



# MESA USA NATIONAL ENGINEERING DESIGN COMPETITION

2014-2015

## Prosthetic Arm Challenge

### CALIFORNIA ADDENDUM

With the exception of the following, all the specifications in the document will be followed.

**Construction:** Teams WILL consider the cost of shipment of device to the local, regional, state and national events. Teams MUST design their device to be disassembled for shipment in a large suitcase(s).

**Project Labeling** – Prosthetic Arm Challenge device, the Itemized Budget Sheet, the Technical Paper and the Academic Poster Presentation Display must be clearly labeled with student(s)' names, school and MESA Center.

- A 25 point penalty will deducted from total score of specific component if it is not properly labeled. If the Itemized Budget Sheet is not properly labeled, 25 points will be deducted from either the device performance or technical paper.

All other testing rules will still apply.

All three components – the Device Performance, Technical Paper and Academic Poster Presentation – are required for the State Championship. However, contact your local MESA Center for requirements for local and regional events.

To preserve the integrity and the spirit of the competition, judges of the performance device, technical paper and academic poster presentation display of the Prosthetic Arm Challenge may ask questions of any student team competitors pertaining to the building of their device or drafting of their technical paper or drafting of their poster presentation display to validate the authenticity of their work. Failure to validate the work turned in may result in zero points for the device performance or zero points for the technical paper or zero points for the poster display.



**MESA USA  
NATIONAL ENGINEERING DESIGN COMPETITION  
2014-2015**

**Prosthetic Arm Challenge**

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**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.

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**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  
2014-2015**



**Competition Overview**

MESA USA presents the engineering design competition specifications for the 2014-2015 year. The Prosthetic Arm Challenge involves the development of a low-cost prosthetic device to complete a set of pre-defined tasks. High school and middle school teams selected to participate at the national event will compete in the three components below:

- 1) **Performance** – Teams will research, design, build, test and compete using a trans-radial prosthesis designed to complete the following tasks:
  - a) Distance Accuracy Task: greatest distance and accuracy achieved by throwing bean bags into the *Target Zone* in the fastest time.
  - b) Object Relocation Task: fastest time achieved by placing all objects into and removing all objects from the specified container.
  - c) Dexterity Task: greatest number of bolts and nuts correctly placed and secured onto the testing device in the fastest time.
  - 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 which examines all aspects of their design process, all major design choices and related STEM concepts.
- 3) **Academic Poster Presentation** - Teams will present academic posters to a panel of judges and will then respond to judges’ questions. The posters should include items such as data (e.g., charts, tables and graphs), photographs, drawings, other ideas, and any necessary written explanations which help to explain their final design’s features and quality.

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 in **June 2015** hosted by Utah 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 Poster Presentation .....	150 points
<b>Total Points .....</b>	<b>450 Points</b>



2014-2015 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 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 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 all objects into and removing all objects from the specified container. (2 trials)

#### High School

- (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 all objects into and removing all objects from the specified container. (2 trials)
- (3) Dexterity Task: greatest number of bolts and nuts correctly placed and secured onto the testing device in the fastest time. (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.
- 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.

### 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. 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.
2. Devices must be in testing condition prior to device inspection. If devices do not meet specification check, design changes will not be allowed. Only devices passing inspection will be allowed to participate in the performance tasks.
3. A completed itemized budget sheet with documentation must be submitted with the technical paper and again at inspection. Any changes to the budget occurring after the technical paper has been submitted must be highlighted. Any device that is over budget or missing complete documentation will be NOT be allowed to compete in the Device Performance.
4. 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.
5. Each device must be ready for competition when called or forfeit that trial.
6. If, during the operation of a device, it is found to violate rules those trials will be disqualified.

### 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



**2014-2015 MESA USA  
National Engineering Design Competition  
Prosthetic Arm Challenge  
Device Performance  
150 points**

**Performance General Rules**

1. Teams must design, build and operate their prosthesis.
  - A. This prosthesis must be a generalized tool and include all parts necessary to accomplish all defined tasks. No parts may be removed and no new parts may be added.
  - B. Adjustments and repairs are allowed and must be done under supervision of a judge. Repairs are allowed using **ONLY** replacement parts and materials.
2. The prosthesis must be designed as trans-radial (below-the-elbow), and must be comprised of the following components:
  - A. The terminal device, the gripping part of the prosthetic arm with the artificial fingers,
    - i. Must extend beyond the team member's own hand,
    - ii. Must include at least two artificial fingers which must open and close and may **ONLY** be operated by the actuator, and
    - iii. **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 specific objects.
  - B. The prosthetic interface, the "socket" connection between the terminal device and the body,
    - i. Must attach between the elbow and wrist and must extend at least 3 inches (7.62 cm) from the team member's wrist along the forearm.
  - C. The actuator, the part of the prosthetic arm that activates and controls the terminal device,
    - i. May **NOT** be controlled by the team member's own hand or by the opposite elbow, forearm or hand.
3. Participating team members must have their wrist, hand and fingers immobilized for the tasks to simulate an amputated arm. The team will determine their own method for immobilization and must demonstrate this for the judges during specification check and impound.
4. In the one minute preparation for each task, the team must demonstrate to the judge(s) that the terminal device can grab and release the specific objects in each task.
5. For each of the tasks, a different team member **MUST** perform each trial.
6. 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 noted in the rules for that task.
7. Devices cannot exceed the \$40 pre-tax price limit for materials.
8. Teams **MUST** submit a completed itemized budget sheet for their device and **MUST** provide documentation to support each and every price listed.
  - A. The budget must include a list of each and every part and/or material of the prosthesis and its corresponding unit dimensions, retail price, price per unit, quantity used, total cost and retail source.
  - 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 be attached to the itemized budget sheet for each and every part and material whether purchased or not. Documentation must be legible.
  - D. The cost will be based only on the actual materials used in the construction of the prosthesis; therefore, teams will need to calculate the cost per unit for their budget. For example, 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.
9. Teams that do not conform to the Performance General Rules will **NOT** be allowed to compete in the device performance, thus resulting in zero points for the device performance.
10. Once competition begins, student teams may not have contact with non-competitors, including but not limited to Advisors, other teachers, and parents. Student teams are solely responsible for interaction with judges and addressing problems with their prosthetic arms.



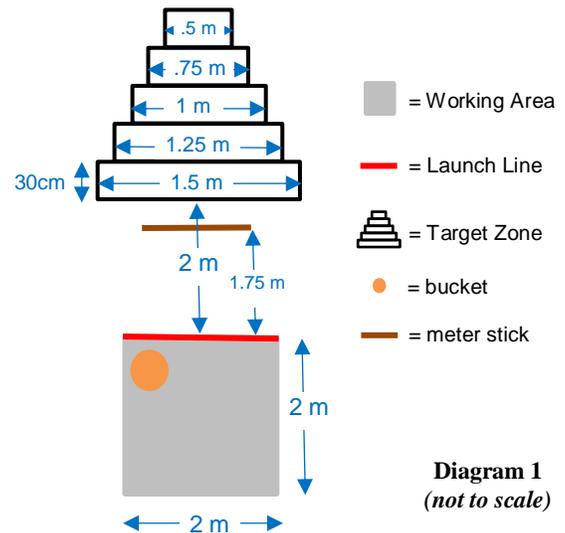
## Performance Task Details -

### 1. Distance Accuracy Task – Grab and Toss

- A. The purpose of this task is to demonstrate the prosthetic arm’s ability to:
- i. Grab an object from inside a container
  - ii. Lift object vertically
  - iii. Correctly time the release of the held object
- B. The objective of this task is to successfully throw as many bean bags into the *Target Zone* as fast as possible.

### Test Configurations and Equipment:

- C. A 2 meter square will be marked off with tape. Only the team member actively participating during the task will be permitted inside this *Working Area*.
- i. One edge will be designated the *Launch Line*. (See Diagram 1)
- D. A step pyramid will be marked off with tape and will be designated the *Target Zone*. (See Diagram 1)
- i. The base of the *Target Zone* will be centered and parallel 2 meters to the *Launch Line*.
  - ii. The *Target Zone* will be divided into 5 scoring zones with tape. Each scoring zone will be 30 cm in height. The dimensions of each scoring zone are:
    - a. Zone 1 = 1.5 m (150 cm) x 30 cm
    - b. Zone 2 = 1.25 m (125 cm) x 30 cm
    - c. Zone 3 = 1 m (100 cm) x 30 cm
    - d. Zone 4 = 0.75 m (75 cm) x 30 cm
    - e. Zone 5 = 0.5 m (50 cm) x 30 cm
- E. A meter stick (one meter) will be centered and parallel 1.75 m (175 cm) to the *Launch Line*, and will be taped to the ground.
- F. The Distance Accuracy Objects will be a total of 12 (twelve) Nylon Bean Bags.
- i. 5 inch by 5 inch (12.7 cm by 12.7 cm) nylon bean bags from [www.orientaltrading.com](http://www.orientaltrading.com) ([Reinforced Bean Bags # IN-61/4000](#)) or equivalent.
  - ii. Nylon Bean Bags will be placed inside a Home Depot’s “Homer’s All-Purpose Bucket” (Model # 05GLHD2) or equivalent.
- G. A stop watch or other type of timer will be used to record trial times.



### Task Preparation:

- H. The team will be given up to one minute to prepare, attach and demonstrate its prosthesis, to place the Nylon Bean Bags anywhere inside the bucket, and to place the bucket anywhere inside the *Working Area*. If at the end of one minute the team is not ready to perform the task, the trial will be declared a mistrial and this process will process will be repeated for the second trial.
- I. When prosthetic arm is prepared, attached and ready or at the end of one minute, the designated team member will stand outside of the *Working Area*.



**Task Details:**

- J. The judge will give the start order and begin the timer.
- K. Once the start order is given, the team member may enter the *Working Area* and will have a maximum of 1 minute (60 seconds) to grab and accurately release the bean bags into the *Target Zone*. The judge will notify the student when 30 seconds, 20 seconds and 10 seconds remain.
- L. ONLY bean bags inside the bucket may be used for tossing.
- M. The team member may hold the bucket in place with the unencumbered hand.
- N. The trial will end when any of the following occur:
  - i. The team may call the end of the trial **after and only after** 3 (three) bean bags have been accurately tossed completely inside the boundaries of the *Target Zone*. The team may signal the end of the trial by calling out “done.” The judge will immediately stop the timer and record the time elapsed as the trial time.
  - ii. One minute has passed. The judge will call out “time” and stop the team from throwing any of the remaining bean bags.
  - iii. The member has thrown all of the available bean bags. Teams that throw all bean bags without accurately tossing at least 3 (three) completely inside the boundaries of the *Target Zone* will be given the full trial time.
- O. The trial will be declared a mistrial when any of the following occur:
  - i. When a team member grabs and tosses more than one bean bag at a time; or
  - ii. When any part of the prosthetic arm or the team member’s body including hand crosses the *Launch Line* when tossing a bean bag.
- P. **At the end of the trial**, the judge will count the number of bean bags inside the boundaries of each scoring zone and record the time used to complete the task.
  - i. Bean bag **MUST** be completely inside the boundaries of the scoring zone in order to receive that score.
    - a. If any portion of the bean bag overlaps scoring zones, team will receive the lesser of scores for that bean bag.
    - b. If any portion of the bean bag is outside the boundaries of the *Target Zone*, team will receive 0 for that bean bag.
- Q. Repeat procedure for 2nd trial. The second trial must be completed by a different team member.
- R. The best performance of the two trials will be used in the scoring.

**Assigning Points to Performance:**

- 1. Scores for scoring zones:
  - a. 5 for each bean bag completely inside the boundaries of scoring zone 1
  - b. 10 for each bean bag completely inside the boundaries of scoring zone 2
  - c. 15 for each bean bag completely inside the boundaries of scoring zone 3
  - d. 20 for each bean bag completely inside the boundaries of scoring zone 4
  - e. 25 for each bean bag completely inside the boundaries of scoring zone 5
- 2. Team Distance Accuracy Score ( $D_t$ ) = greatest team score-to-time ratio (score/seconds)
  - a. Team score-to-time ratio = total score divided by the trial time
- 3. Task Winner ( $D_w$ ) = greatest score-to-time ratio (score/seconds) for any team
- 4. Task Points = Team Score ( $D_t$ ) divided by ( $D_w$ ) times maximum points, or  
 Task Points =  $D_t / D_w \times 75$  or  $D_t / D_w \times 50$

**Example**

Task Winner	Team 5	Team 5 Points
Task Winner ( $D_w$ ) = 4.8	Trial 1: 120 score /60 s = 2.0 Trial 2: 90 score /40 s = 2.25 Team Score ( $D_t$ ) = 2.25	Middle School Score = (2.25/4.8) x 75 = 35.16 pts High School Score = (2.25/4.8) x 50 = 23.44 pts



## 2. Object Relocation Task – Pick and Place

- A. The purpose of this task is to demonstrate the device's ability to:
  - i. Grab objects of varying size, shape, consistency, and weight
  - ii. Lift objects vertically and move them laterally
  - iii. Place objects into and remove objects from container
- B. The objective of this task is to move objects in and out of the designated container as fast as possible.

### Test Equipment and Configuration:

C. A standard six foot table with approximate dimensions of 180 cm (L) x 74 cm (W) x 75 cm (H) will be divided with tape into three zones each approximately 60 cm in length. (see Diagram 2)

- i. The two end areas will be the *Task Areas* and each will be used for the container or objects.
- ii. The area in the middle will be *The Void*. Objects dropped in this area must be moved back to the designated *Task Area* to be tried again.

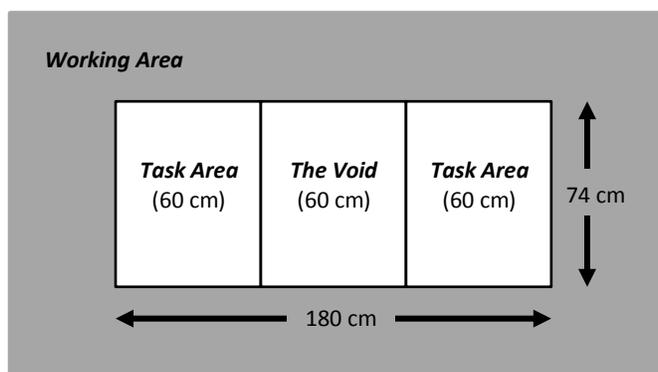


Diagram 2

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

- D. The container to be used for this task will be a plastic crate with approximate dimensions of 10.5" H x 13.75" W x 15.25" L (similar to the Sterilite milk crate #1692). This container will be lined to prevent objects from falling out.
- E. The 10 objects to be placed into and removed from the container are as follows:
  - i. One – 18.8 ounce cans of soup (approximately 12.7 cm in height x 8 cm in diameter)
  - ii. One – 2 liter bottle of soda (soda may be replaced with water)
  - iii. One – Composition Notebooks, approximately 100 pages, approximate page size 7.5" L x 9.5" W
  - iv. One – 12" rulers
  - v. One – Rolls of 1" x 60 yards masking tape
  - vi. Five (5) unidentified objects that will vary in size but will be no wider and no heavier than a 2 liter bottle (approximately 10 cm in diameter and approximately 2 kg) and no smaller or lighter than a penny (approximately 19 mm in diameter and approximately 2.5 g)
- F. A stop watch or other type of timer will be used to record trial times.

### Task Preparation:

- G. The 10 objects will be placed randomly in one of the task areas. Teams may choose in which *Task Area* to place the objects and how to place the objects within that area. The container will be placed by the team anywhere in the other *Task Area*.
- H. The team will be given up to one minute to prepare, attach and demonstrate its prosthesis, to choose a task area and to arrange the objects in the selected *Task Area*. If at the end of one minute the team 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. When prosthesis is prepared, attached and ready and objects are prepared or at the end of one minute, the designated team member will stand outside the *Working Area*.



**2014-2015 MESA USA  
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Prosthetic Arm Challenge  
Device Performance  
150 points**

**Task Details:**

- J. The judge will give the start order and begin the timer.
- K. The team member may enter the *Working Area* and will have a maximum of 1 minute (60 seconds) to complete the task. The judge will notify the student when they have 30 seconds, 20 seconds, and 10 seconds remaining.
- L. During the task, the team member will place one object at a time into the container; when all 10 objects have been placed into the container, the team member will then remove one object at a time from the container and place the object back into the *starting Task Area*.
  - i. The object **MUST** be carried across the entirety of *The Void* by the terminal device. Objects cannot be thrown across *The Void*.
  - ii. An object that is dropped in *The Void*, outside the container, or on the floor must be picked up by the terminal device of the prosthesis and placed back into the *starting Task Area* or the container that it was retrieved from before attempting to place into the container or to move back to the *starting Task Area*.
  - iii. An object may be slid to the edge of the table to be lifted. An object cannot be slid into *The Void*. An object slid or moved over into *The Void* must be returned (slid/carried) to the *Task Area* using only the terminal device of the prosthesis before attempting to place them into the container.
- M. The team member may hold the container in place with the unencumbered hand.
- N. The judge will stop the timer when the last object has been placed back into the *starting Task Area*. Or the judge will call “time” after one minute has passed.
  - i. Any object held by the device when time is called will not count. This object will be considered a “remaining object” for scoring purposes.
  - ii. Any object broken will not count. These objects will be considered a “remaining object” for scoring purposes.
  - iii. The judge will record the time needed to complete the task.
  - iv. If a team did not move **ALL objects** back to the *starting Task Area* within one minute, 5 seconds will be deducted for each remaining object from the maximum trial time of 110 seconds.
- O. Repeat procedure for 2nd trial. The second trial must be completed by a different team member.
- P. The best performance of the two trials will be used in the scoring.

**Assigning Points to Performance:**

1. Team Object Relocation Score ( $P_t$ ) = Maximum trial time (110 seconds) less the fastest trial time (seconds) less 5 second penalty for each “remaining object”
2. Task winner ( $P_w$ ) = Greatest Team Objection Relocation Score for any team
3. Maximum Trial Time = 60 second max trial time plus 50 seconds for a total of 110 seconds
4. 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 Maximum Trial time = 110 s Fastest Overall Trial Time = 35 s Task Winner ( $P_w$ ) = 110-35= 75	Team 5 Trial 1: 48 seconds Trial 2: 59 seconds Team Score ( $P_t$ ) = 110-48= 62	Team 5 Points Middle School Score = (62/75) x 75 = 62.0 points High School Score = (62/75) x 50 = 41.30 points
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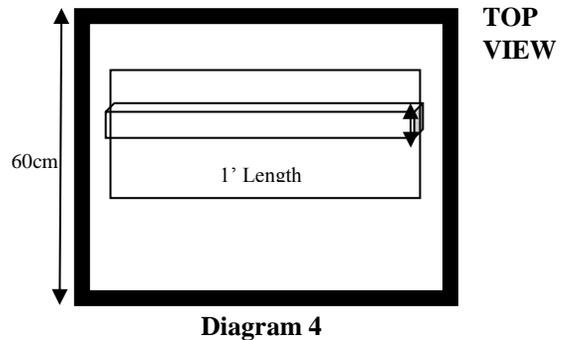
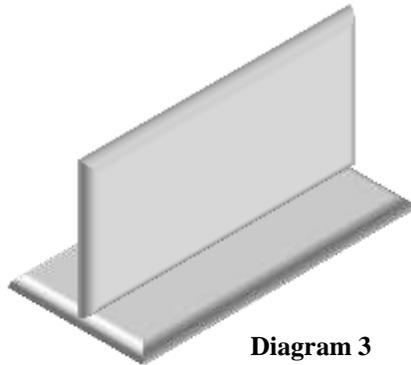
**3. Dexterity Task – Nuts and Bolts**

- 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 an object around an axis
- B. The objective of this task is to secure all nuts as far as possible onto the corresponding bolts as fast as possible.

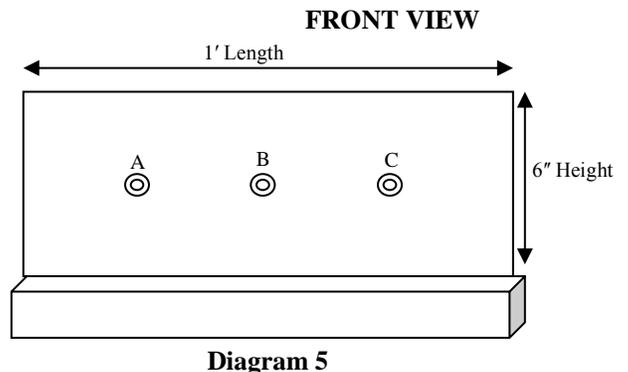
**Test Equipment and Configuration:**

- C. A standard six foot table with approximate dimensions of 180 cm (L) x 74 cm (W) x 75 cm (H) will be divided with tape into three zones each approximately 60 cm in length (see Diagram 2). The two end areas will be the *Testing Areas*.
- D. A perimeter approximately one (1) meter around the table will be marked with tape. Only team member actively participating during the task will be permitted in this *Working Area*.
- E. A testing device will be placed on top of the table within the selected *Testing Area*. Before the trial the team will select one of the two areas to place the testing device.
  - i. The testing device will be made from 2 (two) 1 foot x 6 inch x 1 inch boards attached perpendicular to each other (See diagrams 3 and 4).
    - a. Standard Lumber

Nominal	Actual	Actual-Metric
1" x 6"	¾" x 5 ½"	19mm x 140mm



- ii. The vertical board will have 3 (three) pre-drilled holes made from drill bits A, B, and C as described below (see Diagram 5). The center of the holes will be centered vertically on the board, and evenly spaced horizontally across the board.
  - a. Hole “A” = US Drill Bit 23/64” (0.359375 in or 9.128125 mm) – Home Depot Model 48-89-2729 / Store SKU # 767398 or equivalent
  - b. Hole “B” = US Drill Bit or Paddle Bit 1/2” (0.5 in or 12.7 mm) – Home Depot Model 48-89-2738 / Store SKU # 771919, Model # 88824 / Store SKU # 959154, or equivalent
  - c. Hole “C” = US Drill Bit or Paddle Bit 11/16” (0.6875 in or 17.4625 mm) – Home Depot Model # 48-89-2744 / Store SKU # 774206, Model # 1768419 / Store SKU # 958190, or equivalent



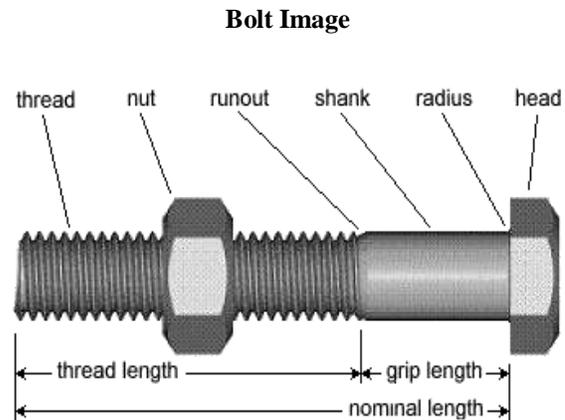


F. Bolts and Nuts are as follows (Metric, Zinc plated class 8.8 steel from www.boltdepot.com):

- i. Set "A" – (1) 8mm x 1.25mm x 70mm hex bolt and corresponding 8mm hex nut
  - a. Product #6230, Product #4788
- ii. Set "B" – (1) 12mm x 1.5mm x 70mm hex bolt and corresponding 12mm hex nut
  - a. Product #6341, Product #6877
- iii. Set "C" – (1) 16mm x 2.0mm x 70 mm hex bolt and corresponding 16mm hex nut
  - a. Product #6292, Product #7360

G. Measurement Equipment: 4 inch digital Caliper

- a. HarborFreight.com, [Item #47256](#) or equivalent



**Task Preparation:**

- H. The team will be given up to one minute to prepare, attach and demonstrate its prosthesis, 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 selected *Testing Area*.
  - ii. The testing device may be placed anywhere inside of the selected *Testing Area*.
- I. When device is prepared, attached, and ready and the dexterity materials prepared or at the end of one minute, the designated team member will stand outside the *Working Area*.

**Task Details:**

- J. The judge will give the start order and begin the timer.
- K. The team member may enter the *Working Area* and will have a total of 2 minutes (120 seconds) to secure all three (3) hex nuts and bolts. The judge will notify the team when 30 seconds, 20 seconds and 10 seconds remain.
- L. The task will proceed as follows:
- i. The member will grab one of the hex bolts with the terminal device and insert the hex bolt into the corresponding pre-drilled hole.
  - ii. The member will then grab the corresponding hex nut with the terminal device and secure the hex nut onto the hex bolt.
  - iii. The hex nut must completely pass a marking on the bolt to be scored in the higher scoring zone.
- M. The member may select any order of the task (e.g. all bolts and then all nuts, each bolt/nut set, etc.).
- N. The member may hold the hex bolt with the unencumbered hand by holding the bolt head ONLY. The member may only hold the bolt head in place and is not allowed to twist or screw in any way.
- O. The testing device must remain within the selected *Testing Area* at all times and is allowed to be rotated, but the flat bottom board must remain in contact with the table at all times. (See Diagram 3). The team member may rotate or hold in place the testing device with the unencumbered hand.



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150 points**

- P. If a bolt or nut is dropped, it must be picked up by the terminal device of the prosthesis and placed on the table outside the *Testing Area*.
- Q. Once a nut is secured, the terminal device of the prosthesis may be used to strike the nut to advance it further on the bolt.
- R. The trial will end when any of the following occur:
  - i. The team may call the end of the trial **after and only after** all three (3) hex bolts and all three (3) hex nuts have been secured. The team may signal the end of the trial by calling out “done.” The judge will immediately stop the timer and record the time elapsed as the trial time.
  - ii. Two minutes have passed. The judge will call out “time” and record the full trial time of 120 seconds.
  - iii. If an item is dropped and is not able to be placed on the table, the judge will record the full trial time of 120 seconds.
  - iv. If the team member is found to have aided in the securing or screwing of the bolt, the trial will be declared a MISTRIAL.
- S. Repeat procedure for 2nd trial. The second trial must be completed by a different team member.
- T. The best performance of the two trials will be used in the scoring.

**Assigning Points to Performance:**

- 1. Scores for Scoring Zones on each bolt
  - a. 5 for each nut secured on a bolt
  - b. 50 for each nut secured past 0.5 cm
  - c. 65 for each nut secured past 1.0 cm
  - d. 80 for each nut secured past 1.5 cm
  - e. 95 for each nut secured past 2.0 cm
- 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 ( $X_w$ ) = 3.00	Team 5 Trial 1: 210 score/120 s = 1.75 Trial 2: 210 score/100 s = 2.10 Team Dexterity Score ( $X_t$ ) = 2.10	Team 5 Points High School Score = (2.10/3.00) x 50 = 35 pts
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### Objective

To offer a close examination of your team's engineering design process, especially as it relates to all major design choices and STEM concepts.

### 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

The preferred format for technical papers is the Portable Document Format (.PDF). If your team does not have the ability to save your document as a .pdf, you can save and submit it in Microsoft Word format prior to submission. Teams shall also ensure the submitted final product can be read using Adobe Reader (10.0 or newer) or Microsoft Word (2007 or newer) and that it matches your original, printed document. Please note that the formatting of papers saved as Microsoft Word documents (.DOC or .DOCX) will change depending on the kind of computer (PC or Apple) used to open the file. This can drastically alter the formatting of your document, which is why we recommend submitting your document in .pdf format.

### 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 sought in any aspect of the design process, or the creation of the paper or poster/presentation, authors should specifically explain how in this paper and also include their names in the appropriate section.

### Deadline

- *Local/State.* Check with your local MESA office for the procedure for local/state competitions.
- *National Competition.* For teams advancing to the national competition, the technical paper must be submitted via e-mail to Utah MESA on or before 4:00 pm in your local time zone, on **June 5, 2015** (subject to change). The papers will be judged and scored prior to the National Competition. Papers must be e-mailed to: Utah MESA, Head Judge at [nationalcompetition@mesausa.org](mailto:nationalcompetition@mesausa.org). Check the MESA USA national website at [mesausa.org](http://mesausa.org) for further information. **Please note that the host and Head Judge are not responsible for any Internet service delays or misguided papers. It is the responsibility of the student team members to ensure that the paper is delivered successfully prior to the deadline.**

### Using Your Engineering Design Notebook as a Foundation for Your Paper

Everything you do to prepare for this competition – be it your design brainstorming, your sketching of possible approaches, your informal and formal research, your exploration of the MESA USA Curriculum, your building of various prototypes, your testing of each material, modification, or new model, or even your gathering and analysis of the data – everything you do to prepare your final design prototype is part of your engineering design process.

Like most STEM professionals, you will be keeping a notebook to make notes of everything you explore. From Day 1 – you will be using your notebook to track your ideas, your progress, your let-downs, your innovations, your interviews, your drawings and your data. If your team remembers, during each time you meet, open up your team's notebook(s) and document everything – even your goofiest ideas and your worst drawings or testing results – then when it comes time to write your paper, you should have most everything you need in that notebook to write a strong technical paper.

### Written Presentation

The paper should be typed, double-spaced, and have a cover sheet. When possible, graphics should be computer generated. The font 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. Bibliography
- I. Acknowledgments
- J. Appendix (not included in the page count)

### **A. Title Page**

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

### **B. Abstract**

This section, which is identical to the abstract included in the poster, is an engaging, brief synopsis of your project (200-250 words). It should be written using minimal technical terms. As the most important part of your paper, it paraphrases the design problem and summarizes the team's purpose or motivation. The abstract should also clearly summarize the team's design approach/methodology, testing results and your analysis. Finally, it should also clearly summarize your final design's key features and your conclusions. Especially in this section, make sure to be as succinct as possible.

### **C. Table of Contents**

Your table of contents should correctly identify each required component of the paper.

### **D. Introduction**

This section aims to engage readers while preparing them for the discussion that follows – *before* introducing any technical data or definitions, unless they are necessary. It is broken down into three sections which provide, in your own words, a clearer sense of your team's design purpose, the design problem, and any background information. Each section should average one to two paragraphs each:

1. *Purpose*. In your own words, provide a compelling overview of your team's design purpose or motivation (e.g., to solve a problem, to address a particular need, to evaluate or introduce a new concept etc.). This should expand upon what you shared in the Abstract.
2. *Scope*. Provide a clear restatement, in your own words, of the design problem including success criteria, limiting factors/constraints, and key variables to consider. After overviewing the design problem, make sure to overview your investigation approach and your design method.
3. *Background Information*. Present facts the reader should know, conditions or events prior to the project and any details of previous reports. This should include your review of other investigators/designers, as well as any of your related design objectives or hypotheses.

### **E. Discussion of Design Process**

This is the longest section of the paper. It presents and thoroughly discusses all key evidence from your engineering design process and findings. As you explain these findings, make sure to include the right kind of compelling graphics to help readers better visualize your data or information (e.g. data tables/graphs or other figures/charts). These graphics, while they are referred to and explained here, should be located only in the appendix. As you explain your process and points, make sure to refer to the appropriate graphic within the paragraph in which it first becomes relevant.



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Technical Paper  
100 points

1. Discuss your team's design process, including:
  - a. *Process Overview*. Clearly overview your team's design process.
  - b. *Roles*. Explain the roles of each team member at all stages of design.
  - c. *Self-assessment*. Detail the nature and efficacy of each stage of your design process (including brainstorming, research, etc.)
  - d. *Evidence of Quality in Design Notebook*. Include enough tidy, scanned/photocopied images from design notebooks to clearly reflect your thoroughness and planning.
  - e. *Testing Procedures*. Clearly describe your experimental procedures and test setup, including relevant pictures or diagrams.
  - f. *Rationale for Design Choices*. Clearly explain what aspects of your design process (including brainstorming, research, design selections, modifications, testing, etc.) most informed all of your major design choices. Be specific. What part of your process most impacted your choices and how?
2. Briefly summarize any particular STEM (Science, Technology, Engineering and Math) concepts that most informed your team's design process.
  - a. *Math/Physics/Science Concepts*. Teams are encouraged to examine and report on relevant concepts relating to mathematics, physics or science. We encourage teams to visit the MESA USA Curriculum for this competition (at [www.mesausa.org](http://www.mesausa.org)) as part of your investigation.
    - i. **NOTE:** Please also clarify if your team explored ANY advanced concepts, techniques, algorithms or other materials that would not normally be included in middle or high school subjects. The paper must reflect the team's comprehension and capacity to explain such concepts. If these ideas were incorporated based on suggestions by people you sought out in your research, by volunteer STEM professionals at your school, or through other advanced text or web resources, make sure to also briefly reference this either here or in the Appendix.
  - b. *Engineering/Technology Challenges/Solutions. Advanced Concepts*. Teams are encouraged to examine and report on relevant concepts relating to engineering and technology. As with the last standard, please clarify if your team explored advanced concepts, etc., relating to engineering or technology.
  - c. *Relevant Graphics*. Be sure to reference tables/graphs which reflect key data from each major design prototype or modification. These should be located in your Appendix.
  - d. *Data Analysis*. Be sure to include any related data reduction, analysis tools, models or operations used to explore your data.
  - e. *Design Variable Overview*. Be sure to clearly explain all design variables – including those you weren't able to address effectively.
  - f. *Design Variable Optimization*. The discussion should also clearly explain which specific variables your team addressed or optimized for and why.
3. Quality and Thoroughness
  - a. *Support Sections*. Make sure to include all support sections (e.g. references, acknowledgments, appendix).
  - b. *Go The Extra Mile*. Clearly describe any extra measures your team made to be more conscientious in ensuring that your design's quality went beyond the call of the specifications. For example, is your final design durable, or easy and affordable to repair? If your design had a particular client (user/consumer) in mind – or group of clients – what additional considerations went into your design (e.g. particular functionality desired, aesthetics)? If you did a viability or impact study to see the positive and adverse impacts of your design (i.e. on society, the environment, hypothetical clients, etc.), what did you learn?
  - c. *Cost-Labor. Summary*. Include a very detailed list of student time commitment as well as volunteer support. See Appendix section below for more information.
  - d. *Itemized Budget Sheet*. Include a very specific, complete pricing table reflecting new, retail value equivalents for all parts/materials. Further information is provided in the Appendix section below.



- e. Documentation/receipts. Document all costs at new retail value (e.g. store receipts or store pricing from the web).
- f. *Bibliography*: In your bibliography, be sure to include at least 8 highly relevant sources that are appropriately formatted (i.e. APA, IEEE, or other standard format).

Overall, 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, which is 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 your conclusions. This requires more careful organization but also allows for 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.

#### **F. Conclusion**

This section should be identical to the conclusion section included in the poster. In this section, state the major inferences that can be drawn from the discussion. No new evidence should appear in this section.

#### **G. Recommendations**

This section should be identical to the recommendations section included in the poster. Imagine that in the future, other student design teams – or even your own design team – will get to take your design to the next level. In this section, suggest further work to be done and why. If several solutions are presented in your paper, what do you recommend would be the best solution? What key questions would you have liked to explore if you had additional time or resources? What were your current design's strengths and shortcomings? Write recommendations to future designers, in strong definitive terms using first person and active verbs.

#### **H. References or Bibliography**

All sources that are consulted should be properly cited according to either APA, IEEE, or another standard format. Please introduce all sources with a brief sentence explaining which format you chose and why. See Resource Materials section for example references and additional information. We encourage you to seek at least eight (8) highly relevant sources that are appropriately formatted. If you borrowed any particular ideas from the MESA USA National Prosthetic Arm Design Curriculum (at [www.mesausa.org](http://www.mesausa.org)), make sure to reference the specific sections/pages as well.

#### **I. Acknowledgments**

This section should be used to recognize individuals or groups who have provided support and guidance throughout the design process. If any of your team's design or analysis work was influenced by these people, make sure to specifically explain how in the body of the text.

#### **J. Appendix**

This section contains, in detail, any additional supporting data, charts, tables, photographs, test results, etc. that were referred to earlier in the paper. As it relates to costs, please be sure to also include here the following:

- a. Cost-Labor Summary. Include a very detailed table reflecting student time commitment as well as volunteer support. This should estimate any student or volunteer hours that applied to complete any project elements (i.e. Device, Technical Paper, Academic Display and Oral Presentation).
- b. Minimum size: An 8 ½ by 11 sheet of paper.



- c. Itemized Budget Sheet. For each materials/part, include the following: part, unit dimensions, retail price, price per unit, quantity used, total cost and source. For used or donated items, include new retail rate cost when totaling expenses. The new retail rate is needed here to ensure team equity (i.e. so that no team has a spending or design advantage). Teams must use the detailed budget sheet provided.
- d. Documentation/receipts. Include store receipts or printed documentation for all costs (including any used or donated items) which reflects each item's new, retail value.

### **Conventions (Format, Language, Grammar, etc.)**

Each of the standards listed below, though they are scored at a lower level (2 pts max), make an enormous difference in your team's ability to create a well-organized, compelling paper. Don't forget to check your paper length, make sure all sections are included, provide a title page, and adhere to the font, spacing, layout and grammar standards below:

- a. The paper length, not including cover, title pages and Appendix, should be 5 to 15 pages.
- b. Remember to include the key sections in your paper (listed above)
- c. Your title page should include authors/ team members, school, MESA state and date.
- d. Be sure to use 1" margins and double space your text using 12 pt. Times New Roman font.
- e. Remember to use spelling, sentence, paragraphing and transition conventions that are appropriate to standard business English throughout 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 of Design Process Methods / Approach (30 pts)
- STEM Concepts and Analysis (30 pts)
- Quality and Thoroughness (30 pts)
- Conventions (10)

With the scoring criteria rubric, please keep in mind that judges will score all design goals based on the evidence you provide. For all items except for the conventions, these will be scored on a scale of 0 to 5. While the judges' rubrics may be more specific, please know that most scores will generally be based on the following:

- (5)-Exceptional. Exceeds all aspects of the standard when possible.
- (4)-Meets all aspects of the standard very effectively.
- (3)-Meets all aspects of the standard somewhat effectively;
- (2)-Almost meets the standard. May be inaccurate or unclear.
- (1)-Attempts to meet the standard but provides information which is irrelevant or unnecessary.
- (0)-No attempt appears to have been made to meet this standard.



### Overall Objective

To overview the functionality of the team's final device. Teams will present their device and relevant aspects of the design process from their technical paper. The focus of the display and presentation should only be the actual device presented for performance. 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. Displays and speeches must be the original work of the team. The poster and presentation will each be worth 75 points.

### Materials Provided

- Easel or ample wall space for poster – or cafeteria style table (30" x 72" x 29").

### Required Poster Elements (by Section)

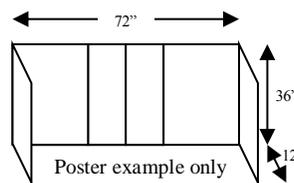
1. **Abstract Section.** This abstract, which is identical to the abstract included in the paper, is an engaging, brief synopsis of your project (200-250 words). This section should be written using minimal technical terms. It is the most important part of your paper which paraphrases the design problem and summarizes the team's purpose or motivation. The abstract should also clearly summarize the team's design approach/methodology, testing results and your analysis. Finally, it should also clearly summarize your final design's key features and your conclusions. Especially in this section, make sure to be as succinct as possible.
2. **Design Features and Drawings Section(s).** Provide viewers with the following:
  - a. Your final design's key features, prominently identified. All illustrations should be detailed, easy to read/interpret, and neatly done. Make sure to use labels/pointers to effectively highlight the features of your device or important data.
  - b. One (1) orthographic drawing which includes at least front, side and top views, as well as the design dimensions and scale of the actual, final device designed and built. The maximum paper size for this drawing shall be 11"x17." It should also include a 3" x 5" Title Card including drawing title, brief description, the date completed, and the scale used. Your orthographic drawing should detail all key parts of your final design very clearly. See sample on Page 28. Please keep in mind that while photographs are allowed in the poster, they do not serve in place of a scaled, orthographic drawing. These drawings may be drawn by hand or computer generated as both methods will be scored equally.
  - c. Two (2) creative models or isometric (3D) drawings which very clearly illustrate the outward appearance of your final design as well as your key design considerations.
3. **Results/Data Section(s).** Show team exploration and testing of final device design by including the following:
  - a. Two (2) very relevant, compelling data tables.
  - b. Two (2) very relevant, compelling data charts or graphs.
  - c. The results section should not include any analysis or interpretation.
4. **Analysis Section.**
  - a. Interpretation/analysis of data should be very clear and relevant, with all inferences following very logically from the data/evidence you present.
  - b. In this context, explain the design's strengths and at least two (2) shortcomings.
5. **Conclusion and Recommendations Section(s).**
  - a. Your conclusions and recommendations can be combined into one section or left as separate sections.
  - b. Both sections should include no new data and should be derived from visible aspects or insights gained through your design process.
  - c. The recommendations should include three (3) ideas for future work. These sections should be written in first person with active verbs.

**Overall, teams are also encouraged to incorporate** any text, photographs, drawings, images, tables, charts, graphs, models etc. that share information relevant to the overall project. Likewise, be sure to include any modifications made to your device to help it be a stronger contender.



**Poster Layout Guidelines.** As you design your posters, please pay special attention to the following:

- *Layout.* Effective posters/displays will carefully consider their use of space to ensure that it will capture and hold the interest of audience members very effectively. Make sure your design is neat, uncluttered and very easy to follow.
- *Title and Team Names.* As you arrange all major sections, make sure to also clearly display a compelling title card/header (with the official MESA USA logo as well as the names of all team members, your team's state and your school) in a prominent location.
- *Size and Type.* The maximum display area should either be the equivalent of two 36" x 48" tri-fold presentation boards placed side-by-side – or a single 36" by 96" poster. Regarding whether you use a display or poster, we strongly recommend using posters as these are more commonly used in the colleges and universities you will attend in the future. If you choose not to design a poster (maximum 36" x 96"), keep the following in mind for your trifold board display: 1) the entire display must be on the table and not extend beyond the table top; and, 2) displays may be taped to the table for stability.



**Here are some other important points to consider:**

- Your team's Engineering Design Notebook should be placed near your poster/display – or be provided during your presentation – so that your team, or judges, can refer to it.
- Electronic media are not allowed.
- Except for the tri-fold presentation board, no element of your school's previous year's display may be reused. All elements must be original for this year.
- Finally, please keep in mind that the full budget should only be included in the paper. If the MESA budget guidelines impacted the specific kind of prototype you developed, make sure to briefly explain this here

**Required Presentation Elements** (though teams are not expected to present in this order)

1. **Verbal Introduction.** All team members should participate in providing judges with:
  - a. A brief creative introduction of team members and responsibilities as well as a compelling design rationale; and,
  - b. A clear restatement, in your own words, of the design problem including any relevant background information needed (key facts, conditions, events prior to project and previous work).
2. **STEM Explanations and Quality.** As you present, be sure to provide for judges the following:
  - a. A thorough description of the scope of your work as well as key design parameters/constraints;
  - b. A clear explanation of relevant factors/variables the team chose not to address and why;
  - c. A clear explanation of specific factors/variables the team addressed/optimized for and why;
  - d. A precise, succinct description of three (3) to four (4) Math/Physics/Science concepts that informed your design choices (including advanced concepts if used); and,
  - e. A precise, succinct description of three (3) to four (4) Engineering/Technology phenomena, challenges or solutions that informed your design (including advanced concepts if used).
3. **Design Process/Approach. Overview your design's development by sharing:**
  - a. Your approach, methodology, and design timeline;
  - b. A clear explanation of how your team's research informed at least two (2) design choices and a clear explanation of how your team's design and testing informed at least four (4) design choices;
  - c. The effective utilization – at least two (2) times – of your engineering design notebooks as a visual aid; and,
  - d. A clear sense that all observations and conclusions follow directly from your research and design process and are clearly well thought out.
4. **Analysis.** As you discuss your findings, make sure to use your poster and engineering design notebook(s) as visual aids to refer to any specific observations or data relating to your experiments, testing or research.
5. **Conclusions.** Briefly share your conclusions and/or recommendations – and make sure that these are all derived from the engineering design process as noted above.



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Academic Poster Presentation  
150 points**

**Presentation Rules**

1. 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.
2. The Design Poster, Props, models, design notebook or other visual aids should be used.
3. Each team may speak for a maximum of ten (10) minutes. A 5-point deduction will be applied for presentations exceeding 10 minutes. Judges will expect to regularly hear directly from all team members throughout the presentation.
4. If judges allow audience members at poster presentations, teams may invite audience members at their discretion to attend the presentation. Once the presentation begins, audience interruptions will not be permitted. During the judges' question-and-answer period, no audience questions are allowed.
5. Teams are expected to do research. They may interview and quote experts, associates, or use quotations from written or web sources. They may provide examples, and/or use illustrations, facts, and figures.
6. All key concepts should be well understood by all team members. The use of any advanced concepts, techniques, algorithms or other materials that would not normally be included in middle or high school subjects must be explained. Whether these ideas were incorporated based on suggestions by people you sought out in your research, by volunteer STEM professionals at your school, or through other advanced text or web resources, your presentation must reflect the team's comprehension and capacity to explain such concepts.
7. Teams will be randomly selected to determine speaking order.
8. Students must give their presentations in the order drawn. No exceptions or late arrivals are allowed.
9. Judges will provide time signals at 3 minutes, 1 minute, 30 seconds, and 5 seconds before time is called.
10. Once the presentation is complete, the judges will conduct a five (5) minute question-and-answer period. These questions will be brief and to the point, and solely to ascertain student knowledge of the project.
11. Overall, keep in mind the following guidelines for the presentation:
  - a. All team members should share equally in your presentation. No matter what approach you take, please make sure your team's demeanor and appearance is well suited for the event.
  - b. All team members' voices should be heard and understood by all judges. All team members' eye contact should be distributed across the audience.
  - c. All team members should stay very focused on the topic, transitioning very smoothly from point to point. Do your best to maintain the attention of the judges/audience through engaging activities and/or discussion.

**Criteria for Evaluation and Scoring of Academic Poster Presentation (150 pts)**

Shown below are the main areas that will be considered in the evaluation of the poster (75 pts) and the presentation (75 pts). See the scoring materials section for specific details and overall criteria.

Team Poster (75 pts.) includes:

- Abstract (20)
- Design Features and Drawings (15)
- Results Data and Analysis (30)
- Organization and Creativity (10)

Team Presentation (75 pts.) includes:

- Introduction (10)
- STEM Explanations and Quality (25)
- Design Process / Approach (25)
- Oral and Visual Overall (15)

With the scoring criteria rubric, please keep in mind that judges will score all design goals based on the evidence you provide. For all items, these will be scored on a scale of 0 to 5. While the final judges' rubrics may be more specific, in general, the 0-to-5 scale will generally be based on the following:

- (5)-Exceptional. *Exceeds* all aspects of the standard *when possible*.
- (4)-Meets all aspects of the standard *very* effectively.
- (3)-Meets all aspects of the standard *somewhat* effectively;
- (2)-*Almost* meets the standard. May be inaccurate or unclear.
- (1)-*Attempts* to meet the standard but provides information which is irrelevant or unnecessary.
- (0)-*No* attempt appears to have been made to meet this standard.



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Device Performance  
150 points**

Inspection and Performance Datasheet

MESA Center: \_\_\_\_\_ MESA School: \_\_\_\_\_ Level: MS HS  
 Advisor/Teacher: \_\_\_\_\_ Student Team: \_\_\_\_\_

**INSPECTION LIST:**

	YES	NO
Device is a generalized tool and includes all parts necessary to accomplish all tasks .....	<input type="checkbox"/>	<input type="checkbox"/>
Device is a trans-radial (below the elbow) prosthetic .....	<input type="checkbox"/>	<input type="checkbox"/>
Terminal Device, included and extends beyond the team members hand .....	<input type="checkbox"/>	<input type="checkbox"/>
Prosthetic Interface, attaches at least three inches beyond the wrist on the foreman .....	<input type="checkbox"/>	<input type="checkbox"/>
Actuator, is not controlled by the hand or opposite, elbow, forearm and/or hand .....	<input type="checkbox"/>	<input type="checkbox"/>
The terminal device includes at least two artificial fingers operator by actuator .....	<input type="checkbox"/>	<input type="checkbox"/>
Team has demonstrated that they have immobilized the wrist, hand and fingers .....	<input type="checkbox"/>	<input type="checkbox"/>
The team provided an itemized budget with references and documentation .....	<input type="checkbox"/>	<input type="checkbox"/>
Device does not exceed the \$40 pre-tax price limit .....	<input type="checkbox"/>	<input type="checkbox"/>

Device Mass (not including all replacement parts and materials): \_\_\_\_\_ kg      Device Total Cost: \$ \_\_\_\_\_

**PERFORMANCE:**

**Distance Accuracy Task**

<b>Trial 1</b>	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
# of bean bags					
<i>x</i>	5	10	15	20	25
<i>Sub-total</i>					
Total Score					
Trial Time (00.00 seconds)					

<b>Trial 2</b>	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
# of bean bags					
<i>x</i>	5	10	15	20	25
<i>Sub-total</i>					
Total Score					
Trial Time (00.00 seconds)					

**Object Relocation Task**

Trial 1:  
 Trial Time: \_\_\_\_\_ (00.00 seconds)  
 Objects remaining: \_\_\_\_\_ (x 5 seconds) = \_\_\_\_\_

Trial 2:  
 Trial Time: \_\_\_\_\_ (00.00 seconds)  
 Objects remaining: \_\_\_\_\_ (x 5 seconds) = \_\_\_\_\_

**Dexterity Task (high school only)**

Trial 1:  
 Bolt 1 points: \_\_\_\_\_ Total Points (P): \_\_\_\_\_  
 Bolt 2 points: \_\_\_\_\_ Trial Time (T): \_\_\_\_\_  
 Bolt 3 points: \_\_\_\_\_

Trial 2:  
 Bolt 1 points: \_\_\_\_\_ Total Points (P): \_\_\_\_\_  
 Bolt 2 points: \_\_\_\_\_ Trial Time (T): \_\_\_\_\_  
 Bolt 3 points: \_\_\_\_\_

Points for Scoring Zones:

- 5 for each nut secured on a bolt
- 50 for each nut secured past 0.5 cm
- 65 for each nut secured past 1.0 cm
- 80 for each nut secured past 1.5 cm
- 95 for each nut secured past 2.0 cm



**TECHNICAL PAPER SCORING CRITERIA**  
(MESA USA NEDC)

Team:
School:
Center/State:

**Overview:** Values circled reflect the degree of evidence for design goals: (5) Exceptional/Exceeds Standard When Possible; (4) Meets Very Effectively; (3) Meets Somewhat Effectively; (2) Almost Meets/Inaccurate or Unclear; (1) Attempts/Irrelevant; (0) No attempt. *Please note: to meet any design goal below, all aspects listed in the standard (i.e. row) must be met.*

<b>Discussion of Design Process Methods / Approach. (30)</b> a-Design Process , b-Roles, c-Efficacy of each stage, d- Notebook Quality, e-Testing Procedures, f- reason for design choices.							
a. Clear overview of team’s <b>design process</b> .	5	4	3	2	1	0	
b. <b>Details roles</b> of all team members at all stages of design.	5	4	3	2	1	0	
c. Details <b>nature &amp; efficacy of each stage</b> of design process reflects (including brainstorming, research, etc).	5	4	3	2	1	0	
d. At least 3 tidy, scanned/photocopied <b>images from design notebooks</b> reflecting thoroughness & planning.	5	4	3	2	1	0	
e. Very clear description of <b>testing procedures</b> . Includes 2-3 relevant diagrams or pictures.	5	4	3	2	1	0	
f. Clearly explains <b>how design process/testing informed all major design choices</b> .	5	4	3	2	1	0	
<b>Subtotal</b>	<b>/30</b>						
<b>STEM Concepts &amp; Analysis. (30)</b> a- Math/Science Concepts, b-Engineering/Tech Concepts, c-Data Presented Visually, d-Data exploration, e- all design variables, f- specific variables.							
a. Precise, succinct explanation of 3-4 Math/Physics/Science concepts that informed design, including advanced concepts if used.	5	4	3	2	1	0	
b. Precise, succinct explanation of 3-4 Engineering/Technology challenges/solutions, including advanced concepts if used.	5	4	3	2	1	0	
c. Very relevant <b>tables/graphs/ reflect key data</b> for each major design prototype or modification. Includes at least 3.	5	4	3	2	1	0	
d. Paper includes related data analysis or operations used to <b>explore the data</b> .	5	4	3	2	1	0	
e. All relevant <b>design variables</b> clearly explained, including those not addressed.	5	4	3	2	1	0	
f. Clear explanation of <b>specific variables</b> team addressed/optimized for and why.	5	4	3	2	1	0	
<b>Subtotal</b>	<b>/30</b>						
<b>Quality &amp; Thoroughness. (30)</b> a-All Support Sections, b- Extra Mile, c- Cost-Labor Summary, d- Materials List, e-Full Cost Documentation, f-Relevant Bibliography							
a. <b>All Supporting Sections included:</b> References, Acknowledgments, Appendix.	5	4	3	2	1	0	
b. <b>Extra Mile.</b> Clear description of extra measures team made to be more conscientious in ensuring design’s quality went beyond the call of the specifications.	5	4	3	2	1	0	
c. <b>Cost-Labor Summary.</b> Very detailed list of student time commitment as well as volunteer support.	5	4	3	2	1	0	
d. <b>Itemized Budget Sheet:</b> Very specific, complete pricing table reflecting new retail value equivalents.	5	4	3	2	1	0	
e. <b>Documentation/receipts:</b> for all costs reflecting new retail value.	5	4	3	2	1	0	
f. <b>Bibliography:</b> At least 8 highly relevant sources that are appropriately formatted (APA, IEEE, or other standard format).	5	4	3	2	1	0	
<b>Subtotal</b>	<b>/30</b>						
<b>Conventions. (10)</b> a-Length, b-Sections, c-Title Page, d-Font & Layout, e- Grammar. <i>In this section only, a two (2) reflects fully meeting the standard; a one (1) reflects that it was almost met; and a zero (0) reflects zero evidence addressing the standard.</i>							
a. Length: 5-15 pages (not including cover, title page & appendix)					2	1	0
b. All Key Sections included.					2	1	0
c. Title page includes authors/team members, school, MESA state & date					2	1	0
d. Font & Layout: double-spaced, 12, Times New Roman. 1” margins.					2	1	0
e. Grammar, spelling, sentence, paragraphing & transition usage are appropriate to standard business English throughout the paper.					2	1	0
<b>Subtotal</b>	<b>/10</b>						
<i>Judge Name:</i>	<b>TOTAL</b>					<b>/100</b>	

Comments:


**POSTER PRESENTATION SCORING CRITERIA**  
 (MESA USA NEDC)

 Team:  
 School:  
 Center/State:

Academic Poster Presentation Scoring Criteria (Part A + B = 150 points)

**A. POSTER/DISPLAY CRITERIA (75 points)**

**Overview:** Values circled reflect the degree of evidence for design goals: (5) Exceptional/Exceeds Standard When Possible; (4) Meets Very Effectively; (3) Meets Somewhat Effectively; (2) Almost Meets/Inaccurate or Unclear; (1) Attempts/Irrelevant; (0) No attempt. *Please note: to meet any design goal below, all aspects listed in the standard (i.e. row) must be met.*

<b>Abstract. (20)</b> a-Length & Audience, b-Problem & Purpose, c- Methods, Results & Analysis, d- Conclusions & Key Features.						
a. <b>Length:</b> 200-250 words. Engages & informs <b>audience</b> . Written very clearly & succinctly using minimal tech. terms.	5	4	3	2	1	0
b. Very clearly restates <b>design problem &amp; summarizes team purpose</b> or motivation.	5	4	3	2	1	0
c. Very clearly summarizes <b>team's design approach/methodology &amp; testing results &amp; analysis</b> .	5	4	3	2	1	0
d. Very clearly <b>summarizes conclusions &amp; final design's key features</b> .	5	4	3	2	1	0
<b>Subtotal</b>	<b>/20</b>					
<b>Design Features &amp; Drawings. (15)</b> a-Key Features; neatness & clarity; labeling; b- Orthographic Size & Scale; c-Outward Appearance/Isometric Drawing.						
a. <b>Key Features</b> of final design prominently identified in poster. Illustrations are <b>detailed, easily read &amp; interpreted</b> & neatly done. Very effective use of <b>labels/pointers</b> to highlight features of device or data.	5	4	3	2	1	0
b. Orthographic drawing is at most <b>11"x17"</b> & includes at least <b>front, side and top view</b> & design <b>dimensions &amp; scale</b> with Title Card. Orth. drawing <b>details all key parts</b> of final design very clearly.	5	4	3	2	1	0
c. Two (2) creative models or isometric (3D) drawings very clearly illustrate <b>outward appearance</b> of final design as well as key design considerations.	5	4	3	2	1	0
<b>Subtotal</b>	<b>/15</b>					
<b>Results Data &amp; Analysis. (30)</b> a-Data Tables; b-Charts/Graphs; c-Clear Interpretation & Inferences Based on Evidence; d-Strengths/Shortcomings; e-Recommendations; f-Standard Structure.						
a. Results section includes (2) two very relevant, compelling <b>data tables</b>	5	4	3	2	1	0
b. Results section includes (2) two very relevant, compelling data <b>charts or graphs</b> .	5	4	3	2	1	0
c. Analysis section includes: interpretation/analysis of data very <b>clear &amp; relevant</b> ; all <b>inferences</b> follow very logically from data/evidence.	5	4	3	2	1	0
d. Analysis section explains <b>design's strengths &amp; at least two (2) shortcomings</b> .	5	4	3	2	1	0
e. <b>Recommendations</b> include three (3) ideas for future work. Written in first person w/ active verbs.	5	4	3	2	1	0
f. <b>Standard Structure Overall. Results</b> section does not include interpretation. <b>Conclusion &amp; Recommendations</b> include no new data.	5	4	3	2	1	0
<b>Subtotal</b>	<b>/30</b>					
<b>Layout. (10)</b> a-Size, Title & Team, b- Compelling Layout.						
a. <b>Compelling Layout:</b> Very good use of space, neat, uncluttered, very easy to follow. Display captures attention very holds interest very effectively.	5	4	3	2	1	0
b. <b>Title, Team, Size &amp; Sections.</b> Includes clear, compelling title card/header & official MESA USA logo. Team School/Members/State prominently displayed. Poster/display size maximum: two 36"x 48" tri-folds OR 1 single poster 40" x 60." All major sections included.	5	4	3	2	1	0
<b>Subtotal</b>	<b>/10</b>					
<b>DISPLAY Total</b>	<b>/75</b>					

Comments:

Team:	
School:	Center/State:

**B. PRESENTATION CRITERIA (75 points)**

**Overview:** Values circled reflect the degree of evidence for design goals: (5) Exceptional/Exceeds Standard When Possible; (4) Meets Very Effectively; (3) Meets Somewhat Effectively; (2) Almost Meets/Inaccurate or Unclear; (1) Attempts/Irrelevant; (0) No attempt. *Please note: to meet any design goal below, all aspects listed in the standard (i.e. row) must be met.*

<b>Introduction. (10)</b> a-Team Introduction, responsibilities & design rationale; b-Design problem restatement with background.						
a. Creative introduction of <b>team members, responsibilities &amp; design rationale.</b>	5	4	3	2	1	0
b. <b>Clear restatement of problem</b> with <b>sufficient background</b> provided (key facts, conditions, events prior to project & previous work).	5	4	3	2	1	0
<b>Subtotal</b>	<b>/10</b>					
<b>STEM Explanations &amp; Quality. (25)</b> a-Scope, b-Factors Not Addressed, c-Factors Addressed, d-Math/Science Concepts, e-Engineering/Tech Concepts.						
a. Thorough description of <b>scope including key design parameters/constraints.</b>	5	4	3	2	1	0
b. Clear explanation of relevant <b>factors the team chose not to address</b> and why.	5	4	3	2	1	0
c. Clear explanation of <b>specific factors/ variables team addressed</b> /optimized for and why.	5	4	3	2	1	0
d. A precise, succinct description of 3-4 <b>Math/Physics/Science concepts</b> that informed design, including advanced concepts if used.	5	4	3	2	1	0
e. A precise, succinct description of 3-4 <b>Engineering / Technology</b> challenges or solutions, incl. advanced concepts if used.	5	4	3	2	1	0
<b>Subtotal</b>	<b>/25</b>					
<b>Design Process / Approach. (25)</b> a-Approach, Methods & Timeline, b- Research impact; c- Design & Testing Impact; d- Notebook as visual aid; e- All observations follow from R&D.						
a. Brief overview of team’s design <b>approach, methods</b> and <b>timeline.</b>	5	4	3	2	1	0
b. Clear explanation of <b>how team’s research informed at least two (2) design choices.</b>	5	4	3	2	1	0
c. Clear explanation of <b>how design &amp; testing informed at least four (4) design choices.</b>	5	4	3	2	1	0
d. <b>Engineering Design Notebook</b> effectively utilized as visual aid at least two (2) times.	5	4	3	2	1	0
e. <b>All observations</b> & conclusions well-thought out, accurate, & clearly <b>follow directly from research &amp; design process.</b>	5	4	3	2	1	0
<b>Subtotal</b>	<b>/25</b>					
<b>Oral &amp; Visual Overall. (15)</b> a-Shared presentation/appearance, b-Projected Voice/Eye Contact, c- Engaging Focus/Flow.						
a. <b>ALL students share equally in presentation.</b> Student <b>demeanor &amp; appearance</b> well suited for event.	5	4	3	2	1	0
b. <b>ALL voices heard &amp; understood.</b> <b>Eye contact</b> is distributed across the audience.	5	4	3	2	1	0
c. <b>Engaging Focus &amp; Flow.</b> Team stayed very focused on the topic & transitioned very smoothly from point to point. <b>Engaging</b> activities & discussion captured & maintained audience/judge attention very well.	5	4	3	2	1	0
<b>Subtotal</b>	<b>/15</b>					
<b>Presentation Total (Pre-deduction)</b>	<b>/75</b>					
<b>Deductions</b> (e.g. 5 pts if not wearing T-shirt; 5 pts if not within time limits)	<b>/10</b>					
<b>PRESENTATION Total</b>	<b>/75</b>					

<b>Combined Academic Poster Presentation TOTAL:</b> ( <i>Display _____ + Presentation _____</i> )	<b>/150</b>
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Judge Name:

Comments:



**Itemized Budget Sheet SAMPLE**

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>
<b>TOTAL COST</b>						



**2014-2015 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

```

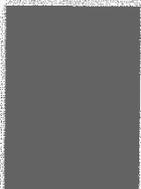
=====
ITEM - 12345          2 @ 12.34 = 24.68
SECOND - 98765       2 @ 15.00 = 30.00
THIRD - 44887744     2 @ 5.00 = 10.00
=====
SUBTOTAL = 64.68
TAX 10% = 6.47
TOTAL = 71.15
  
```

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

THANKYOU FOR SHOPPING AT  
ACME

**Printed page from National Retailer Website**

05/12 1 x 12 x 8 #2 Whitewood Pine Board 545-458538 at The Home Depot



**1 x 12 x 8 #2 Whitewood Pine Board 545**  
Model # 458538 Store SKU # 458538  
★★★★★ Write The First Review  
**\$15.65 /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 fairly 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](#)

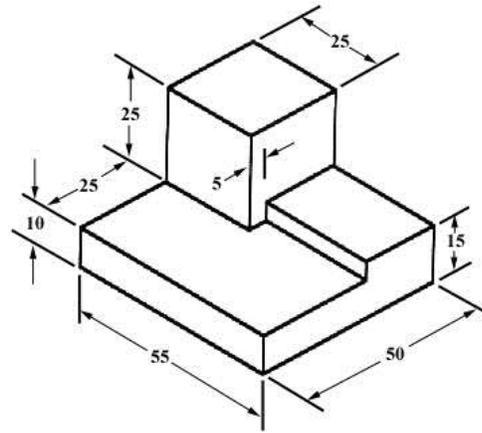
**SPECIFICATIONS**

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.)	6	Nominal Width	12 in
Nominal product width	12	Portion of product made	

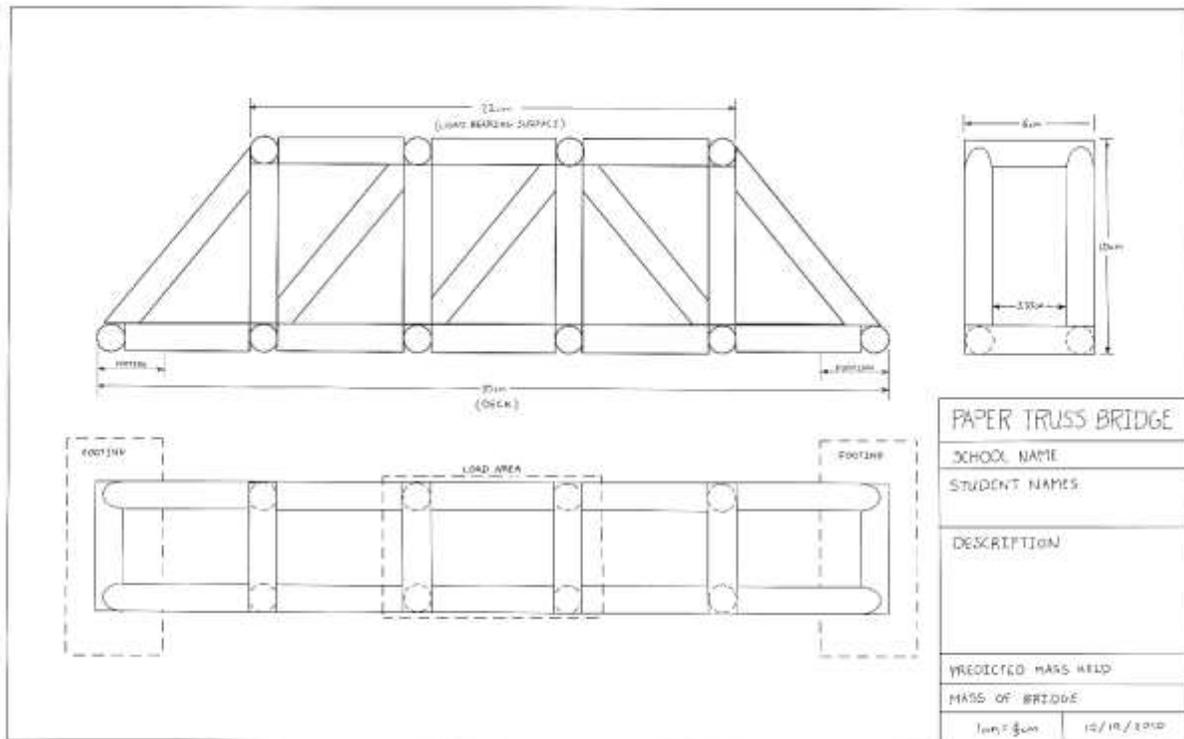
[somedepot.com/Lumber-Composites-Boards/A\\_d1/N-5yc1vZbqmc/R-100922337/A\\_d2/ProductDisplay?](http://somedepot.com/Lumber-Composites-Boards/A_d1/N-5yc1vZbqmc/R-100922337/A_d2/ProductDisplay?)

1/2

Isometric Drawing with Dimensions<sup>1</sup>



Orthographic View<sup>2</sup>



1. Blanco, Ernesto E., David G. Wilson, Sherodaly Johnson, and LaTaunynia Flemings. "Engineering Drawing and Sketching." *Engineering Drawing and Sketching*. University of Minnesota Mechanical Engineering Department, n.d. Web. 25 July 2013. <<http://www.me.umn.edu/courses/me2011/handouts/drawing/blanco-tutorial.html>>.
2. Moriarty, Dylan. Paper Truss Bridge Drawing. Digital image. Arizona MESA, 26 Oct. 2010.



**2014-2015 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 [competition\\_rules@mesausa.org](mailto:competition_rules@mesausa.org).

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  
Rules  
Scoring

Performance Tasks  
Judging  
Other

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

Comments: