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WHAT IS SEAPERCH?

SeaPerch is an innovative underwater robotics program that teaches teachers and students to build an underwater Remotely Operated Vehicle (ROV) in either a classroom or out-of-school setting. Students build the ROV from a kit comprised of low-cost, easily accessible parts, following a curriculum that teaches science, technology, engineering and mathematics (STEM) with a marine engineering theme. Throughout the project, students will learn engineering concepts, problem solving, design skills, and teamwork. In addition, they are exposed to all the exciting careers that are possible in naval architecture and marine/ocean engineering.
Building a SeaPerch ROV teaches basic skills in ship and submarine design, and encourages students to explore naval architecture and ocean engineering principles. Additionally, students gain knowledge of tool safety and technical procedures.

SeaPerch…
- Is a hands-on educational program for Middle and High School Students
- Is fun and challenging
- Is a curriculum that meets national learning standards
- Integrates STEM (Science, Technology, Engineering, Mathematics)
- Provides training for teachers
- Builds teamwork and inspires young minds
- Introduces STEM career discussions

Students learn best by doing; and during the SeaPerch program they follow steps to completely assemble an underwater ROV. After the SeaPerch ROV is constructed, students are encouraged to test their vehicles, deploy them on missions, and compete in a competition (a SeaPerch Challenge), to take what they have learned to the next level. SeaPerch Challenges foster an end goal, reward sportsmanship, spirit and presentation skills, as well as mastery of engineering and science concepts. Events at the Challenge can include:

- Vehicle performance - maneuvering and object recovery
- Innovative design
- Team presentations
- Engineering Notebooks - document planning, design, construction, testing, and learning
- Team spirit and sportsmanship at the event

Winners of recognized regional or state challenges qualify to compete in the International SeaPerch Challenge held each spring.

One of the most important aspects of SeaPerch is that it includes training for teachers. The two methods of training are online, either with a webcast or video training modules, or on-site training. One to one-and-a-half-day onsite training may be arranged upon request, based on availability. Please visit http://seaperch.org/contact and submit a request if you are interested in discussing SeaPerch training at your location. Continuing education and/or professional development credits may also be offered, as educators are often required to attend workshops throughout the year to maintain their teaching license.
The SeaPerch curriculum has been designed to meet many of the national learning standards identified by the U.S. government, as well as the new Common Core standards. With one project, schools are able to teach many of the concepts required for their grade level using a fun, hands-on activity for students. Some of the concepts the students learn while building the SeaPerch ROV include the following:

- Ship and submarine design
- Buoyancy/displacement
- Propulsion
- Soldering/tool safety and usage
- Vectors
- Electricity/circuits and switches
- Ergonomics
- Waterproofing
- Depth measurement
- Biological sampling
- Attenuation of light
- Moment arm, basic physics of motion
- Career possibilities

**PROGRAM BENEFITS**

**Meets National Learning Outcomes:**
The SeaPerch Program meets many of the national learning outcomes for science, including NSTA science standards.

**Encourages STEM Education:**
SeaPerch heavily focuses on science, engineering, technology, and mathematics to support future scientists in these important areas.

**Supports Diversity:**
The program focuses on presenting the possibilities of technical careers to minorities, girls, and other underrepresented populations.

**Costs Per Student Are Low:** The price per kit is $179, and a single kit can be used for a team of up to 5 (depending on age range). Seed funding or subsidies may also be available to help start your program. Please visit [http://www.seaperch.org/order_kit](http://www.seaperch.org/order_kit) for current pricing.

**Provides Web Resources & Community:**
The SeaPerch website, [http://www.seaperch.org](http://www.seaperch.org), provides resources, tools, information, and an active community.
THE STEM CHALLENGE

The world is changing. Every job of the future will require a basic understanding of math and science. STEM (Science, Technology, Engineering, and Mathematics) education is vitally important for our students to learn and become excited about, because the demand for STEM-educated workers continues to grow exponentially each year.

In 2016 the U.S. ranked 3rd in the world in the number of college graduates in STEM related programs. However, the number of U.S. STEM graduates was only 12% compared to the number of STEM graduates in China. Only 5% of science degrees are awarded in engineering, as compared with 50% in China. If it is not addressed, the expected shortage of skilled workers could decrease the nation's global competitiveness and result in a lack of expertise in critical areas.

The Countries With The Most STEM Graduates
Recent graduates in Science, Technology, Engineering & Mathematics (2016)

<table>
<thead>
<tr>
<th>Country</th>
<th>Graduates</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>4.7m</td>
</tr>
<tr>
<td>India</td>
<td>2.6m</td>
</tr>
<tr>
<td>United States</td>
<td>568,000</td>
</tr>
<tr>
<td>Russia</td>
<td>561,000</td>
</tr>
<tr>
<td>Iran</td>
<td>335,000</td>
</tr>
<tr>
<td>Indonesia</td>
<td>206,000</td>
</tr>
<tr>
<td>Japan</td>
<td>195,000</td>
</tr>
</tbody>
</table>

These statistics show how few students are engaged in STEM fields:

- 33% of eighth graders are interested in STEM careers…
• …but only 6% of them will graduate college with a STEM degree.
• Only 18% of high school seniors are ranked science-proficient.
• Only a third of high school seniors are ranked math-proficient.
• Undergraduate programs in science and engineering report the lowest rate of retention of all college disciplines.

Although the numbers of students interested in and working towards degrees in STEM fields is very low in the United States, the benefits of a STEM education are high:

• Students with bachelor’s degrees in engineering had the highest average starting salaries of all their peers.
• Jobs in mathematics are increasing four times faster than the average job growth.
• More than 30% of current science and technology professionals are expected to retire in fewer than eight years.
• More S&P 500 CEOs earned their undergraduate degrees in engineering than in any other field.
• Scientific innovation has produced roughly half of all U.S. economic growth in the past 50 years.

The STEM challenge is to increase enthusiasm for these vital fields of education, and SeaPerch is committed to doing just that through innovative, hands-on, and engaging activities and curriculum.

**IMPACT**

SeaPerch can make a huge impact on the student who may be on the fence about entering a STEM-related field, as well as on the one who has never even been exposed to STEM education. In order to take the first steps towards majoring in a STEM program in college, a student must be both interested and proficient in STEM. SeaPerch is an ideal opportunity to foster both a passion for STEM as well as teaching important concepts and standards.

**STEM Interest**
- SeaPerch provides many venues for teachers to encourage enthusiasm for STEM, as students learn about, build, operate, and compete with their robots.
- SeaPerch provides teachers with the opportunity to talk with their students about majoring in STEM, as well as careers in those fields.
- The engaging, fun, and hands-on activities SeaPerch offers can spark an interest in STEM even in students who previously showed no enthusiasm for these areas.

**STEM Proficiency**
- SeaPerch aligns to the national educational standards for science, including the NSTA science standards.
• The activities in SeaPerch teach proficiency in many STEM areas in a way that is appealing and fun for students.
• SeaPerch lends itself well to interdisciplinary projects, giving teachers the opportunity to increase proficiency in many areas of science, mathematics and literacy.
• Areas of SeaPerch that students find interesting - building, problem solving, etc. - have direct correlations to skills needed for a career in a STEM field.
• STEM careers can have a huge impact on the world, and are challenging and satisfying for students.

WHY NAVAL STEM?

Inspiration, discovery, and innovation are the hallmarks of the U.S. Navy's Research Enterprise. Maintaining a technological edge requires a dynamic portfolio of scientific research and technology development, a culture of innovation, and the capacity to draw upon diverse ideas and approaches. Tomorrow's scientists and engineers will be at the heart of this innovation process. Without a steady stream of civilian and enlisted scientists and engineers, the Navy's ability to maintain its science and technology superiority will falter over time. Consequently, increasing the STEM pipeline has become a critical priority for the Navy so that it is capable of tackling the challenges of the future.

By offering a broad range of STEM education and outreach programs, the Navy seeks to address the national crisis of decreasing college enrollments and careers in science and engineering. Through programs like SeaPerch, the goal is to engage and inspire young people by exposing them to exciting, hands-on, and mentor-based programs that build science, engineering and technology skills, while at the same time fostering self-confidence and life skills.
**COSTS**

**Educators are Able to Control Costs**
Among the virtues of the SeaPerch program is the available leverage to spend as little or as much as you want. Some teachers/leaders borrow tools from school shops or parents for the construction. Some teachers/leaders reuse every part from year to year. The program lets teachers be creative and figure out how SeaPerch best fits into their classroom or program.

**Parts are Inexpensive, Easy to Find & Replace**
We've made every effort to find the lowest cost, best quality, most easily accessible parts for the SeaPerch ROV. We wanted to make every bit of a SeaPerch easy to find and replace. We offer key replacement parts on the website at a low cost, so a program is able to reuse some parts, and purchase those they need to replenish directly from the website.
FREQUENTLY ASKED QUESTIONS (FAQs)

For complete up to date FAQs, please visit http://seaperch.org/faqs

Who sponsors the program?
The Office of Naval Research is one of the primary sponsors of the SeaPerch program. For a full list of current sponsors, please see http://www.seaperch.org/sponsors.

Who manages the program?
SeaPerch is managed by RoboNation, located at 2700 S. Quincy Street, Ste. 400, Arlington, VA 22206. Visit http://www.robonation.org/ to learn more.

How do I get kits?
All kits must be ordered online at http://www.seaperch.org/order_kit.

Can I buy just one kit?
Yes. Just visit the website and click “Order kits” on the right-hand side, and click the “I will pay for my kits” icon and you will be on your way! Consider whether you need to purchase a tool kit if you don’t have the tools – a list of them can be viewed from the order page.

What age group is SeaPerch appropriate for?
Any age from 6th grade through college freshmen can benefit from the program, as it’s easily scalable for those ages depending on how you wish to use it.

If you will be using the kits with younger students, we recommend lots of supervision and that you allow extra time for completion of the build.

Please keep in mind that the tools and supplies that are used during a build require dexterity and good hand-eye coordination. For this reason, we typically recommend building the ROVs with kids who are in at least 6th grade. However, students of any age can drive a SeaPerch with adult supervision.

Who can be a part of SeaPerch?
Schools can use SeaPerch as part of a curriculum or after school activity. Clubs such as 4-H, Boy or Girl Scouts, or homeschoolers are also good candidates. Just about any group of middle or high school students gathered with an interest in STEM can participate in SeaPerch!

Is there a curriculum connected to SeaPerch?
Yes, there is both a standard build curriculum (found on the website under “Build”), as well as complimentary lessons and activities (found under “Teach”). The lessons meet many of the national learning standards for STEM for middle and high school, which is one of the key benefits of the program.
Can we add enhancements to our ROV?
Yes, we encourage students to think outside the box in the creation of their ROVs. You can purchase any small underwater camera and add it to the vehicle. A sensor suite can also be added which can measure and report data, this will soon be available on the website. Students also often choose to decorate their ROVs with paint or colored floatation devices.

How long does the build take?
SeaPerch is scalable to meet your needs and learning outcomes. If you wish to simply build the vehicles, you can do so in a few days. At a minimum, we recommend you schedule 10 hours of build time. If you wish to stretch out the learning process and incorporate other activities/teaching units into the actual build, that works well also. Some schools have taken a whole semester to build the SeaPerch ROVs. It’s all up to you and what concepts/outcomes you want to teach and achieve with the SeaPerch and your students.

How many kits are required for my group of students?
We recommend one kit per 4-6 elementary students, 3-5 middle school students, or 2-4 high school students.

Do I need tools?
There is a teacher tool bag that you can order via the website, which provides everything you will need to build the SeaPerch. Tools can be shared by students and reused yearly. You may also use your own tools if you have them available.

Is training available?
If you are interested in bringing a SeaPerch build training to your location, contact us to learn more. We also have online training videos that step through the entire build process and are available for beginner or advanced users. It is helpful to do an actual build with a SeaPerch kit (and using the tools from the toolkit) while watching the online training videos. The videos may be downloaded for viewing offline, and are designed to be paused as needed.

What if we don’t have a pool?
Many local hotels, YMCAs, or colleges will allow access for your testing and challenges, once you explain your mission. If all else fails, you can purchase a small above-ground pool or use a large plastic tub.

What does it cost?
The SeaPerch Kit (including battery and charger) costs $179. A Tool Bag containing tools that can be used for multiple SeaPerch builds, that can be reused year after year, costs $249. There are also special parts and replacement parts available on the website for various other needs. For current prices, please visit http://www.seaperch.org/order_kit.

I would like to do this, but have limited funding. Can you help?
Through the Office of Naval Research (ONR), there may be some limited grant funding available to
help provide up to five kits and one tool kit to help you get started. There is a short grant application that you will be asked to complete as part of the kit ordering process. These kit grants are based on funding availability.

**What do we need to make a successful program?**
A committed champion willing to advocate for the program! The more people that can provide support for the program, the better. It is always helpful to have a larger group of teachers working together, as well as an administration willing to provide support. If possible, a university, college, or community college partner, local industry support, community volunteers/mentors, and/or tech support can all help your program reach great heights!
Starting a Program

In this guide, you will find everything you need to start a SeaPerch program, from lists of necessary materials to competition framework, to information about building the ROVs. Additional information, including extensive lesson plans and curriculum, can be found on the SeaPerch website, http://www.seaperch.org/index, as well as the MIT SeaPerch website, http://seaperch.mit.edu.
The following flowchart gives an overview of the SeaPerch framework in the U.S. and internationally. Because SeaPerch is a fast-growing program, we encourage states and countries interested in growing their SeaPerch program to follow the following framework. SeaPerch is committed and eager to help all new groups become a part of our program!
**STATES DIVERSITY**

SeaPerch embraces all new groups and regions that wish to become involved. No matter how small your group might be, you have the opportunity to impact students for lifelong learning through the SeaPerch program.

In the U.S., all 50 states, plus the District of Columbia, are currently participating in SeaPerch. Because participation is still growing each year, states may be at different levels of organization. For example, Indiana has participated in SeaPerch for eight years and has multiple regional competitions and a state competition, and takes several teams to nationals. States with smaller programs do not hold regional competitions, but participate in out-of-state regionals. Our goal is to eventually have all states able to participate in the national framework levels of regionals, state competitions, and the International Challenge.

**NEED FOR A CHAMPION**

In order to make SeaPerch run smoothly and successfully for your school or organization, you need a committed champion who is willing to advocate for the program and its impact for students. This person can be a parent, teacher, administrator, local industry or university partner, or anyone else who is able to promote the program and its benefits while helping students succeed. A champion should be able to support the students from beginning to end, including the build, testing, and competitions. They should also be the one to maintain contact with other regional and/or state teams, and the SeaPerch website.
TARGET AUDIENCE

Any age from 6th grade through college freshmen can benefit from the program, as it's easily scalable for those ages depending on how you wish to use it. If you will be using the kits with younger students, we recommend lots of supervision and that you allow extra time for completion of the build.

Please keep in mind that the tools and supplies that are used during a build require dexterity and good hand-eye coordination. For this reason, we typically recommend building the ROVs with kids who are in at least 6th grade.

SeaPerch Challenges provide two separate groupings for middle and high schoolers.

MANAGING A PROGRAM BUILD

There are many things to consider when starting a SeaPerch program for your school or organization. What materials are necessary? How many students can work on one ROV? How will I (the teacher/leader) learn how to build the robot in order to teach my students? All the necessary information for starting a SeaPerch program build can be found in this manual. Additional information, including build videos and connection links, can be found on the SeaPerch main website, http://www.seaperch.org/index.
SeaPerch is appropriate for students from sixth grade through their freshman year in college. The curriculum can be adjusted to work with the ages of the students, but in general they should have at least a fifth-grade understanding of science and mathematics. The SeaPerch curriculum has both beginner and advanced lesson plans to accommodate different levels of learning.

Beginning-level students will learn a great deal while building the basic design. As they use and practice with their ROV in the water, they will also begin to learn the connections of the build to the ROV’s maneuverability and speed. More advanced students will be able to integrate additional physics and engineering concepts into their designs and competition strategies.

In order to start a SeaPerch program, at least one teacher/leader needs to have been trained through SeaPerch, or should have the knowledge and ability to support a build after viewing the supporting materials provided here and on the website, including build videos.
SeaPerch kits are available online at a cost of $179.00 per kit. Supplemental materials, such as screwdrivers, soldering irons, etc., can be purchased individually, or you can purchase our Teacher’s Tool Kit for $249.00. We recommend one Teacher’s Tool Kit for every 5 individual SeaPerch kits. To check current pricing and make purchases, please visit http://www.seaperch.org/order_kit
If you would like to apply for a grant through the AUVSI Foundation program to help cover the cost of the SeaPerch kits, please click “I wish to apply for a grant” at the bottom of the order page.

If you choose not to purchase a Teacher’s Tool Kit, many of the materials needed to build your SeaPerch ROV can be found in a parent’s toolbox, or a school’s wood or theater shop. If not, most can be purchased inexpensively and reused for many years. Below is a list of our recommended tools:

**Individual Tools (Recommended for each SeaPerch kit)**

- 1 PVC Pipe tubing cutter (ratchet style)
- 1 Phillips screwdriver, small
- 1 Pair scissors
- 1 Slip-joint and/or needle-nose pliers
- 1 Diagonal cutter pliers (wire cutters)
- 1 Wire stripper (for 26-16 AWG stranded wire)
- 1 Pair safety glasses (1 pair per student actively working)
- 1 Soldering iron

**Shared Tools (Shared by multiple SeaPerch kits)**

- 1 Drill bit, 1/4”
- 1 Drill bit, 3/32”
- 1 Hand drill, variable speed
- 1 Digital Multimeter for testing and troubleshooting (optional)
- 1 Desoldering pump (optional)
- 1 Bench vise, 4” (optional)
One of the most important aspects of SeaPerch, and one that differentiates it from similar programs, is it includes training for teachers and leaders. The two methods of training are online videos or on-site training. One to one-and-a-half-day onsite training may be arranged upon request. Please visit http://seaperch.org/contact and submit a request if you are interested in discussing SeaPerch training at your location. Continuing education and/or professional development credits may also be offered, as educators are often required to attend workshops throughout the year to maintain their teaching license. To access the online training videos, please visit http://www.seaperch.org/online_training_videos.
MENTORS AND VOLUNTEERS

A single teacher or leader, though vital, is not enough to ensure the success of a SeaPerch program. Mentors and volunteers play a critical part in the building and testing process, as well as the competition. Their encouragement of students is so important to the success of the program. Reach out to parents and community members – often they will be more than happy to mentor your students and help during the build. If there is a local college, students (and sometimes even professors based on availability) make excellent mentors.

If you are holding a local SeaPerch competition, you will need many volunteers to ensure the competition runs smoothly. Volunteers can help set up the competition area and challenges beforehand. During the actual competition, you will need people in charge of registration, lane judges, a swimmer to reset challenges or retrieve lost parts, people to direct participants and spectators, etc. Finding volunteers to help might sound like a challenge, but it can be easy. If you get a good number of people who can support and back the program, SeaPerch at your school or organization will run smoothly and can provide the most benefit for your students. Below are some tips to help you find volunteers:

- Ask parents and older siblings if they can help with the program. Anyone with a STEM background is ideal for becoming a mentor, but anyone with an interest in supporting students can help.
- Call local college professors and ask if they or their students might be interested in helping with the program.
- Remember to ask for mentors specifically to help with engineering notebook judging and presentations. These mentors do not necessarily need to have a STEM background, but should be able to help the students present the material and improve their public speaking abilities.
- Ask for a specific time so as not to overwhelm potential volunteers – for example “Can you come in for just one hour a week to mentor our students as they build their ROVs?”
- Stress that everyone can help with the SeaPerch program – not just science or engineering professionals. Something as simple as bringing a snack for hard-working students can be a huge help.
- Don’t forget to thank everyone who has helped to make your SeaPerch program a success!
WATER ACCESS

For some schools and organizations, access to water may not be a problem. However, if your school or organization does not own a pool, there are several things you can do:

- A 50 gallon trash can or large tub is ideal for testing in the classroom.
- Local lakes or ponds often have free water access.
- If a student’s family owns a swimming pool, ask if you can have access to that resource.
- Local YMCAs may offer access to their pools.
- Local hotels with pools may also be willing to let you use their resources.
- A small inflatable pool (at least 2 to 3 feet deep) may be set up outside.
- Fire departments may be willing to bring in their reservoir for students to use.
- Even a clean cow trough can be used for buoyancy testing.

Be sure to always call ahead of time and make sure that the water resource you are planning to use is accessible and that you are permitted to use it.
GROUP SIZE AND TEAMWORK

SeaPerch works best when students are encouraged to cooperate and work together in teams. There is a great deal of material to be learned in order to complete a build. When students each choose an area to study more fully, they can share their knowledge with the team.

Any size of group can work to build a SeaPerch, from a single student to a large group. However, the following list of recommended group sizes will maximize the SeaPerch experience, reducing the need for excessive kits while allowing each student to participate:

- **Elementary**: 4-6 students
- **Middle School**: 3-5 students
- **High School**: 2-4 students

In middle and high school, we recommend that each student take a particular area of engineering and apply it to their team and their SeaPerch ROV build. They can then prepare short lessons on their particular area of expertise in order to share with their teammates. The following student “specialties” are recommended:

- **Mechanical Engineer**: In charge of motors and mechanical systems.
- **Materials Engineer**: In charge of structural systems. Checks quality of structure on daily basis.
- **Electrical Engineer**: In charge of control box and control systems. Maintains battery charge.
- **Systems Engineer/Project Overseer**: Maintains positive flow, oversees project and maintains a record of the build.
- **Presentation Designer**: In charge of creating the final SeaPerch presentation.
- **Technical Writer/Illustrator**: In charge of maintaining the engineering notebook.

We also recommend a certain number of adult supervisors in order to keep the build experience flowing smoothly and to prevent safety mishaps:

- **Elementary**: 1 adult per team
- **Middle School**: 1 adult per 2-3 teams
- **High School**: 1 adult per 4+ teams
SCHEDULING OPTIONS

SeaPerch is a program that can be used in many different venues, from public and private schools to homeschools, to clubs and extracurricular activities. Therefore, scheduling activities, lesson plans, build sessions, and quality testing/practices are up to the discretion of the teacher/program supervisor. In a school setting, lesson plans may be set up so that teachers can use one or several class periods.

You may choose to do an entire unit with SeaPerch, or you may spread it out throughout a year or semester, interspersing SeaPerch activities with other classroom lessons. In a homeschool or club setting, you may choose to only focus on the build and testing procedures to fit the available meeting times. Whichever you choose, SeaPerch is flexible enough to fit any time constraint and availability!

Below are two examples of SeaPerch schedules:

**Example I: Embedded in a Semester of High School**
Sessions during class, 1 time per week

Weeks 1-3: Underwater Oceanography
Week 4: Buoyancy
Week 5: Density
Weeks 6-7: Electrical Circuitry
Weeks 8-9: Scientific Method and Presentations
Weeks 10-14: SeaPerch ROV Build
Weeks 15-17: Testing/Data Collection
Week 18: School Competition

**Example II: Club or Group Meetings**
Meetings 1 time per week

Week 1: Introduction to SeaPerch
Week 2: Exploration of Navy and underwater challenges
Week 3: Materials and build discussion; watch beginning build videos
Week 4: Building the Control Box
Week 5: Constructing the Frame  
Week 6: Adding Motors  
Week 7: Propellers and Battery Connections  
Week 8: Adjusting Flotation and Water Testing  

**COMPUTER ACCESS**

Computer availability for all students can be helpful, especially if you plan on having the students research topics and discover answers on their own time. Some lesson plans can benefit from each team having computer access.

However, in order to complete the SeaPerch build and to compete, it is not necessary for students to have computer access. As long as a teacher or volunteer can get onto the SeaPerch website and provide necessary instructions and materials, the students can have a complete SeaPerch experience. The build videos can be found on the SeaPerch website through the following link:

http://www.seaperch.org/seaperch_complete_build
Students benefit greatly from having the opportunity to demonstrate their new knowledge and their SeaPerch ROVs. They have the chance to interact with other students interested in engineering and STEM, and will gain confidence through presenting and competing. The following information will assist you in managing a local, regional, and/or state competition.
LOCAL and REGIONAL COMPETITIONS

Local competitions are small events to allow for exploration and friendly competition between students from the same school, small school district, or area and provide a chance to showcase their SeaPerch ROVs and optionally compete on a small scale.

Regional competitions are larger events that welcome teams from large cities, counties, and even multiple states. Regional, as well as State competitions (where they exist) are used as qualifiers for the International SeaPerch Challenge.

Please see specific guidance at [http://seaperch.org/challenge_application](http://seaperch.org/challenge_application) for team entry rules for the next International SeaPerch Challenge. Event coordinators that intend to send teams to the International SeaPerch Challenge must submit a Qualifying Competition Registration Form and add their event(s) to the SeaPerch Calendar of Events as directed on the website page referenced previously. If you have a large turnout, the regional event may also serve to determine which SeaPerch teams will attend a State event or the International Challenge.

If you plan on creating a local or regional competitions, contact teachers and mentors from other schools and clubs in your area to see who might be interested. If they have not yet begun a SeaPerch program in their area, mention that they can find all the necessary information on the SeaPerch website: [http://www.seaperch.org/index](http://www.seaperch.org/index)

A competition, no matter how small, can really serve to pique interest in the SeaPerch program. When parents, teachers and friends see for themselves how fun and educational SeaPerch is for the students, they will be more likely to support the program and help ensure its continuation. Challenges during an event can vary, but there are several that are consistently used across the USA. These tried-and-true events are easy to set up and prepare, and are both fun and challenging for students:

- **Obstacle Course:** Students must maneuver their ROVs through an underwater obstacle course. This can be constructed of PVC pipe structures, weighted hula hoops, etc.
- **Salvage:** Students use their ROVs to retrieve diving rings from the bottom of a pool or from clips hanging on a simple metal or PVC frame.
- **Sprint:** Students race their ROVs on the surface of the water.

Planning a SeaPerch competition may sound challenging, but it can actually be condensed into a few simple steps:

1. Schedule the event
2. Find and secure a location with a pool
3. Engage volunteers and judges
4. Create and set obstacles
5. Event day!
More specific information to help you plan a successful and stress-free local or regional event can be found under “Planning an Event” in this guide.

**STATE COMPETITIONS**

State competitions are a terrific opportunity as regional competitions begin to grow in your area. This tiered system allows the winners of regional competitions to refine their ROV designs as well as their presentation skills, and to compete at a higher level against other champions at the state level.

In several areas, universities and colleges have been pleased to host state competitions in order to support STEM initiatives.

**INTERNATIONAL SEAPERCH CHALLENGE**

Winners of state competitions, or of regionals if a state competition has not yet been implemented in your area, have the opportunity to attend the annual International SeaPerch Challenge. This is an exciting event for students who love the chance to travel and to meet other science- and technology-minded students from around the country.

The first National SeaPerch Challenge was held in Philadelphia, Pennsylvania in 2011 with just 38 teams. Since then, Nationals has grown every year, and has been hosted in diverse cities around the U.S. In May of 2017, the Georgia Tech Aquatics Center, home of the 1996 Olympic Games, was pleased to host the 7th National SeaPerch Challenge! This was the second largest to date, with 188 SeaPerch teams competing from around the U.S and the world.

The featured events included a brand-new special pool challenge, as well as the first-ever Engineering Notebook presentation. Students participated in a welcome party the night before the challenge, and an awards ceremony after. A rousing success, the seventh National SeaPerch challenge shows the growth of the program, as well as the potential to spread internationally. Teams from Puerto Rico have participated in the National SeaPerch Challenge since 2013, and since the participation of international teams has grown the National SeaPerch Challenge became the International SeaPerch Challenge starting in the 2017-2018 school year. To date, teams from Australia, the Cayman Islands, New Zealand, and the Virgin Islands have participated in the International Challenge.

More information on the current International SeaPerch Challenge can be found at: [http://www.seaperch.org/seaperch_challenge](http://www.seaperch.org/seaperch_challenge). Please note that information on the next International SeaPerch Challenge may not have been posted yet.
Below is a checklist that may be helpful when planning a local, regional or state competition. Note that it is prudent to begin planning at least 6 months before the event is to be held.

### 6-9 Months Before Event:

- Secure a location. The location should have a pool as well as classrooms or other areas nearby for presentations.
  - Keep in mind the cost of using the facility, if applicable.
  - Remember that some facilities may charge custodial expenses.
- Inquire if any insurance/liability riders are necessary.
- Set registration timeframe and fees.
- Invite local business partners to support the upcoming challenge (financially or volunteers).

### 2 Months Before Event:

- Plan schedule for competition day.
- Send out competition day details to all participants, including schedule and directions.
- Organize underwater obstacle structures and materials.
- Solicit judges and volunteers:
  - Lane judges
  - Presentation judges
  - Security, Divers, First Aid and Life Guards
  - Registration workers
  - General volunteers to manage flow of participants and spectators
  - Camera men/women for stills and/or video
- Order shirts or other items for participants (optional).
- Order awards.
- Inform local news media.
- Secure materials for Triage table.
Day of Event:

- Set up obstacle courses, etc.
- Set up ROV inspection area.
- Organize registration table.
- Set up awards and triage areas.
- Set up volunteer area with information and refreshments.
- Enjoy the competition!

**DEFINING A LOCATION**

The pool area of a high school or university is often the ideal place to hold a SeaPerch event, because it usually has all the resources necessary to keep the event running smoothly. The pool with lanes is the perfect place for the competitions to occur, while a diving well or small side pool can be used for last-minute testing and modifications. Spectators can use the stands to watch competitions, and classroom areas are available for the ROV presentation judging.

If this resource is not available to you, often local YMCA associations or gymnasiums are more than happy to accommodate a SeaPerch competition. Make sure that you call far ahead of time so that you can book the location and obtain lifeguards. Even small locations are suitable for regional competitions, as long as the pool can contain two or three ROVs at a time.

**DEFINING THE CHALLENGES/GAMES**

Regional challenges may encompass any variation of activities for the pool and presentation portions of a competition. However, it is beneficial for at least some, if not all, of the challenges to align with International SeaPerch Challenge in order for teams to be better prepared to compete at the international level. The description of the International SeaPerch Challenge, rubrics, and rules can be found on the SeaPerch website through the following link: [http://seaperch.org/seaperch_challenge](http://seaperch.org/seaperch_challenge).

In the past, challenges have included obstacle courses, salvage, “oil spill” cleanup, underwater retrieval, orbs course, surface sprints, and a “platform/origin” challenge.
SCHEDULING

Although scheduling will vary between competitions, below is a sample schedule that may help you to organize your own agenda for competition day:

6:30-7:30 A.M.
- Set up pool obstacles, registration table, and presentation rooms
- Organize a volunteers room with refreshments and information
- Set up trophy/awards area
- Judges and volunteers arrive

7:30-8:30 A.M.
- Teams arrive
- Registration
- Welcome ceremony

8:30-12:30 A.M.
- Teams rotate through the following sections:
  - Obstacle Challenge
  - Open Challenge(s)
  - Presentations

12:30-1:30 P.M.
- Lunch
- Scoring calculations by judges

1:30-2:00 P.M.
- Awards and photos
- Teams leave

2:00-3:00 P.M.
- Cleanup
ADVERTISING AND PUBLIC RELATIONS

A SeaPerch competition is an excellent opportunity to show parents, businesses, and the community the meaningful learning that students can accomplish with SeaPerch’s interactive program. Take time to plan for photo opportunities and involve your local newspapers and news agencies. By getting the word out that you are participating in a fantastic STEM initiative program, you will not only be able to grow the program, but you may also find that local businesses are willing to support your students.

Below are some ways you can advertise SeaPerch:

- Invite a local news source to do a story about your SeaPerch competition.
- Hang up posters around town inviting spectators to watch the competition.
- Put a notice in a school or local newspaper.
- Have students talk about their SeaPerch experiences at a local club or guild.
- Social media is also a great means of promoting and advertising the competition.

After your competition is complete, take time to send in a brief description of the event, as well as pictures, to info@seaperch.org. We want to feature your competition on the SeaPerch website and acknowledge your successes!
VOLUNTEERS

Volunteers play a vital part in any SeaPerch competition. You may be surprised at the number of volunteers that want to help with your event! For a local, regional or state competition, you will need to enlist several different types of volunteers, listed below. The number of volunteers in each category will vary depending on the size of your event.

- Lane judges
- Presentation judges
- Registration volunteers
- Set-up and tear-down crew
- Swimmers/divers to reset challenges and/or retrieve dropped parts
- Photographers
- Volunteers to direct participants and spectators

When searching for volunteers, consider approaching the following groups of people:

- Local business partners
- School teachers and administrators
- Any area military installations/support offices including contractors, government employees, and National Guard outposts
- State officials
- Parents
  - Note – parents should not judge events that their children may be participating in
- University staff

*Remember to thank all volunteers for their time and efforts to make your SeaPerch competition a positive and successful event!*
A triage table is a table with spare parts and tools just in case something breaks or goes missing. In a competition with lots of kids running around with robots, be sure that something will go wrong. It’s always better to be prepared rather than have to scramble for extra parts in the heat of the moment. A typical triage table might contain the following equipment and parts:

- Soldering iron and solder
- Wire
- Wax
- Epoxy
- Propellers
- Propeller shafts
- Pre-waxed motors
- General tools such as screwdrivers, vise grips, wire cutters, etc.
- Safety glasses
AWARDS

Awards are up to your discretion, but as a rule, more is better. Although there will be some teams who are clearly ahead in certain areas, all students should be congratulated and encouraged, since all students have worked hard to create and use their SeaPerch ROVs. Even the teams who do not move up in the competition will be thrilled to receive a smaller award acknowledging their efforts. Plan to celebrate the successes of all participants!

In general, awards should be awarded separately at both the middle school and the high school level. Below is a sample framework of awards:

- **Obstacle Course:**
  - First Place
  - Second Place
  - Third Place

- **Presentations:**
  - First Place
  - Second Place
  - Third Place

- **Open Competition:**
  - First Place
  - Second Place
  - Third Place

- **Other Challenge(s) (Salvage, Sprint, etc.)**
  - First Place
  - Second Place
  - Third Place

- **Best Use of Engineering Principles**

- **Most Unique Build**

- **Most Innovative Adaptation**
COSTS FOR KITS

The SeaPerch Kit (including battery and charger) costs $179. A Tool Bag containing tools that can be used for multiple SeaPerch builds, that can be reused year after year, costs $249. There are also special parts and replacement parts available on the website for various other needs. For current prices, please visit http://www.seaperch.org/order_kit.

GRANT OPTIONS

Grant funding is available on a limited basis and may cover some student kits and one teacher tool bag. Grants are usually awarded to schools or areas entering their first year of SeaPerch programming. In order to apply for grant funding, go to the following website:

http://www.seaperch.org/kit_checklist?grant=1

If you do not qualify for a grant, check for other teacher grants and funding that may cover kit cost, or look for local businesses to sponsor your students.

Also, check http://seaperch.org/teacher_tools for a donor letter template, and sustainability guide.
SeaPerch is more than just an opportunity for students to build a cool robot. It can be turned into an entire curriculum based on the SeaPerch ROVs. We have a collection of lesson plans, in addition to supplemental materials like PowerPoint presentations and worksheets, to help you make the most of this amazing opportunity. These materials can be found through the “Teach” link on the SeaPerch website at http://www.seaperch.org/teach.

Whether you want to take a single day and learn something new through one of our SeaPerch lessons, or if you wish to delve deep into our STEM curriculum and create an entire unit, we have resources you can use to enrich your students’ SeaPerch experience. All lesson plans cover national science standards.

**ACADEMIC COMMON CORE STANDARDS**

As of October 1, 2012, the United States Department of Education is continuing to support the movement to refine national standards for science, currently labeled as the Next Generation Science Standards. These standards complement the Common Core standards for Mathematics and English/Language Arts. When completed, most states will likely choose to adopt the science standards in order to streamline science education criteria throughout the United States.

SeaPerch is committed to creating a curriculum that will be in alignment with all national standards, including the Common Core and Next Generation standards. As we continue to receive updates on their progress, we will add to and refine our lessons to reflect the changes. On the following two pages is a topical matrix of the most current NGS standards. More information, including detailed standards for each grade, can be found via the National Science Teachers’ Association at the following website:

http://www.nsta.org/about/standardsupdate/

In addition, Cross Curricular lessons are updated with the Common Core standards for English/Language Arts, which can be accessed through the following website:

http://www.corestandards.org/the-standards
# 1. Academic Common Core Standards (2 of 3)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Life Science</th>
<th>Earth and Space Science</th>
<th>Physical Science</th>
<th>Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>Interdependent Relationships in Ecosystems</td>
<td>Weather and Climate</td>
<td>Forces and Interactions: Pushes and Pulls</td>
<td>K-2: Engineering Design</td>
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<tr>
<td>1</td>
<td>Structure and Function</td>
<td>Space Systems: Patterns and Cycles</td>
<td>Waves: Light and Sound</td>
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<tr>
<td>2</td>
<td>Interdependent Relationships in Ecosystems</td>
<td>Earth’s Systems: Processes that Shape the Earth</td>
<td>Structure and Properties of Matter</td>
<td>3-5: Engineering Design</td>
</tr>
<tr>
<td>3</td>
<td>Interdependent Relationships in Ecosystems; Inheritance and Variation of Traits</td>
<td>Weather and Climate</td>
<td>Forces and Interactions</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Structure and Function</td>
<td>Earth’s Systems: Processes that Shape the Earth</td>
<td>Energy; Waves: Waves and Information</td>
<td>3-5: Engineering Design</td>
</tr>
<tr>
<td>5</td>
<td>Matter and Energy in Organisms and Ecosystems</td>
<td>Earth’s Systems; Space Systems: Solar System and Stars</td>
<td>Structure and Properties of Matter</td>
<td></td>
</tr>
</tbody>
</table>

## Elementary School
- Structure and Function
- Matter and Energy in Organisms and Ecosystems
- Interdependent Relationships in Ecosystems
- Natural Selection and Adaptations
- Growth, Development, and Reproduction of Organisms

## Middle School
- Structure and Function
- Inheritance and Variation of Traits
- Matter and Energy in Organisms and Ecosystems
- Interdependent Relationships in Ecosystems
- Natural Selection and Evolution

## High School
- Structure and Function
- History of Earth
- Earth’s Systems
- Weather and Climate
- Human Impacts

Matrix prepared by NSTA based on the release of the Next Generation Science Standards, April 2013
<table>
<thead>
<tr>
<th>Elementary School</th>
<th>Life Science</th>
<th>Earth and Space Science</th>
<th>Physical Science</th>
<th>Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>From Molecules to Organisms</td>
<td>Earth’s Systems; Earth and Human Activity</td>
<td>Motion and Stability; Energy</td>
<td>K-2: Engineering Design</td>
</tr>
<tr>
<td>1</td>
<td>From Molecules to Organisms; Heredity</td>
<td>Earth’s Place in the Universe</td>
<td>Waves and Application to Technology</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Ecosystem Interactions; Biological Evolution</td>
<td>Earth’s Place in the Universe; Earth’s Systems</td>
<td>Matter and Its Interactions</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>From Molecules to Organisms; Ecosystem Interactions; Heredity; Biological Evolution</td>
<td>Earth’s Systems; Earth and Human Activity</td>
<td>Motion and Stability</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>From Molecules to Organisms</td>
<td>Earth’s Place in the Universe; Earth’s Systems; Earth and Human Activity</td>
<td>Energy; Waves and Application to Technology</td>
<td>3-5: Engineering Design</td>
</tr>
<tr>
<td>5</td>
<td>From Molecules to Organisms; Ecosystem Interactions</td>
<td>Earth’s Place in the Universe, Earth’s Systems; Earth and Human Activity</td>
<td>Matter and Its Interactions; Motion and Stability; Energy</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Middle School</th>
<th>Life Science</th>
<th>Earth and Space Science</th>
<th>Physical Science</th>
<th>Engineering</th>
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<tr>
<td></td>
<td>• From Molecules to Organisms</td>
<td>• Earth’s Place in the Universe</td>
<td>• Matter and Its Interactions</td>
<td>MS: Engineering Design</td>
</tr>
<tr>
<td></td>
<td>• Ecosystem Interactions</td>
<td>• Earth’s Systems</td>
<td>• Motion and Stability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Heredity</td>
<td>• Earth and Human Activity</td>
<td>• Energy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Biological Evolution</td>
<td></td>
<td>• Waves and Application to Technology</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High School</th>
<th>Life Science</th>
<th>Earth and Space Science</th>
<th>Physical Science</th>
<th>Engineering</th>
</tr>
</thead>
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<td></td>
<td>• From Molecules to Organisms</td>
<td>• Earth’s Place in the Universe</td>
<td>• Matter and Its Interactions</td>
<td>HS: Engineering Design</td>
</tr>
<tr>
<td></td>
<td>• Ecosystem Interactions</td>
<td>• Earth’s Systems</td>
<td>• Motion and Stability</td>
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<tr>
<td></td>
<td>• Heredity</td>
<td>• Earth and Human Activity</td>
<td>• Energy</td>
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<td></td>
<td>• Biological Evolution</td>
<td></td>
<td>• Waves and Application to Technology</td>
<td></td>
</tr>
</tbody>
</table>

Matrix prepared by NSTA based on the release of the Next Generation Science Standards, April 2013
**TEACHING UNITS**

SeaPerch has a large collection of lesson plans that can be used with and about the SeaPerch ROVs. For ease of navigation through the plans, we have divided them into five units:

- Design and Build Lessons
- Testing and Troubleshooting Lessons
- Engineering/Robotics Lessons
- Oceanography Lessons
- Cross-Curricular Lessons

These lessons can be used in any order and in any combination in order to enhance the SeaPerch experience. These teaching materials can be found on the SeaPerch website under “Teach” at [http://www.seaperch.org/teach](http://www.seaperch.org/teach). Some lessons have accompanying PowerPoint presentations, which can also be found on the website.

Our SeaPerch educational directors will be continuously adding to and updating the curriculum and sample lessons. If you have a stellar lesson plan that you have used with your SeaPerch teams, we would love to help share your knowledge and success. If your lessons are added to our resources, we will give you and your SeaPerch program credit for the lesson or lessons you have developed.

Please send any lessons to lstiglitz@seaperch.org
PURPOSE AND IMPACT

Students are encouraged to create presentations over the SeaPerch build and testing process. While the hands-on experiences are important, it is also crucial that students learn how to share those experiences concisely and clearly with others. These skills will be important as students begin preparing for college, internships, and jobs.
ENGINEERING NOTEBOOK

Engineering notebooks are used by engineers to document their ideas and steps taken to solve engineering problems and engineering design projects. They provide a legal document that can be used as proof of invention for products they design.

Engineering notebooks are sometimes referred to as an Engineer’s Notebook, Design Notebook, Laboratory Notebook, or Inventor Notebooks. The purpose of the notebooks is to carefully and systematically track and analyze progress and results.

The use of an engineering notebook is highly recommended throughout the SeaPerch program. The use and submission of an engineering notebook is part of the International SeaPerch Challenge, and is part of many Regional SeaPerch Challenges.

Teams competing in the International SeaPerch Challenge submit their engineering notebook online as a Portable Document Format (PDF) file. The engineering notebooks are judged by panels of judges and scored according to the engineering notebook rubric. The top scoring teams from the engineering notebook challenge who are participating in the International SeaPerch Challenge will present their SeaPerch project during a juried session on competition day. It is beneficial for students to do the same type of presentations at their regional or state challenges as well. These presentations will be judged by a team of professional engineers and educators, and the team will follow International SeaPerch Challenge Presentation Rubric prepared for all divisions, High School, Middle School, and Open Class. Please visit the website to view the engineering notebook and presentation challenge rules and rubrics.

- Each team will be given up to 10 minutes for an oral presentation, followed by 5 minutes of questions from the judges.
- Teams must bring their SeaPerch ROV, any supporting equipment, and their Engineering Notebook to the presentation.
- The focus is on a live presentation by the team members; therefore, posterboards, trifolds, PowerPoint presentations, videos, etc. are not permitted. This is a change from previous years.
- All team members are expected to participate in the presentation.
- The Engineering Notebook is a critical part of the entire SeaPerch building and testing process, and should NOT be written last-minute. Students should work on the notebook throughout the entire process of working with their SeaPerch ROV.

Additional information regarding the SeaPerch Engineering Notebook and presentation can be found on the SeaPerch webpage at [http://seaperch.org/seaperch_notebook](http://seaperch.org/seaperch_notebook).

The following is the 2018 Engineering Notebook Rubric. Adjustments may be made to this rubric each year and will then be updated on the website.
# 2018 SeaPerch Engineering Notebook Rubric

## Cover Page
- **Used Cover template and includes all elements:**
  - School or club name
  - City and State
  - Team name
  - Project title
  - Photo of ROV

  - **Points awarded:**
    - All or nothing - 0 or 5 points for required elements.
    - Subtract 2 points if cover includes team picture
    - Subtract 2 points for sloppiness.

  - **Section Score:**
    - 5 Possible Points

## Team Information Page
- **Includes all elements:**
  - Teacher, coach, mentor, or advisor name and email address
  - Team members’ names, grade levels, and project roles

  - **Points awarded:**
    - All or nothing - 0 or 5 points for required elements.
    - Subtract 2 points for sloppiness.

  - **Section Score:**
    - 5 Possible Points

## Table of Contents Page
- **Follows the American Psychological Association (APA) style guide.**
  - Includes page description and page numbers.

  - **Points awarded:**
    - All or nothing - 0 or 5 points for required elements.
    - Subtract 2 points for sloppiness.

  - **Section Score:**
    - 5 Possible Points

## Reference Page
- **Follows the American Psychological Association (APA) style guide.**
  - Includes page description and page numbers.

  - **Points awarded:**
    - Page included: 2 points
    - Award 1 point per citation
    - Subtract 2 points for sloppiness.

  - **Section Score:**
    - 5 Possible Points
# Engineering Notebook Rubric, Cont’d

<table>
<thead>
<tr>
<th>Engineering Design Process Section</th>
<th>Excellent</th>
<th>Good</th>
<th>Fair</th>
<th>Needs Improvement</th>
<th>Element Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content is related to the Engineering Design Process (EDP). (Specific EDP steps do not have to be listed, but the content should show the use of the process.)</td>
<td>35 to 40 points</td>
<td>21 to 35 points</td>
<td>11 to 20 points</td>
<td>5 to 10 points</td>
<td>40 points max</td>
</tr>
<tr>
<td>- Content as a whole clearly demonstrates that the EDP was followed.</td>
<td>- Majority of content clearly demonstrates that the EDP was followed.</td>
<td>- While the content demonstrates the use of the EDP, it was not completely followed.</td>
<td>- It is not clear that the EDP was used.</td>
<td></td>
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</tr>
<tr>
<td>- Shows design iterations.</td>
<td>- Shows design iterations.</td>
<td>- Design iterations not completely shown.</td>
<td>- Design iterations are either not shown or are not completely described.</td>
<td></td>
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</tr>
<tr>
<td>- Describes design deficiencies of initial designs.</td>
<td>- Does not describe design deficiencies of initial designs.</td>
<td>- Does not fully describe why final design was chosen.</td>
<td>- Test results are either not shown or do not validate design decisions.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Describes why final design was chosen.</td>
<td>- Describes why final design was chosen.</td>
<td>- Test results are clear and validate design decisions.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Test results are clear and validate design decisions.</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Use of graphics (Illustrations, sketches, CAD drawings, photos, diagrams, charts, and graphs)</th>
<th>8 to 10 points</th>
<th>5 to 7 points</th>
<th>2 to 4 points</th>
<th>0 to 1 point</th>
<th>10 points max each element</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 100% of design iterations are described using graphics.</td>
<td>- 50% of design iterations are described using graphics.</td>
<td>- 50% of design iterations are described using graphics.</td>
<td>- 25% or less of design iterations are described using graphics.</td>
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<tr>
<td>- 3 or more types of graphics are included.</td>
<td>- At least 2 different types of graphics are included.</td>
<td>- Test results do not include the use of graphics.</td>
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<tr>
<td>- Test results include the use of graphics.</td>
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<td></td>
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</table>

<table>
<thead>
<tr>
<th>Explanation of graphics</th>
<th>8 to 10 points</th>
<th>5 to 7 points</th>
<th>2 to 4 points</th>
<th>0 to 1 point</th>
<th>10 points max each element</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 100% of graphics are described.</td>
<td>- 50% of graphics are described.</td>
<td>- 50% of graphic are described.</td>
<td>- No explanation of graphics.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Descriptions are clear and lead to a complete understanding of the graphics.</td>
<td>- Most descriptions are clear and lead to a complete understanding of the graphics.</td>
<td>- Most descriptions are unclear or lead to an incomplete understanding of the graphics.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Use of engineering and scientific terms</th>
<th>8 to 10 points</th>
<th>5 to 7 points</th>
<th>2 to 4 points</th>
<th>0 to 1 point</th>
<th>10 points max each element</th>
</tr>
</thead>
<tbody>
<tr>
<td>- At least 7 engineering and scientific terms are used throughout the notebook.</td>
<td>- Between 4 and 6 engineering and scientific terms are used throughout the notebook.</td>
<td>- Only 1 to 3 engineering and scientific terms are used throughout the notebook.</td>
<td>- No engineering or scientific terms used.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Professional appearance</th>
<th>8 to 10 points</th>
<th>5 to 7 points</th>
<th>2 to 4 points</th>
<th>0 to 1 point</th>
<th>10 points max each element</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Professional and neat appearance throughout the notebook.</td>
<td>- Professional and neat appearance in the majority of the notebook.</td>
<td>- Professional and neat appearance in less than half of the notebook.</td>
<td>- Very sloppy throughout the notebook.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Point deductions:
- Subtract 1 point per page for faded, light, or illegible text.
- Subtract 1 point per occurrence for faded, light, or small graphics.
BUILD

Students are always so excited about the SeaPerch build – the actual creation of an ROV. It has such an impact because it is of their own creation, something that they have learned about and made themselves. What they might not realize is that, during the build process, they are gaining so many new abilities, from engineering to life skills like how to handle tools safely. The SeaPerch manual, found on the SeaPerch website, will show you how to help your students complete a successful, fun, and educational build.

MANUAL

A full set of build videos, as well as tips and a printable manual, are available on the SeaPerch website to assist teachers and students in the build process:

http://www.seaperch.org/build

The website build information is updated regularly to give students and teachers the most recent instructions.
Trick Out Your SeaPerch

One of the most exciting things about SeaPerch is that students don’t have to ascribe to a to-the-letter model. They have the freedom to add enhancements and change the design of their ROV so that it reflects their personal ideas and imaginations. SeaPerch is an opportunity to think outside the box!
ENHANCEMENTS

Now that you’ve built a SeaPerch, it's time to take it to the next level. Enhancing your SeaPerch can take on many different paths: you can build your own sensors, add a video camera, give your Perch more power, and add some pizzazz, anything YOU can think of. The possibilities are endless! While you're figuring out your own hacks, you can try these out:

Upload Your Modifications at Instructables.com

Instructables.com is a website dedicated to hacking, modifying, and improving every day technology. While you modify your SeaPerch, take some pictures and jot down some notes, and when you are finished, log in to Instructables.com and add your hack to the SeaPerch group. This is also a great place to get some ideas of how you can hack your own SeaPerch in various different ways.

Advanced ROV

The Advanced ROV demonstrated during the latest SeaPerch conference featured several new projects available to teachers whose students desire to move beyond the initial level of the SeaPerch's capabilities. Significantly more powerful motors, a Stereo Hydrophone system, a bank of LED lights, and the mounting of instruments such as a compass and depth gauge in front of the camera are just a few of the upgrades. The frame, while much larger than that of a normal SeaPerch, is made of the same materials: PVC pipe with floats affixed on top and weights below.

Below are documents for building components of the Advanced ROV. These are still under development, and comments and suggestions are always appreciated.

- Thrusters: http://seaperch.mit.edu/docs/AdvancedROV/Thrusters.pdf
- Stereo Hydrophone: http://seaperch.mit.edu/docs/AdvancedROV/Stereo_Hydrophone.pdf
- Lighting Bank: http://seaperch.mit.edu/docs/AdvancedROV/Lighting_Bank.pdf
- Frame Design: http://seaperch.mit.edu/docs/AdvancedROV/FrameDesign.pdf

Sea Star Surface Craft

During the SeaPerch Conference, the Sea Star Surface Craft was unveiled. The Surface Craft project is intended to introduce students to the basic concepts of hull design, and related concepts such as buoyancy, center of gravity, center of buoyancy, righting moment, fluid dynamics, drag, etc. It is based on the forming of a hull out of foam, allowing students to experiment with varied designs. The motor and radio control system are easily movable from one hull to another.
Below are the documents for building the Sea Star Surface Craft. These are still under development, so comments and suggestions are appreciated. Advanced SeaPerch documents will be posted soon.


Other Manuals

Hydrophones

Want to hear what is going on underwater? Build a hydrophone! A single hydrophone or a stereo hydrophone can be made with basic parts from any electronics store. Check out these nifty instructions:

- How to Build a Hydrophone: http://www.dosits.org/resources/all/classroom/buildhydrophone/

Video Cameras

To add an underwater camera, check out these suppliers:


Sensors

- Water Sampler: http://seaperch.mit.edu/docs/Water_Sampler-FC.pdf
- Data Logger Solutions: http://www.onsetcomp.com/

Other ROV Videos

- Testing the ROV: http://www.youtube.com/watch?v=XKVSwV7ybU&feature=player_embedded
- A View From the ROV While Underwater: http://www.youtube.com/watch?v=-aJ5uM3zOH4&feature=player_embedded
BECOME

SeaPerch is a perfect avenue to direct students towards majors and careers in STEM. But in order for them to fulfill their potential and become true STEM students, they need the resources to choose a college, a career, and other opportunities such as internships and work experiences. In the following pages, you will find these resources to offer your students and to help set them on the path to success!
CAREER OPTIONS

Did your students enjoy building and using their SeaPerch ROVs? There are dozens of careers that will allow them to have that kind of fun every day. Engineers and scientists in the field of marine science and engineering face interesting challenges involving water, robots, marine life, complex electronics, water and pressure resistant housings, corrosion, video navigation, computer control problems, and flight dynamics (just like an airplane, but wet).

If your students found a certain part of the SeaPerch process particularly interesting, they may be surprised to find that there are careers that fit their interests perfectly. Below you can see different steps of the building and operating procedure, and a few careers that match up with them:

- **Frame Construction**
  - **Mechanical Engineer** - A mechanical engineer or MechE (pronounced mek-e) is responsible for selecting the materials, designing the structure, drawing a 3-D model, optimizing the design, and minimizing the cost. A good deal of time is spent analyzing the design in the digital 3-D world to ensure that the vehicle will work exactly as planned. The MechE will need to be familiar with the concepts of structural analysis, fluid flow, material science, machining techniques, aerodynamics, and the ocean environment.

- **Waterproofing the Motor**
  - **Mechanical Engineer** - The MechE will be responsible for designing a housing that is capable of keeping the water out of the motor at whatever depth the vehicle is designed to operate at, while allowing a shaft to protrude from the housing and rotate the prop.
  - **Ocean Engineer** - The ocean engineer is responsible for understanding the properties of the ocean at the depth of interest. This person also works with or in place of the MechE in choosing materials and designing components to work in the harsh ocean environment.

- **Building the Control Box**
  - **Electrical Engineer** - The electrical engineer or EE will design the entire control system for an underwater vehicle. He or she will use switches, resistors, diodes, capacitors, and circuit boards to make it possible to push a button and have the vehicle go in the desired direction. The EE is also responsible for designing the battery charging system and the energy delivery system, and ensuring that the proper voltage goes to the correct component at all times.
  - **Mechanical Engineer** - The MechE will design the control housing.

- **Choosing a Battery**
  - **Electrical Engineer** - Since the EE has designed the entire electronics package up until this point, there is no one better to decide what type of battery will best suit the
needs of the vehicle. Taking into consideration how long the vehicle should run for and at what power, the EE will choose the most efficient battery to power the vehicle.

- **Mechanical Engineer** - With the battery now selected by the EE, the MechE needs to fit the battery in the hull and figure out how much flotation is needed to offset the added weight.

- **Adding Ballast and Flotation**
  - **Mechanical Engineer** - Since the MechE designed the vehicle they are the most knowledgeable of how much ballast and flotation it needs to either sink or float, and how much space there is available for this added material.
  - **Ocean Engineer** - With an understanding of the forces of the deep ocean, the ocean engineer will design the ballast and flotation to withstand both the forces at the surface of the ocean and the forces at depth. These include high pressure at extreme ocean depths and extreme temperatures.
  - **Marine Scientist** - This is the person who will be using the vehicle and is therefore in charge of what we put onboard. If the marine scientist wants a sensor or a camera, the rest of the team needs to accommodate those needs and make sure those items fit on the vehicle.

- **Driving the SeaPerch**
  - **ROV Pilot** - Have you ever played a flight simulator game? This is what an ROV pilot does every day. From the safety of an onboard computer and flight control center, the pilot drives the ROV using video feedback. The only difference is that the ROV pilot's crash can cost millions of dollars, so he or she had better get it right the first time.

- **Video**
  - **Communications Engineer** - The communications engineer is in charge of getting information from one place to another as efficiently as possible. Have you ever watched a jumpy video feed over the Internet? The communications engineer must ensure that video feeds are stable and uninterrupted.

- **Building Sensors**
  - **Electrical Engineer** - If they are standard sensors and do not exist in the size and shape of interest, the EE will have to build these from scratch. This can be a very challenging process as the tolerance may be a few thousands of a volt or an amp, and that is a difficult thing to accomplish in the electronics world.
  - **Mechanical Engineer** - When a force or other parameter could affect the vehicle performance, it needs to be monitored. This is up to the MechE to design and build sensors that can track the vehicles status.
  - **Marine Scientist** - When a scientist is anticipating a possible new discovery, he or she needs work with engineers to design customized sensors. This involves knowing everything about the material to be detected and knowing how to interpret the data.
  - **Computer Scientist** – Sensors produce raw data that is stored and sometimes streamed live for real-time analyses and presentation. The computer scientist will design programs and algorithms to organize and store the data from multiple sensors.

- **Programming Sensors**
o **Computer Scientist** - Almost all electrical sensors measure the environment and output a small proportional electrical voltage or current; computer scientists have to create computer programs that convert raw data into values such as temperature, salinity, or pressure. The programs must filter out electrical interference and acoustic noise.

- **Studying the Ocean**
  o **Marine Scientist** - Marine scientists are significant users of the ROV and AUV technology. They determine what to study in our coastal waterways and depths of the ocean. Understanding fish population, habitats, water quality and seasonal variability are a few of the areas in which marine scientists would use ROV technology to assist them in data collection.
  o **Ocean Engineer** - Just like a MechE, an ocean engineer solves mechanical problems; however, unlike the MechE, the ocean engineer's specialty is applying the unforgiving parameters of the ocean environment to the mechanical design. As a result, these engineers will spend a lot of time determining what the environment actually consists of such as the temperature and pressure extremes.

- **Improving SeaPerch Design**
  o **Mechanical Engineer** - Even after the vehicle is built, there is always room for improvement. The MechE will constantly analyze the success or failure of a mission, and determine what can they can improve or redesign on the vehicle to make it better.
  o **Electrical Engineer** - Just as the MechE knows, nothing is perfect; there is always a more efficient way to control the use of power. There will always be a better way to use a motor, camera, and battery, and it is up to the EE to constantly make sure that those systems are in use.
  o **Computer Scientist** – As sensors and control systems are improved or modified, the computer scientist must update and improve the data collection and data analyses programs. As more data is collected the computer scientist must embrace new technologies such as big data processing and machine learning techniques.
  o **Marine Scientist** - As a user of the technology, the marine scientist determines what needs improving on the vehicle so that appropriate data is collected and what new features would benefit science. The marine scientist then passes this information to one of the engineers to implement the change.

- **Adjusting the Motors**
  o **Mechanical and Ocean Engineers** - Pointing the motors in the correct direction isn't as simple as it sounds. There is a balance between having the fewest number of motors for power consumption reasons, and having the most maneuverable vehicle possible. As a result, small changes in force vectors make a huge difference and need constant maintenance and updating so that the vehicle is running as efficiently as possible at all times.
Inventing New Components

- **Mechanical and Ocean Engineers** - Just because it doesn't exist doesn't mean it can't exist. This is a motto of a good engineer. If you want to accomplish something that hasn't been done before (which is common for underwater exploration), it is up to these people to make the part or system that will allow this to happen.

- **Electrical Engineers** - Again, an electrical engineer can't be daunted by the fact that a task has never been accomplished before. The EE makes the parts so that the new task can be attempted.

- **Communication Engineers** - This is a field in underwater technology that is far from perfect. It's an evolving field, with upgrades always welcome.

Microcontrollers

- **Electrical Engineers** - A microcontroller developer board is a quick way to build an experimental or prototype circuit. Instead of spending hours designing a perfectly efficient circuit to just try out a concept, EE's will use a microcontroller developer board to test it out. And then if it works, they will build a circuit from scratch to accomplish the same task more efficiently.

- **Computer Engineers** - All computers need to be programmed, so the computer engineer has to make sense of all of the data coming into the microcontroller and have it perform the desired command afterwards.

Choosing a Propeller

- **Mechanical Engineer** - How fast should the vehicle go? How much energy can we spend? How much drag will there be? These are the questions of propeller design that a MechE must answer. Using their knowledge of aerodynamics and fluid properties, the MechE will build a 3-d model that can be tested and optimized to perform exactly as intended.

Water Sampling

- **Marine Scientist** - The marine scientists need to know the conditions of the water that is being studied in order to understand any other data they may be measuring. Different temperatures, conductivities, dissolved material contents, and pH will greatly affect the meaning of any data collected that day, so it is important to know how to measure these parameters.

**Other Careers in STEM**

There are many other STEM careers available, as your students may be interested to learn. In fact, STEM careers are among those with the highest demand in the United States. Science, technology, engineering, and mathematics careers include (but are certainly not limited to) these interesting, challenging, and in-demand jobs:

- Aerospace Engineer
- Anthropologist
- Architect
- Astronomer
- Automotive Engineer
- Biochemist
Career Resources

Below are some online resources for teachers and students interested in the variety of STEM careers:

- The top 100 jobs in America (many of which are in STEM):
- Science and Engineering careers:
Marine Life Opportunities

Do your students like jumping right in and getting their feet wet – literally? A marine career might be the perfect choice for them. Some marine careers include marine biology, marine geology, seismology, coastal geography, physical oceanography, chemical oceanography, and ocean engineering. To check out more in-depth information about marine careers and other opportunities, visit the following links:

- Marine Careers:  
  - [http://www.marinecareers.net/](http://www.marinecareers.net/)
- NOAA’s Ocean Explorer page – careers and other resources:  
  - [http://oceanexplorer.noaa.gov/edu/oceanage/](http://oceanexplorer.noaa.gov/edu/oceanage/)

Naval Career Opportunities

People trained in the field of Naval Architecture, Marine Engineering, and Ocean Engineering are always in demand. In today’s world of increasing international trade, amid growing awareness of our environment, and concern about maritime security and national defense, people with these skills are essential. They design, build, and operate vessels to transport and protect people and goods; they design all types of ocean structures. Maritime trade, national defense, environmental protection, and security are not temporary concerns, but permanent responsibilities. The demand for maritime professionals will continue to increase.

Facts about Naval and Maritime Careers:

- Over 95% of the world’s goods arrive at their destination by ship
- A principal mission of the Navy is the protection of sea lanes and merchant ships
- The merchant marine is considered the fourth arm of our national defense
Additional ROV Opportunities

RoboNation, the organization that manages the SeaPerch program, also manages or supports several other robotics programs and competitions. RoboBoat and RoboSub are natural progressions to the SeaPerch program and offer advanced competitions that will help challenge and prepare middle school through graduate level students to face real world challenges in autonomous vehicle design, fabrication, programming, and use.

Programs

- STEM Education & Robotics
  [http://www.robonation.org/stem-education-robotics](http://www.robonation.org/stem-education-robotics)
- SeaGlide
  [http://www.robonation.org/seaglide](http://www.robonation.org/seaglide)
- RoboTour
  [http://www.robonation.org/robotour](http://www.robonation.org/robotour)

Competitions

- RoboBoat
  [http://www.robonation.org/competition/roboboat](http://www.robonation.org/competition/roboboat)
- RoboSub
  [http://www.robonation.org/competition/robosub](http://www.robonation.org/competition/robosub)
- Maritime RobotX Challenge
  [http://www.robonation.org/competition/robotx](http://www.robonation.org/competition/robotx)
- Intelligent Ground Vehicle Competition (IGVC)
  [http://www.robonation.org/competition/igvc](http://www.robonation.org/competition/igvc)
- Student Unmanned Air Systems (SUAS)
  [http://www.robonation.org/competition/suas](http://www.robonation.org/competition/suas)
- International Aerial Robotics Competition (IARC)
  [http://www.robonation.org/competition/iarc](http://www.robonation.org/competition/iarc)
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