MESA USA
NATIONAL ENGINEERING DESIGN COMPETITION (PILOT)
2016-2017

ARDUINO RESEARCH & DESIGN CHALLENGE

Objective:

Student teams will conduct a research project that uses at least one sensor with Arduino to collect data. Teams will then use the results of their project to implement the Engineering Design Process and develop an Arduino-based prototype of a product that addresses the chosen issue.

Research projects must address a community challenge around the theme of water. Water is one of the building blocks of life and in today's world there are many challenges that communities face in regards to water. Below are some the most common challenges and some problem statements to get started, **but** your team can choose any water-based community challenge to research. These challenges and problem statements are not all inclusive. You can go in many other directions if you choose to do so.

Common Water Challenges

- Access to clean drinking water
  - Proximity - Distance to Source
  - Contamination
  - Sanitation and Wastewater Treatment
- Agriculture
  - Irrigation Methods
  - Irrigation Automation
  - Sustainability (Aquaponics or Hydroponics)
- Abundance/Shortage
  - Flooding
  - Drought
  - Watershed Management (Aquifers, Harvesting)
  - Overuse or Waste

Problem Statements:

Agriculture

- States are putting water restrictions on farms and ranches. How can we monitor and control water usage and continue to grow crops?
- Aquaponics are becoming more popular in commercial farming. How can we design a system that maximizes output while minimizing water usage?
- Water consumption by animals is an issue. It can also include evaporation of water, freezing of water, and purity of water. Can we monitor the water for animals?

Quality

- Clean drinking water is necessary to maintain a healthy life. Can we monitor water to ensure water is free of pollutants? Or measure the level of pollutants?
- Cities create problems with runoff by building impervious surfaces (i.e. roads, curbs, etc.). Water then either creates floods on roads and/or becomes polluted. How can we work to redirect surface runoff?

Atmospheric Monitoring

- Severe thunderstorms and flash flooding is becoming more prevalent. Can we monitor the atmosphere to provide warning of these types of storms?
- Can we monitor the environment to predict when it might rain so we can turn off the watering system to our garden/crops?

Conservation

- In some places, people are being asked to cut down on their residential water usage. Can we create a device that measures the water usage of a faucet and let the user know when they have used a certain quantity of water at one time?
- Up to 70 percent of water use is outdoors, so managing landscape/garden water use is one of the easiest ways to save water around the home. Can we design a device that only waters the lawn/garden when it is needed and/or water in a way that conserves water?

Student projects will be assessed on the following components:

1. Project Briefing - a 15-minute presentation with Q&A of the project including:
    a. Definition of the problem addressed
    b. Criteria and constraints of the project
    c. Team's methodology and research
    d. Data collection device demonstration
    e. Prototype description and/or demonstration
    f. Evaluation and conclusions of the project
2. Arduino-based design
    a. Technical Implementation and use of Arduino
    b. Demonstration of the Arduino-based products
3. Quality of required deliverables

Scoring Summary:

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

- Introduction of team members and responsibilities ....20 points
- Team Research and Methodology..35 points
- Arduino Design Specifications and Implementation.....................35 points
- Project Evaluation ....15 points
- Evaluation of Presentation Skills ....15 points
- Project Deliverables (Report & Design Notebook).......................30 points
- **Total Points ....150 points**

Safety Rules:

1. Students must operate their device(s) in a safe manner. The device(s) may only be activated when directed by the judges. Teams using UNSAFE PROCEDURES may be disqualified or penalized at the discretion of the judges.
2. The device(s) must not pose a danger to students, officials, spectators or cause damage to the host facility, as determined by the judges.

General Rules:

1. Teams must:
   a. Design and conduct a research project that uses at least one sensor with Arduino to collect data. Teams must demonstrate the data collection method to judges.
   b. Use the results of their research project to develop an Arduino-based prototype of a product that addresses chosen issue. Teams must present the prototype to judges
   c. Prepare and present a 15-minute Project Briefing and Q&A with supporting documentation and visual/graphical aids.
2. Each competing team must consist of 2-4 students who are active members of MESA.
3. Teams must submit the following project deliverables:
   a. Project Report: This document will summarize the performance and technical characteristics of your project. Document should be no longer than (10) pages, single sided.
      i. Title Page, should include School and Team member names.
      ii. Project Overview/Abstract
      iii. Bill of Materials. There is no budget limit, but materials used must be documented. No receipts are required. Teams are encouraged to use the MESA Cost template used for the National Competition.
      iv. Visual Data (Charts, Photos). These should be used during briefing. Include any Photos of Actual Data Collection Device and Photo(s) of Final Project.
      v. Wiring Diagram for any and all parts of the project that utilize Arduino.
      vi. Commented Source Code for any and all Arduino programming.
      vii. Evaluation and Summary

   b. Engineering Design Notebook. May be a physical copy or an electronic notebook.
4. There is no guarantee of electricity, internet, or computer availability at host location so testing device and prototype must be able to be demonstrated with materials brought to competition.
5. Teams are encouraged to build efficient designs with regards to size (for transport), cost, and use.
6. All material samples and device demonstrations must be self-contained and not expel liquid, dirt, or any other materials deemed "messy" or damaging.
7. Student teams are responsible for creation of all elements of their project. All members must be able to operate and add to the development of their project.
8. Student teams are solely responsible for all interaction with event judges and addressing questions about their team performance.

Project Briefing Details (15 minutes):

1. Teams are expected to present information about their project to a panel of judges.
2. Teams will be given a maximum of (10) minutes with a (5) minute Question and Answer Session. 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.
3. Project briefing must include:
   a. Definition of the problem addressed
   b. Criteria and constraints of the project
   c. Team's methodology and research
   d. Data collection device demonstration
   e. Prototype description and/or demonstration
   f. Evaluation and conclusions of the project
4. Visual Aids (i.e. design poster, PowerPoint, Project Report, props, models, and/or design notebook) should be used during the briefing.
5. 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.

Arduino Design Details:

1. Data Collection Device:
   a. Teams must design and build a data collection device. This must be an operational device to collect usable data for the research project.
   b. The data collection device must:
      i. Use a minimum of (1) Arduino Sensor to collect data critical to the research
      ii. Deliver measurable data that is used to analyze the defined issue.

   c. Teams must be able to demonstrate data collection device and the device must be physically present at time of competition.
      i. Demonstration must be a live demonstration to simulate device ability. Example: Although soil moisture sensor used at a community site will give a different reading, teams must bring varying small samples to demonstrate collection method.
      ii. Demonstration must include a visual display of numerical data output. (I.e. Computer analog reading, display sensor showing quantity, etc.).
      iii. Demonstration must include the interpretation and knowledge of data output. This will include units of measurement and use of numerical data.
      iv. Teams must be prepared to demonstrate when called.

2. Prototype:
   a. Teams must develop an Arduino-based prototype to respond to collected data.
      i. Prototype can be a working device in response to research results.
      ii. Prototype can be a proof of concept model or drawing of a desired response to demonstrated testing.
   b. Teams must be able to describe data flow from “input” in data collection to “output” in prototype.
   c. Teams must be able to describe the function of the prototype in relation to the results of the data and its intended effect on the chosen issue.

PROJECT SCORING CRITERIA

Team Members:____

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.*

I. Introduction and Definition of the Problem (20 pts)						
a. Introduction of **team members** and **responsibilities**	5	4	3	2	1	0
b. Clear **statement of problem** with key parameters and performance criteria	5	4	3	2	1	0
c. **Existing solutions** for the problem are thoroughly explored and defined	5	4	3	2	1	0
d. Identification of **project impact** on the **community**	5	4	3	2	1	0
Subtotal						**/20**
II. Team Research and Methodology (35 pts)						
a. Research conducted into design idea and problem shows understanding of related scientific concepts and their relation to the chosen challenge.	5	4	3	2	1	0
b. Design is unique from current solutions and reasoning behind improvements is explained	5	4	3	2	1	0
c. Thoroughly stated the meaning behind the specific type of data used for the design	5	4	3	2	1	0
d. Identified the data collection method and the benefits of the specific technique	5	4	3	2	1	0
e. Research data is thoroughly identified and clearly summarized using a graph or chart.	5	4	3	2	1	0
f. Analysis of data summarizes its significance and relationship to the problem and solution	5	4	3	2	1	0
g. Potential sources of error in data collection are identified	5	4	3	2	1	0
Subtotal						**/35**
III. Arduino Design Specifications and Implementation (35 pts)						
a. Copy of **source code** is included and contains **comments** explaining function of each line for both the research methods and prototype (if applicable)	5	4	3	2	1	0
b. **Arduino sensors** are accurately and effectively utilized in data collection	5	4	3	2	1	0
c. **Circuit design** is explained and a wiring diagram or schematic is shown to illustrate its layout	5	4	3	2	1	0
d. **Implementation of hardware** in actual data **collection environment** is documented with a photograph or diagram	5	4	3	2	1	0
e. Multiple **prototype iterations** demonstrate progressive improvement in design	5	4	3	2	1	0
f. **Final prototype** is of high quality and is indicative of a **thoughtful engineering** approach	5	4	3	2	1	0
g. Design solution produces useful **output** in response to input of data from sensor	5	4	3	2	1	0
Subtotal						**/35**

IV. Project Evaluation (15)						
a. **Recommendations** for future designs are identified and **scalability of solution** is analyzed.	5	4	3	2	1	0
b. Solution demonstrates **benefit to community** and is shown to mitigate initial problem	5	4	3	2	1	0
c. Final design solution is **evaluated** relative to original **performance criteria** and **design constraints**	5	4	3	2	1	0
Subtotal						**/15**
V. Evaluation of Presentation Skills (15)						
a. Each team member **equally contributes to presentation**. Student **demeanor and presence** is well suited for event.			3	2	1	0
b. **ALL voices heard** & understood. **Eye contact** is distributed across the audience.			3	2	1	0
c. Team stayed focused on the topic and transitioned smoothly between critical points.			3	2	1	0
d. **Engaging** activities and discussion captured and maintained judges' attention throughout presentation.			3	2	1	0
e. Engineering Design Notebook is used as a visual aid and referenced throughout discussion of design process.			3	2	1	0
Subtotal						**/15**
VI. Deliverables (Project Report & Design Notebook) (30)						
a. **Quality of Project Overview/Abstract & Project Evaluation and Summary**	5	4	3	2	1	0
b. **Quality of Bill of Materials**	5	4	3	2	1	0
c. **Quality of Visual Data (Charts, Photos)**	5	4	3	2	1	0
d. **Quality of Wiring Diagram**	5	4	3	2	1	0
e. **Quality of Commented Source Code**	5	4	3	2	1	0
f. **Quality of Engineering Design Notebook**	5	4	3	2	1	0
Subtotal						**/30**
Project Subtotal (Pre-deduction)						/150
Deductions (5 pts if not within time limit)	-					/5
PROJECT TOTAL						**/150**

*Judge Signature:*________________________________ *Student Rep Signature:*______________________________

Comments: