Remotely Operated Vehicles (ROV)

Researchers look on as the ROV sends images from the ocean floor. Courtesy NOAA

Grade Level

6th- 8th and easily adapted for 9-12

Timeframe

Suggested time for curriculum is three 45-min blocks, but can be expanded or shortened as needed.

Materials

Materials for each activity are simple and inexpensive.

Teachers may borrow kits for the design and construction of the ROVs. A small pool is also available for loan. If schools want to create their own kits, step-by-step instructions are provided.

Workshops

To schedule a free educator ROV workshop or for more information, contact

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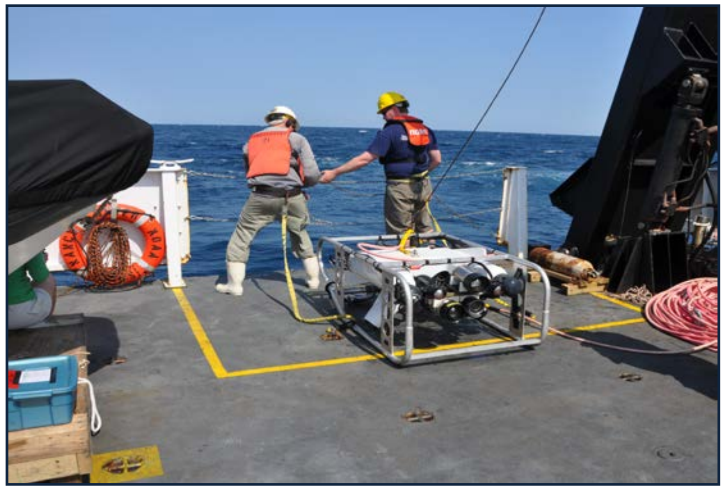


Maritime archaeologists deploy an ROV from NOAA Ship *Nancy Foster*

Curriculum Summary

This curriculum introduces students to remotely operated vehicles (ROV) and careers in marine science and underwater archaeology. Through a variety of hands-on activities, using problem-based learning, students learn the science behind an ROV. They also work to solve real world problems, while learning about the engineering design process. Students design, build, and test an ROV, as they ready for competition. The curriculum can be used in its entirety or activities can be used independently as appropriate for individual teaching objectives.

Learning Objectives

Students will:

- Learn the science principles necessary to construct an ROV, such as Newton's Laws of Motion, buoyancy, and properties of air;
- Understand the engineering design process and that it is reiterative;
- Design and build an ROV for competition;
- Describe how ROVs are used in the marine science and underwater archaeology; and
- Compare the technology of an ROV to other technologies
- Learn more about our nation's National Marine Sanctuary System

Education Standards

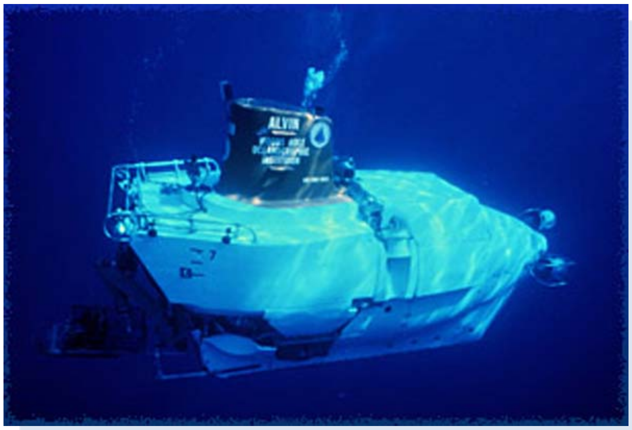
National Science Standards Grades 5-8	NS 5-8.1 Science as Inquiry NS 5-8.2 Physical Science (Motions and Forces) NS 5-8.5 Science and Technology NS 5-8.7 History and Nature of Science
National Science Standards Grades 9-12	NS 9-12.1 Science as Inquiry NS 9-12.2 Physical Science (Motions and Forces) NS 9-12.5 Science and Technology NS 9-12.7History and Nature of Science
Ocean Literacy Principles	Principle 6: The ocean and humans are inextricably interconnected. Principle 7: The ocean is largely unexplored.

Program Overview

This curriculum is designed to enhance and enrich existing curriculum, while exciting and motivating students to engage in the engineering process through captivating underwater exploration. Students will learn how our cultural resources are significant in telling our nation's maritime heritage and how NOAA is working to preserve that heritage.

Suggested Implementation Strategy

1. Before beginning the engineering process, introduce students to remotely operated vehicles (ROV). Assess their prior knowledge of what ROVs are, how they are used, and any other information they might know about ROVs. Make a list of all prior knowledge and save for use at the end of the unit, and add any new information they learned and correct any prior misconceptions.
2. To introduce students to the necessity of ROVs in exploration and research, review *It's All About Air—Teaching Suggestions* (p. 8) and *Putting on the Pressure--Teaching Suggestions* (p. 11). These demonstrations help students better understand the limitations of SCUBA divers and the need for ROVs in research.
3. Explain to the students that they will work in teams to design (engineer) their own ROV. Have students define an "engineer" and discuss the engineering process. Complete activities (pp. 15-18) to help students understand engineering.
4. To introduce the engineering design process, have students conduct the activity *Help! I Could Use a Hand!* (pp. 19-20).
5. Explain to the students that before they begin to engineer their ROV, they need to understand a few basic principles. Review *Buoyancy—Teaching Suggestions* (p.21) and *Newton's in the Driver's Seat—Teaching Suggestions* (p.23). To help students better understand the concepts, use additional activities as needed (pp. 22 and 24).
6. To begin the ROV design phase, break students into groups of 2-4. Give each team a copy of *Working Under Pressure* (pp. 25-27).
7. Show students the various materials available for ROV construction. Review the criteria for design, the competition rules, Newton's Laws of Motion and any other parameters you want to impose.
8. Remind students that they must work as a team to design their ROV. Their design must be drawn on the sheet provided with all parts labeled. Once they have an approved design, then they may collect the materials (parts) needed.
9. To extend student's learning, have students conduct an online research activity: *Deep Sea Exploration with Alvin* (pp. 28-32).
10. To make the ROV engineering and design process more "real-world," use *Keeping It in the Budget* (pp.33-35). In this activity students must pay for their parts and stay on budget!



The *Alvin* underwater, Photo Credit: WHOI

Key Words

air pressure
buoyancy
density
engineer
engineering
fault tree
maritime heritage
National Marine Sanctuaries
NOAA
ROV
SCUBA
water pressure

Background Information

ROV

Remotely operated vehicles (ROVs) are unoccupied robots operated underwater by a person on a ship or boat. They are easy to maneuver through the water and are linked to the ship by a group of cables that carry electrical signals back and forth between the operator and the ROV. Most ROVs have a camera and lights. Additional equipment is often added to the ROV to increase its capabilities. For example, additional equipment might include sonars, magnetometers, a still camera, a manipulator or cutting arm, water samplers, and instruments that measure water clarity, light penetration, and temperature.

ROVs were first developed for industrial purposes, such as inspections of pipelines and testing the structure of offshore platforms. However, today ROVs are used for many applications, many of them scientific. They have proven extremely valuable in ocean exploration. They are also used for educational programs at aquaria and to link to scientific expeditions live via the Internet.

ROV History

In the 1950s, the Royal Navy used a remotely operated submersible to recover practice torpedoes. In the 1960s, the US Navy funded research to develop what was then named a “Cable-Controlled Underwater Recovery Vehicle (CURV). CURV gave the Navy the ability to perform deep-sea rescue operations and recover objects from the ocean floor. ROVs became essential in the 1980s when much of the new offshore development exceeded the reach of human divers. Submersible ROVs have been used to locate many historic shipwrecks, including the RMS *Titanic*, *Bismarck*, USS *Yorktown*, and SS *Central America*. However, there is a lot of work that remains to be done!

More than half of the Earth’s ocean is deeper than 3000 meters, which is the depth that most ROVs can currently work. That leaves a lot of ocean to be explored. ROVs are mostly used by the oil and gas industry, but they are also used for science research, military applications, and marine salvage operations of downed planes and sunken ships. As technology improves, the ROV will perhaps one day in the near future be capable of exploring the deepest depths of the ocean.

ROV Construction

Conventional larger work class ROVs are built with a large flotation pack on top of an aluminum chassis, to provide the necessary buoyancy. A special type of foam is often used for the flotation. A tool sled may be fitted at the bottom of the system and can hold a variety of sensors for conducting tests. The ROV not only needs to be buoyant, but it also must be stable. In order to make the ROV stable, the lighter components are placed on the top of the structure while the heavy components go on the bottom. This creates a large

Vocabulary

air pressure---measure of the force of air pressing down on a surface

buoyancy—the upward force, caused by fluid pressure, that keeps things afloat

density— a property of matter that is defined as the ratio of an object's mass to its volume

engineer—Person who is trained in or follows a branch of engineering as a profession

engineering—the science or profession of developing and using nature's power and resources in ways that are useful to people

fault tree—a graphical representation of the chain of events in the engineering design process that is used by engineers to analyze their designs from a top-down approach to avoid problems or find solutions

iteration—a process in which a serious of operations is repeated a number of times with the aim of a desired result

ROV—remotely operated vehicle which is a tethered robot that operates underwater and is controlled from a boat or ship by an operator

SCUBA—Self-contained underwater breathing apparatus: a portable apparatus containing compressed air and used for breathing under water

water pressure—measure of the force of water pressing on its surroundings

separation between the center of buoyancy and the center of gravity making the ROV stable and stiff so it can work underwater. Electrical cables may be run inside oil-filled tubing so as to protect them from corrosion in seawater. There are usually thrusters in all three axes to provide full control. Cameras, lights, and manipulators are on the front of the ROV or occasionally in the rear to help in maneuvering. Smaller ROVs can have very different designs, each geared towards its specific task.

Science of ROVs

Science ROVs take many shapes and sizes and are used extensively by the science community to study the ocean. A number of deep sea animals and plants, such as the jellyfish Bumpy and the eel-like halosaurs, have been discovered or studied in their natural environment through the use of ROVs. Because good video footage is a core component of most deep-sea scientific research, science ROVs are often equipped with high-output lightning systems and broadcast quality cameras. Depending on the research being conducted, a science ROV will be equipped with various sampling devices and sensors. Many of the devices are one-of-a-kind and state-of-the-art components designed to work in the extreme environment of the deep ocean.

NOAA Corps

NOAA Commissioned Corps Officers are an integral part of NOAA. Officers can be found operating one of NOAA's 19 ships or 12 aircraft to provide support to meet NOAA's missions. Duties and areas of operations can range from launching a weather balloon at the South Pole, to conducting fishery surveys in Alaska. Find out more about the Corps, its mission, and history at http://www.noaacorps.noaa.gov/

For More Information—Web Resources

NOAA Ocean Explorer
Discover how NOAA uses ROVs and learn more about the various NOAA ROVs currently in use. Read how ROV Hercules was built just for scientific research and can travel to depths of 4,000 meters!
http://oceanexplorer.noaa.gov/technology/subs/rov/rov.html

***Monitor* National Marine Sanctuary**
ROV in a bucket! Use easy to follow directions and simple materials to design and construct your own ROV.
http://monitor.noaa.gov/publications/education/rov_manual.pdf

Exploring WWII: Battle of the Atlantic Expeditions
For six years, maritime archaeologists with NOAA and other partners have documented and surveyed the various shipwrecks off the North Carolina coast associated with WWII's Battle of the Atlantic. Visit this site to learn see the remains of German U-boats that plied America's waters and the ships they sank. Experience these underwater treasures firsthand through the divers' blogs and beautiful images.
http://sanctuaries.noaa.gov/missions/battleoftheatlantic/archives.html

Marine Advanced Technology Education (MATE)
A national partnership of educational institutions and organizations working to improve marine technical education in the U.S. The MATE Center and its partners have developed several curriculum modules and programs including: An introduction to Aquaculture, career scenarios (problems) for the classroom, technology rich lab exercises, a new A.S. degree program, high school pathways, and a careers course. Some of these materials are available on-line.
http://www.marinetech.org/home.php

Woods Hole Oceanographic Institution—Though ROVs have been used extensively by the oil and gas industry for several decades, *Jason/Medea* was the first ROV system to be adopted and extensively used by ocean researchers. Visit this site to learn how scientists and researchers use *Jason/Medea* to conduct underwater expeditions.
http://www.whoi.edu/page.do?pid=8423

Monterey Bay Aquarium Research Institute—Learn how the aquarium uses ROVs and AUVs for research.
http://www.mbari.org/dmo/vessels_vehicles/rov.html

NASA for Kids: Intro to Engineering
Watch this video to learn about engineering and who exactly is an engineer.
http://blip.tv/nasa-goddard-tv/nasa-nasa-for-kids-intro-to-engineering-4722805

NASA SCI Files®: *The Case of the Radical Ride*
Join the tree house detectives in this 60-min video as they learn about the engineering design process. An educator guide is also available for download.
http://www.knowitall.org/nasa/scifiles/index2.html

National Marine Sanctuary System

There are 14 marine protected areas in U.S. waters known as the National Marine Sanctuary System. For more information visit http://sanctuaries.noaa.gov

NATIONAL MARINE SANCTUARIES

For More Information—Book Resources

Armstrong, Jennifer. *Shipwreck at the Bottom of the World: The Extraordinary True Story of Shackleton and the Endurance*. Crown Books for Young Readers, September12, 2000. ISBN-10: 0375810498.

Baker, Beth. *Sylvia Earl (Just the Facts Biographies)*. Lerner Publications, January 15, 2006. ISBN-10: 0822534223.

Ballard, Robert D. *Finding the Titanic Level 4*. Cartwheel, November1, 1993. ISBN-10: 0590472305.

Ballard, Robert D., Rick Archbold, and Ken Marschall. *Ghost Liners: Exploring the World's Greatest Lost Ships*. Little, Brown Young Readers, September 1, 1998. ISBN 10: 0316080209.

Cerullo, Mary M. *Shipwrecks: Exploring Sunken Cities Beneath the Sea*. Dutton Juvenile, December 1, 2009. ISBN 10: 0525479686.

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Dinwiddie, Robert; Philip Eales, Sue Scott, Michael Scott, Kim Bryan, David Burnie, Frances Dipper and Richard Beatty. *Ocean (American Museum of Natural History)*. DK Adult, July 21, 2008. ISBN 10: 0756636922.

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Platt, Richard. *Eyewitness: Shipwrecks*. DK Children, June 1, 2000. ISBN 10: 0789458845.

Rose, Paul; Anne Laking, and Phillippe Cousteau. *Oceans: Exploring the Hidden Depths of the Underwater World*. University of California Press, April 15, 2009. ISBN 10: 0520260287

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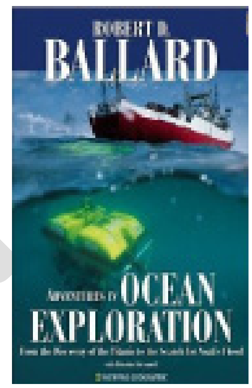
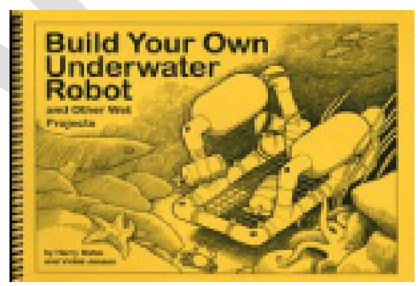
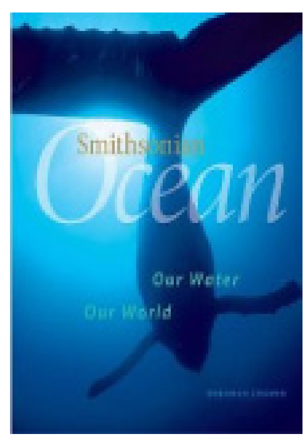
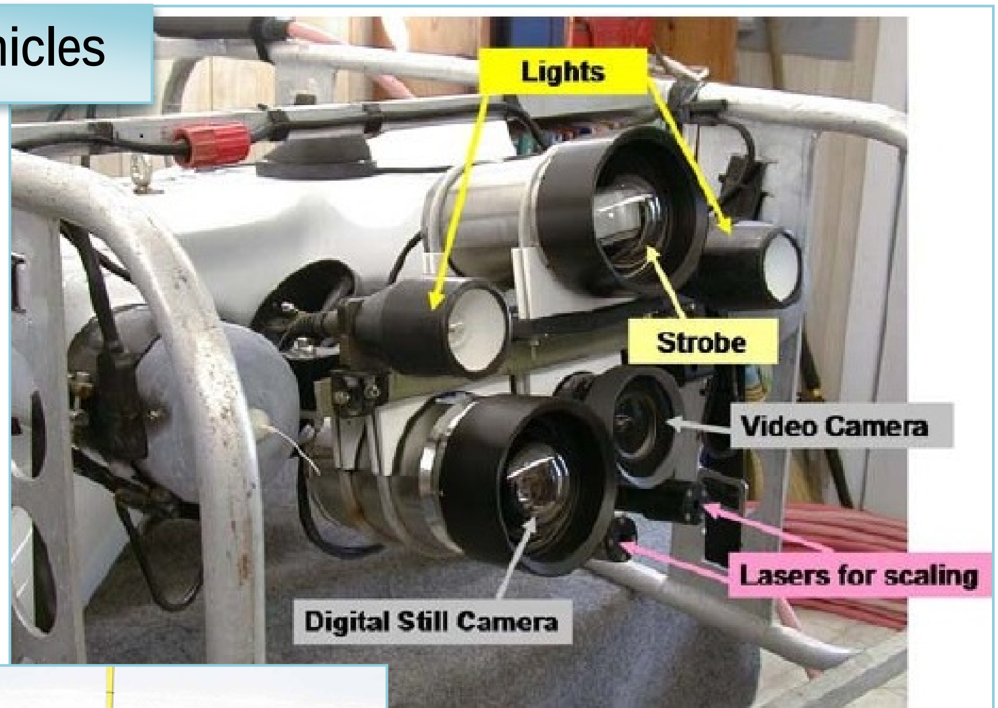






Remotely Operated Vehicles



Careers

- ROV pilot
- ROV technician
- diver
- dive instructor
- maritime archaeologist
- research scientist
- environmental
- engineer
- fishery biologist
- geological
- oceanographer
- laboratory technician
- lifeguard
- submersible pilot

ROVs are often equipped with various types of tools, such as still and video cameras, lasers, lights, mechanical arms, collection jars and more.

ROV Components

There are many ROV components. Some of the basic ones are thrusters, motors, tether, power source, monitor and radio controlled transmitters.

It's All about Air –Teaching Suggestions

Before Building

Before beginning the designing and building process, teachers may want to review and/or assess students' knowledge of several key ideas and concepts, such as the properties of air, air pressure, buoyancy, water pressure and diving. Having a better understanding of these concepts enables students to design and build an ROV more accurately and successfully. Understanding of the properties of air also helps students to recognize the need for ROVs and submersibles in research. The guidance listed in this section can be adapted for various age levels and should be used as appropriate for ages and abilities of the students.

Facts and Properties of Air Demonstrations

- Facts about air—Air is colorless, odorless (unless something is added to air), has no taste, and takes the shape of the container. Most abundant gas in our atmosphere is nitrogen—78% nitrogen, 21% oxygen, and 1% trace gases with argon being 0.9% of the trace gases. Carbon dioxide is 0.03%.
- Air takes up space—To demonstrate, use a tornado tube connecting two 2-liter bottles with one bottle filled with colored water. Carefully, turn the bottle upside down so that the water is on the top and it DOES NOT pour into the bottom half. Although gravity is pulling the water down and water is heavier than air, the water does not go through the opening. This is because the air in the bottom half prevents it from flowing. However, if there is a disturbance (shaking), then there is a transfer of air and water to opposite bottles. Shake bottle and have students observe the bubbles (air).
- Air has mass—Use a triple-beam balance to find the mass of a deflated balloon. Blow air into the balloon until partially filled. Find the mass the balloon now filled with air and note the increase in mass.
- Air exerts pressure—
    - Pushy Air—Place water in a clear plastic cup. Place a piece of cardstock (index card) over the cup and make sure that it has a good seal. Turn the cup upside down and remove your hand from the cardstock. The cardstock continues to stay in place, because air is exerting pressure upward on the cardstock.
    - Can Crushing—place a few milliliters of water in an aluminum soda can. Using tongs set the can on a hot plate (use fire retardant matt), or hold it above a Bunsen burner until steam escapes through the opening. Quickly, flip the can upside down into a shallow pan of water making sure that there is a good seal between the can and the surface of the water. The can will implode immediately. Can Crushing Explanation: Air exerts 14.7 psi in all directions (equal to about three 5 lb. bags of sugar). We don't feel it because our body is exerting 14.7 psi in every direction inside our body. When the air in the can heated, the air molecules began to move excitedly and farther away from each other. Once you flip the can into the water and seal it, the few air molecules inside the can quickly condense and fall to bottom, creating a vacuum inside the can. With no air inside the can to exert pressure outward, the can crushes.
    - Egg in the Bottle—Light a large kitchen match and drop into glass milk jar (old fashioned type). While it continues to burn, quickly place a peeled hardboiled egg on the rim of the jar. In a few seconds, the egg will be pushed into the jar by air pressure. Burning match uses all the oxygen creating a vacuum, thus no air inside the jar is exerting pressure back up. To get the egg out of the jar, position egg over opening and blow into jar with lips sealed on rim.

Fluids—Air and Water

Air and water are both fluids and have similar properties. They take up space, have mass, take the shape of the container and exert pressure. To demonstrate air is a fluid, fill an aquarium with water. Take two clear plastic cups and turn one cup upside down and submerse so that the air remains inside the cup. Repeat with second cup and then tip the second cup to the side to release the air. Let students observe the bubbles. Hold the two cups (one with air and one with water) close to each other and pour the air into the cup with water. The air in the cup is a bubble and when you pour it into the other cup, the bubble rises and is trapped by the other cup before it can escape to the top and burst. It displaces the water in the other cup.



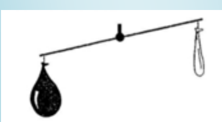


A Massing We Will Go

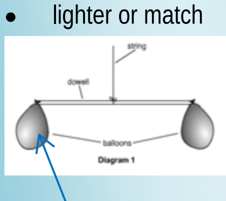
Materials:

Experiment 1:
- lab scale
- balloon
- small piece of tape

Experiment 2:
- dowel or meter stick
- string
- 2 equal balloons
- marker



Experiment 3:
- all materials from Experiment 2
- lighter or match



Light match to pop balloon.

Purpose: To determine that air has mass

Background

The elasticity of a balloon works like a rubber band to return it to its original shape. That elasticity of a balloon compresses air to a higher density than the air around it. Therefore, balloons can hold enough compressed air to be measurable on a lab scale.

Experiment 1:

1. Using a lab scale or triple beam balance, on the pan place a small piece of tape folded so that it is double sided. Place the empty balloon next to the tape.
2. Find the mass of a balloon.
3. Inflate the balloon by blowing into the balloon and tie it off. Place the balloon on the tape so that it does not roll off.
4. Find the mass of the inflated balloon and calculate the difference.

Experiment 2:

1. Loosely tie a piece of string around a dowel or meter stick.
2. Tie a small piece of string to each end and secure. At the end of each string attach a bull dog clip.
3. Clip a deflated balloon onto each end using the clip.
4. Hold the string in the middle and adjust the string left or right until the dowel balances. Using a pencil, mark the spot.
5. Remove one balloon and inflate it. Tie it off and reattach it to the clip.
6. Make sure the center string matches the spot you marked.
7. Observe the dowel. Is it balanced? Is one side lower than the other? Why?

Experiment 3:

1. Repeat steps 1 and 2 in Experiment 2.
2. Inflate two balloons equally as possible.
3. Clip an inflated balloon to each end of the dowel.
4. Hold the string in the middle and adjust the string left or right until the dowel balances. Using a pencil, mark the spot.
5. Have an adult light a match and touch the balloon.
6. After the balloon bursts, observe the dowel. Is it balanced? Why or Why not?

Extension:

Watch this three-minute Wonderville video: *Heavy on Gases*
http://www.wonderville.ca/asset/heavyongases

Who's In My Space?

Materials:

Experiment 1:

- two-liter bottle
- two-liter bottle with hole in the side
- balloon

Experiment 2 and 3:

- clear larger container
- clear plastic glass
- tissue
- ping pong ball

Purpose: To determine that air takes up space

Background

Our Earth is covered with air, and it is called the atmosphere. Air is a mixture of gases: 78% nitrogen and 21% oxygen and 1% trace gases. Trace gases are water vapor, carbon dioxide, argon, and various other components. Some of the properties of air are that it has mass, takes up space and exerts pressure.

Experiment 1:

1. What happened when you blow air into a balloon?
2. Predict what will happen when air is blown into a balloon inside a bottle.
3. Place a balloon inside the two-liter bottle without the hole and spread the edges of the balloon around the lip of the bottle (see picture to left).
4. Blow up the balloon. What happened? Why?
5. Repeat step 3 using the two-liter bottle with the hole. Make a prediction.
6. Try blowing the balloon up. What happened? Why?

Experiment 2:

1. Fill a fish tank or other clear container about 2/3 full of water.
2. Place of piece of rolled tape at the bottom of a clear plastic cup.
3. Scrunch up a napkin and push it down into the cup.
4. Turn the cup upside down and push it into the water being careful to not tip the cup. Observe.
5. Carefully, remove the cup from the water and touch the napkin. Is it wet? Why or why not?
6. Remove the napkin and place the cup in the water again. Tip the cup slightly to the side and observe. What did you see? Why?

Experiment 3:

1. Fill a fish tank or other clear container about 2/3 full of water.
2. Place a ping pong ball in the tank.
3. Predict what will happen to the ping pong ball when you place a clear cup over the ball and push it to the bottom of the container. Will it stay at the top, go to the middle, or to the bottom?
4. Place cup over the ping pong ball and push directly down being careful to not tip the cup.
5. Observe. Was your prediction correct? Why did this happen?

Putting On the Pressure –Teaching Suggestions

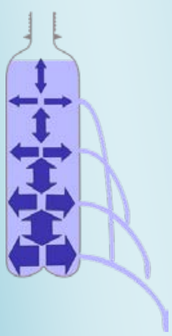
SCUBA Facts:

Pressure increases by one atmosphere for every 33 ft. of water

Diving on air alone, divers can dive to depths of about 100 ft.

Mixed gas, compressed air, and rebreathers allow divers to reach deeper depths

The deeper the depth, the shorter the bottom time



Water Pressure

To help students understand why ROVs and submersibles are important for exploring and researching our ocean, they should understand the limitations of a human body under extreme pressure in water. The following activities and explanation may help students to understand.

- Demonstrate a column of water by stacking several books on top of each other. Explain that each book has a mass. As you stack more books onto the first book, you increase the total mass of the books. With the additional books, the bottom book now has more mass pressing down on it. The same is similar as you go deep into the ocean. The deeper you go, the more water you have pressing down on an object.
- Just like air, water has mass. For every cubic foot of water you add on top of another, the greater the mass of the water. The pressure exerted from a column of air from the upper reaches of the atmosphere to the surface of the land/water is known as one atmosphere of pressure. For every 33 feet you go below the surface of the water, pressure increases by one atmosphere.
- The greater the depth, the greater the pressure—Using a 2-liter bottle, puncture one hole near the top of the bottle and a second hole near the bottom of the bottle. Place masking or duct tape over the holes. Fill the bottle with water and hold it over a sink or basin and remove the tape from both holes. Observe the streams of water. The one at the top does not arch out as far as the one at the bottom. This is because the one at the bottom is under more pressure, which creates more force to expel the water.

Water Pressure and Divers

How deep can a diver go in the ocean?

- As a diver enters the water, the pressure on exerted on her body is determined by the mass (weight) of the atmosphere. At the surface, air pressure is 14.7 psi. For a comparable pressure under the ocean, you only have to go 10 meters or 33 feet. Water is about 1000 times denser than air. Therefore, the pressures at a depth of only 33 feet is equal to two times normal atmospheric pressure—combine the weight of the air on top of the water and the weight of the water above the diver.
- For every 33 feet a diver submerges, one more atmosphere of pressure pushes down.
- As a balloon floats upward high into the sky, air pressure decreases (there is less air in the upper atmosphere), so the air inside the balloon becomes less compressed (it expands out making the balloon enlarge). Therefore, the same amount of air takes up more volume than at sea level. However, the deeper you go in the ocean the greater the pressure, because the more water (increased mass) you have pressing on you. In the water, the air inside a balloon would become more compressed taking up less volume, and the balloon would become smaller. If you took a Styrofoam cup to the bottom of the ocean, it would shrink to a very small size!
- A diver's lungs are filled with air and at the surface they are normal. But at 33 feet, there is twice the amount of air in the lungs, because the air in the lungs compressed with the pressure, thus allowing the diver to breathe in more air. Divers have to keep their lungs filled or their lungs will collapse, and they would die. At 99 feet, a diver's lungs hold about 4 times the amount of air as they do on the surface.
- To demonstrate how pressure acts upon objects (and divers' lungs), you can use a vacuum pump and marshmallows or Peeps. As you create a vacuum in the bell jar, the Peep will expand to fill the jar. As you allow air back into the bell jar, the Peep will decrease in size. You can also use the activity *Dive, Dive, Dive* (p. 13).

Putting On the Pressure

Materials:

Experiment 1:
- small, clear plastic cup
- index card
- water
- sink or bucket

Experiment 2:
- gallon-sized zip locked bag (1 per student)
- straw (1 per student)
- several heavy books
- tape

Teacher Note:
For demonstrations of how air exerts pressure, see *It's All about Air—Teaching Suggestions*, p. 8)

Key Words:
air molecules
air pressure
atmosphere
mass

Purpose: To discover that air exerts pressure

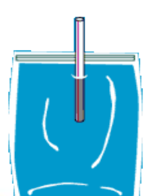
Background:
Our Earth is surrounded by a layer of gases known as our atmosphere. The common name for these gases is air. Although air molecules are invisible, they still have mass (weight) and take up space. Air pressure is the force exerted by the mass of air molecules. Air presses down with a force of 1 kilogram per square centimeter (14.7 pounds per square inch). You don't feel the weight because the air inside your body is pressing out 14.7 psi, keeping everything balanced.

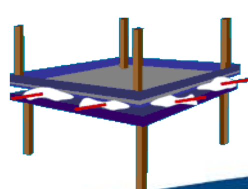
Experiment 1:
1. Fill a small clear plastic cup with water.
2. Place an index card over the entire mouth of the cup.
3. Over a sink, hold the card with one hand, while carefully flipping the cup upside down.
4. Carefully, remove your hand and observe.
5. What happened? Why?

Experiment 2:
1. Using a large gallon-sized zip locked bag, close the bag completely. About 1-2 inches from the zipped end, use a pencil to make a small hole in the bag. Insert a straw into the hole and tape the opening around the straw until it is fully sealed.
2. Place the bag on a flat surface and stack several large books on top of the bag.
3. Placing your mouth on the straw, blow into the plastic bag. Stop to rest if needed, but keep your finger over the straw's opening.
4. What happened to the books? Why?

Extension:

Try to raise a table. Make a gallon-sized bag (Experiment 2—Step 1) for each student. Place the bags side-by-side around the outer edge of the table so that the straws are facing away from center. Lay another table on top of the bags leaving straws extended. Have each student blow into his/her bag. Continue blowing until you lift the table! Have an adult sit on top of the table in the center and try it again. Explain what happened.





DIVE! DIVE! DIVE!

Materials:

- small plastic bottle with lid
- water
- eyedropper

Suggested Time:
15 minutes

Key Words:
ballast
buoyancy
compressed
density
displacement
gravity

Extension—Make hooks and try to connect them

Purpose: To understand how pressure compresses air

Background

A submarine or a ship can float because the weight of the water that it displaces is equal to the weight of the ship. This displacement of water creates an upward force called the buoyant force and acts opposite to gravity, which would pull the ship down. Unlike a ship, a submarine can control its buoyancy, thus allowing it to sink and surface at will.

To control its buoyancy, a submarine has ballast tanks and auxiliary, or trim tanks, that can be alternately filled with water or air. When the submarine is on the surface, the ballast tanks are filled with air and the submarine's overall density is less than that of the surrounding water. As the submarine dives, the ballast tanks are flooded with water and the air in the ballast tanks is vented from the submarine until its overall density is greater than the surrounding water and the submarine begins to sink (negative buoyancy). A supply of compressed air is maintained aboard the submarine in air flasks for life support and for use with the ballast tanks.

To keep the submarine level at any set depth, the submarine maintains a balance of air and water in the trim tanks so that its overall density is equal to the surrounding water (neutral buoyancy). When the submarine surfaces, compressed air flows from the air flasks into the ballast tanks and the water is forced out of the submarine until its overall density is less than the surrounding water (positive buoyancy) and the submarine rises.

Procedure:

1. Fill a plastic bottle with water.
2. Fill an eyedropper two-thirds full of water and place dropper in the bottle. Eyedropper should float about 1-2 inches from the top of the bottle. If not, repeat changing the amount of water in the dropper until you obtain neutral buoyancy. Place the cap on the bottle and tighten.
3. Observe the eyedropper and bottle and record your observations in your journal.
4. Your task is to make the dropper become negatively buoyant so that it sinks to the bottom of the bottle without turning the bottle upside down.
5. Once the dropper sinks, then make the dropper become positively buoyant and return to its neutral buoyant position.

Conclusions:

1. Describe how you obtained negative buoyancy. Positive buoyancy.
2. Explain what happened inside the bottle and dropper to create different buoyancies.
3. What role did air density play in making the dropper dive and rise?
4. How is this activity similar to a submarine?
5. When a human diver sinks towards the ocean floor, the deeper he/she goes, the more pressure on their body. Describe what you think happens to divers as they go deeper. Research SCUBA diving and explain how a diver achieves neutral, negative and positive buoyancy.

Air Pressure and Bernoulli

Materials:

- straws
- paper
- 2 balloons
- string
- 2 ping pong balls
- coin-quarter/nickel
- flexible straw

Daniel Bernoulli—Swiss mathematician

Tent with a Straw

Fold a 20-cm X 13-cm piece of paper in half to make a tent. Place the paper tent on the desk. Using a straw, blow under the tent and observe what happens. Blow harder and observe what happens. Try blowing hard against the side of the tent and observe what happens.

Balloon Blow

Blow up two balloons and tie off the ends. Cut two pieces of string 30 cm each. Tie one end of each string to each balloon. Hold the balloons in front of you by the strings about 5 cm apart. Blow very hard between the two balloons and observe what happens. What did the balloons do?

Ping Pong

Place two ping pong balls on a table about 2 cm apart. Using a straw, blow very hard between the two balls and observe what happens. Did the balls move closer together or farther apart?

Paper Paper

Hold two pieces of notebook paper in front of you about 5 cm apart. Blow hard between the papers and observe what happens. Which way did the papers move?

Stuck to It

Cut out a square of paper approximately 3 cm X 3 cm. Place the paper in the palm of your hand, and using your thumb and middle finger, hold a quarter (or nickel) about 1 cm above the paper. Place your mouth above the coin and blow hard. Observes what happens.

Ball and Straw

Bend a flexible straw so that the short end is pointing up. Hold a ping pong ball over the opening of the straw and blow. Let go of the ball and observe what happens. What happens if you tilt the straw?

Explanation

Air is pretty pushy stuff. It never pulls or sucks; it only pushes. Right now, air is pushing on you from every direction. This constant push of air is called air pressure. Our bodies constantly exert pressure outward, so we don't even notice it. In the 1700's a Swiss mathematician named **Daniel Bernoulli** discovered that when flowing air or water changed its speed, its pressure also changed. In all of the experiments, the air speed was increased, creating a decrease in pressure. When the air pressure under the tent; between the balloons, papers, and balls; and under the paper with the coin was decreased, the air on the other sides had higher pressure. This higher pressure pressed inward, causing the tent to fall to the table and the balloons, pieces of paper, and ping pong balls to go together. In "Stuck to It," the air quickly moves between the paper and the coin, creating low pressure; therefore, the air pressure below the paper is greater and "holds" it against the coin. Now you describe what is happening with the ping pong ball and straw.

Misconceptions

Many books state that air speeds up over a wing because it has farther to travel than air moving under the wing. This statement implies that air separates at the front of the wing and must rejoin behind the wing, but this isn't true. Air moving over the top of a wing speeds up so much that it arrives behind the wing sooner than air that travels beneath the wing.

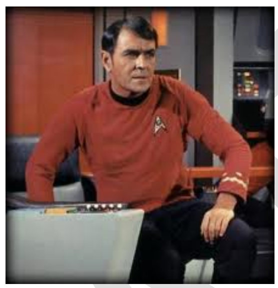
Engineering Process –Teaching Suggestions

Engineer—a person who is trained in or follows a branch of engineering as a profession
Engineering—the science or profession of developing and using nature's power and resources in ways that are useful to people (e.g. designing and building roads, bridges, dams, or machines and creating new products)
Iteration—a process in which a series of operations is repeated a number of times

To help students to understand engineering, make a list of various types of engineers, such as mechanical, electrical, civil, chemical, software, and so on. Discuss what each one does in her job.

Watch MIT Video describing an engineer: *What is an Engineer?* (3 min and 27 sec) http://video.mit.edu/watch/what-is-an-engineer-3788/

To help students learn the engineering design process, conduct the activity, *Help! I Could Use a Hand!* (pp. 19-20).






The Engineering Process

Engineering is fun and exciting, but did you know that most people don't have a clue what an engineer does? Almost everything in society is linked to engineering. If it weren't for engineers, we would not have cars, computers, televisions, and the many other conveniences that we take for granted each day.

So just what is an engineer? An engineer is someone who is creative and thinks of new ways to solve problems by using math, science, and technology. Many people think that an engineer is a scientist, but even though they may use science, engineers are not usually scientists. Theodore Von Karman, an aerospace engineer, put it nicely when he said, "Scientists discover the world that exists; engineers create the world that never was." There are many different types of engineers, such as electrical, mechanical, civil, chemical, aerospace, biomedical, agricultural, computer, and many more. There is an engineer for almost every area that might be interesting to you!

When engineers have ideas, they usually follow a few simple steps to help them as they search for the solution. Use the checklist below to help you as you design your solution to the challenge.

- Keep a design log. Engineers keep a log to record their work and ideas.
- Use your imagination. Think wild and crazy thoughts. Remember that no idea is too silly. Everyone laughed at the Wright brothers and said that man would never fly. Good thing they didn't get discouraged!
- Plan and design your idea. Careful design is important. This is the time to brainstorm for ideas and evaluate them.
- Research. Conduct research to verify that your design is based on sound science and math principles.
- Draw your design. Make a detailed drawing of your idea so others will understand how your design works.
- Make a model of your design.
- Test your design. Test your model to see if it works as planned.
- Evaluate your test results. Use data collected from testing to determine whether your design performs as it was meant to perform.
- Redesign. If your design did not work as planned, do more research, redesign it, and test it again. This procedure is called an iterative process.
- Patent your design. Engineers often have unique designs that others might want, so they apply for a patent from the U.S. Patent Office to protect their ideas from being claimed by others.

Thinking Out of the Box

Scientists, designers, engineers, and many others have to be creative in their thinking as they develop new ideas and designs. You have to cast off the old way of doing things and try to free your mind for innovative ideas. So clear out the old ideas and get ready for the new.

Your mission for this lesson is to help NOAA design a new remotely operated vehicle (ROV) for the future. The field is wide open for your design and materials are not an obstacle. You decide what the ROV should look like, how it should maneuver, how long it should stay submersed, and its uses.

First, you will want to brainstorm some ideas, and once you get an idea for your ROV's design, draw your design on the grid below. Share your ideas and drawing with the class. If possible, make a model of your ROV and present your design to the class.

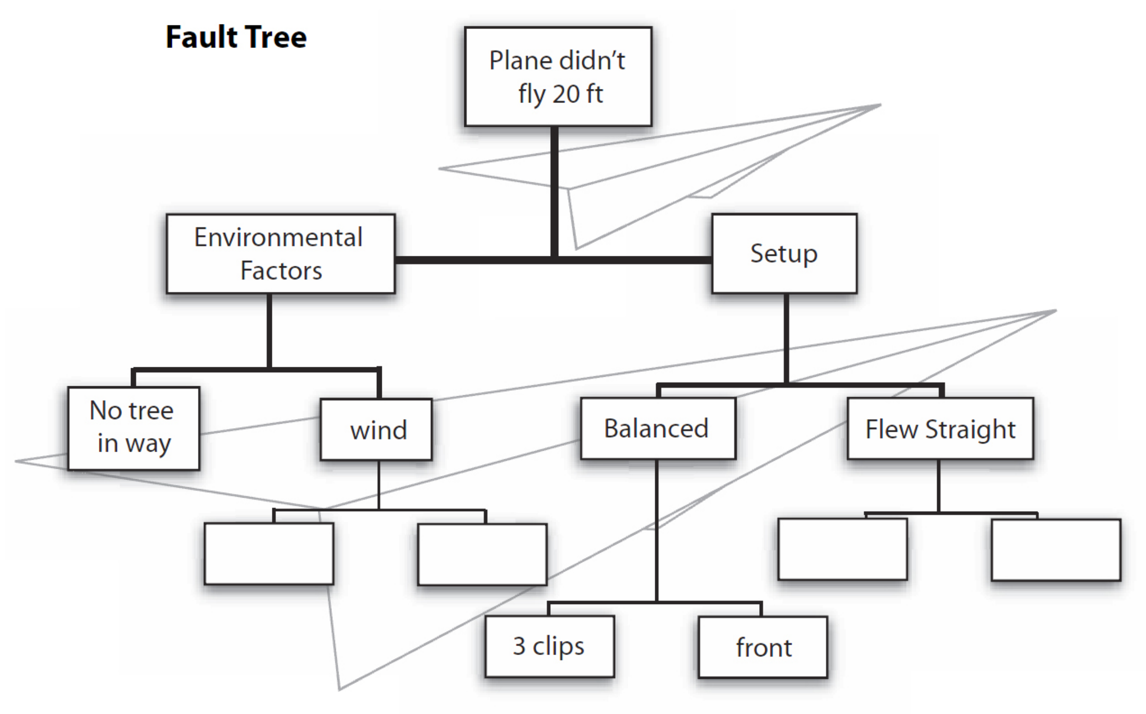
Scale: 1 square = _________

To a Fault

Fault tree analysis is logical, structured processes that can help designers identify potential problems. Fault trees are powerful design tools that can help engineers ensure that their designs successfully meet their objectives. Fault tree analyses are performed from a top-down approach. You begin by determining a top-level event and then work down to evaluate all the contributing factors that may lead to the top-level event's occurrence. It is a graphical representation of the chain of events in the design process.

For example, if you designed a paper airplane to fly 20 m and it only flew 5 m, the top-level event would be that the airplane did not fly 20 m. Also, the fault tree might be built to include, among other things, the manufacturing process and materials, the setup (plane is balanced and flies straight), the test procedure (throwing techniques), and any environmental impacts (strong wind blowing or trees in the way).You would need to take a look at each event in the fault tree and decide which, if any, contributed to the unsuccessful flight. Once you identify the factor(s) that led to the unsuccessful flight, you would decide if any changes should be made. If no factors contributed, then you should consider the possibility that the current design of the plane is not capable of flying that distance. Either way, it is back to the drawing board for another redesign!

When using the engineering design process, include a fault tree to help create a successful design. Use or copy a diagram like the one shown to help you design your own fault tree.



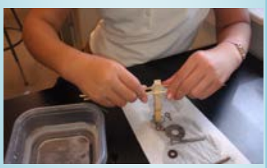
Help! We Could Use A Hand!

Suggested Materials:

For Arm:
- skewers
- straws
- small craft sticks
- large craft sticks
- pipe cleaners
- tape
- clay
- clothespins
- other misc. items

Tools:
- various washers, nuts, and bolts

Other:
- plastic container
- water



Teacher Prep:
- Place various "tools" in a plastic shoe box
- Cover with 10 cm of water
- Make available various materials to build ROV arm
- Suggested time to build is 15 min.

Problem:
NOAA was working off the coast of Virginia. Suddenly, a storm came up. The boat was tossed around by huge waves. It began to take on water and the pump quit working. Luckily, just as the boat was about to sink, the US Coast Guard came and rescued the crew. However, many valuable tools were lost. NOAA needed those tools. So once the storm was over, NOAA sent a group of divers to where the boat sank. When the divers went down, they noticed that the boat had slid down much too deep for them to dive. Fortunately, they brought an ROV with them. But the ROV does not have any way to pick up the tools.

You are an engineer. You and your team must design and build an arm for the ROV that is able to capture all the lost tools. The arm must also be able to pick up several different types of tools because you only have enough time to make one arm. And you need to hurry … …another storm is brewing!

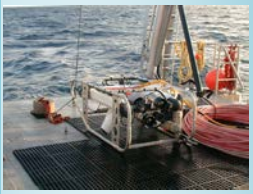
Objective: To build an arm for an ROV that is able to pick up a variety of objects off the ocean floor

Procedure:
1. As a team, look at the "tools" that need to be recovered.
2. Review the materials available to build an arm.
3. As a team, decide how best to design an arm that can be attached to the ROV to pick up the tools.
4. As a team, draw a design of your arm. Be sure to label all parts.
5. Select the correct materials and build your arm.
6. Retrieve the tools. YOU HAVE 15 MINUTES!

Design Your Arm Below:

An ROV was used onboard the NOAA Ship *Nancy Foster* to identify an unknown shipwreck. By using the ROV's lights and cameras, the maritime archaeologists identified it as a WWII, US Navy ship, YP-*389*. A German U-boat sank the YP in 1942.

http://sanctuaries.noaa.gov/missions/battleoftheatlantic2/welcome.html



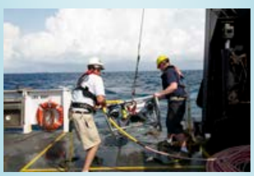


Photo-mosaic of YP-*389* created from images taken by ROV

Help! We Could Use A Hand!—Continued

Discussion:

1. Explain your design. Tell why you chose this design.

2. Explain your choice of materials. Why did you choose those items to build your arm?

3. Did your arm pick up all the “tools” on the ocean floor? Why or why not?

4. What could you do to make your arm better for the next rescue mission?

Buoyancy –Teaching Suggestions

Sink and Float

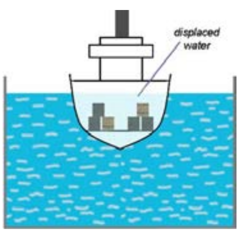
Density

Density is a property of matter that is defined as the ratio of an object's mass to its volume. Mass is the amount of matter contained in an object and is commonly measured in grams (g). Volume is the amount of space taken up by a quantity of matter and is commonly expressed in cubic centimeters (cm^3) or in milliliters (ml) 1 cm^3 = 1 ml. Therefore, common units used to express density are grams per milliliters (g/ml) and grams per cubic centimeter (g/cm^3).

To demonstrate the role of density, fill a clear large tub or small aquarium two-thirds full of water. Ask students to predict if objects will sink or float. Drop objects of various densities into the water and discuss. Ask students to hypothesize about objects that are equal in volume, such as a can of soda. Drop various sodas (regular and diet) into the tank and observe. Although they are equal in volume (same ml), regular sodas sink, while diet sodas float. Regular soda has about 16 teaspoons (40 grams) of sugar, while diet has aspartame or some other sugar substitute. It takes less sugar substitute than sugar to sweeten a soda. Therefore, diet sodas have less mass.

Buoyancy

Any object, wholly or partly immersed in a fluid, is buoyed up by a force equal to the weight of a fluid displaced by the object.



- Fill a clear tub about half full with water. Mark the water level. Add a heavy object, and watch the water level rise as the object is added. Mark the new level for the water.
- Explain Archimedes' Principle—an object in a fluid experiences an upward force equal to the weight of the fluid displaced by the object. Given that various fluids have differing densities, this upward or buoyed force changes accordingly. If an object is less dense than the fluid it is in, then it will float. If it is denser than the fluid, it will sink. This concept explains why some objects float on water, while others sink. Wood floats on water because it is less dense and a piece of steel sinks because it is denser.
- But how can a large steel ship float? Archimedes' Principle explains this phenomenon. The water that the ship floats in has a constant upward force equal to the weight of the fluid displaced by the object. So if a boat weighs 1,000 pounds, it will sink into the water until it displaces 1,000 pounds of water. However, the boat must displace the 1,000 pounds of water before the boat is completely submerged! It is fairly easy to design the shape of a boat so that the weight is displaced before the boat sinks, because a good portion of the interior of any boat is air. And the average density of a boat is very light compared to the average density of water. View demonstration of Archimedes' Principle at YouTube http://www.youtube.com/watch?v=xniW3_afO-0
- The weight of a displaced fluid can be found mathematically. This fluid displaced has a weight of $W=mg$. The mass can be expressed in terms of the density and its volume $m=pV$, hence $W=pVg$.
- We call things that float, positively buoyant and things that sink, negatively buoyant. Objects that neither float nor sink are neutrally buoyant. To simulate the feeling of weightlessness in space, astronauts practice space walking in a huge pool where they become neutrally buoyant.

Submarines can both float on top of the water and sink to the bottom. To help students understand how submersibles sink and then float, use the activity *Dive, Dive, Dive* (p. 13) This activity can also be used to demonstrate how air is compressed in a diver's lungs. Explanation: There is a small space of air at the top of the dropper. When you squeeze the bottle, the added pressure compresses the air in the dropper. As the air compresses, there is more room for water to flow into the dropper. With more water in the dropper, it is now heavier and sinks (negatively buoyant).

Sinking in Density

Materials:

Experiment (per group):

- clear jar
- clear syrup
- cooking oil
- small plastic objects
- grapes
- corks

Demonstration:

- small aquarium or large clear container
- various brands of regular soda
- various brands of diet sodas
- water

Key Words:
density
mass
volume

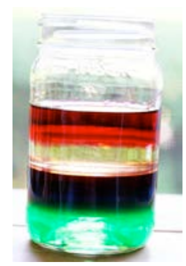
Teacher Note:
For demonstration explanation, see *Buoyancy—Teaching Suggestions* (p. 21).

Purpose: To learn how density affects an object's ability to sink or float

Background:
Density is the amount of mass an object has compared to its volume: D=M/V. Different objects have different densities. When placed in liquids, objects will either float or sink depending on their density. Objects that float will float at different levels and will tend to layer themselves in the order of their own density. Ocean waters also have various density layers. Colder water is denser and is usually found below warmer water. Saltwater is denser and is usually found below freshwater.

Experiment:

1. Pour 80 mL of syrup into a glass jar. Add 80 mL of cooking oil to the jar and observe.
2. Add 80 mL of water to the jar and observe.
3. One at a time, drop a small piece of plastic, grape, and cork into the jar and observe after each.
4. What happened to the liquids? Why?
5. Did the objects all rest in the same place? Why or why not?
6. Explain how this experiment explains density.



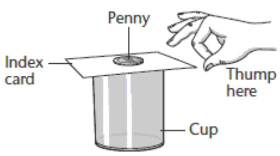
Demonstration:

1. Fill a small aquarium two-thirds full of room temperature water.
2. Acquire several brands of sodas in cans, both regular and diet.
3. Explain that each can is the same size and has 12 fluid ounces. Therefore, they each have the same volume.
4. Ask the students to predict if the sodas will sink or float.
5. Drop each can of soda into the aquarium one at a time. After the first few, ask if students want to change their predictions.
6. What happened? Why? Explain how density affected the sodas ability to sink or float.

Newton's in the Driver's Seat –Teaching Suggestions

How does an ROV move?

ROV's have motors with thrusters that help propel them through the water. In building an ROV, it is important that students understand Newton's Three Laws of Motion (*Newton Lays Down the Law*, p. 24).



- 1st: An object will stay in motion or at rest, until acted upon by an outside force. (Also known as the Law of Inertia.)
    - Demonstrate the Law of Inertia by using a chair with several books piled in the chair. Quickly push the chair along the floor and then suddenly stop. The books will fall off the chair because they continue to go forward since there is not an outside force acting upon them. Wearing a seatbelt is another good example.
    - Another activity to demonstrate the Law of Inertia is to place an index card on top a plastic cup so that it completely covers the cup. Place a penny in the middle of the index card. Have students use their index finger to quickly flick the card away from the cup. The penny will fall directly into the cup.
    - The ROV will just sit in the water until a force, such as your motor, acts upon the ROV to move it.

- 2nd: Force equals mass times acceleration F=ma. It takes more force to move a heavier object the same distance as a lighter object.
    - If the ROV is really large, then it might be really heavy and need a larger force, which means a bigger motor. So students should carefully consider the size of the motor to be used when designing and building the ROV.
    - Demonstrate by having a student pick up a light object versus a heavy object. Ask which one took more force to lift.

- 3rd: For every action there is an equal and opposite reaction.
    - The ROV will need to move forward, backward, and sideways. There are only three motors, so think about Newton's Third Law before placing them.
    - If you want to move your ROV forward, which way will your motor need to push the water?
    - Use a Newton's Cradle to demonstrate the 3rd Law of Motion.

After Reviewing

After reviewing and/or learning about air pressure, buoyancy and water pressure, discuss submarines, submersibles, ROVs, and AUV's.

ROV AND AUV

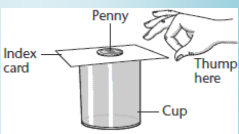
- Distribute ROV information and photographs. Explain that to go deep into the ocean, scientists can use a submarine, but they are very expensive. A less expensive alternative is to use ROVs or Autonomous Underwater Vehicles (AUV). The main difference between the two is that an ROV is tethered to the ship by a cable and the AUV is not; it is radio controlled.
- ROVs allow people to work at deep depths or in hazardous environments, while the operator is safely on the surface. ROVs can also be used to lift or recover heavy items.
- Downside to using an ROV is a loss of the human senses—you cannot touch or smell, and you can only "see" through video monitor.
- ROV Arms—Discuss how ROVs pick up objects and other special features found on many ROVs (see p. 7).

Newton Lays Down the Law

Materials:

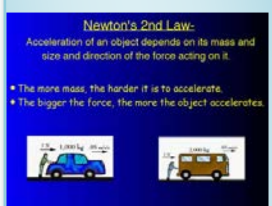
1st Law:

- clear cup
- index card
- penny



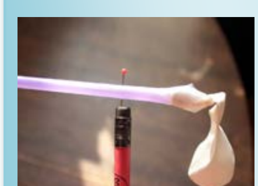
2nd Law:

- 3 meter sticks
- tape
- books
- toy cars
- washers
- stopwatch



3rd Law:

- balloon
- straw
- pin
- pencil with eraser
- tape



Newton's Three Laws of Motion

Law of Inertia—First Law of Motion

1. Put an index card on the cup so that it fully covers the mouth of the cup.
2. Place a penny in the center of the index card/cup.
3. With a sharp flick of your finger, hit the card so that it is no longer on the cup.
4. Observe the penny.
5. In your own words, explain the Law of Inertia.

Newton's Second Law of Motion

1. To create a ramp, tape three meter sticks together side by side. Use several books to elevate the ramp about 20 cm.
2. Using a stopwatch, record the time it takes for a toy car to travel from the top of the ramp to the bottom. Conduct two more trials.
3. Tape two washers to the top of the car and repeat step 2.
4. Tape an additional two washers to the car (four total) and repeat step. 2.
5. Raise the ramp 10 cm and repeat steps 2-4.
6. Explain how this experiment follows Newton's second law of motion.

Newton's Third Law of Motion

1. Stretch the balloon by hand and then blow it up to stretch it a bit further. Release the air.
2. Tape the balloon to the end of a straw (not the bendy end).
3. Place the straw with the balloon on your index finger and find the balance point (point where the straw is balanced).
4. Push a sewing pin through the balance point and into the eraser top of a pencil. Spin it several times to stretch the pin hole so the straw can easily spin.
5. Blow up the balloon and once it is filled with air pinch the end so that the air does not release.
6. Hold the pencil in one hand and then release the end of the balloon so that the air is released. Observe.
7. Explain what happened and why. How does this experiment show Newton's third law of motion?

Working under Pressure

Materials:

- PVC pipe and fittings
- multiple sets of small motors with controller
- zip ties
- duct tape
- crabs
- noodles
- swimming pool
- auto or marine
- batteries (2+)

Teacher/Adult Prep:

- See detailed instructions for creating ROV kits at http://monitor.noaa.gov/publications/education/rov_manual.pdf
- Suggested time for building an ROV is 2 hours for 5th-8th, less for older students.
- Suggested time for testing, redesigning, and competition in the pool is about 2 hours.

Problem:
Oh no! The bay has been invaded by small baby crabs! They are in danger of getting eaten by the large monster crabs. You must capture as many of the babies as you can and get them back to the protected area of the bay as quickly as possible!

Objective:
Design and build an ROV with the ability to successfully capture the baby crabs, maneuver to the protected area (corner of the pool), and deposit the baby crabs into the designated area.

Point Criteria:

- Touch any crab = 1 point (given only once)
- Pick up large crab = 3 points
- Pick up small crab = 4 points
- Deposit crab in corner = 3 points

Things to Think About!

- Need to balance buoyancy with ability to pick up crab.
- The ROV can be any size, but think about the size of your motors and how much force it will take to move the ROV.
- Need to be able to pick up the crabs, carry to corner, and deposit.
- In what directions are you going to need to move? Will you need to go up, down, sideways? Keep this in mind as you place the motors. Remember Newton's Third Law of Motion!
- How are you going to attach motors, buoyancy sleeves, etc?.

Procedure:

1. With your team discuss the mission objective.
2. Observe the crabs.
3. Review the materials available to build your ROV.
4. In your team, discuss how to engineer and design your ROV.
5. Draw your design onto graph paper, and be sure to label all the parts.
6. As you draw your design, make a list of supplies you will need.
7. Show your design to one of the ROV Specialists (teacher).
8. Return to the team to discuss any necessary changes.
9. Gather the ROV supplies.
10. Build your ROV.
11. At the pool, test your ROV design and make any changes needed.

Working under Pressure—Continued

Designing is an iterative process. Iterative means that first you design something, build it, test it, and then you analyze the data from the tests. From the data, the design is modified over and over again until it is correct. To begin the iterative process for your ROV, carefully design and draw it. Remember to draw in detail and label it clearly, neatly, and correctly so that others can follow it. Write a detailed description of your ROV.

To view a short clip on engineering, designing and the reiterative process http://www.youtube.com/watch?v=6PJTlzY0Aak&list=UUyf-z0ENg77xiAy1COGN-2w&index=35&feature=plpp_video2w&index=35&feature=plpp_video

Points Awarded:

Team 1:

Team 2:

Team 3:

Team 4:

Team 5:

Team 6:

POOL TIME!!!

At the pool—

- Each team will have five minutes to test their ROV in the water and to make any adjustments needed.
- Competition Time: Each team will have five minutes to pick up as many crabs as possible and return them to their corner, as instructed.

Oh no…the baby crabs are in danger!

Here comes the big monster crabs!

Conclusion:

1. How well did your ROV perform?

2. What would you do differently next time?

3. Why is it important to design the ROV before building it?

4. Describe how scientists and researchers might use an ROV underwater.

Deep Sea Exploration with ALVIN

Purpose: To learn and understand how ROVs, AUVs, and submersibles are used in underwater exploration.

Site One: http://www.whoi.edu/home/interactive/alvin/

Explore the site to answer the following questions (the answers can be found throughout the different tabs)

Introduction:

1. How many people are in Alvin?
2. What are the two ways Alvin can be used to explore the sea floor?
3. How does Alvin collect samples from the ocean bottom?
4. How is Alvin controlled?
5. What famous ship wreck was founded by Alvin?
6. What is the name of the institution that operates Alvin?
7. What is Alvin?
8. Who (name of government agency) owns Alvin?

Vehicle Tour:

1. How does Alvin remain "state of the art?"
2. Why are cameras put into pressure housings?
3. What are some things Alvin can store in its sample basket?
4. What are manipulators?
5. What are the dimensions of the manipulators and how much can they carry?
6. What is the first thing most people see when Alvin emerges from the water?
7. Explain how Alvin can move:
8. What are the dimensions of Alvin's personal sphere?
9. Explain how Alvin's electrical systems are designed to prevent shorting out?

10. How many viewpoints are there in Alvin?

11. What does Alvin use as its power source for electricity?

12. How does Alvin adjust its exact depth?

13. What is used in Alvin to make it buoyant?

On the bottom of the screen, click on “360 view” and check out Alvin from all its angles.

On the bottom of the screen, click on “evolution of Alvin” and answer the following by clicking on the different dates:

1. How did Alvin get its name?

2. What year was Alvin commissioned?

3. What two changes were made to Alvin from 1964 to 1973?

4. What is added in 1978 to Alvin?

5. Why was a color changed in 1982?

6. What are a few things scientists want to add to Alvin in the future?

On the bottom of the screen, click on “specifications” and answer the following:

1. How long is Alvin?

2. How tall is Alvin?

3. How much does Alvin weight?

4. How much can Alvin bring back?

5. How deep can Alvin dive?

6. How long can Alvin dive?

7. How many people can dive in Alvin?

Deep Sea Exploration with ALVIN--Continued

On the bottom of the screen, click on "fun facts" and answer the following:

1. What do scientists have to do if they have to use the restroom?
2. What happened in 1967?
3. What is the average temperature inside the vessel?
4. What is the average temperature outside the vessel?
5. How many men have driven Alvin? ___ How many women have driven Alvin? ____
6. How are pilots "baptized"?

On the top, click on "In the field"

1. Let the video load, and watch the video. Initial here that you watched the video _____

On the bottom, click on "exploring the sea floor" and click on the different features and answer the following:

1. What are black smokers?
2. What do octopi eat?
3. How are white smokers different than black smokers?
4. What do zoarcid fish eat?
5. In the Atlantic Ocean, where do shrimp swarm?
6. What do Anemone eat?
7. How do mussels move?
8. What do crabs eat?
9. What do yeti crab look like?
10. What do hagfish eat?
11. How do clams move?
12. How do dandelions move?

Deep Sea Exploration with ALVIN--Continued

On the bottom, click on "Alvin's Mother ship" and answer the following:

1. What is the name of the ship that houses "Alvin?"

On the top, click on "milestones" and answer the following:

1. How much was the initial cost of Alvin?
2. What did the Navy do with Alvin in 1966?
3. What happened to Alvin in 1968?
4. What is the name of the ship that recovered Alvin?
5. Describe project "FAMOUS"
6. What famous ship was discovered in 1986?
7. What neat event happened in 2007?

Site Two: http://www.whoi.edu/home/interactive/nereus/

Explore the site to answer the following questions (the answers can be found throughout the different tabs)

Interactive Tour:

1. *Nereus* can be switched to become an autonomous underwater vehicles (_____) or a remotely operated vehicle (_____) operated by shipboard ______________ via a _____________
2. What does the AUV give researchers?
3. What is the ROV equipped with?

AUV Mode:

1. In AUV mode, what does it do?
2. Click on Sonar Mapping and Camera System: once the vehicle reaches the ocean floor what happens?
3. Click on Ceramic Spheres, how much does *Nereus* weight?
4. How do they keep *Nereus* floating?
5. What part of the AUV keeps the vehicle stable and able to track in a straight line?
6. What does the AUV use for a lighting system?

Deep Sea Exploration with ALVIN--Continued

ROV Mode:

1. When researchers see something interesting in AUV mode, what can scientists do to the vehicle to explore areas more closely?
2. What does the manipulator arm do?
3. How much weight can the sampling basket hold?
4. What does the vehicle use for its energy source?
5. How do scientists protect all their equipment from the ocean pressure?

Click on 360-view Describe the difference between the vehicles when it is in ROV mode versus AUV mode:

Click on Animation: (let the video load then play the video)

1. What is the video showing you?

Analysis Questions (using what you learned in this activity and your BRAIN):

1. List two examples of advantages of using ROV's:

2. List two disadvantages of using ROV's:

Keeping it in the Budget

Situation

Your Marine Engineering Company has won the bid for designing and building a Remote Operated Vehicle prototype. The criterion that must be met in testing the prototype is attached. You have a budget of $145.00 to build the Remote Operated Vehicle.

Problem: Design a Remote Operated Vehicle to meet the above situation.

Specifications: On attached sheet

Design Requirements

- Each team will have ___________________________________ (ex: 2 hours per day for 20 days [total of 40 hours]). Note: any conflicting dates will be rescheduled.
- Mechanical connections only. No glue or tape unless okayed by instructor.
- The team is to present a sketch of the proposed solution on or before __________. Include a material list for the ROV.
- The Marine Engineering teams are to draw individual parts of the ROV. An assembly and orthographic drawings will be made from the above sketches. The Engineering Design teams will draw an orthographic sketch of their design.
    - The above preliminary drawings are due on __________.
        - Include a list of all materials to be used in the ROV
        - Include dimensioning.
        - Include all original drawings, parts lists, and an explanation of any changes made from the original drawings.
    - Daily journals (Notebook) of ROV construction, problems encountered assignments, and problem solving activities.
    - Presentation (PowerPoint or equivalent)
        - To include but not limited to the team name, team members, brief history of your ROV, the design challenges and why you're ROV should be picked to be built.
    - Preliminary drawings, journals and presentations are due __________.
    - Preliminary testing of ROV's will be on __________ for refining purposes.
    - Presentations will be __________.

Assessment:

- Group Portfolio to include:
    - Day by day progress. Include what each person did on ROV.
    - How group came up with design.
    - What changes were made to the ROV and why.
    - Team drawings (All sketches and final drawings).
    - Team material list.
    - Journals (Notebook)
- Staying within budget.
- Demonstrate teamwork.
- Adhering to timetable (Working on ROV during class instruction time will result in grade reduction).
- Craftsmanship
- Meet all design criteria.
- ROV is able to complete the entire trip.

Keeping it in the Budget—Continued

Materials List

Team Members ______________________, ________________________, ___________________

- Total Budget = $145.00
- The following materials may be secured from inventory. Note: No materials may be secured from outside of class.

Material	Price	Quantity	Cost
o DPDT Switch (Switch On/Switch Off)	$_____	______	$_____
o DPDT Switch (Center Off)	$_____	______	$_____
o Wire (22 Gauge, Red)	$_____	______	$_____
o Wire (22 Gauge, Green)	$_____	______	$_____
o Wire (22 Gauge, Black)	$_____	______	$_____
o Female Terminal (P/N 19017-0005-C)	$_____	______	$_____
o Cable Ties (4 inch)	$_____	______	$_____
o Controller (P/N J093)	$_____	______	$_____
o 1 1/2” Male Adapter (P/N 436-005)	$_____	______	$_____
o 1/2" Conduit Connector	$_____	______	$_____
o Bilge Pump	$_____	______	$_____
o Direct Drive Propeller Adapter	$_____	______	$_____
o Propeller	$_____	______	$_____
o Tether Wire (100’)	$_____	______	$_____
o Wire (18 Gauge)	$_____	______	$_____
o Rubber Tape (P/N 2155)	$_____	______	$_____
o Electrical Tape	$_____	______	$_____
o Shrink Tubing	$_____	______	$_____
o 1 1/2” Conduit Clamps (P/N 5133734B)	$_____	______	$_____
o Tie Wraps (4” Long)	$_____	______	$_____
o Machine Screw Pan Head, 10-32UNC X 1” Long	$_____	______	$_____
o Nut, 10-32UNC	$_____	______	$_____
o Washer, No. 10-32	$_____	______	$_____
o 1/2” X 10’ PVC Pipe	$_____	______	$_____
o 1/2" 90 Degree Elbow, Schedule 40	$_____	______	$_____
o 1/2" Cross, Schedule 40	$1.00	______	$_____
o 1/2" Tee (Manufacturer Lasco)	$_____	______	$_____
o 1 1/2" X 10’ PVC Pipe	$3.50	______	$_____
o 1 1/2" PVC End Caps	$0.65	______	$_____
o Tie Wraps (14” Long)	$_____	______	$_____
		TOTAL COST	$_____

Notes: Materials purchased from inventory must be recorded on this sheet. No sheet, no materials! Materials may only be purchased the first 20 minutes of time set to work on ROV. All prices rounded up to next dollar.
ROV = Remote Operated Vehicle, NC = No Charge.

Remote Operated Vehicle Scoring Rubric

Team Name ____

Team Member No1 ________________________________
Self-Evaluation _____ Final Grade _____

Team Member No 2 ________________________________
Self-Evaluation _____ Final Grade _____

Team Member No 3 ________________________________
Self-Evaluation _____ Final Grade _____

Total Points	Grade	Description
10	_____	Demonstrate Teamwork
20	_____	Presentation
20	_____	Notebook (to include) • What each person did on the ROV • How team came up with design • What and why changes were made to the ROV • The work that went into designing/building the ROV • Student Evaluation
10	_____	Original Sketches
20	_____	Final Drawings (AutoCAD/Inventor) • Isometric • Multi-view Drawing • Detail Drawing • Assembly Drawing o Do not forget to add a parts list to drawing set
5	_____	Craftsmanship
5	_____	ROV meets all design criteria
5	_____	Completed course in time allotted
5	_____	Bonus points
Total	_____	**Points** (100 points)

Notes: