



MESA USA NATIONAL ENGINEERING DESIGN COMPETITION 2012-2013

Prosthetic Arm Challenge

Contents

Overview

In order to maximize each team's experience during this event, it is important to properly execute all aspects of the testing process and event administration. Although each MESA state may elect to present this event in different format(s), the MESA USA host site and the corresponding National Event Planning Committee will be required to adhere to the processes outlined below. Please note that the following processes not only outline the event but also the roles and responsibilities of student team members and advisors.

MESA USA Code of Sportsmanship

During the course of this event, MESA students, staff, advisors and supporting family members will be expected to act in a professional and courteous manner at all times. All judges' decisions are final. Staff, advisors and parents shall not engage judges during the event.

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MESA USA
NATIONAL ENGINEERING DESIGN COMPETITION
PROSTHETIC ARM CHALLENGE
2012-2013



Competition Overview

MESA USA presents the engineering design competition specifications for the 2012-2013 year. The Prosthetic Arm Challenge involves the development of a low-cost prosthetic device to complete the pre-defined tasks. High school and middle school teams selected to participate at the national event will compete in the four components below:

- 1) **Performance** – Teams will research, design, build, test and compete using a prosthetic device designed to mimic the movement of the wrist, hand and fingers. Performance will be judged as it relates to the following tasks:
 - a) Distance Accuracy Relay: greatest distance and accuracy achieved by tossing balls of three different sizes into target containers located at three different distances.
 - b) Object Relocation Task: greatest mass-to-time ratio achieved by placing objects of varying weight into the specified container.
 - c) Dexterity Task: greatest number of bolts and nuts correctly placed and secured onto the testing device.
 - d) Design efficiency: greatest ratio of device performance to device mass.

Middle school teams will compete in tasks “a” and “b”. High school teams will compete in tasks “a”, “b”, and “c”. All teams will be scored for Design Efficiency.

- 2) **Technical Paper** – Teams will submit a 5-15 page technical paper that details the design, development, experimentation and understanding of their device.
- 3) **Academic Display** – Teams will present the findings of the above-described research in display format. The display should include items such as data (e.g., charts and graphs), photographs, drawings, other ideas, and any necessary written explanations.
- 4) **Oral Presentation** – Teams will give an oral presentation based on investigation, experimentation, design, testing, and experiences related to their device. This presentation will be delivered to a panel of judges. After the presentation, teams will be asked questions by the judges.

Each competing team must consist of 2-4 students who are active members of a MESA center program in a MESA USA state. Individual states should encourage their respective teams to participate in all performance components at the statewide level. Individual states will determine the dates and location of their respective events.

The first place middle and high school teams from State events will travel to the national competition. These teams must compete in all tasks listed above. This event is scheduled to occur **June 20-23, 2013** hosted by Oregon MESA. Feedback/comments should be submitted via the attached *Activity Feedback Form*.

Scoring Summary

Final team rankings will be based on the total score which is derived by adding all of the task scores.

Device Performance	150 points
Device Efficiency	50 points
Technical Paper	100 points
Academic Display	100 points
Oral Presentation	100 points
Total Points	500 Points

Acknowledgement:

MESA USA would like to thank Dr. Suzanne Olds, the VaNTH Engineering Research Center for Bioengineering Educational Technologies, and Northwestern University for allowing MESA USA to use the “Get A Grip!” curriculum as an inspiration and example for the development of these specifications.



**2012-2013 MESA USA
National Engineering Design Competition
Prosthetic Arm Challenge
Device Performance
150 points**

Objective

Teams will build a low-cost Prosthetic Arm for use by a classmate who recently lost part of her arm below the elbow. The device should be designed to be low-cost and easily maintained and allow her to complete daily tasks in school and at play. The device must meet the criteria outlined in the rules and be designed to perform the following tasks:

Middle School

- (1) Distance Accuracy Relay: greatest distance and accuracy achieved by tossing balls of three different sizes into target containers located at three different distances. (2 trials)
- (2) Object Relocation Task: greatest mass-to-time ratio achieved by placing objects of varying weight into the specified container. (2 trials)

High School

- (1) Distance Accuracy Relay: greatest distance and accuracy achieved by tossing balls of three different sizes into target containers located at three different distances. (2 trials)
- (2) Object Relocation Task: greatest mass-to-time ratio achieved by placing objects of varying weight into the specified container. (2 trials)
- (3) Dexterity Task: greatest number of bolts and nuts correctly placed and secured onto the testing device. (2 trials)

Both - Design Efficiency – greatest ratio of performance score to device mass

Materials

- Hazardous materials may not be used in the construction or operation of the device, including but not limited to lead.
- All other materials to build the device are legal and optional
- There will be a \$40 pre-tax price limit for materials. Teams may use on-line national retail prices for materials as long as they provide the proper documentation as defined in the rules below.

Rules

General Rules

1. Teams must design, build and operate their own prosthetic arm. This device will include all parts necessary to accomplish all defined tasks.
2. The device must be designed as a trans-radial (below-the-elbow) prosthetic. The device must attach half way between the elbow and wrist. The device must extend beyond the hand.
3. The device should be designed to be low-cost and easily maintained.
4. The device cannot utilize the opposite elbow, forearm or hand to control the prosthetic device.
5. The device must include a hand mechanism that includes at least two “fingers” and must open and close without assistance from the opposite elbow, forearm or hand.
6. The hand mechanism must be able to open to at least 10 cm. The device **MUST** grasp, take hold of, or grab the specific objects in each task.
 - a. The specific objects **MUST** be grasped, taken hold of, or grabbed on the part of the device that extends beyond the hand (i.e. the “fingers” of the device). Teams may **NOT** use any other part of the device or parts of their own hand, wrist or arm to grasp, take hold of, or grab the specific objects.
7. In the one minute preparation for each task, the team must demonstrate to the judge(s) that the device can grasp, take hold of, or grab the specific objects in each task (i.e. the device must open and close).
8. The device cannot utilize the team member’s wrist, hand, or fingers in any way.

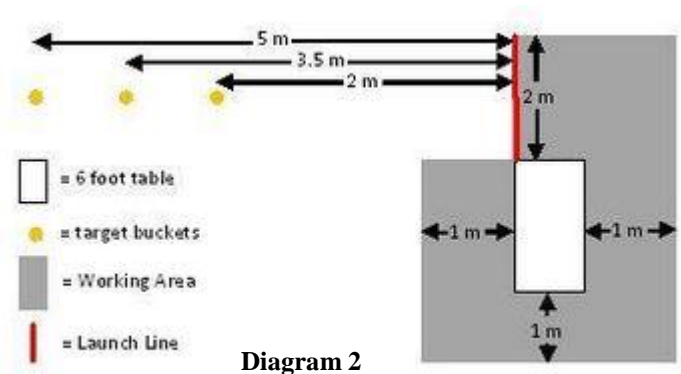
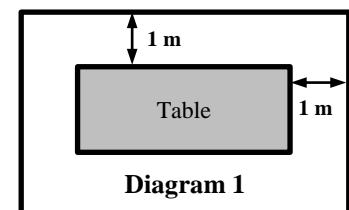


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150 points**

9. Participating team members must have their wrist, hand and fingers immobilized for the tasks. The team will determine their own method for immobilization and must demonstrate this for the judges during specification check and impound. In addition to this method, a latex or similar glove will be placed over the participating team member's **closed fist** before they attach the device for task trials.
10. Team members may use their unencumbered hand to assist in preparing the device for each task, but they will **NOT** be allowed to use their unencumbered hand to assist in completing the tasks, unless otherwise specified in the task details.
11. Parts may **NOT** be added, removed, replaced or readjusted in the middle of a task trial
12. Devices cannot exceed the \$40 pre-tax price limit for materials.
13. Teams must complete the provided itemized budget sheet for their device and provide documentation to support the prices listed.
 - a. The budget must include a list of all parts and materials and their retail prices.
 - b. All parts received through barter, trade, donation, recycling, etc. must be included in the itemized budget. Retail prices for these items must be researched and documented.
 - c. Printed documentation verifying the retail prices (i.e. a store receipt or print out of on-line retail prices) must attached to the itemized budget sheet for all parts and materials whether purchased or not.
 - d. The cost will be based only on the actual materials used in the construction of the device. Therefore, teams will need to calculate the cost per unit for their budget.
- e.g. a 3 pack of foam board (20 in x 30in) cost \$9.00. This breaks down to \$3 per sheet and \$0.005 per square inch. If a team uses 25 square inches on their device the cost would be \$0.125.
14. The device, including all parts of all configurations, cannot weigh more than 3 kilograms.
15. All parts that will be used during competition must be impounded and inspected prior to the start of competition.
16. Reconfiguration or adjustment of impounded parts between tasks will be allowed.
17. All designs that conform to the rules will be allowed to participate.
18. Once performance competition begins, student teams may not have contact with non-competitors. Student teams are solely responsible for interaction with judges and addressing problems with their devices.

Test Configurations and Equipment

1. General –
 - i. a one (1) meter perimeter will be marked around tables used for each task, unless otherwise specified below. Only team members actively participating in the task will be permitted in this *Working Area*. See Diagram 1.
 - ii. Tables used for each task will be Six foot tables with approximate dimensions of 76 cm x 183 cm x 74 cm.
2. Distance Accuracy Relay - , a table, a 2 meter launch line, and 3 target buckets will be used. A 2 meter launch line will be marked off with masking tape, and the corner point of a six foot table will be placed at one end of the launch line, so that the long edge of the table lines up with the launch line.
(See diagram 2) A box with the Relay Objects will be placed on top of the table.





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- i. The target buckets used for this task will be Home Depot's "Homer's All-Purpose Bucket" (Model # 05GLHD2). The target buckets will be placed and centered from the launch line at 2 meters, 3.5 meters, and 5 meters. Each of the target buckets will be taped to the ground.
 - ii. The Relay Objects will be three types of balls:
 - 5 (five) standard size tennis balls, 5 (five) 50.80 mm or 2 inch vinyl kick balls, and 5 (five) standard size ping pong balls.
 - The Relay Objects will be randomly placed inside a cardboard box with approximate dimensions of 460 mm x 300 mm x 85 mm (i.e. top of an Office Depot Copy Paper 10 reams box).
3. Object Relocation Task,
- i. The container to be used for this task will be a plastic Sterilite milk crate with dimensions 10.5" H x 13.75" W x 17" L (available at Target, online item #14089509)
 - ii. The container must remain in one of two Container Areas on either end of the table. These areas will be approximately 50 cm x 76 cm (See diagram 3). Before the trial the team will be allowed to place the container in either one of the two areas. Once the trial begins the container must remain in the selected area.
 - iii. The groups of objects that will be available to place into the container are as follows:
 1. Two – 20 ounce Dasani bottles of water
 2. Two – 1 liter Dasani bottles of water
 3. Two – 1lb boxes of Crayola Modeling Clay
 4. Two – Master Lock 1500D 1 7/8" Combination Locks
 5. Two – Quart size Ziploc bags with 200 Pennies
 6. Two – Spindle of 30 CD's
 7. Two – 2 inch by 20 yard Rolls of Duct Tape
 8. Two – 4 oz. bottles of Elmer's Glue All (white school glue)
 9. Two – Packages of 12 AA Energizer Batteries
 10. Two – Composition Notebooks, 100 pages, page size 7.5" L x 9.5" W
 11. Two – 1 lb Box of Grip-Rite Nails any size, box dimensions approximately 2" H x 4.75" W x 3.5" L
 12. Two – Packs of 100 3" x 5" Index Cards
 13. Two – Spiral Bound 3 Subject Notebooks, 120 pages, size 10.5" L x 8" W
 14. Two – Rolls of 1" x 60 yards masking tape
 15. Two - 1 pound bags of pony beads (approximately 2000 beads)

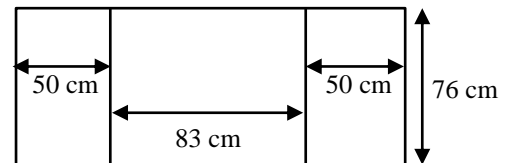


Diagram 3

4. Dexterity Task,
- i. For the Dexterity Challenge, a table and chair will be used.
 - ii. A 50 cm square *Testing Area* will be centered on both of the short ends of the table, and marked with masking tape. The front edge of these areas will be placed along the edge of the table.
 - iii. A testing device will be placed on top of the table within a *Testing Area*. Before the trial the team will be allowed to place the testing device in either one of the two areas.
 1. The testing device will be made from 2 (two) 1 foot x 6 inch x 1 inch boards attached perpendicular to each other (See diagram 4).
 2. The testing device must remain within the selected *Testing Area* at all times (See Diagram 5).



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150 points**

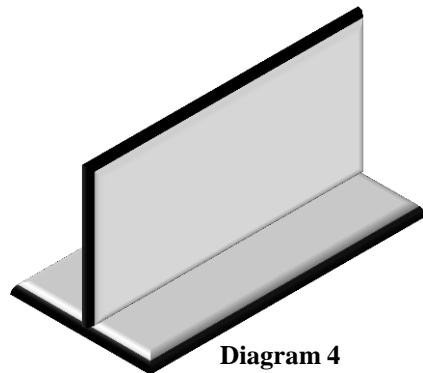


Diagram 4

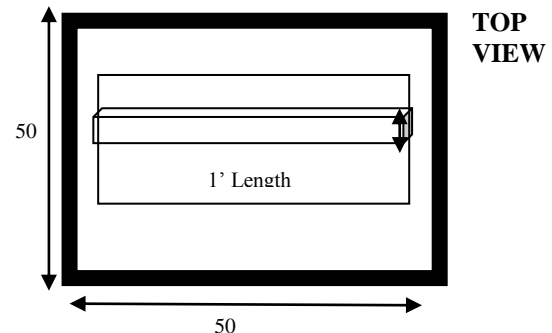


Diagram 5

3. The vertical board will have 3 (three) pre-drilled holes made from drill bits A, B, and C as described below (see Diagram 6). The center of the holes will be placed three inches from the top of the board, and three inches from the edge of the board and/or the center of the holes next to it.

- Hole “A”: Metric Drill-6.9mm (US-17/64)
- Hole “B”: Metric Drill-10mm (US-27/64)
- Hole “C”: Metric Drill-14.2mm (US-35/64)

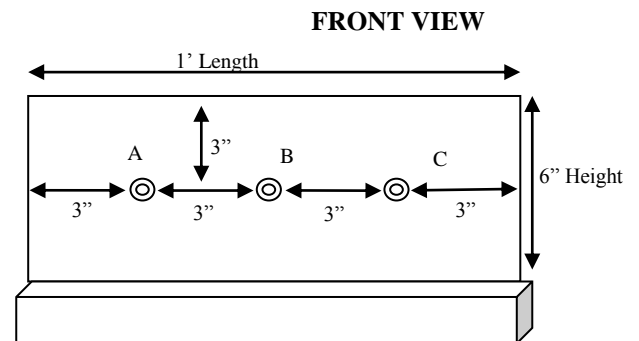
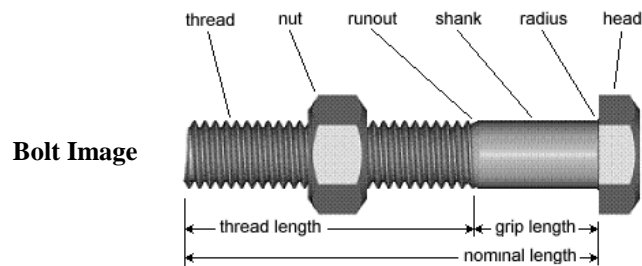


Diagram 6

- iv. The Dexterity Materials will be as follows:

- Set “A” - (1) 8mm x 1.25mm hex bolt with markings every 0.5 cm from the base of the bolt head and corresponding 8mm hex nut
- Set “B” - (1) 12mm x 1.5mm hex bolt with markings every 0.5 cm from the base of the bolt head and corresponding 12mm hex nut
- Set “C” - (1) 16mm x 2.0mm hex bolt with markings every 0.5 cm from the base of the bolt head and corresponding 16mm hex nut
- (3) Corresponding wrenches to fit above hex bolts and nuts
 - Wrench “A” - 13mm Wrench-Craftsman 13mm, 6 pt. Combination
 - Wrench “B” - 19mm Wrench-Craftsman 19mm, 6 pt. Combination
 - Wrench “C” - 24mm Wrench-Craftsman 24mm, 12 pt. Combination
- Metric Nut Size Chart and Scale Images: <http://www.boltdepot.com/fastener-information/Printable-Tools/Metric-Nut-Size-Chart.pdf>
- Metric Hex Bolt Size Chart and Scale Images: <http://www.boltdepot.com/fastener-information/Printable-Tools/Metric-Hex-Bolt-Sizes.pdf>



- v. The Dexterity materials will be placed outside of the *Testing Area*.

Task Details -

1. Distance Accuracy Relay – Grabbing and Tossing Balls

- a. The purpose of this task is to demonstrate the device's ability to:
 - i. Grasp items of varying size
 - ii. Lift objects vertically
 - iii. Correctly time the release of the held object.
- b. The team will be given up to one minute to prepare and demonstrate its device. If at the end of one minute the device is not ready to perform the task the trial will be declared a mistrial and this process will be repeated for the second trial.
- c. At the end of one minute or when device is prepared and ready, the team will place the prosthetic arm device and the box with Relay Objects anywhere on the table.
- d. The first designated team member will stand outside the *Working Area*. (See diagram 2) The member cannot touch the table or the device until given the start order from the judge.
- e. The judge will give the start order and begin the timer.
- f. Teams will have a total of 1 ½ minutes (90 seconds) to accurately toss as many specified balls possible into the target buckets.
- g. Teams **MUST** toss all types of the same balls before tossing subsequent types of the same balls (e.g. all tennis balls must be tossed, then all kick balls must be tossed, and then all ping pong balls tossed).
- h. **At least** two team members must participate in the relay. One team member must toss no more than two types of balls.
- i. Only **ONE** of the balls may be grabbed at a time.
- j. The only team member allowed inside the *Working Area* is the designated team member attaching and removing the device, and grabbing and tossing the balls. No other team members are allowed inside the *Working Area*.
- k. The trial will conclude:
 - i. At the end of 1 ½ minutes (90 seconds);
 - ii. When a team member grabs more than one ball;
 - iii. When a team member tosses the wrong type of ball;
 - iv. When any part of a team member's body including arm and device crosses the launch line when tossing a ball; or
 - v. When the target bucket is knocked over.
- l. **ONLY** balls in designated box on the table may be used for tossing (i.e. balls on the ground or outside of the box may NOT be used).
- m. At the end of the trial, the judge will count the number of balls inside each of the target buckets.
- n. Repeat procedure for 2nd trial.
- o. The best performance of the two trials will be used in the scoring.



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150 points**

2. Object Relocation Task – Pick and Place

- a. The purpose of this task is to demonstrate the device's ability to:
 - i. Grasp items of varying size, shape, consistency, and weight
 - ii. Lift objects vertically and move them laterally
 - iii. Place the items into a container
- a. The team will be given up to one minute to prepare, attach and demonstrate its device, and to place the container anywhere in one of the two "*Container Areas*". If at the end of one minute the device is not ready to perform the task, the trial will be declared a mistrial and this process will be repeated for the second trial.
- b. Items from 10 of the 15 item groups listed in 3.iii. above in the "Test Configurations and Equipment" section will be placed randomly on the table within the area between the two outlined "container areas."
- c. At the end of one minute or when device is prepared, attached and ready, the designated team member will stand outside of the *Working Area*.
- d. The judge will give the start order and begin the timer.
- e. The team member may enter the *Working Area* and will have a maximum of 1 ½ minutes (90 seconds) to complete the task. The judge will notify the student when they have 1 minute, 30 seconds, 20 seconds, and 10 seconds remaining.
- f. The team member will then place the items into the container.
- g. At least five different types of items must be placed in the container. If a team does not have at least five different types of items then the trial will be declared a mistrial.
- h. The team may call the end of the trial at any point before one minute has passed by calling out "done." The judge will immediately stop the timer and record the time elapsed as the trial time.
- i. The judge will call "time" after one minute and 30 seconds has passed.
- j. Any item held by the device when time is called will not be count towards the total mass.
- k. At the end of the trial, the judge will weigh the loaded container and record the total mass and time used to complete the trial.
- l. Repeat procedure for 2nd trial.
- m. The best performance of the two trials will be used in the scoring.



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150 points**

3. Dexterity Challenge – Securing Nuts and Bolts

- a. The purpose of this task is to demonstrate the device's ability to:
 - i. Demonstrate fine motor control
 - ii. Grasp small objects
 - iii. Rotate a tool around an axis
- a. The team will be given up to one minute to prepare, attach and demonstrate its device, to prepare the dexterity materials, and to prepare the *Testing Area*. If at the end of one minute the device is not ready to perform the task, the trial will be declared a mistrial and this process will be repeated for the second trial.
 - i. Dexterity materials may be placed anywhere on the table outside of the *Testing Area*.
 - ii. The testing device may be placed anywhere inside of the selected *Testing Area*.
- b. At the end of one minute or when device is prepared, attached, and ready, the designated team member will stand outside of the *Working Area*.
- c. The judge will give the start order and begin the timer.
- d. Teams will have a total of 2 minutes (120 seconds) to secure all three (3) hex nuts and bolts.
- e. The designated team member may sit or stand to complete task and may move chair and/or stand anywhere in the *Working Area*.
- f. The member will then grab one of the hex bolts with the device and place the hex bolt into the corresponding pre-drilled holes. The head of the bolt must face the front of the testing device (edge facing student) and the shank of the bolt must extend through the back of the testing device.
- g. The team member may secure the hex bolt with the non-prosthetic hand by holding the head of the bolt on the front side only. The team member may only secure the bolt and is not allowed to twist/screw in any way.
 - i. With the prosthetic arm device, the member will then grab the corresponding hex nut and place the hex nut onto the bolt.
 - ii. With the prosthetic arm device, the member will then grab the corresponding wrench and proceed to screw the hex nut onto the bolt.
 - iii. All hex bolts will have a marking every .5 cm from the base of the bolt head. The hex nut must completely pass a marking on the bolt to be scored in the higher scoring zone.
 - iv. The member will then repeat the above steps until all 3 (three) hex bolts have been secured or until trial time lapses.
 - v. Time will be measured in seconds (s). Full time will be given to teams that have not secured all 3 nuts on their corresponding bolts.
- h. If the team member is found to have aided in the securing/screwing of the bolt the trial will stop and be declared a mistrial.
- i. If a nut, bolt, or wrench is dropped it may be picked up by the prosthetic or non-prosthetic hand and placed on the table outside the "Testing Device Area" to attempt again. If the item is not able to be placed on the table to try again, the trial will stop and a score will be given for what has been completed to this point with a full trial time of 2 minutes.
- j. The team will have as many attempts as able within the allotted trial time.
- k. Teams are able to choose in what order they attempt but must secure a nut on a bolt before attempting another. Once all three nuts have been secured on the bolts, securing a score of at least 50 for each nut placed, teams may re-visit any nut/bolt set to score more points if time allows.
- l. One team member is allowed to switch places with the active team member during the trial, but time will continue to run.
- m. Repeat procedure for 2nd trial.
- n. The best performance of the two trials will be used in the scoring.



Construction and Repair

1. Teams should consider the device's shipment cost to the national competition. It is recommended that teams design their device so that it can be disassembled for shipment in a large suitcase(s).
2. Repairs are allowed, but only using replacement parts and materials. All repairs must be done in the impound area under supervision of a judge. The addition of new or alternate parts not previously impounded is NOT allowed.

Safety

1. Standard safety practices including the use of protective eyewear must be observed.
2. Students must operate their device in a safe manner. The device may only be activated when directed by the judges. Teams using UNSAFE PROCEDURES may have trials disqualified at the discretion of the judges.
3. The device must not pose a danger to students, officials, spectators or cause damage to the host facility, as determined by the judges.

Inspection, Impound and Operation

1. The trial order for performance events will be randomly selected.
2. Device inspection will take place prior to being impounded for the performance events. Inspection will include demonstration of device operation for all tasks to the judges.
3. Devices must be in testing condition prior to device inspection. If devices are disqualified during inspection check, design changes will not be allowed. Only devices passing inspection will be allowed to participate in the performance tasks.
4. The itemized budget with documentation must be submitted at inspection and will be reviewed by the judge. Any device that is over budget or missing complete documentation will be disqualified.
5. All repair materials and parts to be used during the competition must be impounded with the device. Devices will be released for trials but will remain impounded between tasks.
6. Each device must be ready for competition when called or forfeit that trial.
7. After teams arrive at task station, Judges will direct them to setup for the task.
8. If, during the operation of a device, it is found to violate rules those trials will be disqualified.

Measurement Equipment

1. Distance Accuracy Relay:
 - Stop-watch or timer
 - Metric Ruler
2. Object Relocation Task:
 - Minimum 50 lb postal scale
 - Stop-watch or timer
3. Dexterity Task:
 - Stop-watch or timer
 - Metric Ruler
4. Control Task:
 - Stop-watch or timer



Assigning Points to Performance

1. The Total Performance Score will be determined by the sum of the points earned in each task.
2. Scores for each task equal the ratio of each device’s performance relative to the winning device’s performance on that task. Those scores are weighted according to the maximum points for each task:

Middle School Tasks: 75 points each
High School Tasks: 50 points each
3. Ties are allowed in each task

Distance Accuracy Relay – Grabbing and Tossing Ball

- Scores for Relay Objects
 - o 5 for each tennis ball accurately tossed into any of 3 target buckets
 - o 10 for each kick ball accurately tossed into any of 3 target buckets
 - o 20 for each ping pong ball accurately tossed into any of 3 target buckets
- Scores for Distances (Buckets)
 - o 5 for each ball accurately tossed into 2 meter target bucket (target 1)
 - o 10 for each ball accurately tossed into 3.5 meter target bucket (target 2)
 - o 20 for each ball accurately tossed into 5 meter target bucket (target 3)
- Score Matrix

	Target 1	Target 2	Target 3
Tennis Ball	10	15	25
Kick Ball	15	20	30
Ping Pong Ball	25	30	40

1. Team Weighted Distance Accuracy (D_{tm}) = score / number of balls left in box
 - a. If 0 balls are left in box, 5 will be added to score.
2. Task Winner = Greatest Team Weighted Distance Accuracy (D_{wm}) receives maximum points (75 or 50)
3. Team Task Points = Team Weighted Distance Accuracy (D_{tm}) divided by Greatest Team Weighted Distance Accuracy (D_{wm}) times maximum points, or

$$\text{Team Task Points} = \frac{D_{tm}}{D_{wm}} \times 75 \quad \text{or} \quad \frac{D_{tm}}{D_{wm}} \times 50$$

Example		
Task Winner Winning Distance/Accuracy (D_{wm}) = 210	Team 5 Trial 1: 175 Trial 2: 200 Team Distance/Accuracy (D_{tm}) = 200	Team 5 Points Middle School Score = (200/210) x 75 = 71.42 pts High School Score = (200/210) x 50 = 47.62 pts



Object Relocation Task - Pick and Place (Middle and High School)

1. Team Object Relocation Score (P_t) = greatest team mass-to-time ratio (g/sec)
 - a. Team mass-to-time ratio = total mass of items placed in container divided by the trial time
2. Task winner (P_w) = greatest overall mass-to-time ratio (g/sec) for any team
3. Task Points = Team score (P_t) divided by (P_w), times max points or

$$\text{Task Points} = \frac{P_t}{P_w} \times 75 \text{ or } \frac{P_t}{P_w} \times 50$$

Example		
Task Winner Winning Score (P_w) = 48	Team 5 Trial 1: 850 g, 35 sec, Ratio = .24.29 Trial 2: 875g, 25 sec Ratio= 35 Team Score (L_t) = 35	Team 5 Points Middle School Score = $(35/48) \times 75 = 54.69$ pts High School Score = $(35/48) \times 50 = 36.46$ pts

Dexterity Task – Securing Nuts and Bolts

1. Scores for Scoring Zones on each bolt
 - a. 50 for each nut placed on a bolt
 - b. 55 for each nut placed past the .5 cm mark
 - c. 60 for each nut placed past the 1 cm mark
 - d. 65 for each nut placed past the 1.5 cm mark
 - e. 70 for each nut placed past the 2 cm mark
 - f. 75 for each nut placed past the 2.5 cm mark
2. Team Dexterity Score (X_t) = greatest team score-to-time ratio (pt/sec)
 - a. Team score-to-time ratio = total score divided by the trial time
3. Dexterity Task winner (X_w) = greatest score-to-time ratio (pt/sec) for any team
4. Task Points = Team Dexterity Score (X_t) divided by (X_w), times 50 points

$$\text{Task Points} = \frac{X_t}{X_w} \times 50$$

Example		
Task Winner Winning Dexterity Score (X_w) = 3.21	Team 5 Trial 1: 180 pts, 120 sec Trial 2: 180 pts, 100 sec Team Writing Score (W_t) = 1.80	Team 5 Points High School Score = $(1.80/3.21) \times 50 = 28.04$ pts

Total Performance Score:

1. Middle School Performance Score
 = Distance Accuracy Relay + Object Relocation
2. High School Performance Score
 = Distance Accuracy Relay + Object Relocation + Dexterity



Objective

To clearly document their engineering design process, MESA students participating in the MESA USA National Engineering Design Competition will write a technical paper regarding the principles, design, and performance of their device.

Length

The paper should not be less than five pages or more than fifteen pages in length (excluding the title page and appendix). Thorough but concise papers are encouraged.

Electronic Format

Teams are required to save the document in Portable Document Format (PDF) or Microsoft Word format prior to submission. Teams shall also ensure the submitted final product can be read using Adobe Reader (8.0 or newer) or Microsoft Word (2003 or newer) and matches their original document.

Authorship

The authors must be members of the student team participating in the competition. The paper must be the original work of the authors. If professional assistance was needed for information or writing assistance, their names should be included in the references.

Deadline

The technical paper must be submitted via e-mail to Oregon MESA on or before 5:00 pm local time on **Tuesday, June 11, 2013**. The papers will be judged and scored prior to the National Competition. Papers shall be e-mailed to: Oregon MESA, Head Judge at competition_rules@mesausa.org.

Written Presentation

The paper should be typed, double-spaced, and have a cover sheet. Graphics should be computer generated. The font used should be **Times New Roman** and the font size should be **12**. A one-inch margin is required on all sides. Readability will help your paper achieve a higher score in the judging.

The paper should include the following:

- A. Title Page - not included in the page count
- B. Abstract
- C. Table of Contents
- D. Introduction
- E. Discussion
- F. Conclusions
- G. Recommendations
- H. References or bibliography
- I. Acknowledgments
- J. Appendices (Optional) - not included in the page count

Title Page

Title, Authors, State, School and Date need to be included

Abstract

This section is a brief synopsis of your project, 200-250 words. It is the most important part of your paper, stating the purpose of the report and its most important features, the main conclusions and recommendations. It should be written in informative, non-technical terms and be interesting so that the reader is drawn to read further.



Table of Contents

Table of contents should correctly identify each required component of the paper.

Introduction

This is the narrative that prepares readers for the discussion that follows. It provides background for the reader before introducing any technical data. It is broken down into three sections that average one to two paragraphs each:

- Purpose: why the project was initiated and why the report was compiled (e.g., to solve a problem, to evaluate or introduce a new concept, etc.)
- Scope: defines the parameters of your report; outlines methods of investigation and any limiting factors
- Background Information: presents facts the reader should know, conditions or events prior to the project, details of previous reports

Discussion

This is the longest section of the paper. It presents and discusses all evidence (facts, arguments, data, tables, charts, graphs, etc. are referred to and explained here but should be located in the appendix).

1. Summarize the teams' device development, including a general description of design research, design selection and modifications made to satisfy event rules and task objectives.
2. Discuss physical phenomena related to the device. (e.g. Teams are encouraged to examine and report on potential and kinetic energy, work, aerodynamics, drag, velocity, force acceleration, mechanical advantage and other factors influencing the performance of their device. Newton's laws of motion may also be addressed in describing the movement of the device using terms such as action/reaction, mass, momentum, inertia, etc.)
3. Use of advanced concepts, techniques, algorithms or other materials that would not normally be included in middle or high school subjects must be explained. The paper must show how the team's research and work led to their selection and use. Appendices may be used for this purpose.
4. Experimental procedures and test setup (pictures or diagram)
5. Data reduction, analysis tools and models
6. Data (Table, graphs, charts, pictures, diagrams)
7. Results

The discussion section should be imaginative enough to hold the reader's interest and organized logically. Three common ways to organize are shown below:

- Chronological development: present information in order of occurrence, usually the easiest way to organize
- Subject development: present information by subjects, grouped in a predetermined order
- Concept development: arrange information as a series of ideas that reveal the reasoning process used to reach the conclusions; requires more careful organization but allows more creativity and persuasion. Writers should anticipate reader reactions. If presenting a controversial concept, establish a strong case before discussing it in detail. If presenting a popular or familiar concept, briefly and simply establish your case.



Conclusion

In this section, state the major inferences that can be drawn from the discussion. Be sure the evidence was presented in the discussion section. No new evidence should appear in this section.

Recommendations

This section is used to indicate further work to be done or to indicate the best solution when several solutions have been presented. Write recommendations, in strong definitive terms using first person and active verbs.

References

All sources that are consulted should be properly cited according to the APA format. See Resource Materials section for example references and additional information.

Acknowledgments

This section should be used to recognize individuals or groups who have provided support and guidance throughout the design process.

Appendices (optional)

This section contains, in detail, supporting data, charts, tables, photographs, test results, etc. that were referred to earlier in the paper.

Criteria for Evaluation and Scoring

Shown below are the main areas that will be considered in the evaluation of the technical paper. See the Scoring Materials section for specific details and overall criteria.

- Discussion (40 pts)
- Abstract (20 pts)
- Introduction (15 pts)
- Conclusion & Recommendations (15 pts)
- Written Presentation (10 pts)



Objective

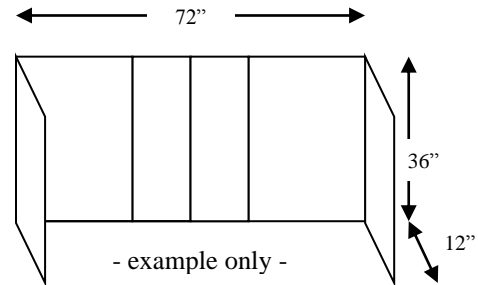
The purpose of the display is to provide a visual representation of the engineering design process used to develop the team's device. Teams will present their device and relevant aspects of the design project from the technical paper. The focus of the display should only be the actual device presented for performance.

Materials Provided

- 30" x 72" x 29" (cafeteria style) table

Form, Key Features & Organization

- The maximum display area is equivalent to two 36" x 48" tri-fold presentation boards placed side-by-side on the table.
- The entire display must be on the table and not extend beyond the table top. Displays may be taped to the table for stability.
- Electronic media are not allowed.
- The team state, school and members should be prominently displayed.
- Except for the tri-fold presentation board no element of previous year's display may be reused. All elements must be original for this year.



Required Elements

- **Abstract** – A brief synopsis of the project, 200-250 words
 - State the purpose of the technical paper and its most important features, the main conclusions and recommendations
 - It should be written in informative, non-technical terms and be interesting to the reader
- **Data and Technical Explanation** – Teams will show their exploration and share explanations of their device and the scientific and engineering ideas involved in the project
 - **Teams should include key physics concepts as well as engineering challenges and solutions**
 - Teams should incorporate text, photographs, drawings, images, tables, charts, graphs, models etc. that share information relevant to the overall project
 - Teams may identify the features of the device using a system of labels or pointers
 - Include modifications made to your device to ensure that it is a top contender.
 - Teams are also encouraged to examine potential and kinetic energy, mechanical advantage, friction, work, Newton's Laws of Motion, and any other pertinent topics.
- **Scaled Drawing** – A three-view drawing depicting the actual device designed and built.
 - See Resource Materials section for example scaled drawing format
 - Front, side, and top views should be included, see sample page 28
 - All parts of the device should be labeled
 - 3" x 5" Title Card including drawing title, brief description, date completed, and scale used
 - Photographs are not permitted in place of a scaled drawing
 - Scaled drawing may be drawn by hand or computer generated, both methods scored equally.
 - Maximum paper size shall be 11"x17"



- **Cost and Labor Summary** – A table summarizing essential cost and labor details of the project.
 - Minimum size – 8 ½” x 11” sheet of paper
 - Required Content:
 - Materials – description, source, purchased or donated, actual or estimated cost. Include an estimated total cost. Teams may use the detailed budget sheet provided.
 - Labor – estimated student hours applied to complete project elements; Device, Technical Paper, Academic Display & Oral Presentation.

Criteria for Evaluation and Scoring

Shown below are the main areas that will be considered in the evaluation of the academic display. See the scoring materials section for specific details and overall criteria.

- Technical Explanations & Data Presentation (40 pts)
- Scaled Drawing & Cost-Labor Summary (30 pts)
- Form, Key Features & Organization (10 pts)
- Abstract (10 pts)
- Creativity (10 pts)



Objective

The purpose of the presentation is to provide information about the engineering design project to a panel of judges. Students will organize and deliver a focused, coherent presentation that provides an overview of the development of their design including research, experimentation and conclusions. The judges should understand the speech and become engaged in the presentation. Speeches must be the original work of the team.

Materials Provided

- Table
- PC computer with Microsoft PowerPoint 2003 or newer
- easel board
- LCD projector and screen

Required Elements

- **The processes and procedures used in design development.**
- **Discussion of related physical phenomena.**
- **Observations and data related to any experiments, testing or research conducted.**
- **Conclusions derived from the engineering design process.**

Rules

1. Each team will have a maximum of 2 minutes to set-up for their presentations.
2. Presentation attire will be the official MESA USA National Engineering Design Competition t-shirts. A 5-point deduction will be applied for teams not wearing the official t-shirts.
3. Props, models, charts, graphs or other visual aids should be used.
4. Electronic presentations using Microsoft PowerPoint are allowed but are limited to text and images. Other electronic materials not allowed. Teams should not rely heavily on electronic media.
5. Teams are expected to bring their presentation on either a CD or USB flash drive.
6. Each team may speak for a maximum of 10 minutes. A 5-point deduction will be applied for presentations exceeding 10 minutes. Judges will expect to hear directly from all team members.
7. Teams may invite audience members at their discretion to attend the presentation. Once the presentation begins, audience interruptions will not be permitted.
8. Teams are expected to do research. They may interview and quote experts, associates, or use quotations from written sources. They may provide examples, and/or use illustrations, facts, and figures.
9. All key concepts should be well understood by the team. The use of advanced concepts, techniques, algorithms or other materials that would not normally be included in middle or high school subjects must be explained. Teams must explain how their research and work led to their selection and use.
10. Teams will be randomly selected to determine speaking order.
11. Students must give their presentations in the order drawn. No exceptions or late arrivals are allowed.
12. Judges will provide time signals at 3 minutes, 1 minute, 30 seconds, and 5 seconds before time is called.
13. Once the presentation is complete, the judges will conduct a 5 minute question and answer period. These questions will be brief and to the point, and solely to ascertain student knowledge of the project.

Criteria for Evaluation

Shown below are the main areas that will be considered in the evaluation of the Oral Presentation. See the Scoring Materials section for specific details and overall criteria.

- Technical Content (40 pts)
- Overall Presentation (30 pts)
- Oral & Visual Performance (20 pts)
- Question Responses (10 pts)



Inspection and Performance Datasheet

MESA Center: _____ MESA School: _____

Level: MS HS Advisor/Teacher: _____

Student Team: _____

Inspection

PASS FAIL

- Device is a trans-radial (below the elbow) prosthetic Y / N
- Device does not utilize the opposite elbow/forearm/hand to control the device Y / N
- Device does not have a mass more than 3 kg..... Y / N
- Device incorporates a hand mechanism with at least two “fingers” Y / N
- The hand mechanism opens to at least 10 cm Y / N
- Team has demonstrated that they have immobilized the wrist, hand and fingers Y / N
- Did the team provide an itemized budget with references and documentation Y / N
- Device did not exceed the \$40 pre-tax price limit Y / N

Device Mass (including all parts of all configurations): kg

Device Total Cost: \$

Performance

Distance Accuracy Relay

Trial 1	TARGET 1			TARGET 2			TARGET 3		
	# of Balls	Multiplier	Points	# of Balls	Multiplier	Points	# of Balls	Multiplier	Points
Tennis Ball		10			15			25	
Kick Ball		15			20			30	
Ping Pong Ball		25			30			40	
Total									

Balls left in box at end of trial: _____

Weighted Distance and Accuracy Score:

If 0 ball were left in the box then score is sum of points for all 3 targets plus 5: _____

If ball remained then score is sum of points divided by the number of remaining balls: _____

Trial 2	TARGET 1			TARGET 2			TARGET 3		
	# of Balls	Multiplier	Points	# of Balls	Multiplier	Points	# of Balls	Multiplier	Points
Tennis Ball		10			15			25	
Kick Ball		15			20			30	
Ping Pong Ball		25			30			40	
Total									

Balls left in box at end of trial: _____

Weighted Distance and Accuracy Score:

If 0 ball were left in the box then score is sum of points for all 3 targets plus 5: _____

If ball remained then score is sum of points divided by the number of remaining balls: _____



Object Relocation Task

Trial 1:
 Trial Time: _____ (s)
 Total Mass: _____ (g)
 Mass to Time Ratio: _____ (g/s)

Trial 2:
 Trial Time: _____ (s)
 Total Mass: _____ (g)
 Mass to Time Ratio: _____ (g/s)

Dexterity Task (high school only)

Trial 1:
 Bolt 1 points: _____ Total Points (P): _____
 Bolt 2 points: _____ Trial Time (T): _____
 Bolt 3 points: _____ P/T Ratio: _____ (pts/s)

Trial 2:
 Bolt 1 points: _____ Total Points (P): _____
 Bolt 2 points: _____ Trial Time (T): _____
 Bolt 3 points: _____ P/T Ratio: _____ (pts/s)

Points for Scoring Zones:

- 50 for each nut placed on a bolt
- 55 for each nut placed past the .5 cm mark
- 60 for each nut placed past the 1 cm mark
- 65 for each nut placed past the 1.5 cm mark
- 70 for each nut placed past the 2 cm mark
- 75 for each nut placed past the 2.5 cm mark

Lead Judge: _____

Signature confirms that scores have been accurately recorded by judges



TECHNICAL PAPER SCORING CRITERIA

2012-2013 MESA USA National Engineering Design Competition – Prosthetic Arm Challenge

TEAM:

SCHOOL:

LEVEL: MS or HS

Discussion a-Physical Phenomena, b-Experiment Procedures, c-Data & Analysis, d-Tables & Charts e-Results	Abstract a-Length b-Purpose & Key Features c-Conclusions & Rec. d-Non-technical e-Informative & Interesting	Introduction a-Purpose b-Scope c-Background Information	Conclusion & Recommendations a-Inferences & Evidence b-Further Work & Reasoning	Written Presentation a-Length b-Font c-Spacing d-Key Sections e-Supporting Sections f-Grammar,Spelling, etc.
Level 4 - 4 points each a. Very thorough discussion of Physics, Math and/or Engineering concepts, including advance concepts if used. b. Very complete description of experimental/testing procedures including diagrams or pictures c. Thorough description of data analysis, any subsequent calculations performed or other operations to explore the data. d. Highly relevant tables, graphs, charts, etc. e. Very clear explanation of results w/graphics	Level 4 - 4 points each a. Length: 200-250 words b. Very clearly restates Purpose & Key Features of report c. Very clearly restates Conclusions and Recommendations of report d. Written very clearly in non-technical terms e. Engages and informs the reader	Level 4 - 4 points each a. Purpose: Very clearly states why project undertaken AND why report developed b. Scope: A very thorough description of parameters, methods, limiting factors & technical terms c. Background: Share key facts, conditions, events prior to project AND previous work on this topic	Level 4 – 4 points each a. Conclusion: Inferences follow very logically from discussion evidence No new material included b. Recommendations: Further work/best solution well identified Written in first person w/ active verbs	Level 4 - 4 points each a. Length: 5-15 pages, cover, title page and appendices not included, 1” margins b. Font: 12, Times New Roman c. Spacing: double spaced d. All Key Sections included: Title page, Abstract, Contents, Introduction, Discussion, Conclusion, Recommendations e. All Supporting Sections included: References, Acknowledgments, Appendix f. Proper grammar, spelling and sentence structure used throughout the paper.
Level 3 - 3 points each a. Effective discussion of key concepts, including advanced concepts if used. b. Effective description of procedures including diagrams or pictures c. Good description of data analysis d. Tables, graphs, charts, etc. useful to report e. Good explanation of results w/graphics	Level 3 - 3 points each a. Length: 150-199 or 251-300 words b. Good restatement of Purpose/Key Features c. Good restatement of Conclusions & Recommendations d. Well written, but includes some technical terms e. Modestly engages and informs reader	Level 3 – 3 points each a. Effective/complete statement of purpose b. Effective statement of scope, 1 or 2 items appear missing or overlooked c. Effective and complete background details, 1 or 2 items appear missing or overlooked	Level 3 – 3 points each a. Conclusion: Inferences follow loosely from discussion evidence No new material included b. Recommendations: Further work/best solution not well identified	Level 3 - 3 points each a. Length: 5-15 pages, 1” margins b. Font: Some inconsistency throughout c. Spacing: Some inconsistency throughout d. 1 Key Section not identified or missing e. 1 Supporting Section not identified or missing f. Some errors in grammar, spelling, etc.
Level 2 - 2 points each a. Limited discussion of key concepts, including advanced concepts if used. b. Limited description of procedures, with few diagrams or pictures c. Data analysis poorly described or not used d. Graphics not well used to support report e. Very little discussion of results, no graphics	Level 2 - 2 points each a. Length: 100-149 or 301-350 words b. Poor restatement of Purpose or Key Features c. Poor restatement of Conclusion or Recommendations d. Many technical terms e. Uninteresting to reader	Level 2 – 2 points each a. Incomplete statement of purpose for project and report b. Incomplete statement of scope, multiple items missing or overlooked c. Limited background information included	Level 2 – 2 points each a. Conclusion: Inferences follow poorly from discussion, evidence not clear Some new material included b. Recommendations: Further work/best solution not well identified	Level 2 - 2 points each a. Length: <5 or >15 pages, >1” margins b. Font: very inconsistent throughout c. Spacing: very inconsistent throughout d. 2-3 Key Sections not identified or missing e. 2 Supporting Sections not identified or missing f. Several errors in grammar, spelling, etc.
Level 1 - 1 point each a. Little or no discussion of key concepts, including advanced concepts if used. b. Little or no description procedures c. Data analysis not included d. Graphics do not support report e. No discussion of finding/results	Level 1 - 1 point each a. Length: <100 or >350 words b. Purpose or Key Features not included c. Conclusion or Recommendations not included d. Unclear to the reader e. Does not engage reader	Level 1 – 1 point each a. Very poor or no statement of purpose for project b. Very poor or no statement of scope, very little information included c. Very poor or no background provided, very little or no information provided	Level 1 – 1 point each a. Conclusion: Inferences do not follow from discussion or evidence present new material included b. Recommendations: Further work/best solution not identified	Level 1 - 1 point each a. Length: <5 or >15 pages, >1” margins b. Font: incorrect throughout or not typed c. Spacing: incorrect throughout d. Most Key Sections missing e. Most Supporting Sections missing f. Poor attention to grammar, spelling, etc
Points Score $/20 \times 40 =$	Points Score $/20 \times 20 =$	Points Score $/12 \times 15 =$	Points Score $/8 \times 15 =$	Points Score $/24 \times 10 =$
Judge			Total	
Judge Feedback:				



ORAL PRESENTATION SCORING CRITERIA

2012-2013 MESA USA National Engineering Design Competition – Prosthetic Arm Challenge

TEAM:

SCHOOL:

LEVEL: MS or HS

Technical Content a-Physical Phenomena b-Process & Procedures c-Data and Explanations d-Observations e-Conclusions	Overall Presentation a-Introduction b-Topic c-Flow d-Content e-Engagement of the Audience	Oral & Visual Performance a-Student Voice b-Presence c-Eye Contact d-Collaboration e-Visual Material	Question Responses a-Accurate & Specific b-Depth of Knowledge
Level 4 - 4 points each a. Several examples of physical phenomena of topic well explained & understood, including advanced concepts if used b. Process & Procedures of development well described c. Data explanations very clear and tied to topic d. Observations follow direct from experiments, testing or research e. Conclusions well thought out and accurate	Level 4 - 4 points each a. Creative introduction of team members & responsibilities b. Very clear description of presentation topic c. Flow – moved very smoothly from point-to-point d. Content – stayed very focused on the topic e. Unique activities & discussion captured and maintained audience & judge attention very well	Level 4 - 4 points each a. ALL voices heard and understood throughout room b. Student demeanor & appearance well suited for event c. Eye contact is distributed throughout room d. ALL student share equally in presentation e. ALL visual aids contribute audience understanding	Level 4 - 4 points each a. ALL questions answered specifically and accurately b. ALL responses show thorough knowledge of project
Level 3 - 3 points each a. Some examples of physical phenomena of topic explained & understood, including advanced concepts if used b. Some of the design process well described c. Data presented/explained well, not related to topic d. Observations follow from experiences, but not clearly from experiments, testing or research e. Conclusions lack detail or include a misconception	Level 3 - 3 points each a. Includes a prepared introduction of team members b. Includes effective topic introduction c. Flow – 1 or 2 poor transitions between points d. Content – strays little from topic unnecessarily e. Activities and discussion engage audience & judges	Level 3 - 3 points each a. Few situations with poor voice projection b. 1 or 2 lapses in student demeanor & appearance c. Few situations of poor use of eye contact d. Some lapses in student collaboration & teamwork e. Most visual aids contribute effectively	Level 3 – 3 points each a. 1 or 2 responses inaccurate or lack detail b. Some responses lack thorough knowledge of project
Level 2 - 2 points each a. Very few examples of physical phenomena of topic, including advanced concepts if used b. Very little of design process described c. Unclear data, poorly explained, not related to topic d. Observations do not follow from experiences, limited evidence of experiments, testing or research e. Conclusions unrelated to technical content or includes misconception	Level 2 - 2 points each a. Team introduction poorly done b. Presentation topic not clearly stated c. Flow – several poor transitions between points d. Content – strays unnecessarily from topic repeatedly e. Some activities do not engage audience & judges	Level 2 - 2 points each a. Repeated lapses in voice projection b. Student demeanor & appearance questionable for event c. Quality eye contact sporadic or not used by all members d. One student dominant or excluded from presentation e. Visual aids unclear or cannot be clearly seen by audience	Level 2 – 2 points each a. 3-4 responses inaccurate or lack detail b. Knowledge of all project elements limited
Level 1 - 1 point each a. No discussion of physical phenomena related to topic, including advanced concepts if used b. No discussion of design process c. No data collection or analysis presented d. No Observations made, or do not follow from activities e. No conclusions or recommendations provided	Level 1 - 1 point each a. Lacks team introduction b. Lacks description of presentation topic c. Flow – erratic, no clear point-to-point discussion d. Content – strays from specific topic e. Does not capture audience/judge attention	Level 1 - 1 point each a. Voices very difficult to hear and understand b. Appearance not appropriate for presentation c. Very poor eye contact, focused on one person or none d. Presentation dominated by one student e. Visual material very difficult to see and understand	Level 1 – 1 point each a. Fails to answer questions or ask for clarification b. Students unprepared to respond to questions
Points Score $/20 \times 40 =$	Points Score $/20 \times 30 =$	Points Score $/20 \times 20 =$	Points Score $/8 \times 10 =$
Judge	Attire 5 point deduction MESA USA event shirts required	Time 5 point deduction for over time limit	Total

Sample Questions

- What do you think would happen if ...?
- Describe a situation when you resolved a design problem.
- Please elaborate on your description or explanation of...?
- What were the most difficult parts of the paper, performance tasks or academic display? And why?

Judge Feedback:



**2012-2013 MESA USA
National Engineering Design Competition
Prosthetic Arm Challenge
Resource Materials
Judging Guidelines**

Overview

The Prosthetic Arm Challenge competition involves the following performance components with their maximum points in parentheses: Technical Paper (100 pts.), Academic Display (100 pts.), Oral Presentation (100 pts.), Device Performance (150 pts) and Design Efficiency (50 pts). The purpose of these guidelines is to outline the procedures for effectively judging this competition.

Preliminary Assignment

All judges need to read and become familiar with all rules, judging guidelines, and scoring criteria regarding their assignment.

Judging the Technical Paper

1. Read each paper without using the scoring criteria.
2. Using the scoring criteria, revisit each paper and assign a score to each paper.
3. Submit a score sheet for each paper to the lead judge.

Judging the Academic Display

1. View each Academic Display without using the scoring criteria.
2. Using the scoring criteria, revisit each display and assign a score to each display.
3. Submit a score sheet for each display to the lead judge.

Judging the Oral Presentation

1. Judges will assemble all competing students in the room. The rules and judging criteria will be read. Teams will be allowed to ask any questions pertaining to the competition at this time.
2. Judges will excuse all teams from the room.
3. Audience members may attend at the team's discretion.
4. Judges will review rules for audience with all observers. Opposing teams are not allowed to participate as audience members.
5. Once the presentation begins, no one will be allowed to enter or leave the room until the presentation is complete. Audience members are not allowed to disrupt or aid the team (e.g. talking, gesturing, etc.). Any non-complying audience members may be asked to leave.
6. Judges will provide time signals for students at 3 minutes, 1 minute, 30 seconds, and 5 seconds before time is called.
7. Judges will have five minutes to ask questions of the team. To the furthest extent possible, the judges should ask questions that are specific to the team. This includes their technical paper, academic display, oral presentation, and/or device.
8. Using the scoring criteria, assign a score to each presentation.
9. Submit a score sheet for each presentation to the lead judge.

Judging the Device Performance

The device performance is the most valued component of the competition (150 points maximum). In addition to the rules, the judge must be aware of the equipment and area specifics, what specifically is being judged, and how to assign a score to each task.



2012-2013 MESA USA
National Engineering Design Competition
Prosthetic Arm Challenge
Itemized Budget Sheet

Itemized Budget Sheet

MESA Center: _____

MESA School: _____

Level: MS HS

Advisor/Teacher: _____

Student Team: _____

Part	Unit Dimensions	Retail Price	Price per Unit	Quantity Used	Total Cost	Retail Source
<i>6061 Aluminum flat (example)</i>	<i>1/8" x 1/2" x 24"</i>	<i>\$1.98/flat</i>	<i>\$0.0825/inch</i>	<i>10 inches</i>	<i>\$.0.82</i>	<i>Metalsdepot.com</i>
<i>Masking Tape (example)</i>	<i>1 inch x 60 yards</i>	<i>\$4.02</i>	<i>\$0.0019/inch</i>	<i>12 inches</i>	<i>\$0.02</i>	<i>TheSupplyTree.com</i>

Part	Unit Dimensions	Retail Price	Price per Unit	Quantity Used	Total Cost	Retail Source
TOTAL COST						



**2012-2013 MESA USA
National Engineering Design Competition
Prosthetic Arm Challenge
Budget Documentation Examples**

The follows are samples of the types of documentation that would be acceptable to attach to your itemized budget sheet.

Printed Store Receipt

ACME HARDWARE
88 MAIN STREET
ANYTOWN, ST 12345-67890
123-555-6789

TAX NO - 987654-321

CUSTOMER - CASH SALE

ORDER - 000456
DATE - 2010-08-07

DESC - SKU
=====

ITEM - 12345	2 @ 12.34 = 24.68
SECOND - 98765	2 @ 15.00 = 30.00
THIRD - 44887744	2 @ 5.00 = 10.00
=====	
	SUBTOTAL = 64.68
	TAX 10% = 6.47
	TOTAL = 71.15

PAYMENT - MASTERCARD
TRANS - 0678453
REGISTER - 22
EMPLOYEE - 456

THANKYOU FOR SHOPPING AT
ACME

Printed page from National Retailer Website

1/15/12 1 x 12 x 8 #2 Whitewood Pine Board 545-458538 at The Home Depot

More images More about

Share Email Print

1 x 12 x 8 #2 Whitewood Pine Board S4S
Model # 458538 Store SKU # 458538
★★★★★ Write The First Review
\$15.55 /EA-Each

Zoom More Views

Product Description Specifications Customer Reviews More Info Shipping Options

PRODUCT DESCRIPTION

Every piece meets the highest grading standards for strength and appearance. This lumber is for a wide range of uses from framing of houses to basic interior finishing applications. Boards can also be used for carpentry, hobbies, furniture, shelving, and general finish work. The wood has straight grain and has uniform texture. It has low shrinkage and is worked very easily by hand and machine tools. The product is easy to glue and has good nailing and screw holding properties. The paint retention properties are good and it is easily treated with preservatives.

- Each piece of this lumber meets the highest quality grading standards for strength and appearance
- Boards can also be used for carpentry, hobbies, furniture, shelving, and general finish work
- This lumber can be primed and painted or stained
- Interior or exterior use
- Note: Product may vary by store.
- MFG Model #: 458538
- MFG Part #: 458538

Return To Top

SPECIFICATIONS

Actual product thickness (in.)	0.75	Actual product width (in.)	11.25
Assembled Depth (in.)	96 in	Assembled Height (in.)	.75 in
Assembled Width (in.)	11.25 in	Item Package Type	Bag
Manufacturer Warranty	n/a	Nominal Length	8 in
Nominal Product H x W (in.)	1x12	Nominal Product Height (in.)	1
Nominal Product Length (ft.)	8	Nominal Width	12 in
Nominal product width	12	Portion of product made	

homedepot.com/Lumber-Composites-Boards/r_d1/N-5yc1vzbqmc/R-100922337/r_d2/ProductDisplay?...

1/2



Device Inspection and Impound (teams called according to drawn competition order)

Measurement Equipment:

- Device Mass: Postal Scale (≥ 5 pounds/ 2.2 kg)
- Object Relocation Task - Postal Scale (≥ 50 pounds/ 22 kg)
- Meter sticks
- Stop Watches

Station 1 - Sign-in, take photo of team with device and sign with school name for visual record

Station 2 - Review device operation to ensure it meets specifications.

Station 3 - Inspect and Record characteristics materials to be used in the tasks:

1. Verify device is a trans-radial (below the elbow) prosthetic.....Y / N
2. Verify device does not use opposite forearm/hand to operate deviceY / N
3. Verify device does not have a mass more than 3 kgY / N
4. Verify that device incorporates a hand mechanism with at least two “fingers”Y / N
5. Verify that the hand mechanism opens to at least 10 cmY / N
6. Have team demonstrate that they have immobilized the wrist, hand and fingersY / N
7. Review itemized budget with references and documentationY / N
8. Verify that device did not exceed the \$40 pre-tax price limitY / N
9. Record device mass (including all parts of all configurations):_____kg

Station 4 - Impound device and all materials...guide students to student seating area.

Competition Management (teams called according to drawn competition order)

Team In-the-hole

Team moves from the student seating area and gathers device from impound area.

Team On-deck

Team moves from impound area to On-Deck area and prepares device for next task.

Team Up

Team moves from On-Deck area to the task area and prepares device for task.

1. Judge – DIRECTS team to prepare device for task. (timed)
2. Students – PREPARE device for operation indicate “ready-to-operate” status and WAIT.
3. Judge – ACKNOWLEDGES team “ready status”.
4. Judge – VERIFIES equipment setup
5. Judge – PREPARE timers
6. Judge – STARTS trial...
7. Judge – MARKS and RECORDS the following:
 - a. Violations, as needed
 - b. Distance and Accuracy Task
 - Which kind and how many balls successfully thrown
 - Balls remaining in box
 - c. Object Relocation Task
 - Total Time (xx.xxx seconds) OR Start/Stop Times on recoding equipment
 - Final Mass (xx.xxx grams)
 - d. Dexterity Task
 - Total Time (xx.xxx seconds) OR Start/Stop Times on recoding equipment
 - Scores for each bolt
 - e. Control Task
 - Total Time (xx.xxx seconds) OR Start/Stop Times on recoding equipment
 - Cups not re-stacked
 - Cups damaged
 - f. Performance and Rule Violation Comments



**2012-2013 MESA USA
National Engineering Design Competition
Prosthetic Arm Challenge
Resource Materials
Judging Guidelines**

Using the Scoring Criteria

MESA USA recognizes that evaluation of student work can be very subjective. The scoring criteria provided with event materials are intended to guide evaluation and provide a more consistent method for assigning scores to student work. The effective evaluation of their work is important to providing effective feedback for them as they continue their education and postsecondary careers.

Each Scoring Criteria sheet has been arranged as follows (see sample below):

1. Divided into columns – representing key topics of evaluation.
2. Each column or topic title also lists sub-topics for scoring.
3. Within each column, four (4) performance levels are shown.
4. Within each performance level items a-f provide descriptions of varying levels of performance.

Recommended strategy for assigning scores to an evaluation:

1. Review the topic (column) and sub-topics (a-f) within each.
2. Highlight the scoring level description you feel the team has achieved for each sub-topic a-e.
NOTE: Each sub-topic a-e should only be highlighted once per topic (column)
3. Repeat this for each topic to complete
4. Each highlighted description earns the assigned points for that scoring level.
5. Use automated scoring or complete included formulas, add all the scores, including deductions, and enter the total score.
6. Written feedback is strongly encouraged. Provide constructive feedback on the strengths and weaknesses of particular topics or sub-topics.

MESA		TECHNICAL PAPER SCORING CRITERIA				LEVEL: MS or HS
2009-2010 MESA USA National Engineering Design Competition		2009-2010 MESA USA National Engineering Design Competition				LEVEL: MS or HS
TEAM:		SCHOOL:				LEVEL: MS or HS
Discussion	Abstract	Introduction	Conclusion & Recommendations	Written Presentation		
<p>Level 4 - 4 points each</p> <p>a. Very thorough discussion of Physics, Math and/or Engineering concepts including advanced concepts if used.</p> <p>b. Very complete description of experimental/procedure procedures including diagrams or pictures.</p> <p>c. Thorough description of analysis tools used.</p> <p>d. Highly relevant tables, graphs, charts, etc.</p> <p>e. Very clear explanation of results with graphs.</p>	<p>Level 4 - 4 points each</p> <p>a. Length: 200-250 words</p> <p>b. Very clearly states Purpose & Key Features of report</p> <p>c. Very clearly states Conclusion and Recommendations of report</p> <p>d. Written very clearly in non-technical terms</p> <p>e. Engage and inform the reader</p>	<p>Level 4 - 4 points each</p> <p>a. Purpose: Very clearly states why project undertaken AND why report developed</p> <p>b. Scope: A very thorough description of parameters, methods, testing factors & technical terms</p> <p>c. Background: Clear key facts, conditions, events prior to project AND previous work on the topic</p>	<p>Level 4 - 4 points each</p> <p>a. Conclusion: Influence follow very logically from discussion evidence</p> <p>b. No new material included</p> <p>c. Recommendations: Further worksheet solution well identified</p> <p>d. Writes in first person of active verbs</p>	<p>Level 4 - 4 points each</p> <p>a. Length: 5-15 pages cover all topic and included</p> <p>b. Font: 12, Times New Roman</p> <p>c. Spacing: double spaced</p> <p>d. All Key Sections included: Title page, Abstract, Conclusion, Introduction, Discussion, Conclusion, Recommendations</p> <p>e. All Supporting Sections included: References, Acknowledgments, Appendix</p> <p>f. Proper grammar, spelling and sentence structure used throughout the paper.</p>		
<p>Level 3 - 3 points each</p> <p>a. Effective discussion of key concepts including advanced concepts if used.</p> <p>b. Effective description of procedure including diagrams or pictures</p> <p>c. Good description of analysis tools</p> <p>d. Tables, graphs, charts, etc. used to report</p> <p>e. Good explanation of results supported</p>	<p>Level 3 - 3 points each</p> <p>a. Length: 150-199 or 201-250 words</p> <p>b. Good statement of Purpose/Key Features</p> <p>c. Good statement of Conclusion & Recommendations</p> <p>d. Well written, but includes some technical terms</p> <p>e. Modestly engage and inform reader</p>	<p>Level 3 - 3 points each</p> <p>a. Effective/complete statement of purpose</p> <p>b. Effective statement of scope, 1 or 2 items agree missing or overlooked</p> <p>c. Effective and complete background details, 1 or 2 items agree missing or overlooked</p>	<p>Level 3 - 3 points each</p> <p>a. Conclusion: Influence follow loosely from discussion evidence</p> <p>b. No new material included</p> <p>c. Recommendations: Further worksheet solution not well identified</p>	<p>Level 3 - 3 points each</p> <p>a. Length: Slightly over or under length</p> <p>b. Font: Some inconsistency throughout</p> <p>c. Spacing: Some inconsistency throughout</p> <p>d. 1 Key Section not identified or missing</p> <p>e. 1 Supporting Section not identified or missing</p> <p>f. Some errors in grammar, spelling, etc.</p>		
<p>Level 2 - 2 points each</p> <p>a. Limited discussion of key concepts, including advanced concepts if used.</p> <p>b. Limited description of procedure, with few diagrams or pictures</p> <p>c. Analysis tools poorly described or not used</p> <p>d. Displace not well used to support report</p> <p>e. Very little discussion of results, no graphs</p>	<p>Level 2 - 2 points each</p> <p>a. Length: 100-149 or 151-199 words</p> <p>b. Four statement of Purpose or Key Features</p> <p>c. Four statement of Conclusion or Recommendations</p> <p>d. Many technical terms</p> <p>e. Uninteresting to reader</p>	<p>Level 2 - 2 points each</p> <p>a. Incomplete statement of purpose for project and report</p> <p>b. Incomplete statement of scope, multiple items missing or overlooked</p> <p>c. Limited background information included</p>	<p>Level 2 - 2 points each</p> <p>a. Conclusion: Influence follow poorly from discussion, evidence not clear</p> <p>b. Some new material included</p> <p>c. Recommendations: Further worksheet solution not well identified</p>	<p>Level 2 - 2 points each</p> <p>a. Length: Not identifying</p> <p>b. Font: very inconsistent throughout</p> <p>c. Spacing: very inconsistent throughout</p> <p>d. 2-3 Key Sections not identified or missing</p> <p>e. 2 Supporting Sections not identified or missing</p> <p>f. Several errors in grammar, spelling, etc.</p>		
<p>Level 1 - 1 point each</p> <p>a. Little or no discussion of key concepts, including advanced concepts if used.</p> <p>b. Little or no description procedures</p> <p>c. Data analysis not included</p> <p>d. Displace do not support report</p> <p>e. No discussion of findings/results</p>	<p>Level 1 - 1 point each</p> <p>a. Length: <100 or >250 words</p> <p>b. Purpose or Key Features not included</p> <p>c. Conclusion or Recommendations not included</p> <p>d. Dislike to the reader</p> <p>e. Does not engage reader</p>	<p>Level 1 - 1 point each</p> <p>a. Very poor or no statement of purpose for project</p> <p>b. Very poor or no statement of scope, very little information included</p> <p>c. Very poor or no background provided, very little or no information provided</p>	<p>Level 1 - 1 point each</p> <p>a. Conclusion: Influence do not follow from discussion or evidence present</p> <p>b. New material included</p> <p>c. Recommendations: Further worksheet solution not identified</p>	<p>Level 1 - 1 point each</p> <p>a. Length: <5 page or >15 page</p> <p>b. Font: incorrect throughout or not typed</p> <p>c. Spacing: incorrect throughout</p> <p>d. Most Key Sections missing</p> <p>e. Most Supporting Sections missing</p> <p>f. Poor attention to grammar, spelling, etc.</p>		
Points	Points	Points	Points	Points	Points	
16/20 x 40 = 32	/20 x 20 =	/12 x 15 =	/8 x 15 =	/24 x 10 =		
Judge			Total			
Judge Feedback:						

SAMPLE SCORE (Technical Paper – Discussion, shown above)

- a. Physical Phenomena earns 3 points
- b. Experimental Procedures earns 4 points
- c. Data and Analysis earns 2 points
- d. Tables and Charts earns 4 points
- e. Results earns 3 points

<p>DISCUSSION SCORE</p> <p>16 pts / 20 max pts x 40 topic pts</p> <p>= 32</p>
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**2012-2013 MESA USA
National Engineering Design Competition
Prosthetic Arm Challenge
Resource Materials
Event Management & Scheduling**

Judging Requirements and Assignments

In order to properly and consistently judge all components of the competition, the following judging team should be utilized. Please refer to “Judging Guidelines” for additional details.

Lead Judge Responsibilities:

Oversee all components of the competition and provide final rulings on event related issues.

Judges Needed:

Component & Responsibilities	Middle School ²	High School ²
Technical Paper	3	3
Academic Display	3	3
Oral Presentation ¹	3	3
Performance Testing and Impound ³	6 or 7	

¹ Oral presentation judges are encouraged to participate in technical paper and academic display judging

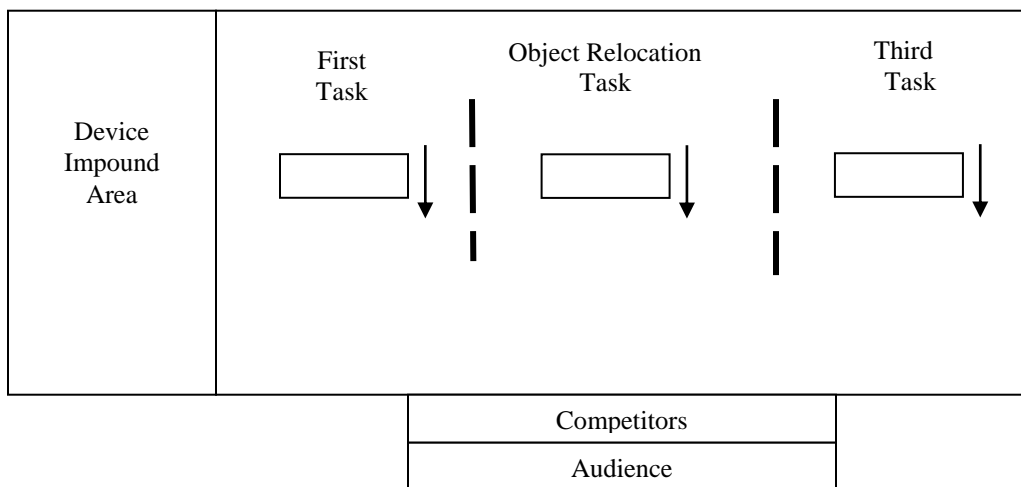
² Judges should be assigned to either Middle or High School level only

³ Performance Judges must complete the device inspection checks and measurements as well as monitor any potential changes in configuration which may provide an unfair energy advantage during the competition.

Event Area Set-Up

The host center will be responsible for the set-up of the device performance test area. Please refer to the test area illustration for specific requirements. The ideal venue for testing is a school gym or similar facility with a smooth, even floor. The following items should be considered when arranging the event area:

- Space – Leave plenty of space between tables, to facilitate foot traffic between them. Also, allow plenty of work or task space in front of the tables
- Audience and Competitor viewing





**2012-2013 MESA USA
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Resource Materials
Event Management & Scheduling**

Performance Task Management

All participating teams will be seated in an area separate from the general audience. Under the direction of the lead judge, only one team will be allowed in the testing area at any one time. Team members will be escorted by judges to each of the respective testing areas. The judges and host center staff must ensure that the test area is not disturbed once it is configured.

Based on a pre-determined order, teams will be summoned to the test area in the following order and will be repeated until all tasks are completed:

- 1) Team Up
- 2) Team On-Deck
- 3) Team In-the-hole

Safety

It is recommended that all team members wear safety goggles during all phases of device performance testing.

Automated Event Scoring

The 2012-2013 MESA USA Prosthetic Arm Challenge Committee has prepared a Microsoft Excel based scoring tool to simplify the judging portion of the event. All states, regions, centers and teacher/advisors are encouraged to utilize this tool to streamline scoring and event management. The file may be requested by emailing the rules committee at leon@arizona.edu.

National Competition Awards Categories

The following awards will be presented at the National Competition.

MESA USA Overall Winners

Highest combined score in Device Performance, Academic Display, Technical Paper & Oral Presentation

Component Winners

Device Performance

- First Task: 1st, 2nd, & 3rd Place
- Object Relocation Task: 1st, 2nd, & 3rd Place
- Third Task (HS only): 1st, 2nd, & 3rd Place
- Design Efficiency: 1st, 2nd, & 3rd Place

Academic Display: 1st, 2nd, & 3rd Place

Technical Paper: 1st, 2nd, & 3rd Place

Oral Presentation: 1st, 2nd, & 3rd Place

Award Notes:

Medals or ribbons will be awarded to members in the overall category and individual categories.



Reference Format:

Citing Sources in Technical Writing

If you use books, journals, magazines, and websites to get ideas for your research, it helps you write a better paper. You can quote other people or quote the research that someone else did, and it will support your ideas and theories. When you use another person's idea, words, or research, you need to cite the source.

For every book, website, conversation, interview, article, etc. that you read, listen to, or look at, you need to write down the following information:

- The **author** of the information (who wrote or spoke the material?)
- The **title** of the text, website, or article
- The **date** that the material was first published (for a conversation or interview, use the date that the discussion occurred; for a website, record the date you accessed the website--the date you first looked at the page)
- For journal and magazine articles, the **title of periodical and position** in a series (e.g. *Journal Name, Volume 5, Issue 49*) and the **pages** where the information is located
- The **publication information** (i.e. city, state, & publisher name)
- For websites, the **URL** address (e.g. <http://www.google.com>)

If you're reading an article or a small piece that's part of a bigger book, then you also need:

- The **title of the larger collection** (if you're reading an encyclopedia article, then this means the name of the encyclopedia)
- The **editor** of the larger collection (someone that collected all the articles together, whether or not they wrote anything themselves)

At the end of your paper, you will need a **Reference** page. This page will include entries for all the sources that you used while writing your research paper. For papers in the field of Engineering, researchers often use a citation style developed by the American Psychological Association (APA). This style permits others who read your paper to find the original sources you used--websites, articles, books, etc.--and experience the original document. It includes all the information someone would need to find your source and it organizes the information in a style so that you don't need headings such as "Title," "Author," or "Date of Publication," because it is obvious from the order in which you present these things.

In APA style, books are cited this way:

An article in a periodical (e.g. a journal, magazine, or newspaper):

Style	Author, A. A., Author, B. B., & Author, C. C. (Date of Publication). Title of article. <i>Title of Periodical, volume number, pages.</i>
Example	Maldonado, J., & Bierly, H. (2002, August 20). Vehicle test trials across the country. <i>Scientific American, 159, 28-31.</i>

A non-periodical (e.g. book, report, brochure, or audiovisual media):

Style	Author, A. A. (Year of publication). <i>Title of work</i> . Location: Publisher.
Example	McNaughton, J. (2000). <i>Engineering Realities and Possibilities</i> . Chicago: University of Chicago Press.

An article in an internet periodical:

Style	Author, A. A., & Author, B. B. (Date of publication). Title of article. <i>Title of journal, volume number</i> (issue number if available). Retrieved month day, year, from http://web address .
Example	Estrada, S. & Williams, C. (2003, June 23). Perceiving the future of technology. <i>Engineering Today</i> , 15 (3). Retrieved June 28, 2003 from http://www.engtoday.org/15.3.html .

A motion picture or video tape:

Style	Producer, P. P. (Producer), & Director, D.D. (Director). (Date of publication). <i>Title of motion picture</i> [Motion picture]. Country of origin: Studio or distributor.
Example	Chavez, A. (Producer), & Walele, J. (Director). (1998). <i>Women Pioneers in Science</i> . [Motion Picture]. U.S.: Educational Films Inc.

Further Information

For more information about APA style, consult the *Publication Manual of the American Psychological Association* (5th edition) which can be found in most libraries. Also, consider looking at these web resources:

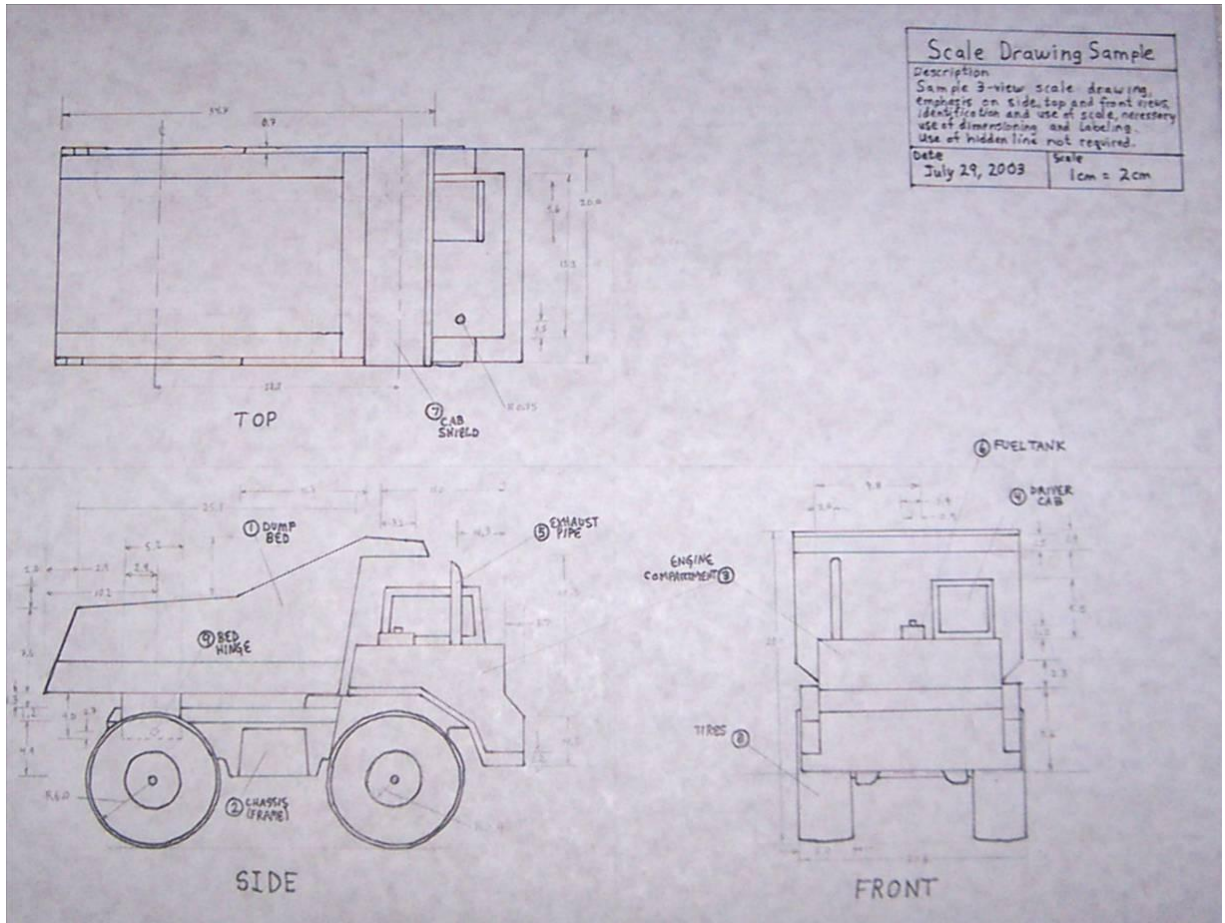
The APA style website
<http://www.apastyle.org>

The Online Writing Lab (OWL) at Purdue University
http://owl.english.purdue.edu/handouts/research/r_apa.html



2012-2013 MESA USA
National Engineering Design Competition
Prosthetic Arm Challenge
Resource Materials
Scale Drawing Sample

← Width – 17” – →



↑ Height – 11” ↓



2012-2013 MESA USA
National Engineering Design Competition
Prosthetic Arm Challenge
Resource Materials
Activity Feedback Form

Thank you for taking the time to give the MESA USA Event Committee feedback! Please email comments to your state representative (see list below).

We are very interested in all elements of this event. Please encourage students, teachers/advisors, judges and staff members to share positive experiences and constructive criticism. Please include ideas related to some or all of the following areas:

- Overall Difficulty
- Performance Tasks
- Rules
- Judging
- Scoring
- Other _____

Please identify the general area and provide detailed comments. Please feel free to include any photos or video from your respective activity.

Arizona.....	Manny Leon.....	leon@arizona.edu
California	Ben Louie.....	blouie@usc.edu
Colorado.....	Richard Weir.....	richard.weir@ucdenver.edu
Maryland.....	Tom Milnes.....	thomas.milnes@jhupl.edu
New Mexico.....	Anita Gonzales.....	anita@nm mesa.org
Oregon	Tamara DePue	tdepue@cecs.pdx.edu
Pennsylvania	Jamie Bracey.....	jamie.bracey@temple.edu
Utah.....	Jeffrey Ojeda.....	jeffrey.ojeda@schools.utah.gov
Washington	Leon Haskins	haskinlj@plu.edu