis should include the purpose of the project, explanation of the model, and scientific and engineering ideas involved in the project. **(up to 3 points)**
 - c. The display has a scaled plan rendering of the prosthetic arm on the front. Each of the three-view drawings (front, side, and top views) should be on three separate 8 ½ x 11

sheets with dimensions. Each arm structure should be identified on each drawing. Students should identify the scale used (e.g. 1 inch = 1 foot). **(up to 3 points)**

- d. The display has a table of all materials utilized with retail price, price per unit, quantity used, total cost, and how each material was acquired. At the bottom of the table, the **grand total cost** for the model should be calculated. **(up to 3 points)**
- i. All cost of materials utilized should be calculated (e.g. if fasteners were obtained free from school, the retail price should be researched and the total cost of the fasteners used should be calculated). If parts are used from kits, cost of the part should be researched, calculated and identified. Students should also calculate the cost per unit [e.g. a 3 pack of foam board (20 in. x 30 in.) cost \$9.00 with \$3.00 per sheet and \$0.005 per square inch]. Points will be awarded to models based on the lowest total cost. A sample follows:

Biomedical Engineering – Prosthetic Arm – Materials Table

Arm Structure	Material	Retail Price	Price per Unit	Quantity used	Total Cost	Acquired
1. Humerus	foam board	\$3.00	\$0.005 / sq. in.	300 sq. in.	\$1.50	Office Depot
2. Radius/Ulna	card board	\$1.20	\$0.002 / sq. in.	200 sq. in.	\$0.40	School
3. Elbow Joint	fastener	\$2.39	\$0.0239 / each	1	\$0.02	School
4. Carpus	mailing tube	\$6.69	\$0.1556 / in.	10 in.	\$1.56	Lyon Art Supply
GRAND TOTAL COST					\$3.48	

2. Points will be awarded to models based on cost. ***If an accurate or reasonable cost for construction of the model is not detailed, student(s) will receive 0 points.*** If cost is questionable, student(s) must submit supporting documentation (e.g. receipts). **(10 points maximum)** See Score Sheet
3. Points will be awarded to models based on total weight. All components of the model will be weighed. **(10 points maximum)** See Score Sheet
4. Points will be awarded for creativity and innovative engineering design. Is the model creative in accomplishing the tasks? Does the model utilize an innovative engineering design to accomplish the tasks? **(10 points maximum)**

Component II: Operation of the Prosthetic Arm

5. The prosthetic arm model must accomplish the tasks within 30 seconds. **(20 points maximum)** See Score Sheet

6. Bonus points will be awarded to models that pour all 50 ml of sand into the standard coffee mug in less than 15 seconds in the same trial. **(5 bonus points)**
7. The model may not be taped or attached to the table.
8. During setup and before the “START” order, the model may not be in contact with the graduated cylinder or coffee mug.
9. Student(s) may not interfere with the model in the grabbing, lifting or pouring function. *See RULE # 4*
10. Each model will be allowed 2 non-consecutive trials.
11. Each model must be ready for competition when called or forfeit that trial.
12. One team member will be responsible for the initiation of the prosthetic arm operation and will indicate to the judge that the model is in the ready position.
13. The team member must wait until the judge gives the “START” order.
14. Only one “False Start” will be allowed per trial in grabbing, lifting or pouring. Two “False Starts” during trial disqualifies that trial.
15. Repairs and modifications are allowed between trials. Repairs and/or modifications must be made by the student(s).
16. The order of competition will be randomly selected.

AWARDS:

1. Medals will be awarded for 1st, 2nd, and 3rd place to the overall winners. However, since this competition is a demonstration event, ribbons will be awarded for this category as well.
2. Ribbons for 1st, 2nd, and 3rd place will be awarded for **Creativity and Innovative Engineering Design**.
3. Only teams placing in the overall display and operation will qualify for Regional MESA Day.

ATTACHMENTS: A – Competition Set-Up
B – Specification Checklist for Students
Score Sheet for Biomedical Engineering – Prosthetic Arm

BIOMEDICAL ENGINEERING – PROSTHETIC ARM

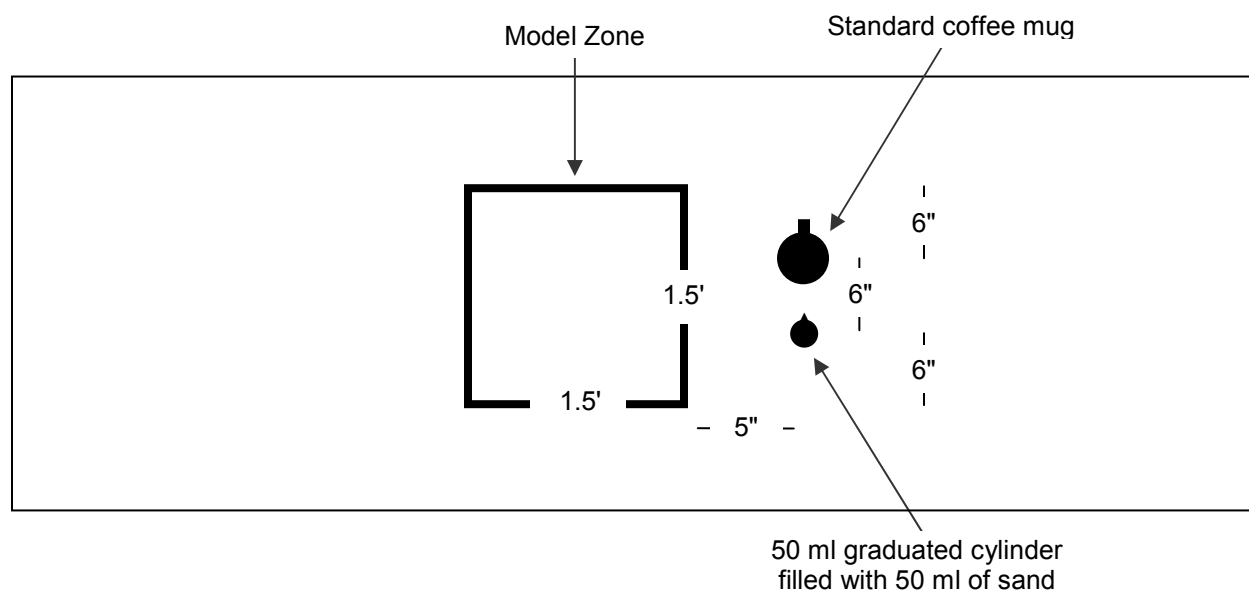
Attachment A – Competition Setup

Materials provided by the host center:

- Standard 6 foot tables for displays
- One Standard 6 foot table for *Operation of Prosthetic Arm Model*
- 50 ml plastic graduated cylinder (with permanently molded graduations – 26 mm diameter and 200 mm height / 1 in. diameter and 7.87 in. height)
- 50 ml of sand
- Standard coffee mug
- Masking Tape
- Stop Watch
- Scale (in ounces) to weigh models

Component II: Operation of the Prosthetic Arm

Top View of Table (*Drawing Not to Scale*)



Definitions

Model Zone: The model zone will be a 1.5 foot square (1.5') and will be identified with masking tape; measurement of 1.5 feet will be from the outer edges of the masking tape. The entire base of the model must be within the model zone (the outer edge of the masking tape). Any part of the model that may be in contact with the table must be within the outer edge of the masking tape.

5": The centers of the graduated cylinder and coffee mug will be 5 inches from model zone (the outer edge of the masking tape).

6": The centers of the graduated cylinder and coffee mug will be 6 inches apart and 6 inches from the edges of the model zone (the outer edge of the masking tape).

BIOMEDICAL ENGINEERING – PROSTHETIC ARM

Attachment B – Specification Checklist for Students

- 2009 – 2010** MESA Day Rules were used.
- The display and model are clearly labeled with student name(s), school and center.
- The entire base of the model fits within a 1.5 foot square. No part of the model that is in contact with the table is outside the 1.5 foot square.
- The **display** fits into a space that is 3 feet x 3 feet x 2 feet.
- The display is freestanding.
- A scaled plan rendering is attached to the display. The three view drawings are on three separate 8 ½ x 11 sheets.
- A materials table with associated cost for each material used and how each material was acquired is attached to the display. Materials table includes the retail price, the price per unit, the quantity used, and the total cost of each material. Materials table includes the grand total cost at the bottom of the table.
- Kit was NOT used.
- If parts of a kit were used, materials table includes cost of parts.

SCORE SHEET FOR BIOMEDICAL ENGINEERING – PROSTHETIC ARM

Grades 11 - 12

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

Student Name(s): _____

Center & School: _____

Judges: _____

Part I: DISPLAY Criteria (0 – 10 points total)

Up to 1 point:

Size/Freestanding _____

Up to 3 points for each criterion met:

Synopsis _____ Rendering _____ Materials Table _____

Subtotal for Part I _____

Part II: MODEL COST and WEIGHT (0 – 20 points total)

Total Cost = _____ (from “Materials Table”)

Total Cost (*10 points total* – circle corresponding points below)

Total Cost	Points
Under \$5.00	10 points
\$5.01 - \$7.00	8 points
\$7.01 - \$9.00	6 points
\$9.01 - \$11.00	4 points
Over \$11.01	2 points
Not included or inaccurate/unreasonable	0 points

Weight = _____ (ounces)

Weight (*10 points total* – circle corresponding points below)

Total Weight	Points
Under 6 ounces	10 points
6.1 ounces – 10.0 ounces	8 points
10.1 ounces – 14.0 ounces	6 points
14.1 ounces – 20.0 ounces	4 points
20.1 ounces – 30.0 ounces	2 points
Over 30.1 ounces	0 points

Subtotal for Part II _____

Student Name(s): _____

Center & School: _____

Part III: CREATIVITY and INNOVATIVE DESIGN of Model (0 – 10 points total)

Up to 5 points for each of the below:

1. Creativity of Model _____

2. Innovative Engineering Design of Model _____

Subtotal for Part III _____

Part IV: OPERATION of Prosthetic Arm (0 – 20 points, plus 5 bonus points = 25 pts total)

Trial 1: _____ (ml of sand poured) _____ (time in seconds – within 30 sec.)

Trial 2: _____ (ml of sand poured) _____ (time in seconds – within 30 sec.)

Circle best of two trials below and award corresponding points:

<i>Sand Poured into Cup</i>	<i>Points</i>
50 ml	20 points
35 ml – 49 ml	15 points
20 ml – 34 ml	10 points
0.1 ml – 19 ml	5 points
0 ml	0 points

Bonus Points: Add 5 bonus points if model poured all 50 ml of sand into the coffee mug in less than 15 seconds in the same trial.

Subtotal for Part IV _____

GRAND TOTAL _____

(Add subtotals for Part I – Part IV)

Maximum score is 65

DEDUCT 6.5 POINTS FROM GRAND TOTAL IF DISPLAY OR MODEL IS NOT CLEARLY LABELED WITH STUDENT NAME(S), SCHOOL AND CENTER