MESA USA
NATIONAL ENGINEERING DESIGN COMPETITION
2017-2018
MESA Arduino STEM Solutions

RESOURCE DOCUMENT

This document provides critical information to assist teams in successfully meeting all competition requirements, including detailed descriptions and examples of various required elements.

PROJECT REPORT

Using Your Engineering Design Notebook as a Foundation for Your Report

Everything you do to prepare for this competition – be it your design brainstorming, your sketching of possible approaches, your informal and formal research, 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 tracks your ideas, your progress, your letdowns, your innovations, your interviews, your drawings and your data. 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 report, you should have most everything you need in that notebook to write a strong project report.

Refer to the Project Report Rubric to further guide you to ensure you are covering all scoring aspects within your report. Make sure to have others review your report using the rubric to provide feedback. The report you submit should not be your first draft.

Contents (Detailed description of each key section is as follows):

A. Title Page

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

B. Problem Statement

This section is an engaging, synopsis of your problem. It should be written using minimal technical terms. It should describe, in detail, the client and their need(s), what need(s) your project is addressing and why, and any limitations you found as you worked through the Engineering Design Process.

C. Design Process

This is the longest section of the report. This section should guide the reader through your entire project showing a clear connection between each stage (Inspiration to Ideation to Implementation). 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) that is embedded in the report. As you explain your process and points, make sure to refer to the appropriate graphic within the paragraph in which it first becomes relevant.

1. Discuss your team's design process, including:
   - *a.* *Process Overview.* Clearly overview your team's design process.
   - *b.* *Research.* Make certain to discuss; prior knowledge about the problem brought by team members; interviews with clients discussing the issue and their needs; and other research done to understand the client's needs, explore current solutions, and information gathered to assist in design process.
   - c. *Design Process/Testing.* 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? How did you ensure that the client's needs were accounted for during the process?
   - d. *Prototype Development* – discuss the evolution of your design including how the client's needs connected to the testing, data analysis, and changes between iterations of the design.

   e. *Discussion of electronics hardware integration.* Detail the integration of the electronic hardware components into your solution. Discussion should include breakthroughs, challenges and compromises made to integrate these components.
   f. *Discussion of Software development.* Clearly describe the development of the code used to control the electronic components. A copy of your commented code should be included in the appendix (See samples on page 18).
   g. *Conclusion and Recommendations.* Clearly define conclusion and recommendations that demonstrate a thorough reflection on the process and final design and include specific suggestions for further development.
2. Quality and Thoroughness
   a. *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 for the client to use? 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?
   b. *Testing Procedures.* Clearly describe your experimental procedures and test setup, including relevant pictures or diagrams.
   c. *Math and Science Concepts.* Clearly articulate what Math and Science concepts were used throughout the process.

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. Results
This section should be about the final iteration of the prototype. It should include why your prototype is a viable solution for your client(s) and what the strengths are.

G. Recommendations

This section should include what your next steps are. If your prototype needs further development, what would you like to do? If your prototype is ready for production, what steps would you take to start the process? This sections should include language about the future and what you would do given more time to work on the prototype, or suggestions to help others who may continue to work on the project.

H. Data

This section is for the data you collected during testing and referenced in the Design Process section. The data should be clearly related to important design steps and improvements. It should include charts, graphs, tables, etc. with a brief explanation of the data (Title, labeled axis, etc.). Any equations you used should also be in this section is a description of the equation, labeled variables, and purpose.

I. Appendix

Please be sure to also include here the following:

a. Commented Arduino Code: What is the code that you used? Did you comment it so the reader can understand the variables and what they do, the different sections of the code and what they do, and what the outputs represent? Examples of Commented Code are included in this guide.
b. Detailed Budget Sheet: A sample budget sheet is included below. The budget sheet should help an investor understand the cost of parts for production. Receipts ARE NOT required.

J. 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.. We encourage you to seek at least eight (8) highly relevant sources that are appropriately formatted.

TECHNICAL INTERVIEW

As the title states this is a technical interview, which means, that judges will be looking to understand the most technical aspects of your project with a focus on the final design. Any information presented should be connected to elements of this final design and help the judges understand how this prototype evolved out of the design process, including how research, design, and testing led to specific design elements. Specific information about how the client's needs are met, and the integration of Arduino are also very important.

The technical interview is made-up of three elements: the poster, the presentation with demonstration, and the interview. While each will be scored separately, all three should work in conjunction to provide an overview of the technical functionality of the presented device.

TECHNICAL INTERVIEW - POSTER

The poster as part of the Technical Interview is meant to be a visual overview of your final design. At the National Event posters will put on display in a symposium in addition to be used during the interview. The poster should be able to stand alone to provide the viewer; a clear understanding of the project; key steps in the design process that led to this design; and the functionality of the prototype including Arduino hardware and software.

All posters must be printed for the National Event. Posters can be designed using PowerPoint and templates are available. For additional resources on Academic Poster Design visit http://gradschool.unc.edu/academics/resources/postertips.html#design.

All posters must have a title, team information, and the official MESA logo (contact your state office for a logo).

POSTER Elements (detailed description by Section)

1. ***Objective:*** This section should include a brief discussion of user requirements, highlight design choices made to meet client needs, and overview desired attributes and qualities. A person reading the objective should be able to understand scope of the project and priorities in design in the 30 seconds it takes to read it.
2. ***Engineering Design Process:*** Provide viewers with the following:
   a. Your team's methodology and process. How did you make your design decisions? What steps did you use to ensure your design met your client's needs?
   b. What challenges did you find? What were the team's solutions to those challenges? You will want to describe where you had difficulty and how you overcame that.
   c. Are there any competing products on the market for your client's needs? Why is your design a better fit than something currently available? You will want to research the competition and describe the advantages of your design over a competing product.
   d. What research and testing led to the design choices you made? As you moved through multiple iterations of the Engineering Design Process, you will do research and make discoveries. This section will describe what you learned and how it led to your solution.
3. ***Results/Data Section(s).*** Show team exploration and testing of final device design by including the following:
   a. Charts and/or graphs that demonstrate the data collected and analyzed that led to major design choices.
   b. A representation of the code used. It can be a schematic, block-logic diagram, or function block diagram.
4. ***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.
5. ***Support Materials.***
   This section is to add any additional details the team feels need to be added to help understanding and/or enhance the visual appeal. It could include, but is not limited to:
   a. Diagram/schematics of the prototype
   b. Relevant pictures, testing conditions or labeled parts. Include scale if needed.
   c. Commented Arduino code or Logic Diagrams

Overall, teams are also encouraged and expected 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.
- 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.
- 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 from the beginning of your project to the end.

TECHNICAL INTERVIEW – PRESENTATION WITH DEMONSTRATION –

The presentation and demonstration is the second part of the technical interview. Teams are expected to provide a verbal overview of their project focusing on the development of the final prototype in a 3-5 minute presentation. The poster must be used to support the presentation, but other visual aids like the engineering design notebook may also be used.

The team will also be given 3-5 minutes to demonstrate the functionality of their prototype. This is where teams can demonstrate to judges the individual elements of the prototype. The focus should be on the team's success in engineering the prototype. Functionality, hardware and software integration, specific features or elements that set the design apart from others should be highlighted.

Overall, keep in mind the following guidelines for the presentation:

- All team members should share equally in your presentation. No matter what approach you take, please make sure your team's demeanor and presence is well suited for the event.
- All team members' voices should be heard and understood by all judges. All team members' eye contact should be distributed across the audience.
- 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.

TECHNICAL INTERVIEW – Q&A WITH JUDGES –

The Q&A with judges may be the most important part of the interview as it allows the judges to dig deeper into the team's thought process and design choices. Although judges will be provided with a set of prompting questions, the point of the Q&A is to provide time for the team and judges to have an open discussion about the prototype. Judges will be able to ask about elements that they were curious about that may have been missed in the presentation. Judges may ask for more specific detail about why one material was chosen over another, or why coding processes were done a certain way versus another.

PROTOTYPE PITCH

In addition to the technical interview, teams will deliver a pitch for their solution. During the prototype pitch, teams will "sell" their idea to a group of "investors" (i.e., the judges). The pitch should be engaging and informative. The judges will consider how well the team presents details of the prototype design, the design process, the impact of the prototype on the target audience, and the overall quality of the presentation.

Elements of the prototype pitch:

The prototype pitch consists of four elements: *Problem Definition*, *Prototype Description*, *Prototype Demonstration*, and overall *Presentation Quality*.

Problem Definition: The judges and audience should gain a clear understanding of the problem that is being addressed. The presentation should include:

- Discussion of all significant variables and aspects of the problem.
- Information about the client base including market size (population), market location, and market area.
- Impact of the problem on the client/end user.
- Specific information gained from the client.
- Ways the problem is being currently addressed and weaknesses of these solutions.

Prototype Description: The judges and audience should gain a clear understanding of the design process as well as the advantages of the team's prototype. The presentation should include:

- Research related to the problem.
- Discussion of how the design process (including testing) led to the prototype.
- Advantages of this prototype over existing solutions.

Prototype Demonstration: The judges and audience should gain a clear understanding of the functionality and usability of the prototype. The demonstration portion of the prototype pitch should include:

- Explanation of all features and functions of the prototype.
- Demonstration of the fully functional prototype.
- Demonstration of ease of use.
- Demonstration of how quickly, easily, and intuitively a user can learn to operate the prototype.
- Next steps needed to bring the prototype to the client.
- Discussion of scalability of the solution.

Presentation Quality: The judges and audience should be engaged and informed by the prototype pitch. The presentation should include:

- Introduction of all team members and equal participation of all team members.
- Effective speaking practices (e.g., appropriate tone and pace, flow, volume, clarity, etc.)
- Body language that uses natural gestures and portrays confidence.
- Effective organization (i.e., strong and inviting introduction, focused and clear body, and effective and unifying closing)
- Content which demonstrates deep understanding of ideas, concepts, themes, and information related to the problem.
- Creativity and/or use of visual aids that contribute to a compelling presentation.

Teams are also encouraged to be creative and dynamic when presenting the prototype pitch. For instance, teams may choose to interact with the panel of judges or the audience during the pitch. Remember, the goal is to convince the "investors" that the team has a great, marketable idea. Teams are encouraged to use PowerPoint as part of the prototype presentation as well as video clips and other audio and visual aids.

HUMAN CENTERED DESIGN

Human-Centered Design is at the heart of this challenge. Identifying a client and researching their needs should be the first step a team takes. The client and their needs will then inform the entirety and be present in every step of the design process.

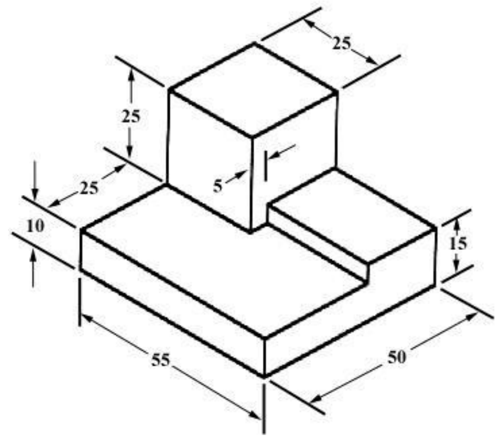
This may be a new approach to your MESA project so if you need assistance in understanding HCD and guidance in starting check out the following resources:

1. IDEO.org – A company with HCD at its core. Learn more about them and their approach.
2. IDEO's Design Kit – dig deeper into HCD with this kit.
3. Stanford's Design School Wallet Project – Project to help you practice HCD

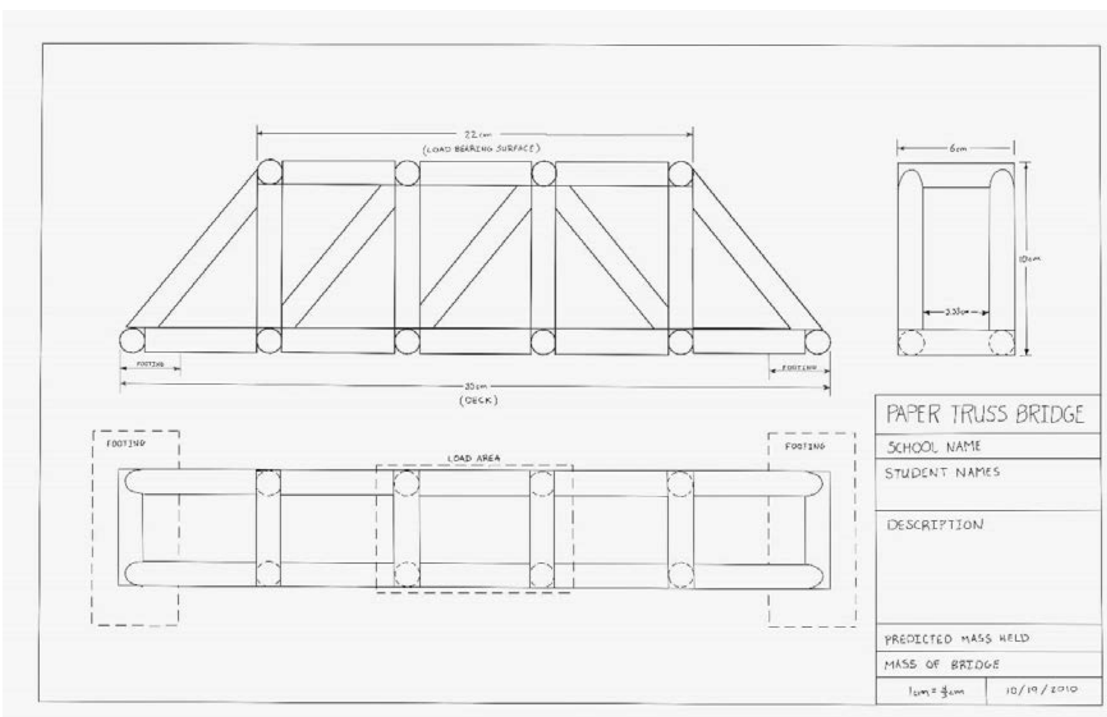
ISOMETRIC & ORTHOGRAPHIC DRAWING SAMPLES

Isometric Drawing with Dimensions[1]

- For more information on how to create isometric drawings visit http://www.me.umn.edu/courses/me2011/handouts/drawing/blanco-tutorial.html



Orthographic View[2]



1. Blanco, Ernesto E., David G. Wilson, Sherodalyn 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 .

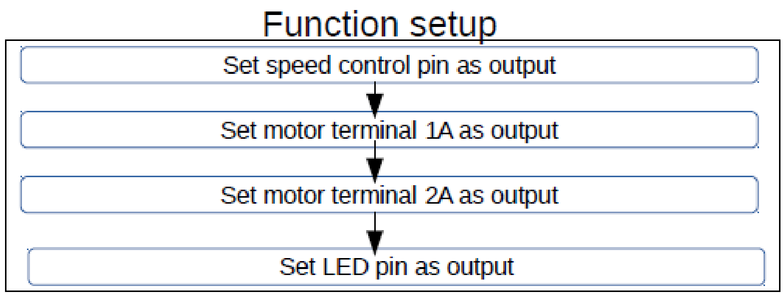
2. Moriarty, Dylan. Paper Truss Bridge Drawing. Digital image. Arizona MESA, 26 Oct. 2010.

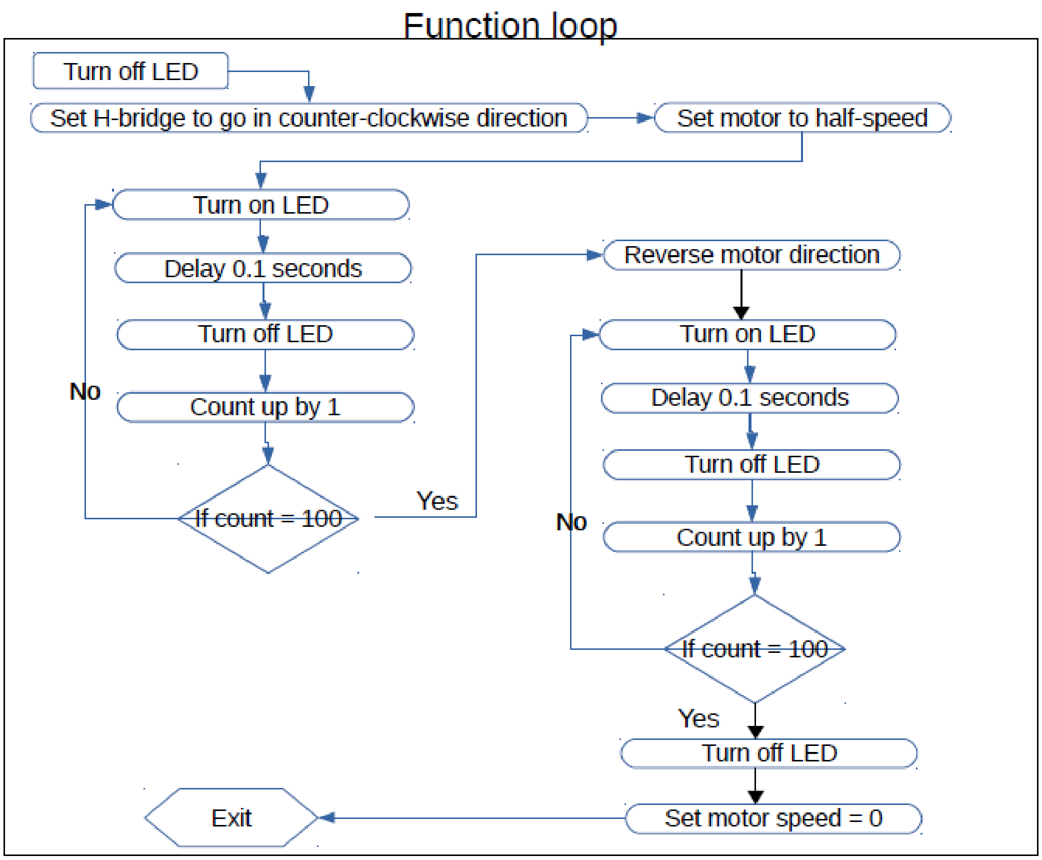
BLOCK LOGIC DIAGRAM SAMPLE

The logic shown demonstrates:

A. Configuring the Arduino input and output signals;
B. Driving the motor first in one direction for 10 seconds, and then reversing the motor direction for another ten seconds;
C. Turning the LED off and on during the running of the motor; and,
D. Exiting the program.

Note: This is only a sample. Please research and use a diagram design that makes sense to you and will be easy for others to follow.





COMMENTED CODE EXAMPLE

```
// Solar Tracker
// Written by Michael Klements

# include < Servo.h>.

Servo tracker; // create servo object to control a servo
int eastLDRPin =0; // Assign analogue pins
int westLDRPin= 1;
int eastLDR=0; // Create variables for the east and west sensor values
int westLDR=0;
int error=0;
int calibration= 204; // Calibration offset to set error to zero when both sensors receive an equal amount of light
int trackerPos=90; // Create a variable to store the servo position

void setup ( )
{
        tracker. attach (11) ; // attaches the servo on pin 11 to the servo object
}
void loop ( )
{
eastLDR =calibration + analogRead (eastLDRPin) ; // Read the value of each of the east and west sensors
westLDR = analogRead (westLDRPin);
if (eastLDR<350 & & westLDR<350) // Check if both sensors detect very little light, night time
{
while (trackerPos<=160) // Move the tracker all the way back to face east for sunrise
        {
        tracker Pos++;
        tracker. write (tracker Pos);
        delay (100) ;
        }
}
        Error= eastLDR - westLDR; / / Determine the difference between the two sensors.
        if (error > 15) // If the error is positive and greater than 15 then move the tracker in the east direction
{
        If(trackerPos<=160) // Check that the tracker is not at the end of its limit in the east direction
{
        trackerPos++;
        tracker. write (trackerPos ); / /Move the tracker to the east
        }
}
else if (error<-15)   // If the error is negative and less than —15 then move the tracker in the west direction
{
        if (tracker Pos > 20) // Check that the tracker is not at the end of its limit in the west direction
        {
        trackerPos--;
        tracker.write (trackerPos) ;/ / Move the tracker to the west delay (100);
}
```

PSEUDOCODE SAMPLES

Pseudocode is an informal description of your programming logic. It should summarize and/or outline the program's steps and should not contain any code syntax or underlying technology considerations. **Most importantly it should make sense to you and be easy for others to follow.**

Below are examples of what pseudocode could look like for the program described in the Block Diagram sample on page 13.

Sample 1:

The "setup" function:
    Speed control is an output
    Motor terminal "1A" is an output
    Motor terminal "2A" is an output
    LED pin is an output
    Set motor_max_speed to 100*Note: maybe speed can take on a different value?*

The "main" function:
  Turn LED OFF then:
  Set H-bridge_dir to "counter-clockwise"
  Set motor speed to (motor_max_speed) * 0.5 *Note: half of my max speed*
  Set counter to 0
  IF counter does not equal 100 THEN:
    Turn on LED
    pause for 0.1 seconds
    Turn off LED
    Add 1 to counter
  OTHERWISE if counter equals 100:
    Note: whatever direction I'm in, go the opposite
    IF h-bridge_dir is set to "clockwise", set to "counter clockwise
    OTHERWISE if its set to "counter clockwise", set it to "clockwise"
    Set counter to 0
    IF counter does not equal 100:
        Turn on LED
        pause for 0.1 seconds
        Turn off LED
        Add 1 to counter
    OTHERWISE if counter equals 100:
        Turn off LED
        Turn off the motor
        EXIT the program

Sample 2:

Set-Up Function
    Speed control is an output. Motor terminal "1A" is an output. Motor terminal "2A" is an output
    LED pin is an output. Set motor_max_speed to 100.*Note: maybe speed can take on a different value?*
Main Function
  Turn LED OFF. Set H-bridge_dir to "counter-clockwise." Set motor speed to (motor_max_speed) times 0.5 *Note: half of my max speed.* Set counter to 0. IF counter does not equal 100. Turn on LED. Pause for 0.1 seconds. Turn off LED. Add 1 to counter. OTHERWISE if counter equals 100. *Note: whatever direction I'm in, go the opposite.* IF h-bridge_dir is set to "clockwise", set to "counter clockwise. OTHERWISE if its set to "counter clockwise", set it to "clockwise." Set counter to 0. IF counter does not equal 100. Turn on LED. Pause for 0.1 seconds. Turn off LED. Add 1 to counter. OTHERWISE if counter equals 100. Turn off LED. Turn off the motor. EXIT the program

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**	**Receipt**
6061 Aluminum flat	*1/8" x 1/2" x 24"*	*$1.98/flat*	*$0.0825/inch*	*10 inches*	*$.0.82*	*Metalsdepot.com*	*1*
Masking Tape	*1 inch x 60 yards*	*$4.02*	*$0.0019/inch*	*12 inches*	*$0.02*	*TheSupplyTree.com*	*2*
				TOTAL COST			

* A spreadsheet that will automatically calculate the budget has been created and is available for teams to use. Contact your state representative or visit the MESA USA website for a copy.

QUESTION AND FEEDBACK PROCESS

When asking for clarification on the National Competition Rules or for any other question about the National Competition the following process will be used:

1. Teams must contact their state representative via email (see the list below).*
2. If possible, the state representative will respond via email. This question and the response will also be provided to other schools within that state.
3. If necessary, the representative will contact the National Rules Committee to discuss the question. The committee's decision will be relayed to all states for public distribution and the question will be listed on the national FAQ list on the MESA USA website (MESAUSA.ORG).

* Questions sent directly to the National Rules Committee will be rerouted to the state representative.

State Representatives:

- Arizona – Manny Leon (leon@arizona.edu) or Bill Pike (wpike@email.arizona.edu)
- California – Carlos Gonzalez (carlosg@engr.ucr.edu)
- Colorado – contact National Committee at nationalcompetition@mesausa.org
- Illinois – Lauren Thompson (lthomp21@csu.edu)
- Maryland – Jason Cartwright (jason.cartwright@jhuapl.edu)
- New Mexico – Anita Gonzales (anita@nmmesa.org)
- Oregon – Tamara Depue (tdepue@cecs.pdx.edu)
- Pennsylvania –Gina Bloise (tud52490@temple.edu)
- Utah – contact National Committee at nationalcompetition@mesausa.org
- Washington – Debbie Blas (Debbie.blas@wsu.edu)