OVERVIEW OF THE PROSTHETIC ARM CHALLENGE 2.0

2015-2016
MESA USA National Engineering Design Competition
Prosthetic Arm Challenge 2.0 Introduction

• A classmate has recently lost part of her arm. She now needs a prosthesis that is low-cost that will allow her to complete daily tasks in school and at play.
What is a Prosthesis?

• A prosthesis is an artificial limb (an artificial substitute) that replaces a missing leg or arm due to disease, accidents, or congenital defects.

• Main types of artificial limbs:
  • Transtibial prosthesis
  • Transfemoral prosthesis
  • Transradial prosthesis *(MESA Prosthetic Arm Challenge 2.0)*
  • Transhumeral prosthesis *(MESA Prosthetic Arm Challenge 2.0)*
A U.S. soldier demonstrates table football with two transradial prosthetic limbs.

**i-limb hand**, by Touch Bionics, has five individually powered digits and went on sale in 2007 for $17,454 and now costs upwards of $100,000 (w/fitting and customizations).
The Jaipur foot, a transtibial prosthesis, is readily available to impoverished nations and costs $35. In contrast, prosthetics in the U.S. cost from $5,000 to over $100,000.

- Prostheses in the United States are made from materials such as plastic, metal (aluminum, steel, titanium), silicon, latex, and carbon fiber. These devices can also have robotics components.
Man builds himself Bionic Hands

• Sun Jifa lost both his hands when a homemade blast fishing bomb exploded prematurely. Unable to afford the prosthetic limbs offered by a hospital, he created his own.

“I survived, but I had no hands,” he explained.

After the accident, Sun Jifa, 51, of Guanmashan, Jilin province in northern China desperately needed to work on his family farm, according to the Daily Mail.
Jifa spent eight years handcrafting prototypes before finally creating metal hands that could grip and hold.

“I couldn’t afford to buy the false hand the hospital wanted me to have, so I decided to make my own,” Jifa says.
The devices depend on a series of wires and pulleys inside, and are controlled by movements in his elbows.

“I made this from scrap metal for virtually nothing,” Jifa says.
Jifa says he will further develop the design for other disable people.

“There is no need to pay hospitals a fortune,” Jifa says.
Prosthetic Arm 2.0 Prototype

Prosthetic Arm 2.0 Video
Phil Gillaspy
UTAH MESA
The Prosthetic Arm Challenge 2.0 involves the development of a low-cost prosthetic device with integrated computer science components to complete a set of pre-defined tasks. The challenge has three components: Performance, Technical Paper, and Academic Poster Presentation.

Objective:

Teams will build a low-cost prosthetic arm for someone who has no use of his/her arm, either through amputation or paralysis. The device must meet the criteria outlined in the rules and be designed to perform the pre-defined tasks.
# Prosthetic Arm Challenge Overview

<table>
<thead>
<tr>
<th>Component</th>
<th>Max Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device Performance</td>
<td>150 Points</td>
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<tr>
<td>Distance Accuracy Task</td>
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<td>Object Relocation Task</td>
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<tr>
<td>Dexterity Task <em>(high school only)</em></td>
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<tr>
<td>Device Efficiency</td>
<td></td>
</tr>
<tr>
<td>Greatest ratio of device performance to device mass</td>
<td>25 points</td>
</tr>
<tr>
<td>Greatest ratio of device performance to total cost of materials</td>
<td>25 points</td>
</tr>
<tr>
<td>Technical Paper</td>
<td>100 points</td>
</tr>
<tr>
<td>Academic Poster Presentation</td>
<td>150 points</td>
</tr>
<tr>
<td><strong>Total Points</strong></td>
<td><strong>450 Points</strong></td>
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Challenge Performance Tasks

1. **Distance Accuracy Task**: greatest distance and accuracy achieved by throwing bean bags into the *Target Zone* in the *fastest time*. *(2 trials)*

2. **Object Relocation Task**: fastest time achieved by placing objects into and removing objects from the specified container. *(2 trials)*

3. **Design Efficiency**: greatest ratio of performance score to device mass plus greatest ratio of performance score to total cost of materials

4. **Dexterity Task**: greatest number of bolts and nuts correctly placed and secured onto the testing device in the fastest time. *(2 trials)*

*Middle schools devices DO NOT perform dexterity task*
General Rules

• Prosthesis must be a generalized tool.
  A. Must includes all parts necessary to accomplish all defined tasks.
  B. No parts may be removed and no new parts may be added.

• The device must have at least two artificial fingers which:
  A. MUST open and close.
  B. MUST grab and release the specific objects for each task. Teams may NOT use any other part of the prosthetic arm or parts of their own hand, wrist or arm to grab or release the objects.
  C. MUST be controlled by Arduino programming and components.

• The device MUST NOT be controlled by the team member’s own wrist, hand or fingers on which the device is attached.

• Adjustments, including Arduino programming, and repairs are allowed under supervision of a judge. Repairs are allowed using ONLY replacement parts and materials.
General Rules

• Wrist, hand and fingers immobilized for the tasks to simulate an amputated arm or paralysis. Team will determine their method of immobilization and must demonstrate this for judges. Immobilization must be separate from device.

• Team members may use their unencumbered hand to activate Arduino components and to hold the bucket, crate, or dexterity testing device during the tasks.

• For each task, a different team member must perform each trial.

• All parts and materials of the device cannot exceed $80 pre-tax price limit.

• Must complete and submit an itemized budget sheet for their device and MUST provide documentation to support ALL prices listed. Itemized list for various parts of the Arduino kit is provided with the competition rules.

• Teams not conforming to General Rules will not be allowed to compete in device performance.
Link to Rules and Resources

2015 -16 Prosthetic Arm 2.0 Rules: https://goo.gl/QAffj2

Prosthetic Arm 2.0 Resource Document: https://goo.gl/XI8UCU

Sparkfun Arduino Kit Price Breakdown: https://goo.gl/0EMeBF

Prosthetic Arm w/Arduino Prototype: https://goo.gl/AY81Z0

Prosthetic Arm Prototype Schematic: https://goo.gl/lbgAZC

CA MESA Website at http://mesa.ucop.edu/
Distance Accuracy Task Highlights

- Two meter square marked off as working area
  - One edge designated as Launch Line

- Target Zone is a **step pyramid** 2 m from Launch Line
  - 5 scoring zones

- An one meter stick will be centered and parallel 1.75 m from the *Launch Line* and will be taped to the ground.

- Objects are 5 inch x 5 inch nylon bean bags (total of 12)

- Objects placed inside a Home Depot “Homer All-Purpose Bucket”
Distance Accuracy Task Highlights

- **ONE minute** to prepare, attach and demonstrate device, to place bean bags anywhere inside bucket, and to place bucket anywhere inside *Working Area*.

- **ONE minute (60 seconds)** to grab and accurately release bean bags into the *Target Zone*.

- Only bean bags inside bucket may be used for tossing.

- Member may hold bucket in place with non-prosthetic hand.

- Trial will conclude:
  - Team can call “time” **after and only after** any 3 bean bags have been accurately tossed **completely inside the boundaries** of *Target Zone*.
  - One minute has passed.
  - Team has thrown all available bean bags. If at least 3 bean bags are not accurately tossed into inside boundaries, full trial time of 1 minute will be given.
Distance Accuracy Task Highlights

• Trial will be a MISTRIAL:
  • When a member grabs and tosses more than one bean bag at a time
  • When any part of member’s body including arm and device crosses Launch Line when tossing bean bag

• At the end of the trial, number of bean bags completely inside boundaries will be counted.
  
  o If any portion of bean bag overlaps scoring zones, lesser of scores will be given for that bean bag.
  o If any portion of bean bag is outside the boundaries of Target Zone, 0 will be given for that bean bag.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Score</th>
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<tbody>
<tr>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
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</tbody>
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Object Relocation Task Highlights

- **Table Setup**
  - *Task Areas* (one for objects and other for container)
  - *The Void* (void space between task areas)

- **10 Objects** (point value)
  1. One – 100 pack of index cards (5pts)
  2. One – Roll of 1” x 60 yards masking tape (5 pts)
  3. One – Composition Notebook, 100 pages, page size 7.5” L x 9.5” W (10 pts)
  4. One – empty 0.5 liter bottle water (10 pts)
  5. One – 2 in. vinyl kickball/hacky sack (15 pts)
  6. One – 12” ruler (15 pts)
  7. One – Unsharpened #2 pencil (20 pts)
  8. One – CD or DVD (20 pts)
  9. Two - unidentified objects that vary in size (no larger or heavier 500 g) (25 pts each)

- One minute to prepare, attach and demonstrate device and to arrange objects and container in selected task areas.
Object Relocation Task Highlights

- **One minute** (60 seconds) to place one object at a time into and then remove one object at a time from container (two steps).

- Once an item is placed into the container, it can be removed and placed into the selected *Finishing Area*. An item must be released and the prosthesis must be fully outside of the open plane of the crate before attempting to remove the object.

- The object must be carried across *The Void* and cannot be thrown.

- An object slid or moved over into *The Void* must be returned (slid/carried) to the *Starting Area* using only the prosthesis before attempting to place it into the container.
Object Relocation Task Highlights

- Objects may be slid to edge of table, but may not be slid into *The Void*.

- An object dropped in *The Void*, outside the container or on floor must is out of play and cannot be re-attempted. A penalty equal to the point value of the object will be assessed.

- Member may hold container in place with unencumbered hand.

- Any object broken will not count. These objects will be assessed a penalty equal to that if they had dropped the object.
Object Relocation Task Highlights

- The team may call the end of the trial **after and only after** at least 5 (five) objects have been placed into the *Finishing Area*. The team may signal the end of the trial by calling out “done” or “time.”

- One minute has passed. The judge will call out “time” and stop the team from attempting any more objects.

- The member has attempted to move all of the available objects. Teams that attempt all of the objects without moving at least 5 (five) into the *Finishing Area* will be given the full trial time.

- **At the end of the trial,**
  - record the time needed to complete the task.
  - record which items have been placed into the *Finishing Area*.
  - record any broken or dropped items for penalty points.
Dexterity Task Highlights

• For high school teams ONLY
• Testing device made from two 1 foot x 6 inch x 1 inch boards attached perpendicular to each other.

• Vertical board with three pre-drilled holes
  • Centered vertically and horizontally
    • Hole “A” = US Drill Bit 23/64”
    • Hole “B” = US Drill Bit ½”
    • Hole “C” = US Drill Bit 11/16”

• Dexterity Materials include:
  • Hole “A” = 8mm x 1.25mm x 70mm hex bolt and nut
  • Hole “B” = 12mm x 1.5mm x 70mm hex bolt and nut
  • Hole “C” = 16mm x 2.0mm x 70mm hex bolt and nut

• For Hosts, measurement equipment = 4 inch digital Caliper
Dexterity Task Highlights

• **One minute** to prepare, attach and demonstrate device, and to prepare “Testing Area” and dexterity materials.
  - The testing device may be placed anywhere on the table.
  - The bolts and nuts may be placed anywhere on the table.

• **Two minutes** (120 seconds) to complete task to secure all 3 hex bolts and nuts.

• Order of securing bolts and nuts up to the team.

• May hold head of hex bolt with unencumbered hand only; not allowed to twist or screw hex bolt.

• Testing device may be rotated or held in place with unencumbered hand; however, flat bottom must remain in contact with table at all times.
Dexterity Task Highlights

• If bolt or nut is dropped, it must be picked up by terminal device of prosthesis.

• Once a nut is secured, the terminal device of prosthesis may be used to strike the nut to advance it further on the bolt.

• Trial will conclude:
  • Team can call “time” **after and only after** all three bolt and nut sets have been secured.
  • Two minutes have passed.
  • If an item is dropped and not able to be placed on table; full trial time of 2 minutes will be given.

• Trial will be a MISTRIAL if member is found to have aided in securing or screwing of bolt.
**Dexterity Task Highlights**

- Score based on every 0.5 cm from base/bottom of the thread.

<table>
<thead>
<tr>
<th>Points</th>
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<tbody>
<tr>
<td>5 for each nut secured on a bolt</td>
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<tr>
<td>50 for each nut secured past 0.5 cm</td>
</tr>
<tr>
<td>65 for each nut secured past 1.0 cm</td>
</tr>
<tr>
<td>80 for each nut secured past 1.5 cm</td>
</tr>
<tr>
<td>95 for each nut secured past 2.0 cm</td>
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Reminders

• **Safety first:** Since prosthesis will be attached to student’s arm, please keep safety in mind at all times.

• Stay within all the parameters of the project.

• Research, brainstorm, build, test, record, revise, build, test, record, revise, build, test,…
  • Use the Engineering Design Process

• **READ ALL THE RULES!!!**
Technical Paper

• Aligns to Common Core (STEM Literacy) and Next Gen Science Standards
• Increases team accountability

• Focuses on documentation of team’s Design Process

• Simplified Scoring Criteria (5 point Likert-type scale)

• Highlights include:
  • Incorporate Engineering Design Notebook
  • Discussion of team’s design choices
  • Discussion of electronic hardware integration
  • Discussion of software development
  • Rigor on STEM concepts
  • The following **MUST** be included in Appendix
    • Cost-Labor Summary
    • Pseudocode describing program logic
Academic Poster Presentation

• Aligns to Common Core (STEM Literacy) and Next Gen Science Standards

• One tri-fold presentation boards or 36” x 48” poster

• Poster must contain the following sections
  • Abstract

  • Design Features and Drawing
    • One orthographic drawing
    • Two isometric drawings
    • One Arduino Block Diagram

  • Results and Data
    • Two data tables
    • Two charts or graphs

  • Analysis
    • Explains design’s strength and at least 2 shortcomings

  • Conclusion/Recommendations
    • Three ideas for future work

• Team to use Poster in Presentation
2016 Competition Dates and Deadlines

- **CA Local Competition:** Check with local MESA Center for competition dates

- **Regional Competition:**
  - **North:** April 30, 2016 @ UC Davis
  - **Central:** April 9, 2016 @ CSU Fresno
  - **LA Metro:** April 9, 2016 (HS) @ CSULB; April 23, 2016 (MS) @ UCLA
  - **South:** April 9, 2016 (MS) @ UCR; April 16, 2016 (HS) @ Imperial Valley
  - Check with host center for Technical Paper due dates

- **CA State Competition @ UC Irvine:** May 14, 2016
  - Technical Papers due: May 7, 2016

- **National Competition in Utah:** June 23 – 25, 2016
  - Technical Paper due: June 3, 2016
  - Email to mailto: nationalcompetition@mesausa.org
  - Late papers accepted up to June 5, 2016 with 10 point deduction
Activity 1 – Relocating Objects

• Objective
  • Design, build and operate a prosthesis from given supplies to grab various size objects **one a time**, release them into a container, and then remove them from the container

• Supplies per group
  • 2 sheets of card stock paper
  • 9 straws
  • 14 craft sticks
  • 3 pony beads
  • String
  • Activity Sheet
Activity 1 – Relocating Objects (cont.)

- Using the given supplies, design and build a prosthesis.
  - Device MUST have artificial fingers and MUST open and close.
  - Can NOT use opposite elbow, forearm or hand OR real hand to operate or control the prosthetic arm. *Note: device for competition MUST be controlled by Arduino programming and components. This is to only demonstrate how a prosthesis can be built and controlled.*

Creating One Finger with Two Joints

- Cut one craft stick into three equal pieces.
- Cut two pieces of straw slightly shorter than the pieces of sticks.
- Glue one piece of straw to one piece of stick. Put the glue on the stick and not the straw or the straw may melt. Do this for a total of TWO straw/stick segments.
- Glue the two stick segments onto a full straw. The sticks should be sandwiched between the straws now. Leave a small space in between each segment, so that bending is possible at the joint.
- Glue full straw’s excess onto a full length craft stick. Leave a small space between the full length craft stick and the first segment, so that bending is possible at the joint.
Activity 1 – Relocating Objects (cont.)

- Glue one more straw segment onto the top of the full length craft stick in line with the other two segments.
- Tie a pony bead onto the end of piece of string. Use the bamboo skewer to thread the other end of the string through the first short straw segment and through the two other short straw segments.
- Wrap each segment with tape to reinforce the glue. Pre-bend the finger at each joint.

Creating Arm and Operation
- Using the remaining supplies, create two more fingers, the arm and the operation of the fingers.

Testing
- Attach the prosthesis and pick up different objects from a table one at a time, release them into the container/box, and then remove them from the container/box.
Activity 2 – Tossing Hacky Sacks into Target

• Objective
  • Design, build and operate a prosthesis from any of given supplies to grab hacky sacks from a cup one at a time and toss them into a Target Zone.

• Supplies per group
  - 4 – sheets of card stock paper
  - 5 feet of masking tape
  - 5 index cards
  - 1 pair of scissors
  - 2 plastic spoons
  - 5 straws
  - 10 craft sticks
  - 5 rubber bands
  - 10 small paper clips
  - 10 large paper clips
  - 10 fasteners
  - Activity Sheet
Activity 2 Instructions

1. Using any of the given supplies, design and build a prosthesis.
   - Device MUST have artificial fingers and MUST open and close.
   - Can NOT use opposite elbow, forearm or hand OR real hand to operate or control prosthetic arm. *Note: device for competition MUST be controlled by Arduino programming and components.*

2. Tape a triangle target zone 3 feet from launch line. No part of team member or device may cross launch line.

3. Place hacky sacks inside cup.

4. Attach prosthesis, grab one hacky sack at a time from the cup, and toss it into the target zone.
Resources

• MESA USA website at www.mesausa.org
  • National curriculum

• CA MESA website at www.mesa.ucop.edu
  • Event Overview PowerPoint
  • State curriculum
  • Excel Scoring Tools
  • Event Management
  • Classroom Activities
    • User Name and Password Protected

• BioMedTech: Bionic Arm
  • Modules
  • http://techxcite.pratt.duke.edu/curriculum/biomed-arm.php
QUESTIONS?

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