MISSION 1
RESCUE!

GOAL: CREATE A ROBOT THAT CAN RESCUE A DISTRESSED SWIMMER

THE PROBLEM

A person is enjoying a nice day at the beach. However, while swimming in the ocean, this unlucky individual is caught in a riptide and carried far away from the shore and the lifeguard station. If help doesn't arrive soon, the person will be in danger of drowning due to exhaustion.

YOUR MISSION

Create a robot that will be able to go from the beach to somewhere near the swimmer. Once the swimmer grabs onto the robot, it should back up and return to the shore, all the while holding the swimmer securely.

PROCEDURE

A ping-pong ball will be used to simulate the drowning swimmer. It will be placed at one end of the pool, and your robot will be placed at the opposite end. The robot will go as straight as possible towards the swimmer, and when the robot reaches the other side and is somewhat close, the swimmer will be placed onto a holder or platform attached to the robot. This will simulate the person grabbing onto the robot. Finally, your robot will back up to the start, carrying the person with it to safety.

REAL-LIFE ROBOT

EMILY (Emergency Integrated Lifesaving Lanyard) is a swimming robot that can rescue people faster than a human lifeguard. It can zoom along at 22 mph, provide flotation, deliver life jackets and even pull a person back to the shore.

For more info real rescue robots, check out: http://waterbotics.org/real-robots/rescue

MISSION CONSTRAINTS

Robot must float on the surface of the water
Move forward and backward in a straight line
Use only 2 motors
Include as many small boat propellers as necessary
Allow each teammate to control the robot during the design, test, and improve cycle.

MISSION ACHIEVEMENTS

SUCCESSFUL SAVE (minimum criteria for success)
Perform a successful save

RAPID RESCUE
Perform a complete rescue in 20 seconds or less

CHEETAH OF THE SEA
Perform a complete rescue in 10 seconds or less

ROOM FOR MORE
Rescue 5 or more ping-pong balls in one trip

ALL ABOARD
Rescue 10 or more ping-pong balls in one trip

HEAVY LIFT
Rescue 1 "elephant" (a heavy wiffle ball)

PACHYDERM PACKING
Rescue 2 "elephants"

ENGINEER YOUR CAREER

Mechanical Engineer
Works on the development of many kinds of machines—engines, tools, power systems, robots and more.

Naval Architect
Designs and builds marine vessels, such as boats, submarines, yachts, ferries and cruise ships.

Biomedical Engineer
Creates technologies and tools that help to improve medical diagnosis, monitoring and treatment.

MISSION 2

CLEAN UP!

GOAL: CREATE A ROBOT THAT CAN CLEAN UP FLOATING POLLUTION

THE PROBLEM

A large ship carrying hazardous materials is traveling across the ocean when it hits some unseen rocks, causing a major spill. Now pollution is floating all over the water's surface, and if it isn't cleaned up soon, it will sink down to the ocean floor, potentially affecting local marine life.

YOUR MISSION

Create a robot that will be able to head out to the floating pollution, gather some or all of it up, and bring it back to a secure collection area. The robot may need to make multiple trips to clean up a satisfactory amount.

REAL-LIFE ROBOT

Seaswarm is a large pack of autonomous floating robots that can be deployed to clean up oil spills. It is being developed by MIT and makes use of oil-absorbing nanomaterials, solar power, wireless communication and group-behavior programming.

For more info on real cleaning robots, check out: http://waterbotics.org/real-robots/cleanup

PROCEDURE

The pollutants in this mission will be simulated by floating ping-pong and wiffle balls, which will be scattered around the pool. Your robot may be placed at any location by the edge of the pool—this will be its home base. From there, it will head out to the balls, gather some up, and bring them back to its home base. Once the robot touches the edge of the pool, the balls it has gathered may be removed. Depending on how much cleanup is desired, the robot may go back out to collect more balls.

MISSION CONSTRAINTS

Robot must float on the surface of the water
Move forward, backward, left and right
Use 2 motors
Allow each teammate to control the robot

MISSION ACHIEVEMENTS

CAPABLE CLEANER (minimum criteria for success)
Collect 3 or more balls

SPOTLESS
Collect all the balls in the pool

QUICK SWEEP
Collect 5 or more balls in 10 seconds or less

GRAB 'N GO
Collect at least 1 ball in 5 seconds or less

BIG GULP
Collect 10 or more balls at once, in one pass

CRAZY CAPACITY
Collect 20 or more balls at once, in one pass

PARTICULAR ABOUT POLLUTION
Collect just the wiffle balls

ENGINEER YOUR CAREER

Environmental Engineer
Develops devices and processes that help improve, protect and clean up the environment.

Chemical Engineer
Uses chemistry to solve many types of problems, such as creating medicines, producing food and fighting pollutants.

Materials Engineer
Develops and improves many types of materials, which are the basis of all devices, structures, and products.

MISSION 3

MINE SWEEP!

GOAL: CREATE A ROBOT THAT CAN DETONATE OR DISABLE UNDERWATER MINES

THE PROBLEM

Underwater mines left over from a long-past international conflict have been found near a frequently traveled shipping route. This is a dangerous situation for any passing ships, and if it is not dealt with soon, innocent people could get hurt.

YOUR MISSION

Create a robot that can go under the water, find the mines, and either detonate them safely or disable them by covering them with a trigger-proof container.

PROCEDURE

Mines for this mission will be simulated by using upside-down plastic cups that have air trapped inside. If they are disturbed and flipped over, they will "explode" and release an air bubble. The trigger-proof containers are simluated with larger plastic cups that can be placed over the mines, thus "disabling" them. Your robot will start on the surface of the water by the edge of the pool and from there will dive down to go after the mines.

REAL-LIFE ROBOT

Knifefish is a robot designed by the US Navy that finds underwater mines and reports their locations. This used to be the work of trained dolphins, but the Knifefish is taking over. Soon, another robot will be developed that will trick the mines into detonating.

For more info on real mine-hunting robots, check out: http://waterbotics.org/real-robots/mine-sweep

MISSION CONSTRAINTS

- ☐ Robot close to neutrally buoyant and stable
- ☐ Move forward, backward, left, right, up and down
- ☐ Use up to 3 motors
- ☐ Use both large and small propellers
- ☐ Try having two people control the robot together
- ☐ Allow each teammate help control the robot

MISSION ACHIEVEMENTS

- ☐ HAD A BLAST (minimum criteria for success)
  Detonate at least 1 mine
- ☐ MASTER MINESWEEPER
  Detonate all mines
- ☐ EXPEDITED EXPLOSION
  Detonate 1 or more mines in 10 seconds or less
- ☐ I'VE GOT IT COVERED
  Cover 1 or more mines without detonating any
- ☐ DEDICATED DISABLER
  Cover all mines without detonating any
- ☐ MINE'S A DUD
  Hit a mine 3 times without detonating it
- ☐ PROPS TO THE PROPS
  Use a propeller to detonate a mine

ENGINEER YOUR CAREER

Systems Engineer
Plans and manages large, complex systems that rely on many different interacting components.

Electrical Engineer
Designs products that interact with and use electricity, including electronics and power systems.

Software Engineer
Develops various types of computer programs, such as word processors, operating systems and video games.

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Mission 3: Mine Sweep!

This chapter covers the third mission of the project, in which your students will build robots that will be able to move in three dimensions in the water, rather than only moving on the surface.

CHAPTER TABLE OF CONTENTS

Note: Activity 2 (Research on Buoyancy and Stability) for this mission will be completed as one of the lessons taught during a visit to the University of South Alabama (USA).

A copy of Activity 2 is provided in your instructor binder as an instructor resource to help you reinforce these major science concepts.

Overview

Learning Goals

Mission 3 challenges students to add vertical movement to their robots, allowing much more freedom of motion. Since underwater motion can be tricky, students will learn the concepts of buoyancy and stability to help them succeed. By the end of the mission, they will have gained experience with the following:

- Enabling vertical motion
- Applying the concepts of buoyancy and stability to accomplish effective underwater control
- Using teamwork to control the robot

Mission Scenario and Simulation

In this Mission Briefing scenario, underwater mines left over from a long-past international conflict have been found near a frequently traveled shipping route. This is a dangerous situation for any passing ships, and it must be resolved carefully. The students will build a robot that can dive under the water and either detonate the mines safely or disable them. To succeed in this task, the robot must be able to move all in three dimensions with good control.

To simulate this situation, a number of “mines” are created using plastic cups and other materials. The plastic cups are turned upside-down and placed underwater, trapping air inside. When flipped over, they “explode” by releasing a big air bubble. Students are tasked with modifying their robots so they are able to dive under the water and “detonate” these mines. There will also be the option of “disabling” the mines by placing larger cups over them without tipping them over. Once covered, the mines are “contained.”

Teams are given an extra motor, an extra small propeller, and two large propellers. Students are introduced to the concepts of buoyancy and stability, both of which are crucial to making their robots behave as intended underwater. Once each team is able to control their robot to dive and move around effectively, they can sweep for mines. Some teams may add attachments to their robots to make the mission easier.

To begin a turn at mine sweeping, a robot is placed on the surface of the water at the pool’s edge.
From there it will dive under the water and go after the mines.

Achievements

All the achievements for this mission are summarized below and are also included in the Mission Briefing.

Achievement	Criteria
HAD A BLAST	Detonate at least 1 mine (minimum criteria for success)
MASTER MINESWEEPER	Detonate all mines
EXPEDITED EXPLOSION	Detonate 1 or more mines in 10 seconds or less
I’VE GOT IT COVERED	Cover 1 or more mines without detonating any
DEDICATED DISABLER	Cover all mines without detonating any
MINE’S A DUD	Hit a mine 3 times without detonating it
PROPS TO THE PROPS	Use a propeller to detonate a mine

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Real-World Connections

The *REAL-LIFE ROBOT* side-panel of the Mission Briefing profiles Knifefish—a robot developed by the US Navy that can seek out and find underwater mines without setting them off. Once it has located one or more mines, it returns to its ship and delivers the coordinates. The ship can then either avoid the mines or take steps to disable or destroy them—possibly with another robot. In the past, mine-locating missions were sometimes performed by specially-trained dolphins, but the Knifefish is replacing them.

The *ENGINEER YOUR CAREER* bottom-panel describes a systems engineer, an electrical engineer, and a software engineer. Encourage students to read this panel when they have time during the mission. It would be useful to have a brief follow-up discussion about these careers at the end of the mission.

Activity Plans

As in the previous chapter, the activity plans for this mission are presented as steps in the Engineering Design Process. Take the time to go through these plans carefully to be sure you are adequately prepared.

Total Activity Time

210-310 minutes

Total Preparation Time

75 minutes

Activity Plan Descriptions

Activity 1: Identify the Problem—Mission Briefing	In this introduction to Mission 3, students learn the guidelines to follow when modifying their robot to move in three dimensions.
Activity 4: Design and Build	Students create robots according to their design ideas chosen in the previous activity.
Activity 5: Test, Improve and Redesign	Students test out their robots, try to complete some achievements, and redesign as necessary.
Activity 6: Communication Posters	Each team begins working on a team communication poster to inform visitors to the Academy about the STEM content they have learned and applied to solve the engineering design challenges throughout the week.

Note: Activity 2 (Research on Buoyancy and Stability) for this mission will be completed as one of the lessons taught during a visit to the University of South Alabama (USA). Therefore, cadets should be able to recall concepts learned at USA to complete the mission. To help prompt their thinking, additional information will be available in their Resource Notebook.

Activity 1: Identify the Problem—Mission Briefing (Thursday Afternoon)

Overview
In this introduction to Mission 3, you will group your students into their teams and present mission details, framed within a real-world context. You will also provide guidelines for them to follow when creating their robot.

Activity Time
15 minutes

Preparation Time
5 minutes

Grouping
2-4 students per team, maximum of 5 teams

Materials
Class Materials
1. Mission Briefing handout (1 per student)
2. Mission 3 Team Engineering Notebook
3. Mine and Mine Cover
4. Large Propeller

Preparation
1. Print out a Mission Briefing handout for each student. Color copies are preferable.
2. Familiarize yourself with the Mission Briefing, particularly the “Mission Constraints” and “Mission Achievements” sections.

Procedure

1. Distribute a **Mission 3 Briefing** sheet to each student.
2. Go over the Mission Briefing with the group.
   a. Describe the problem that needs to be solved. You may choose to alter or embellish the story.
   b. Explain the mission. Elaborate if any students seem confused.
   c. Point out the robot profiled in the “Real-Life Robot” panel as an example.
   d. Go through the procedure, making sure the students understand what their robot will be required to do. Have one "mine" and one "mine cover" available for teams to view as you review the mission achievements.
   e. Review the mission constraints carefully. Let students know they can use this list as a checklist while working on their robot.
   f. Go over the available mission achievements and their requirements. Be sure to highlight the minimum criteria for success.
   g. Point out the “Engineer Your Career” panel. Encourage students to read about the profiled careers and think how they might connect to either the current mission or a previous one.
3. Hand out the **Mission 3 Team Engineering Notebook** and direct teams to turn to **page #2** of the TEN which lists the General Achievements and remind teams that instructors will be monitoring each team’s General Achievements.
4. Direct teams to turn to **page #3** of their TEN and remind teams that Mission Achievements will be tracked as they were in Missions 1 and 2. Mission Achievements should be tracked on **page #3** of the **TEN.**
   - Have teams quickly record the constraints and minimum criteria for success for this challenge on **page #4** of their **TEN** (items #1-2)
5. Important things to note for students:
   ◊ Stability is critical in this mission. The more stable the robot, the easier it will be to control.
   ◊ Since there will now be three motors to control, two IR remote controls will be needed. Therefore, it is likely that two people will need to work together to control the robot. Teamwork will be critical for this mission.
   ◊ Before students begin, let them know that in addition to the regular propellers, they will now have access to up to two larger propellers. Display a propeller so they have an idea of the size.
   ◊ Try to be creative in achieving the main goal of the mission.
   ◊ Teams should provide an opportunity for everyone to contribute ideas. The best designs often come from a combination of ideas.
6. Allow a few minutes for individuals to sketch their new design ideas on the back of their mission briefing to help the team develop a consensus design during the next activity.

Activity 4: Design and Build

(Thursday Afternoon)

Overview

In this activity, students create robots according to the design ideas chosen in the previous activity. They may use the robot from the previous mission and modify it, or they may choose to build a new kind of robot. The prototype will no longer need to undergo the drop test to check durability. Teams will work to get their robots stable and neutrally buoyant but will NOT practice driving their robots.

Activity Time

90 minutes

Preparation Time

5 minutes

Grouping

Teams

Vocabulary:

stability
buoyancy
neutrally buoyant
negatively buoyant
positively buoyant

Materials

General Team Materials

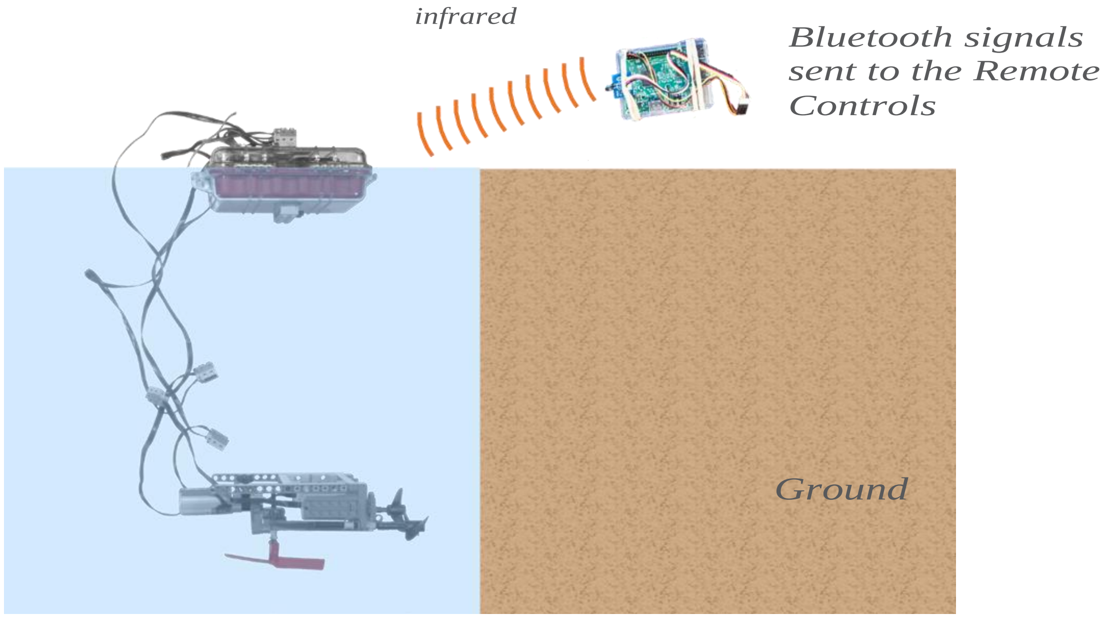
1. Current robot prototype
2. LEGO pieces kit
3. 3 motors
4. 2 or more small boat propellers (pre-glued to axle)
5. 2 large propellers
6. Pieces of pool noodle
7. Several rubber bands
8. Ruler or meter stick
9. Towels
10. Washers, 10-15 per team
11. 3 extension cables
12. Mission 3 Team Engineering Notebook
13. Resource Notebook

Class Materials

1. Pool (filled)
2. Mission 3 Slides
3. General Achievements Checklist
4. Sample Mines and Mine Covers (teams may use when building prototypes)

Procedures

1. Teams must have three motors for this mission. Since they already have two motors on their robot, distribute another motor to each team's workstation.
2. Distribute one large propeller to each workstation for teams to start with. They may request another one later on. Teams may use up to two large propellers for their designs.
3. Distribute one additional small propeller to each workstation as well, since some teams may wish to use one or more of them rather than the large one.
4. Provide one or more fresh, dry towels to each workstation.
5. Tell teams their prototypes will be DETACHED from the IR Receiver for this mission.
    a. The IR receiver case is detached from the robot and will remain floating on the surface of the water. The robot will be connected to it using the 20-inch extension cables, allowing it to dive beneath the case.
    b. Teams should be given 10-15 washers and three 20-inch extension cables.



Advantages of having robot detached from IR Receiver:

- IR communication will be unaffected.
- Students will have to work harder to achieve satisfactory stability, which will help them understand the concept better.
- Without the need to submerge the IR receiver case, significantly fewer washers will be needed for ballast.
- Leakage issues for the IR receiver case are minimized.

Potential issues:

- The greater difficulty of achieving good stability may be frustrating for some students.
- The cables are somewhat thick and rigid, which can interfere with the robot's movement. There will also be tugging from the case whenever the robot stretches the cables.
- The cables limit the depth that the robot can dive, although more cables can be chained together to allow the robot to dive deeper.

6. Remind teams that each prototype must satisfy the following criteria:
    a. The robot should have a sturdy structure, but it will no longer have to survive the drop test.
    b. The motors and propellers must be attached in a way that will allow the robot to move in 3 dimensions (up-down; left-right; forward-backward).
    c. The robot must be neutrally buoyant and relatively stable; (teams will test for this during this activity).

7. Explain to the whole group that they will have at about 35 minutes to come to consensus on a new design and build their robot for this mission before testing begins.
    a. They may choose to modify the robot from the previous mission, or they may build a completely new robot.
    b. Teams should complete items #3-6 on **pages #4-5** of their **TEN** to document their ideas and decisions.
    c. Initially, the robot's design should be the one that the students record in their Team Engineering Notebook (TEN). However, they may choose another idea at any point.
8. Give the teams time to build their design before the first buoyancy and stability test. As teams are ready, allow them to take their prototypes to the pool area for testing.
    a. Remind students of the importance for their robots to be both buoyant and stable, since that will allow for much easier and predictable control.
    b. Direct students to the location of the water test.
    c. Remind students to dry their robots after removing them from the pool.
    d. Teams should use **pages #6-7** of their **TEN** (items #7-9) to document results from each test and plans to improve their designs.
9. Tests should take place at the pools outside and be concluded when approximately 15 minutes are remaining for this activity. A staff member should be designated to remain at the testing pools to assist teams and verify that the requirements have been met. Teams should be allowed to move back and forth from their work area to the testing area. **The goal of this set of tests is to ensure the prototypes are close to neutrally buoyant in the water and remain stable**. Teams will determine when their robots pass this test by confirming that the robot meets the mission constraints.
    a. To test for neutral buoyancy, the robot should be put under the water near mid-depth of the pool and released. If it hovers in place, sinks slowly or rises slowly, then it is either neutrally buoyant or close enough.
    b. To test for stability, the robot should be tilted sideways and released. If it flips back to its original orientation very quickly, then it is acceptable.
    c. At this point, teams are NOT trying to drive their robots. Rather, they are trying to focus only on stability and buoyancy.

10. After teams have created a stable and neutrally buoyant prototype, allow the teams to improve the structure of their robot and add armature as needed to complete mission achievements. However, it must still remain stable and should be retested after any modifications. All modifications should be completed in the work area, and major modifications noted in on **pages #6-7** in their **TEN**.

11. When 15 minutes remain for this activity, have all teams reassemble in the work area for a discussion about the buoyancy and stability of their robot. Have teams share about any success and failures they had when testing their initial designs. Use this as an opportunity to check for students' understanding of the following key concepts:
    a. Buoyancy:
        i. positively buoyant: consistently floats to the top of the water even after being submerged
        ii. negatively buoyant: consistently sinks to the bottom of the pool
        iii. neutrally buoyant: remains at approximately the same level in the water after being stabilized
    b. Stability:
        i. a stable robot will return to its proper orientation in the water after being flipped
        ii. how quickly the robot returns to the proper orientation can be used as a measure of its stability

Activity 5: Test, Improve and Redesign

(75 min Before Dinner & 60 min After Dinner)

Overview

In the previous activity, each team performed some basic tests of its robot's buoyancy and stability. However, the true test of each robot's functionality will take place during this activity. Students first make sure their robot can move forward, backward, left, right, up and down using the two IR controllers. Then they practice controlling the robot underwater, evaluate how well it maneuvers, and adjust the buoyancy and/or stability as needed. Finally, they attempt to successfully complete one or more mission achievements.

Activity Time

Session 1: Test & Redesign 75 minutes

Session 2: Test for Mission Achievements 60 minutes

Preparation Time

30 minutes

Grouping

Teams

Materials

General Team Materials

1. LEGO pieces kits
2. Current robot prototype
3. Pieces of pool noodle
4. Several rubber bands
5. Towels
6. Previous student handouts
7. Washers 10-15 per team (see Activity 4)
8. Markers, pens, or pencils
9. Team Engineering Notebook
10. Resource Notebook
11. 2 IR remote controls

Note: The "mines" and "mine covers" will be provided to you pre-assembled.

Class Materials

1. Materials for a single “mine” (you will make 5-8):
2. 2 white, 3-oz plastic cups
3. 17-20 washers
4. 4 small binder clips (preferably with colors)
5. 3 rubber bands, ~6-7 inches in perimeter (preferably with colors matching binder clips)
6. Kitchen scale (optional)
7. Materials for a single “mine cover” (you will make one for each “mine”):
8. 1 red, 9-oz plastic cups
9. 4 small binder clips
10. 2 washers
11. Small sharp scissors or x-acto knife
12. Stopwatches
13. Pool (filled)
14. Pool decorations (optional)
15. Mission 3 Slides

Preparation

1. Make sure the pool is filled and ready for the mission.
2. Prepare 5-8 “mines”. Procedure for each one:
    a. Place a white, 3-oz plastic cup on a flat surface and wrap a rubber band around it just under the rim. Clamp two small binder clips over the rim and rubber band so that the clips are opposite one another. Then flip the handles of the clips down.



    b. Place 17-20 washers into the cup. (If you have a kitchen scale, aim for mass of about 170 g).

    c. Get another 3-oz cup and clamp two small binder clips over the rim on opposite sides. Flip the outermost handles of the clips down. Leave the inner handles up.


d. Place the second cup into the first so that the line joining its clips is at a 90-degree angle to the line joining the clips on the first cup.

e. Pull each section of rubber band on the first cup up and over the handle of each clip on the second cup. Then flip the inner handles of the clips on the second cup down over the rubber band sections.

f. Turn the assembly over. Wrap one or two more rubber bands around the top cup to increase the visibility of the mine underwater and to generate more friction when a robot touches it.

g. Test the mine underwater.
   - Keeping it in the orientation from the previous step, bring it into the water so that air is trapped in the cup.
   - Carefully place it on the bottom of the underwater testing area. It should settle easily.
   - The mine should remain stable when pushed lightly. However, with a slightly larger push it should topple over and release the trapped air, thus “exploding”.

     If the mine is too sensitive in your opinion, add one or more washers. Conversely, if it takes too much force to activate, remove one or more washers. Measure and record the total number or mass of washers that works best.

h. Prepare 5-8 “mine covers”; one for each mine. Procedure for each one:

i. Place a red, 9-oz plastic cup on a flat surface. Clamp two small binder clips over the rim on opposite sides. Slide a washer under each binder clip and fold the clip handles down.

j. Turn the cup over. Use a marker to draw a 3/4-inch by 1/2-inch “rectangle” on opposite sides of the cup bottom. One of the 3/4-inch sides should be along the circumference of the cup’s edge. (Thus the shape is not a true rectangle.) Orient the markings so that the line connecting them is perpendicular to the line connecting the washers.

j. Using small, sharp scissors or an x-acto knife, carefully cut along the marker lines to create two holes. Then place a binder clip in each hole and clamp it to the cup's side. Keep the clip handles up so that robots may be able to hold or hook onto the assembly using axles or other LEGO® pieces.

3. Place and distribute the mines under the water.
4. Open up each team's IR receiver case and set the pair of IR receivers to one of two channel combinations: either channels 1 and 2 or channels 3 and 4. The extra channel on each robot is necessary in order to control the third motor. Due to the extra channel use, robots that use the same channel combination will be subject to interference. Note which robots are using identical channel combinations so that you will be able to inform students and warn them about IR interference.
5. The students may want to refer to previous handouts. Have additional copies available. (These will be contained in their Resource Notebook.)
6. As with Missions 1 and 2, General Achievements should be monitored by a staff member assigned to that duty. A clipboard with the General Achievements should be available to record achievements as they happen throughout the design challenge.
7. Mission Achievements will be recorded in the Team Engineering Notebook at the testing area. A staff member posted in the testing area should initial any achievements completed. Teams should report initialed achievements to the appropriate staff person in the work area to be added to the displayed of completed achievements.
8. (Optional) You may want to add decorations to the pool to provide context. For example, a coral reef made of colorful towels on the bottom of the pool or a shoreline made from a tan tablecloth stretched at the start line.

Session 1 Procedures

1. Assemble all teams at their workstations.
2. Remind teams that each IR receiver can only control two motors at a time. Therefore, in order to control a third motor, both IR receivers will be used. And since they can't share the same channel, each robot will require two channels. Explain what this means for their controllers.
   a. Be sure each team knows which channel combination their receiver case is using. Instruct them to set each IR remote control to one of the channels. Also warn any teams with duplicate channel combinations of the possibility of signal interference.
   b. Explain that each IR receiver outputs to only two of the four connectors on the top of the IR receiver case. Therefore, each IR remote control will only affect one pair of connectors. Students should experiment with the motors to find out which lever on which remote will affect the motor. The color labels on the connectors will help immensely.
   c. It is recommended that one remote be used for the horizontal movement and the other be used for the vertical movement. Ultimately, though, it is up to each team to decide how the controls should work.
   d. Help all teams get their motors working with their IR remote controls.
3. Before students begin trying out their robots in the water, quickly go over the Mission Briefing once more. Explain that teams must first get their robots to move around in three dimensions with reasonable buoyancy and stability. Once that is done, they may then work towards completing achievements. They will have approximately 45 minutes to accomplish these tasks (before dinner) and then will have an additional 60 minutes (after dinner) to test for specific achievements. Remind students how mission achievements are being counted.
   i. They must have an instructor or assistant observe each Mission Achievement for it to be completed. Remind teams to record Mission Achievements on **page #3** and then inform the instructor so these achievements can be displayed on **Slide #2**.
   ii. The general achievements will continue to be tracked by the instructor(s) and assistants as they go around the room and observe the teams.
4. Before teams begin working, demonstrate how to "detonate" a mine and how to "cover" a mine.
   a. Show that a mine may be "detonated" by tipping it over.
   b. Show that a mine cover may be placed over a mine, thus disarming it. To use the mine cover, a robot must begin at the surface of the water against the edge of the pool. A mine cover may then be manually attached, hooked, or placed onto it. Once ready, the robot will carry the mine cover under the water and attempt to place or drop it over a mine.
   c. Explain that each team may come up with its own method for getting the robot to hold and carry the mine cover.
   d. Let students examine the mines and mine covers throughout the mission. This can help them plan. You may even choose to make extras for this purpose.
5. Allow students to use the time remaining before dinner to work. Walk around and help students as necessary.
   a. Stopwatches should be available at the testing area for teams that are going to attempt any of the time-based achievements.
   b. Periodically let the students know how much time is left (10 minutes, 5 minutes, etc.).
   c. Prioritize helping teams that are having issues getting their robots to move in 3 dimensions. The sooner all teams have accomplished this, the more time they will have to work towards the achievements.

d. Remind groups that the IR transmitters must be pointed towards the IR receivers for their robot to work. Students often forget this in their excitement.

e. Use **Slide #2** to document Mission 3 Achievements; continue to monitor for General Achievements that are observed. Be sure to inform a team when they have successfully completed an achievement, as this can provide a morale boost and inspire them to try for more.

f. If a team does not succeed in an attempt, encourage them to try again. Make suggestions for improvement if necessary, such as trying out different rotation speeds or vertical speeds by modifying their gears or motor placements.

Break for Dinner
When about 3-4 minutes are remaining in Session 1, have teams stop testing and place their robot prototypes on a towel in the center of their workstations. Teams should plan to pick up wherever they left off once they return from dinner.

Session 2 Procedures

1. Allow teams to continue testing for specific Mission Achievements during the first 60 minutes of Session 2. Follow the same testing procedures as Missions 1 and 2. Teams may modify their design as necessary to complete achievements, but all modifications should be completed in the work area.
2. Wrap up the testing by bringing all teams back to their workstations and directing them to record final conclusions on **page #8** of their **TEN.**
3. The last 30 minutes of Session 2 should be spent preparing teams for the poster presentations (described in Activity 6.)
   a. Explain teams will be communicating their work on designing underwater remote operating vehicles for all three missions, with a major emphasis on mission 3. Teams will be communicating to MCPSS administrators, industry leaders, and other invited guests.
4. Ensure that teams are aware of the importance of communicating both successes and failures.
   a. Direct teams to look at **pages #9-10** of the **TEN**.
   b. Use some of this time to have teams share some information they think should be included on their posters.
5. Use the remaining time to have teams begin planning the information to be included and the layout of their poster. Inform them that they will have approximately an hour and a half (150 minutes) to prepare their poster and practice their 2-minute presentation the next day.
6. While teams are pre-planning their presentation, instructors should select a team to display their poster and demonstrate their robot in the testing area during the presentation time. This team should be informed of this decision before the completion of Activity 5 so that they may plan accordingly.

Activity 6: Communicating Results

(Friday Morning)

Overview

This final session of the challenge will emphasize the importance of communication. Teams will work together to create a STEM Challenge Brief and plan a two-minute oral presentation. As this session is also the last session of the Academy, teams will prepare to give their presentations to visiting guests. Instructors will also have a pre-selected team prepare to demonstrate their design to visitors along with their poster presentation. During this session, one PLATOON at a time will leave for 30 minutes to take the Academy post-test.

Activity Time

150 minutes for Activity
30 minutes for Academy Survey

Preparation Time

10 minutes

Grouping

Teams

Materials

Team Materials

1. Tri-fold board (1 per team)
2. Missions 1 and 2 Team Engineering Notebook
3. Mission 3 Team Engineering Notebook

Class Materials

1. Copy paper
2. Markers, pens, pencil, etc.
3. Tape
4. Various colored paper to be used as backing

Preparation

Plan for the Poster Session-work with the other Instructor in your ballroom to consider and plan for the poster session. Teams from both platoons will participate in a practice poster session with another team using the Communication Brief Rubric to receive feedback and improve their posters and team presentation.

Posters should be arranged on the tables so that teams can stand in front of their posters and talk with visitors (and other teams) as they walk around the room. If table space is not available for all posters, identify additional locations in the ballroom to arrange posters and teams. Each team will need to have their poster, prototype, and TEN.

Procedure

Prepare for Communication and Complete Post-Assessment (100 min):

Allow cadets to spread out in the room to begin designing their posters and writing up notes to help them with their presentation. Remind teams to use **pages 9** and **10** of their **Mission 3 TEN** as a guide for designing a high-quality communication poster and presentation. Refer to the sample poster diagrams in their TEN if teams need some guidance on how to organize the information. Tell teams they will have about an hour to complete their posters and practice their presentations. Encourage cadets to record their talking points on index cards.

Note: Teams will be interrupted during the preparation time to complete the JROTC STEM Leadership Academy post-test and questionnaire. Cadets will complete the assessment by squad, rotating out of the ballroom in turns. This activity may take up to 30 minutes for each squad. So, team will really have about 70 minutes to develop their posters and presentations.

Practice Communicating Results: (35 min)

Direct teams to put away all unused presentation materials and display their posters in the designated areas of the room. Either gather these materials or have cadets return them to a central location in the room. Teams should keep their TEN and prototype with them. Be sure to space the presentation areas so that one team can cluster around their poster while another team listens to the presentation. Teams should turn to **pages #10** of their **TEN**.

Explain that now teams will have a chance to practice their presentation and evaluate their communication brief (poster) with the other teams in the ballroom through a practice poster session. Emphasize that poster sessions are a little different from other types of presentations in that people are usually walking around and discussing the information on the visual aid and the general project in a more informal way. However, it is the responsibility of each team to make sure visitors coming up to them walk away with a clear picture of their challenge, how their team addressed the challenge, and how they used the mathematics and science content in this challenge.

In coordination with the other instructor in the ballroom, briefly explain how teams will pair up to each teams' poster presentations. Teams will take turns being the listeners and the presenters. Be sure to cadets understand:

- One team will start off as the Presenters. These teams will station themselves around their posters and have their robot prototype in their hands.
- The other team will start off as the Listeners. Each Listening Team will start the activity at one of the Presenting Team's posters (1 Listening Team per 1 Presenting Team).
- The Presenting team should give their **TEN** to the Listening team. The Listening team will complete the Communication and Design Scoring Rubric on **page 10**.
- When an instructor says "Begin Presentations," the two teams can interact more casually, understanding that the goal is to give the Presenting Team a chance to practice talking about how they addressed the engineering design challenge (about 2 minutes) and allowing time (about 2 minutes) to respond to questions posed by the "Listening Team."
- After about 4 minutes, an instructor will signal all to stop and direct the listening teams to complete a *Communication Scoring Rubric* for the Presenting Team. While the Listening Team completes the rubric, the Presenting Team should discuss ways to improve their presentation. After 2 minutes the Listening Team will give the completed rubric back to the Presenting Team.
- Instructors will direct Teams to switch roles and repeat the process.

Encourage teams to use the scores on their rubrics as feedback to help them make their presentations better before the Academy special guests arrive.

Prepare for Formal Presentations and Demonstrations (15 min)

Once teams have had a chance to practice, tell them they are now going to make final plans to present for guests who will attend the Academy celebration. This is their opportunity to show people what they have learned over the week and how they used their knowledge to solve this engineering design challenge.

Have the team selected to demonstrate their robot transfer their poster to the testing area.

All other teams must be ready for guests in the 2nd Floor Ballrooms no later than 11:25.

JROTC STEM ACADEMY

Mission 3: Mine Sweep!

MISSION 3
MINE SWEEP!
GOAL: CREATE A ROBOT THAT CAN DETONATE OR DISABLE UNDERWATER MINES

Team Name	Had a Blast	Master Minesweeper	Expedited Explosion	I've Got it Covered	Dedicated Disabler	Mine's a Dud	Props to the Props

STEM in the Water

Mission 3: Mine Sweep!

Team Engineering Notebook

Team Name:_______________________________

Platoon Color: ___________ **Squad #**______

Team Cadets:_______________________________

____

____

____

MISSION 3

MINE SWEEP!

GOAL: CREATE A ROBOT THAT CAN DETONATE OR DISABLE UNDERWATER MINES

THE PROBLEM

Underwater mines left over from a long-past international conflict have been found near a frequently traveled shipping route. This is a dangerous situation for any passing ships, and if it is not dealt with soon, innocent people could get hurt.

YOUR MISSION

Create a robot that can go under the water, find the mines, and either detonate them safely or disable them by covering them with a trigger-proof container.

PROCEDURE

Mines for this mission will be simulated by using upside-down plastic cups that have air trapped inside. If they are disturbed and flipped over, they will "explode" and release an air bubble. The trigger-proof containers are simluated with larger plastic cups that can be placed over the mines, thus "disabling" them. Your robot will start on the surface of the water by the edge of the pool and from there will dive down to go after the mines.

REAL-LIFE ROBOT

Knifefish is a robot designed by the US Navy that finds underwater mines and reports their locations. This used to be the work of trained dolphins, but the Knifefish is taking over. Soon, another robot will be developed that will trick the mines into detonating.

For more info on real mine-hunting robots, check out: http://waterbotics.org/real-robots/mine-sweep

MISSION CONSTRAINTS

- ☐ Robot close to neutrally buoyant and stable
- ☐ Move forward, backward, left, right, up and down
- ☐ Use up to 3 motors
- ☐ Use both large and small propellers
- ☐ Try having two people control the robot together
- ☐ Allow each teammate help control the robot

MISSION ACHIEVEMENTS

- ☐ HAD A BLAST (minimum criteria for success)
  Detonate at least 1 mine
- ☐ MASTER MINESWEEPER
  Detonate all mines
- ☐ EXPEDITED EXPLOSION
  Detonate 1 or more mines in 10 seconds or less
- ☐ I'VE GOT IT COVERED
  Cover 1 or more mines without detonating any
- ☐ DEDICATED DISABLER
  Cover all mines without detonating any
- ☐ MINE'S A DUD
  Hit a mine 3 times without detonating it
- ☐ PROPS TO THE PROPS
  Use a propeller to detonate a mine

ENGINEER YOUR CAREER

Systems Engineer
Plans and manages large, complex systems that rely on many different interacting components.

Electrical Engineer
Designs products that interact with and use electricity, including electronics and power systems.

Software Engineer
Develops various types of computer programs, such as word processors, operating systems and video games.

GENERAL ACHIEVEMENTS DESCRIPTIONS

☐ LIKE A PHOENIX
Recover from a tough failure

☐ TRUE GRIT
Recover from a tough failure 3 times (Achieve LIKE A PHOENIX, then 2 recoveries after.)

☐ TERRIFIC TEAMWORK
3 or more instances or teamwork

☐ ALL FOR ONE, ONE FOR ALL
6 or more instances of teamwork (Achieve TERRIFIC TEAMWORK, then 3 instances after.)

☐ BLOOPER REEL
1 or more funny mistakes or failures

☐ SOUND LIKE ENGINEERS
3 or more discussions of engineering terms or careers

☐ SOUND LIKE SCIENTISTS
3 or more discussions or explanations of science concepts

☐ THE ALTRUISTS
Help another team

☐ SHOW ME THE DATA
Use measurements to inform decision-making process

☐ RESEARCH PARTNERS
As a group, read an article about robots, science or engineering

Mission 3 Achievements

These are all of the achievements for Mission 3. When you test your prototype at the pool, have an instructor write his/her initials in the box next to the achievement you completed to verify your accomplishment. When you return to the ballroom, show this checklist to your instructor so he/she can update the slide projected on the screen. This will allow other teams to see what your team has accomplished!

Achievement	Instructor Initials
HAD A BLAST ***Detonate at least 1 mine*** ***(minimum criteria for success)***	
MASTER MINESWEEPER ***Detonate all mines***	
EXPEDICTED EXPLOSION ***Detonate 1 or more mines in 10 seconds or less***	
I'VE GOT IT COVERED ***Cover 1 or more mines without detonating any***	
DEDICATED DISABLER ***Cover all mines without detonating any***	
MINE'S A DUD ***Hit a mine three times without detonating it***	
PROPS TO THE PROPS ***Use a propeller to detonate a mine***	

Mission 3: Mine Sweep!

Research & Plan

1. List any **constraints** your design must meet to be considered compliant.

2. What is the **minimum criteria for success** in this mission?

3. List any components of your robot that will need significant redesign due to the change in mission achievements.

4. List at least 2 distinct components of your robot that could be designed separately and then combined into your final product. (Assigning these separate components to sub-groups within your team could make your work more efficient.)

5. Use this space to write some notes about any important discussions your team members had while completing your research.

Mission 3: Mine Sweep!

Research and Plan

6. In the space below provide a sketch of your new robot design. Be sure to include the placement of motors and orientation of propellers. Below your diagram, sketch what you would expect to see in the pool if your robot is negatively buoyant. Include an additional diagram of what you would expect if your robot is positively buoyant.

Mission 3: Mine Sweep!

Test, Improve, and Redesign

7. Describe what you observed during your first "in the water" test of your robot.
    a. List at least two aspects of your robot that met the expectations developed during the design process.

    b. List at least two aspects of your robot that could be improved (i.e., stability, control, buoyancy, speed…). Include possible adjustments to fix these areas of concern.

Area of Concern:	**Possible adjustment:**

Mission 3: Mine Sweep!

Test, Improve, and Redesign

8. In the space below sketch a diagram of how you plan to implement the changes recorded in the table above.

9. Give a two to three sentence explanation of how your design accounted for the stability of your robot. (What specific design aspects were included to ensure a stable robot in the water?)

Mission 3: Mine Sweep!

Test, Improve, and Redesign

Results

List the title of any mission achievements your team was able to accomplish in this mission.

Observations

a. What worked well?

b. Using vocabulary from your research, list at least 3 things that would help your team complete additional achievements. (If all achievements were accomplished, list ideas to improve the overall functionality of your robot.)

1.

2.

3.

Mission 3: Mine Sweep!

Communicating Team's Design Process, Robot Design, and Results

Your team will need to plan, develop, and present a Design Challenge Brief. Your brief will be presented orally, along with a large visual aid, which you will need to develop. Your team should prepare for a 2-minute presentation. Each team member should have a speaking part. Your presentation will be evaluated using the "Communication Scoring Rubric" located on the next page in your Team Notebook. This rubric provides additional important information about how your team's presentation of your brief will be evaluated.

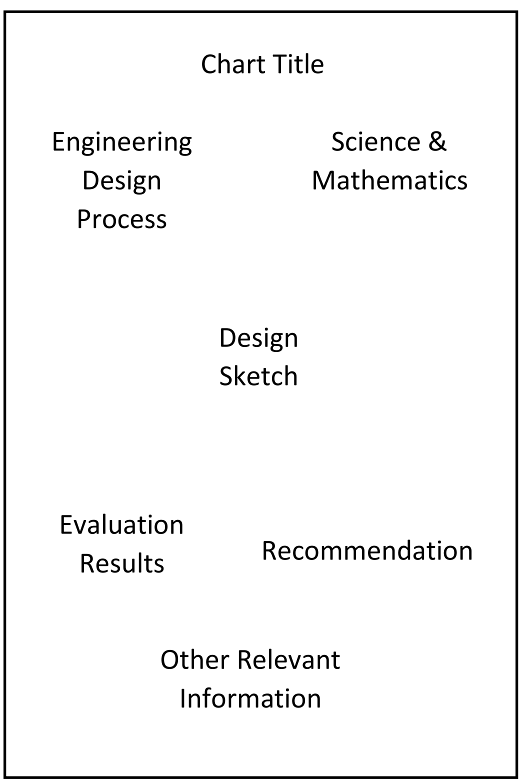
Criteria for Presentation Brief. You need to include the following components in your brief:

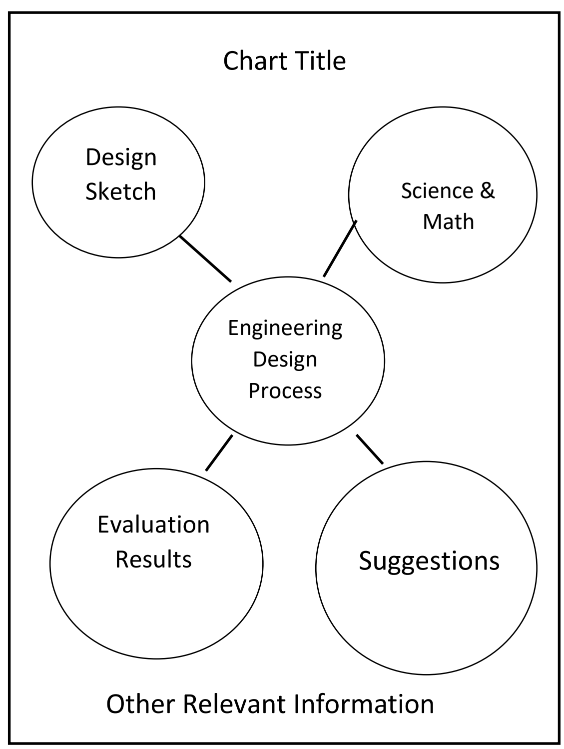
1. An explanation of how you used the Engineering Design Process to solve this challenge.
2. A sketch of your design (with labels).
3. A brief explanation of the science and mathematics content you applied to solve this challenge.
4. The final design prototype and Team Engineering Notebook.
5. The test results and recommendations for how you might continue to improve your design.

Materials. To help you create your visual aid, your team will use the following materials:

- 1 tri-fold poster
- 1 set of colored construction paper
- Index Cards
- Scratch paper
- Table kit materials

Use the materials, rubric, and time wisely to prepare your Brief and presentation. Consider the following layouts as possible ways to organize your information on the display. These are suggestions only and may not include all the required components. Be creative and be sure to include all required information.





Mission 3: Mine Sweep!

Communication Rubric

	Criteria	Needs Improving	Satisfactory	Outstanding
Overall Presentation	**Presentation Organization**	Either not very organized or not very clear	Mostly logical and clearly presented	Very logical and clearly presented
	Oral Presentation Quality	Very little eye contact, mostly reading poster; low voice volume and often hard to understand words	Some eye contact; reads poster about ½ of the time, adequate voice volume & fairly easy to understand words	Substantial eye contact (over ½ of time), rarely reads poster; speaks clearly, good voice volume
	Involvement of Team Members	Only 1 team member involved	2 team members involved	All team members involved
Content In Presentation	**Describes Design Process (that led to final design)**	Does not include a description of the steps of the Team's design process.	Includes a description of most of the steps of the Team's design process.	Includes a description for each step of the Team's design process.
	Includes STEM Content (applied in design process)	Does not correctly convey using or applying at least 1 content fact, with targeted vocabulary	Correctly conveys using or applying 2 to3 content facts, with targeted vocabulary	Correctly using or applying 4 or more content facts, with targeted vocabulary
	Includes Skills Learned about Effective Teams	Does not convey at least 1 skill learned about effective teams.	Conveys 2 to 3 skills learned about effective teams.	Conveys 4 or more skills learned about effective teams.
	Includes Evaluation Results and Recommendations	Does not include both results and recommendations	Includes completed achievements and at least 1 recommendation	Includes completed achievements and multiple recommendations
Overall comments:				

2018 JROTC STEM Leadership Academy Activity Calendar

Sunday, 3 June 2018	Monday, 4 June 2018	Tuesday, 5 June 2018	Wednesday, 6 June 2018	Thursday, 7 June 2018	Friday, 8 June 2018
Morning 8:00 am – Check-in / Registration; Set up dorm rooms 9:15 am- Opening Assembly-Introductions, Expectations 9:35 am Pick Up Snack 9:45 am STEM Team Building Exercises, Winning Colors,	**Morning** 5:30 am – Wakeup 6:00 am – Physical Fitness Training 7:00 am–Breakfast-SHC 7:30 am Load Buses 8:30 am Bus 1&2 Austal & Amazon; Bus 3&4 AL Port Authority & GulfQuest 11:45 am Load Buses	**Morning** 5:30 am – Wakeup 6:00 am – Physical Fitness Training 7:00 am–Breakfast-SHC 7:30 am Load Buses 8:30 am Bus 1 &2 Rappelling & USCG Sector; Bus 3&4 Aker Solutions, Technip 11:45 am Load Buses	**Morning** 6:00 a.m. – Wakeup 7:00 am–Breakfast-SHC 7:30 am – Load Buses 8:00 am Bus 1&2 arrive at USA Shelby Hall College of Engineering sessions & 11:10 am Campus Tour 8:00 am Bus 3 & 4 Five Rivers Delta & Boat Tours	**Morning** 6:00 a.m. – Wakeup 7:00 am–Breakfast-SHC 7:30 am Load Buses 7:45 am – Depart for Blakely 8:30 am Land Navigation Class & Field Experience	**Morning** 6:00 am.– Wakeup & Pack 7:00 am–Breakfast-SHC 8:00 am – Photos MAJ Holt 8:30 a. –Prepare & practice Presentations; On-Line Post Assessment 11:30 am STEM Poster Sessions
Afternoon 12:00 pm – Lunch at SHC 12:45 pm Optional Church Services in Cafeteria; Other Cadets in Ballrooms 1:15 pm Pre-Assessment Part II, LEGO Build It Finish Teambuilding Activities 2:45 pm Launch STEM in the Water -WaterBotics Project Kickoff & Mission 1- Rescue!, Activities 1, 2, 3, & 4	**Afternoon** 12:00 pm Lunch CNP Arlington Park Brookley 12:45 pm Load Buses 1:00 pm Bus 1&2 AL Port Authority & Gulf Quest Bus 3 & 4 Austal & Amazon 4:15pm Load Buses-SHC 4:45 pm After Action Review 5:15 pm Reflections	**Afternoon** 12:00 pm –Lunch Air Nat'l Guard at Brookley 12:45 pm Load Buses 1:00 pm Buses 1& 2 Aker Solutions, Technip Bus 3&4, Rappelling & USCG Sector Mobile 4:15 pm Load Buses 4:45 pm Buses arrive at SHC 5:00 pm After Action Review & STEM Challenge 2, Mission 2 Clean Up! Activity 1	**Afternoon** Buses 1&2: 12:00 p.m. –Load Buses Go to 5 Rivers Delta 12:30 pm CNP Lunch 1:00 pm 5 Rivers Delta& Boat Tours 4:30 pm Load Buses SHC Buses 3&4: 11:30 pm CNP Lunch at 5 Rivers Delta 12:15 pm Load Buses-USA 1:00 pm USA Campus Tours & 1:50 pm College of Engineering sessions 5:00 pm Load Buses-SHC	**Afternoon** 11:30 pm –Lunch (Provided by Army Nat'l Guard) 12:00 pm Load Buses 12:45 pm Return to SHC Cadre Collect Uniforms 2:30 pm After Action Review-USA & Missions 3:00 pm Launch Final STEM Challenge – Mission 3 Mine Sweep Activities 1, 4, & 5	**Afternoon** 12:15 pm – 2:00 pm Lunch followed Guest Speaker – Dr. Robert V. Barrow (Frank's Dad!) & Awards Ceremony 2:00 pm Academy Closeout 4:00 pm Dismiss staff
Evening 5:30 pm – Dinner (SHC) & Guest Speaker 1LT Mia Ancrum 6:30 pm–STEM Challenge 1 Mission 1 Activities 4 & 5 8:30 pm Reflections 9:00 pm – Personal Time 10:00 pm – Lights Out	**Evening** 5:45 p.m. – Dinner (SHC) & Guest Speaker Capt Helen Williamson 6:45 pm Load Buses 7:00 pm – Drown-proof Training (ATC) 9:00 pm Load Buses 9:30 pm– Personal Time 10:00 pm – Lights Out	**Evening** 6:00 pm – Dinner (SHC) & Guest Speaker MAJ Brad Israel – CEO 68 Ventures 7:00 pm –STEM Challenge Mission 2, Activities 2, 3, 4, 5 & 6 9:00 pm Reflections 9:30 pm – Personal Time 10:00 p.m. – Lights Out	**Evening** 5:30 pm Reflections 6:00 pm Dinner (SHC) & Guest Speaker – Ms Kelli Hope, Mobile Chamber 7:15 pm Sports Night 9:00 pm – Personal Time 10:00 p.m. – Lights Out	**Evening** 6:00 pm – Dinner (SHC) & Guest Speaker COL Robert B. Keyser, P.E., F. SAME 7:00 p.m. – Complete Final STEM Challenge, Mission 3, Activities 5- 6 8:30 pm Reflections 9:00 pm – Personal Time 10:00 p.m. – Lights Out	**Evening**

05.10.2018