

## Biomedical Engineering – Prosthetic Arm

<b>LEVEL:</b>	High School
<b>DESIGN TYPE:</b>	Prepared in Advance
<b>DESIGN TEAM COMPOSITION:</b>	1 – 4 students per team
<b>NUMBER OF TEAMS:</b>	1 – 2 per school

**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 Colorado MESA:

- 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. Model and Materials Table should be clearly labeled with student name(s) and school. **If model is not clearly labeled with student name(s) and school, a 6.5 point penalty will be deducted from the grand total.**
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. A Material Table should be submitted with the model. The Material 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 #1a*)
7. 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.

**JUDGING:**

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

Component I: Prosthetic Arm

1. Points will be awarded for each of the following: **(5 points maximum)**
  - a. The materials list 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 5 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.	\$1.40	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
<b>GRAND TOTAL COST</b>					<b>\$3.48</b>	

2. Points will be awarded to model 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 designs. 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 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 set up 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 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 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 trail.
15. Repairs and modifications are allowed between trials. Repairs and/or modifications must be made by the student(s).

**AWARDS:**

1. Awards will be given for 1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> place to the overall winners.
2. Award for 1<sup>st</sup> place **Creativity and Innovative Engineering Design** will be given.

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

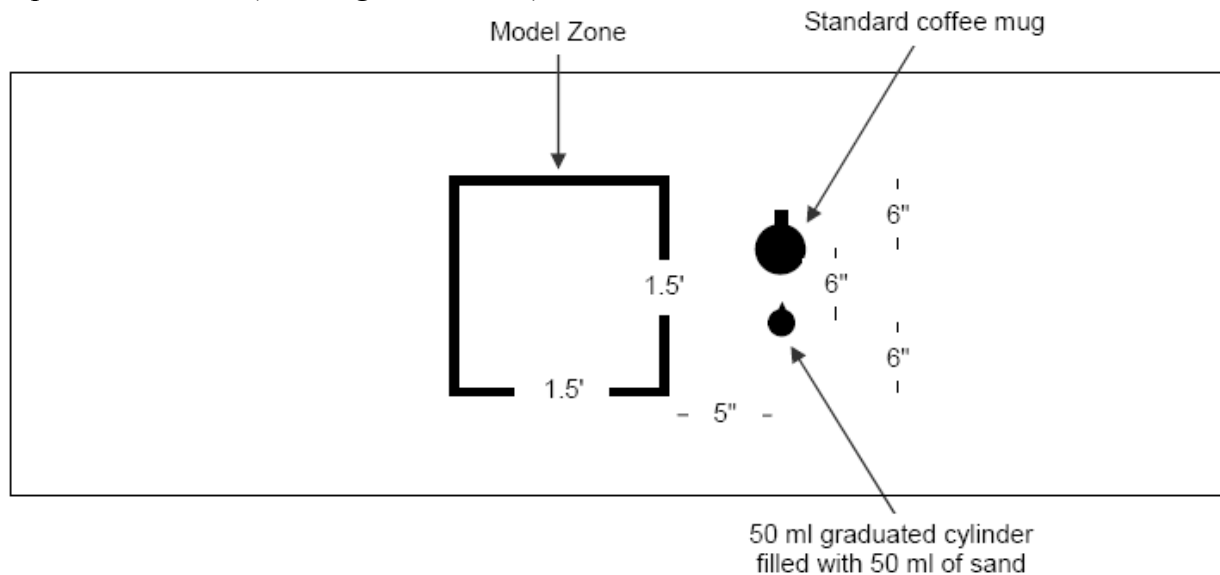
**Attachment A – Competition Setup**

Materials provided by Colorado MESA

- One Standard 6 foot table for *Operation of Prosthetic Arm Model*
- 50 ml plastic graduated cylinder (with permanently molded graduations – 26 mm / 1 in diameter and 2000 mm / 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 the 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 tale).

**BIOMEDICAL ENGINEERING – PROSTHETIC ARM**

**Attachment B – Specification Checklist for Students**

- 2009 – 2010 High School Science and Engineering Jamboree Rules were used.
- The model is clearly labeled with student name(s) and school.
- 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.
- A Material Table with associated cost for each material used and how each material was acquired is turned in with model. 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, Material Table includes cost of parts.



**SCORE SHEET FOR BIOMEDICAL ENGINEERING – PROSTHETIC ARM**  
**GRADE: High School**

*Copies of this score sheet will be provided by Colorado MESA.*

Students Name(s): \_\_\_\_\_

School: \_\_\_\_\_

Judges: \_\_\_\_\_

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

**Total Cost = \_\_\_\_\_ (from “Materials Table”)**

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

<b>Total Cost</b>	<b>Points</b>
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)

<b>Total Weight</b>	<b>Points</b>
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 I \_\_\_\_\_**



2009-10 High School Science and Engineering Jamboree  
Design Challenge Rules - April 20, 2010

Student Name(s): \_\_\_\_\_

School: \_\_\_\_\_

**Part II: 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 II** \_\_\_\_\_

**Part III: 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 seconds)

**Trial 2:** \_\_\_\_\_ (ml of sand poured) \_\_\_\_\_ (time in seconds – within 30 seconds)

Circle best of two trails below and award corresponding points:

<i>Sand Poured into Cup</i>	<i>Points</i>
50 ml	20 points
35 ml – 49 ml	8 points
20 ml – 34 ml	6 points
0.1 ml – 19 ml	4 points
0 ml	2 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 III** \_\_\_\_\_

**GRAND TOTAL** \_\_\_\_\_

*(Ass subtotals for Part I – Part III)*

*Maximum score is 55*

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