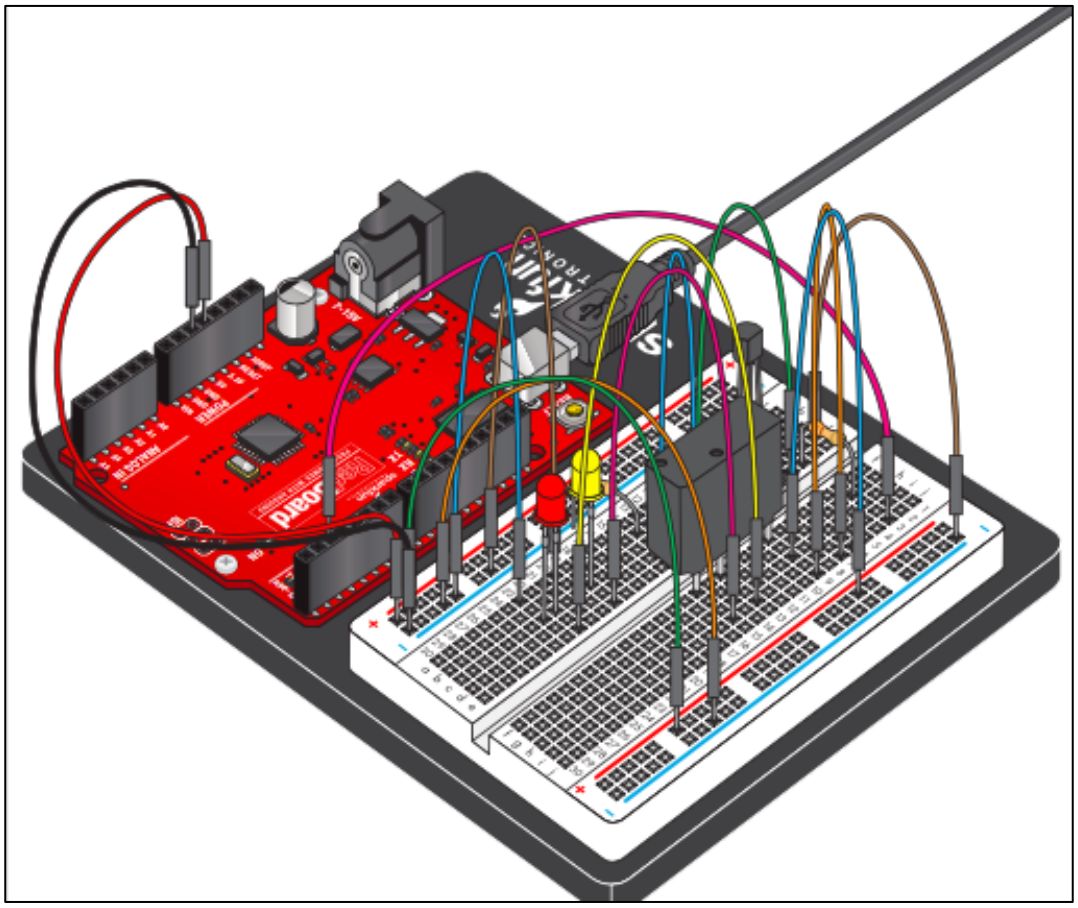
Senior Design Challenge: Drawbridge Simulation



McMaster University
ENGINEERING

Table of Contents:

Clubs & Teams:

Schedule:

Saturday, October 21st, 2017

2:30pm - 3:30pm	Registration & Orientation
3:30pm - 4:00pm	Opening Ceremony
4:00pm - 4:30pm	Setup/Divide Teams
4:30pm - 10:30pm	Construction/Design Period
10:30pm - 11:30pm	Qualifications Round

Sunday, October 22nd, 2017

8:30am - 9:30am	Breakfast & Setup
9:30am - 10:30am	Finalist Presentations
11:30am - 1:00pm	Lunch & Awards
1:00pm – 2:30pm	Networking (Sponsor Tables Setup)

Introduction:

Drawbridges are commonly found across rivers, lakes, and other waterways where we may need transportation both across and with the waterway. Although several drawbridge designs are present, they all work to serve the same function; to allow for traffic to flow in two ways with the use of pathways that can both open and close when needed. However, challenges arise when determining what design is the most efficient in opening/closing, causes the least maintenance, and is made of reliable and durable materials. Furthermore, many designs are now advancing in technology to create a drawbridge that has no human contact, and is entirely done through robotic automation.

The mechanism for an automated drawbridge has several factors to consider working efficiently. The bridge should be able to open and close over a waterway using sensors that efficiently detect traffic on the waterway. This should enable the use of motors that can open the bridge to allow the waterway traffic to pass through before closing for the road traffic. As stated before, many designs are possible of accomplishing this task, although constructing a design that can withstand the load of the bridge, is time efficient, and experiences no other problem or delay is crucial in developing a reliable automated drawbridge design.

Deliverables:

Two main deliverables are required at the end of the given time period, being:

- A prototype of your design, including a working demonstration.
- A short presentation/explanation of your design.

Prototype Testing:

Each group will present their design with a working demonstration to a panel of judges in their given time slot. This test will consist of multiple steps or phases to ensure that the drawbridge can complete all tasks with consistency.

> First, traffic will be placed in the waterway heading in the direction of the bridge. This step requires the motion sensor to detect the traffic and open the bridge accordingly.
>
> Second, the traffic must be able to pass through the open bridge without any interference.
>
> Third, the bridge must be able to close when the waterway traffic is out of jurisdiction of the drawbridge.
>
> Lastly, the road traffic should be able to pass across the bridge efficiently, with the bridge capable of handling the traffic's weight.

Throughout all steps, the LED's should be able to express the position of the drawbridge. For example, the red LED must light up for the road traffic when the waterway traffic is in motion, and the green LED must light up when the road traffic is in motion.

Presentation:

A short presentation of approximately 5 minutes is to be conducted by every group explaining their design and their thought process throughout the construction period. Some of the major points every group is expected to address include:

- Explain the design process; why did your group choose to use those materials? Why and how is your design reliable?
- Describe any changes that were made when creating your design. Justify and explain these changes.
- Explain any unique aspects of the design; why do you believe your design is more efficient than others?
- Briefly explain how your design works altogether.

The presentation is only required for students who advance to Sunday's finalist round. A total of only **FIVE** teams will advance from Saturday's qualifications round.

Materials List:

- The design store follows an "open market" concept, with materials given on a first come first serve basis, although the MEC has made an effort to have enough materials for all teams.
- Trading of materials with other groups is forbidden.
- There is no limit for how much each team may be able to purchase, although each team's budget is recorded and considered in the judging process.
- You may return unused materials to the store for 50% of the cost.
- The store will close 15 minutes before the competition end time, and is in **ETB B122.**

Material	Cost
Redboard Microcontroller	Included (1)
Gear Box Motor	Included (2)
Transistor	Included (2)
Diode	Included (2)
Resistor (250, 1000 and 10000 ohm values)	Included (of Each)
Jumper Wires (M to M, M to F, F to F)	Included (20 of Each)
Ultrasonic Sensor	Included (2)
Battery (9 Volt)	Included (1)
Breadboard	Included (1)
Battery to Barrel Jack Adaptor	Included (1)
Micro USB Cable	Included (1)
Glue Gun	Free (rental)
Glue Sticks	$1.00 (per stick)
Cardboard	$6.00 (per sheet)
Chip Board	$8.50 (per sheet)
Elastic Band	$0.25 (per band)
Toothpicks	$0.20 (per toothpick)
Popsicle Sticks	$0.75 (per popsicle)
Springs (assorted sizes)	$1.00 (per spring)
Wooden Dowels	$1.25 (per dowel)
Zip Ties	$0.50 (per zip tie)
Thumbtacks	$0.25 (per thumbtack)
Steel Wire	$1.00 (per foot)
Scotch Tape	$0.75 (per foot)
Masking Tape	$1.00 (per foot)

Duct Tape	$1.25 (per foot)
Beads	$0.10 (per bead)
Metal Ring	$0.75 (per ring)
Construction Paper	$0.50 (per sheet)
Paper Clips	$0.25 (per paper clip)
Aluminum Foil	$1.25 (per sheet)
Stretch Bands	$2.00 (per half foot)
String	$0.75 (per foot)

General Rules:

- All questions regarding the competition and case details must be addressed during the welcome and briefing session.
- Teams are not allowed to leave the competition until they have submitted their final presentation and report at the end of the construction period.
- Competitors can only use the approved resources and materials they are provided with or bought from the materials store.
- The “open market” store is open throughout the construction period with each team being given the same amount of credit to “buy” materials from the store. The store is at BSB 122.
- Competition rooms must be left in the same condition upon entering.
- Online communication tools (Messenger, WhatsApp, E-mail, etc.) and social media websites (Facebook, Twitter, etc.) are prohibited. Violation of this rule will result in immediate disqualification.
- Visitors are not allowed during the construction period. Violation of this rule will result in immediate disqualification.

Permitted Tools:

During the competition period, the following tools are permitted for use by competitors:

- Computers/Internet

Use of any other tools apart from what is stated above MUST be cleared by the competition director prior to use. Use of any unapproved tools will result in immediate disqualification.

Awards:

First Place: Win an Arduino Redboard kit, in addition to a fully covered trip to the OEC and a $75 prepaid card.

Second Place: $50 prepaid card

Third Place: $25 prepaid card

All 3 top finalists win an MEC sponsored hat, mug, and other cool swag!

Grading Scheme:

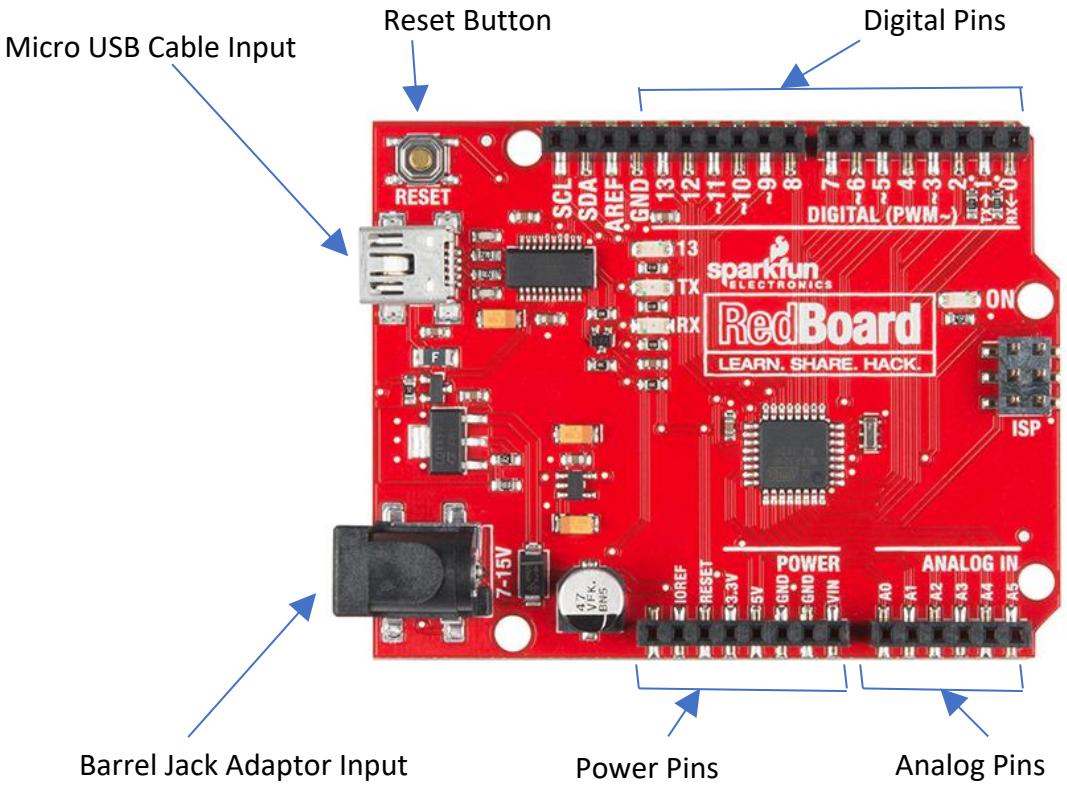
Scoring Rubric:

Category	Requirements	Scoring
Design & Performance	Does the design work? How well does the design meet the requirements of this project? Are all components used efficiently and coordinated with one another? Did the prototype pass the tests with no delay, human interaction, and interference?	/45
Team Work	Did the members of the team appear to work well as a team? Did all members make a fair contribution to the design process?	/10
Presentation	Were the benefits and design process clearly explained? Was the presentation within time limit? Did all team members make a fair contribution to the presentation?	/20
Creativity/Originality	Were the materials used effective in the goal of the project? Was the team's budget significantly high, significantly lower, or close to the relative average? Was the prototype able to withstand the load and still function efficiently?	/25

Penalties/Deductions	Misuse of time or late handing-in prototype (-3%/min) Prototype damages test set up table or surroundings, (-15%) Number of failed attempts (-2% x number of attempts)	

Technical:

Redboard (Microcontroller):



Reset Button: Used when restarting the code programmed on the Arduino.

Micro USB Cable Input: Used to connect the cable to the Arduino that is connected to a computer. Gives the Arduino power and allows for any code run on the Arduino software to be programmed to the Redboard.

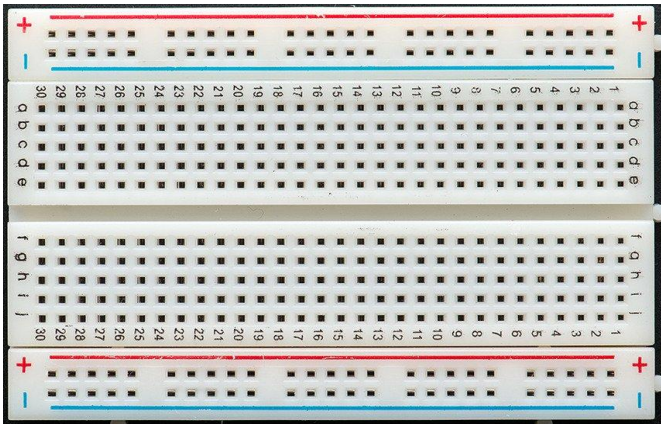
Barrel Jack Adaptor Input: Used to connect a battery source to the Arduino to give it power.

Power Pins: Includes 7 pins, with the 'GND' pins connected to the breadboards negative terminals. The pins with a listed voltage, such as the '5V' or '3.3V' pins are connected to the breadboards positive terminal. It is strongly encouraged to use the pin with the larger power, being the '5V' pin.

Digital Pins: Includes 14 pins, labelled from 0-13. These pins are used for connections with the breadboard components (such as the ultrasonic sensor, motor, LED's, etc.), representing the inputs and outputs of the Arduino.

Analog Pins: Includes 6 analog input pins, which are helpful for reading outputs which can vary in voltage. These pins can be used for functions such as controlling the speed of the motor or dimming a light bulb. The analog pins can also be used as digital input and output pins if need be.

Breadboard:

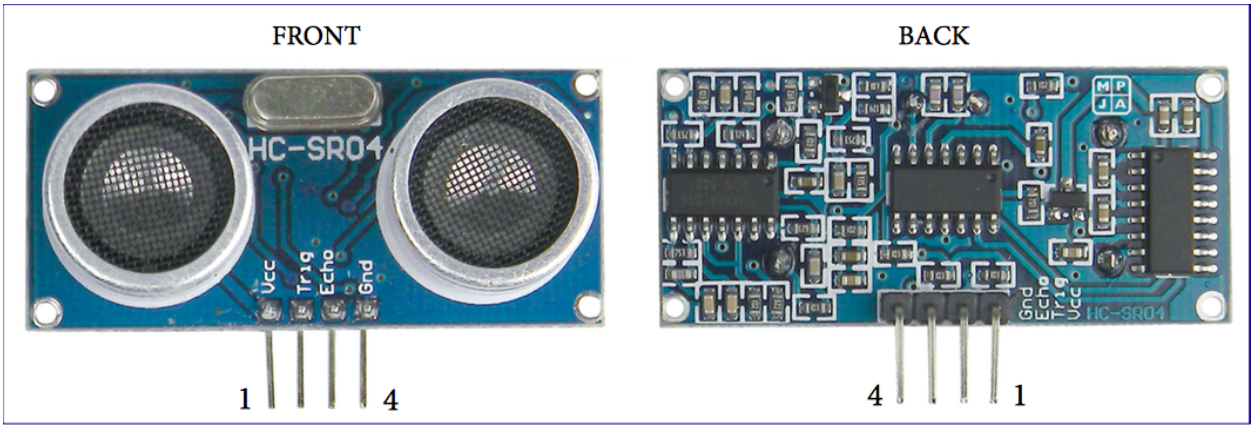


The breadboard is used as the platform for where all the electrical components (ultrasonic sensor, LED's, motor) are connected. From here, the inputs and outputs of the components can be connected to the Arduino.

The top and bottom rails (marked with blue or red) represent the power rails of the breadboard. The '+' and '-' represent the negative and positive rails. In addition, every column of the breadboard is interconnected, numbered from 1-30. However, the columns of the breadboard are not connected across the middle of the breadboard. Therefore, there is a top and bottom portion of the breadboard.

NOTE: The breadboard is NOT allowed to be permanently glued or fixed into any position on the drawbridge. In other words, the breadboard should be able to be replaced if need be.

Ultrasonic Sensor (Elegoo HC-SR04):



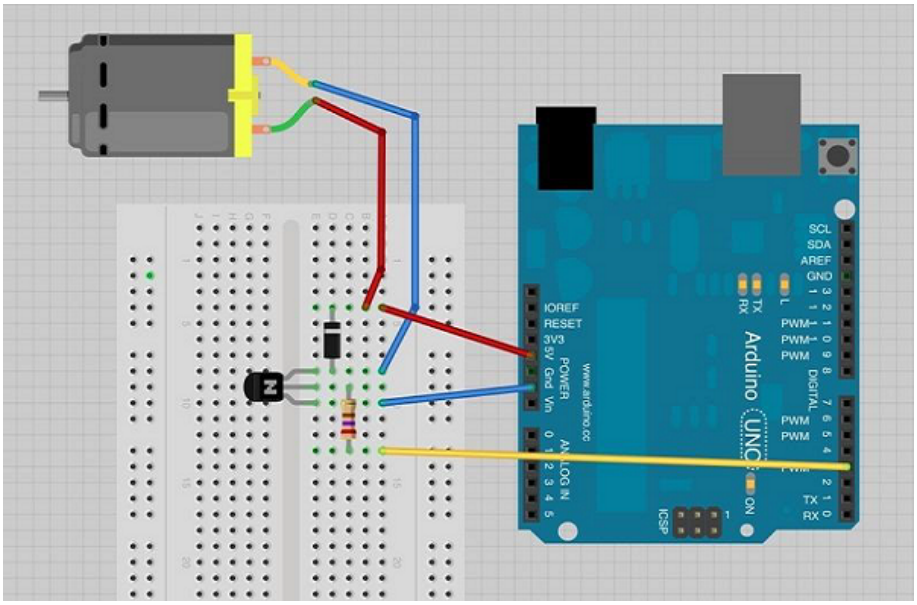
	Pin Symbol	Description
1	VCC	5V power supply, connected to either breadboard or Arduino.
2	Trig	The trigger pin is an output on the microcontroller, sends out a trigger signal toward the object.
3	Echo	Receiver output pin, usually input to the microcontroller, detects the motion of the object in vicinity.
4	GND	Power ground connection.

Warning: DO NOT connect the module with power applied. ALWAYS apply power after connecting 'GND' terminal first.

The ultrasonic sensor is widely used to calculate the distance of an object from the component itself. First, a signal or wave is sent out by the ultrasonic sensor which detects objects (within the range of the sensor). If an object is detected, using the time the signal took to detect the object, the distance of the object is calculated. In our challenge however, we do not need to worry about the distance of the object. Our main concern is to send a positive signal to the DC motor to open/close the bridge when motion is detected.

Gear Box Motor:

Materials required include: gear box motor, transistor, diode, 220-ohm resistor. These materials are connected on the breadboard and Arduino.



NOTE: The diagram should above uses an NPN transistor, although we are using a PNP transistor. To accommodate for this, switch the collector and emitter pins of the transistor. This can be done by simply placing the transistor to opposite way (flat face facing away rather than facing toward you).

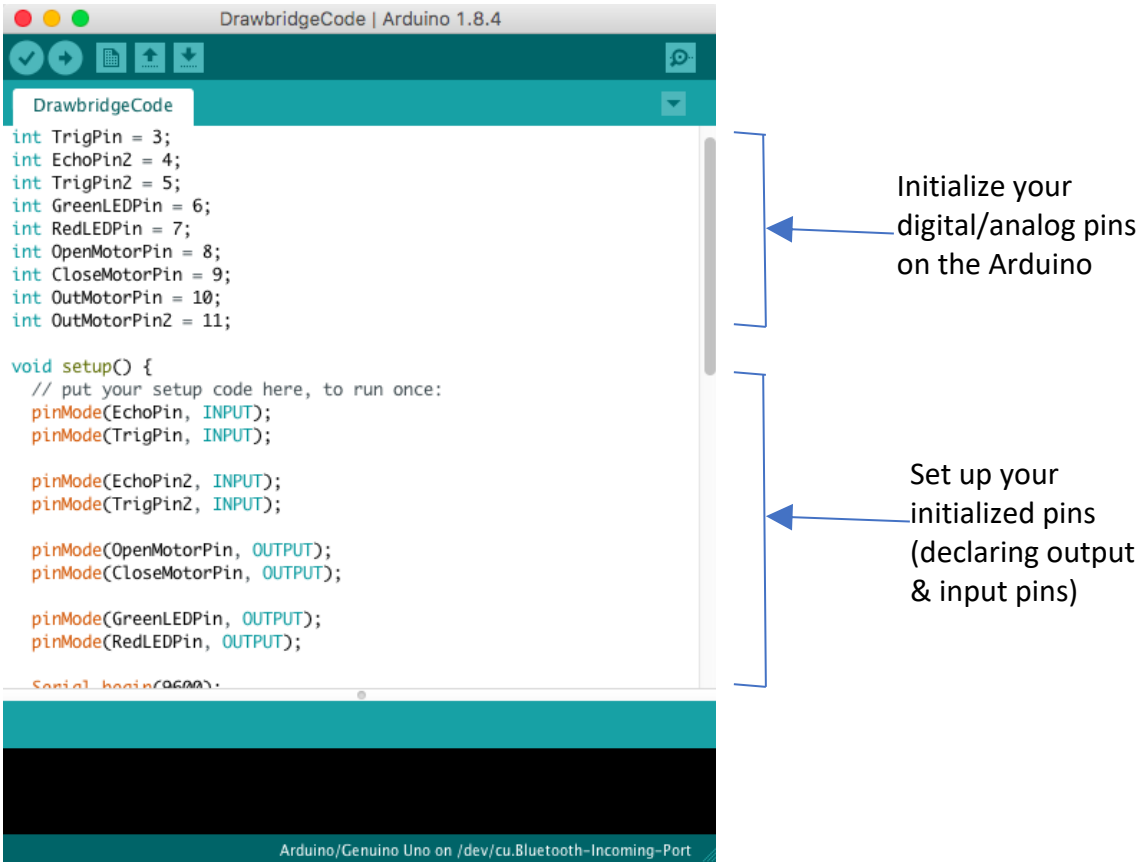
The diagram above shows a schematic of how to connect the motor in a form where the Arduino can control the speed of the motor, which is crucial when opening and closing the drawbridge. In this formation, the transistor acts as the switch for the motor, as it is directly connected to the Arduino.

NOTE: Make sure the connection of the diode and transistor is shown EXACTLY as above (apart from the above note about the transistor). The positive side of the diode (with the band) should NOT be connected to the transistor, as this can be harmful to the electrical components. In addition, the FLAT side of the transistor is shown in the diagram above.

There are several ways to connect and code the motor on the Arduino. For example, connecting the motor to the analog pins and connecting the motor to the digital pins are BOTH acceptable! Although, keep in mind that depending on which section your motor is connected, the code would be significantly different.

Further reading and information: https://www.tutorialspoint.com/arduino/arduino_dc_motor.htm

Arduino (Coding Software):



NOTE: The code above is shown simply to explain how to use the Arduino coding software. The code is NOT necessarily correct, and therefore should NOT be copied.

Installing the Arduino Software:

The installation of the Arduino software can take up to 30 minutes and can be time consuming. It is recommended to be done prior to the construction period of the competition if you are using a device. The full instructions of downloading on Mac OS, Windows and Linux (along with information about the redboard itself) can be found at the following link:

https://learn.sparkfun.com/tutorials/redboard-hookup-guide

Other useful links for coding of the ultrasonic sensor and the DC motor can be found at:

http://howtomechatronics.com/tutorials/arduino/ultrasonic-sensor-hc-sr04/

https://www.tutorialspoint.com/arduino/arduino_dc_motor.htm (also provided earlier)

Resistors:

Color	Digit	Multiplier	Tolerance (%)
Black	0	10^0 (1)	
Brown	1	10^1	1
Red	2	10^2	2
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	0.5
Blue	6	10^6	0.25
Violet	7	10^7	0.1
Grey	8	10^8	
White	9	10^9	
Gold		10^{-1}	5
Silver		10^{-2}	10
(none)			20

The chart above shows the different coloured bands of a resistor and their corresponding values. This will help you differentiate between the several resistors that were provided for you.

Servo Rotation Motors:

Servo rotation motors can also be used by groups, although is totally optional. Teams with members who are experienced with the servo motor are free to rent one out from the design store.

NOTE: This component is entirely optional and does not affect the grading of your prototype.

Tips for Success:

1. Be Creative: A crucial element in having an attractive prototype that stands out is creativity. You will realize that there are several routes that can be taken to the same solution. Take some time to reflect on the materials and layout of your prototype before assembling. You need to dig into something that stands out, maybe was the riskier choice, and something that excites you to present and speak to your judges and peers.

2. Play to Your Team's Strengths: As said before, there are several different routes that be taken throughout this case. This is not a project where everyone must do everything equally, it is far more beneficial to assign tasks throughout the case that align with your team member's

strengths. For example, the tasks could be split up where one member is working on the report, one on the technical aspects, and another two working on the construction of the bridge. Take some time at the beginning to determine your team's strengths, knowledge and abilities related to the challenge.

3. The Judges Knows You Only Have 6 Hours: Don't feel pressured to come up with the perfect, extremely detailed solution by the end of the construction period. Manage your time wisely and simply go with the flow. The judges know that there is a time constraint, and will score you accordingly. The purpose of this challenge is to test your ability to think and act quickly with the best possible quality you can deliver.

4. Don't Stress – Have Fun: Cases like the one given especially with a time constraint can get stressful. This is the nature of cases, although your emotions throughout the challenge can be dealt with. Simply go with the flow, see where your construction and solution take you, and make the effort to convince the judges that your solution is the best answer.

5. Give It Your All, It's Your One Chance: The opportunity to express your creativity and intelligence doesn't come by often, and this could be the start of a new journey for you. From McMaster, to Ontario Provincials, to International Competitions!

If you have any questions about anything regarding the 2017 MEC or about the Senior Design Competition, PLEASE ask prior to the beginning of the construction period.