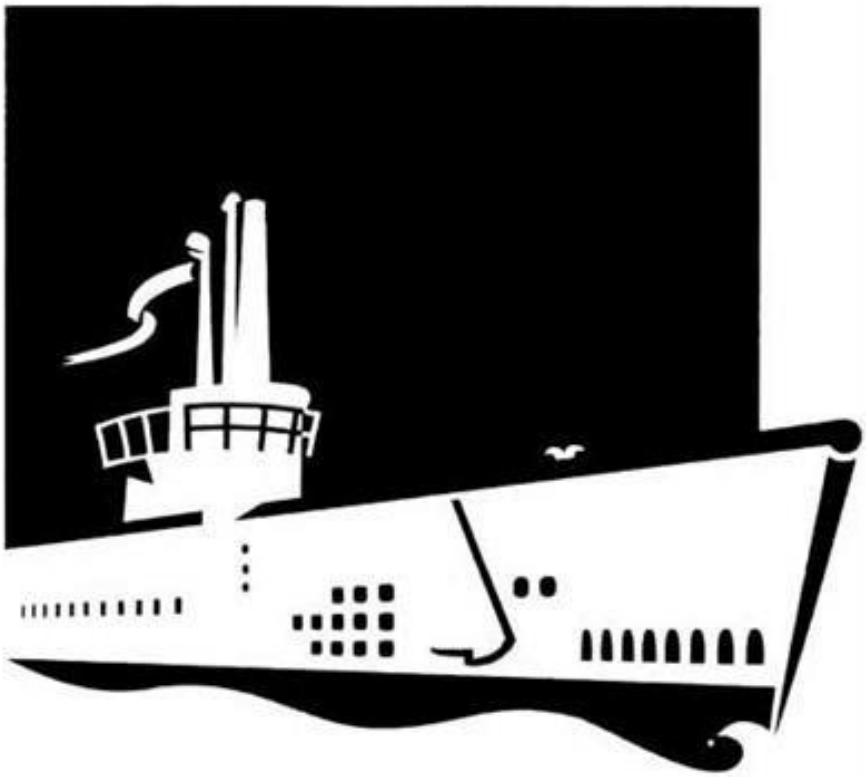
USS PAMPANITO
SS-383



Submarine School

Where History Meets Science

Day Program Teacher's Guide **(edit date 7/25/17)**

San Francisco Maritime National Park Association

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Part I

About the Program

- Introduction/Objectives/Policies

Trip Planning

- Getting Ready
- What To Bring/What Not To Bring
- Using The Head
- Parking Instructions, Directions & Maps

Safety Information

- Safety Measures
- Emergency Phone Numbers
- Evacuation Instructions

Rules of Conduct and Forms

- Rules of Conduct and Acknowledgment Form
- Medical/Liability Forms

Part II

Lesson Plans and Activities

- Buoyancy
- Light (w/worksheet)
- Pre-Visit Quiz

Appendix

- Teacher's Station On Board: Making a Chemical Battery
- Background for Teachers: States of Buoyancy and Sound in Water
- Worksheet And Quiz Answers

Part I

ABOUT THE PROGRAM

INTRODUCTION

The World War II submarine USS *Pampanito* (SS-383) offers students and their teachers a unique glimpse into America's past. Walking the decks of this submarine brings history to life. Recognized as a National Historic Landmark, the USS *Pampanito* has helped instructors interpret the events of World War II to their students in a memorable way that books alone cannot.

But that's not all. A submarine is a most unique sort of vessel. The *Pampanito* was designed for a very special purpose: to travel on long patrols independent of support from other naval vessels and carry a large crew to operate her varied and complicated equipment in often hostile environments--and to do it submerged part of the time! To accomplish this, the submarine's designers had to answer a variety of questions, such as how to make the submarine dive, how to propel it, how to navigate, how to make its weapons operate, how to communicate inside the boat and out. How could they make the submarine do all these things and at the same time make it habitable and as comfortable as possible for its crew? The answers to these basic questions lay in the realm of science.

Science was used to address virtually all the design challenges submarine builders faced. In this way, the USS *Pampanito* presents teachers and their students an unusual platform for the study of a variety of topics spanning the physical sciences: Force & Motion, Electricity & Magnetism, Energy, Light, and Sound. In fact, most of these topics can be directly correlated with content outlined in the Science Framework for California Public Schools.

In the following curriculum, we'll examine some of these topics as they relate to submarine operation. The activities presented here only begin to scratch the surface of how submarine systems can be used as a means of teaching physical science. However, these lessons are essential to providing your students with the skills necessary to master the *Pampanito* Submarine School program. Teachers are encouraged to add supplemental activities to enhance their students' experience. A resource list of web-sites, books, and other materials is included in the Appendix.

OBJECTIVES

Students will:

- Explore practical applications of scientific concepts using an interdisciplinary approach
- Develop specific science skills
- Develop teamwork and social skills

OUTLINE OF SCIENCE ACTIVITIES

Stations:

- Optics - Learn about mirrors and make a periscope
- Buoyancy - Learn why a boat floats by making your own bottle submarine
- Sonar - Principles of passive and active sonar are explored here
- On-Board Pampanito – Guided tour of the vessel and the history of World War II
- Chemistry - Create a chemical battery and use it **

**Battery station is generally reserved for students in the 7th and 8th grade.

SCENARIO

Throughout the program, students onboard the USS *Pampanito* will rotate through 4 hands-on science stations. All of the stations will have adult supervision, either by the teacher, adult chaperones, or our program staff. Because of its relative complexity, the Chemical Battery station will be operated by the science teacher (you!) It requires knowledge of how a battery works and the safe handling of chemicals. Our staff will facilitate the other 3 stations. Students are given individual notebooks (supplied by the *Pampanito*) in which to keep notes and track answers. The students will be acting in teams or crews during the activities. Although all notebooks will be turned in, each crew will designate one notebook to represent their team's work. The crew with the best overall accuracy will receive an award at the end of the program.

POLICIES

Cancellations and Refunds:

- Your deposit will be used towards the total cost of the program. Final payment is due no later than 60 days prior to the program date. If the reservation is made less than 60 days than the program date, full payment is expected with the signed contract before its due date.
- Changing the date of your program **less than 60 days prior to the current program date will incur a $100 date-change fee**. Changes with more than 60 days' notice will not incur a penalty. **Cancellation of a program less than 60 days prior to the program date will hold the group responsible for the full cost of the program minimum**. Cancellation with more than 60 days' notice will not require full payment of the program minimum, but will still forfeit the non-refundable deposit. Notice of cancellation must be made and acknowledged in writing.
- On very rare conditions, inclement weather may create hazardous conditions, requiring us to close the boat. In such cases every effort will be made to provide scheduled groups with advanced notice so that they can reschedule their visit, or if they choose, cancel altogether and receive a full refund of their deposit. The San Francisco Maritime National Park Association will not be responsible for any other inconveniences or consequences arising from cancellation of a group's visit.

You are required to furnish the following:

- A current, valid insurance certificate. **(Important: The Certificate of Insurance should be in the amount of $1 million for bodily injury and property damage, and should list the San Francisco Maritime National Park Association as an additional insured.)**
- Complete Medical and Liability forms for ALL participants. These are included in this packet and due on the day of the program.
- Signed acknowledgement of the Safety Procedures and Rules of Conduct. This form is also located in this packet and due on the day of the program.
- Contract Terms and Conditions signed by the teacher and principal (or other administrator). This should be sent in by the contract due date.

No group may board the vessel until all these forms have been received. This manual provides more detailed information about our program and the aforementioned forms. You are responsible for reading it in advance of your visit. If you have any questions, please feel free to contact:

Education Coordinator Alice Watts at 415-561-6662 (email sfmaritimecoordinator@gmail.com)

Pampanito Education Director Dylan Drovdal at (415) 775-1943 (email: ddrovdal@maritime.org).

TRIP PLANNING AND LOGISTICS

GETTING READY:

Immediately upon receiving this packet….

- Confirm that the field trip date on your contract is the same as the date on your class calendar.
- Arrange transportation.
- Submit paperwork to the school district office; payment is due 60 days prior to the day of the program, in the form of **one check**. If your school needs to file a purchase order, it must be received early enough to allow the **check to be mailed in time.**
- Arrange for insurance coverage for your field trip. (We require a Certificate of Insurance indicating a $1 million limit of liability for Bodily Injury and Property Damage, listing the San Francisco Maritime National Park Association as an additional insured (i.e., "Certificate holder is an additional insured.")

One month prior to your trip….

- Have a parent information meeting.
- Recruit your parent chaperones.
- Distribute medical forms to students and adults.
- Ensure that Insurance Certificate has been sent to our Education Coordinator.
- Implement pre-visit activities.

One week prior to your trip….

- Collect medical forms from students and adults.
- Meet with chaperones to go over program details.
- Make sure all participants bring a sack lunch
- Split class into 5 groups for the 5 science station rotations.

24 hours to go…

- Confirm all medical forms have been collected.

When you arrive at Pier 45….

- Arrive at Pier 45 at 9:45 between sheds A & C and meet a member of our staff who will help you park vehicles (see map under Parking and Directions). We have a 10 car maximum, so if you have more than 10 cars they will need to park nearby in a paid garage/lot; have participants arriving on foot to the Pier at 10:00am.

- Bring students and lunches to Pier 45 and line them up by crew. Teacher should bring class list and medical forms to the office while the students wait on the pier in a supervised and orderly manner.

Timeline of trip activities…

7th/8th Grade Students:

10 - 1015 Welcome
Sub Rules

1015 - 1045 Audio Tour of Submarine

1045 - 1100 Tour of Historic Artifacts on the Pier

1100 - 1150 Head Call & Lunch

1150 - 13 Four 25 min. Stations: Battery, Buoyancy, Sonar, Periscopes
Rotation 1: 1150 - 1215
Rotation 2: 1215 - 1240
Rotation 3: 1240 - 1305
Rotation 4: 1305 - 1330

1330 - 1345 Wrap Up & Goodbye

4th/5th Grade Students

10 - 1015 Welcome
Sub Rules

1015 - 1035 Tour of Historic Artifacts on the Pier

1035 - Four 25 min. Stations: On-Board History Tour, Buoyancy, Sonar, Periscopes with Lunch Break

Rotation 1: 1035-11:00
Rotation 2: 11:05-11:30

Lunch Break & Head Call 11:30 – 11:50

Rotation 3: 11:55-12:20
Rotation 4: 12:20-12:45

1245 – 13:00 Wrap Up & Goodbye

Please keep in mind that these timelines are approximate and may vary according to each program. If you have a special request for timing of the program or the content, please contact Pampanito Education Director Dylan Drovdal at 415-775-1943 or ddrovdal@maritime.org

PREPARING YOUR CREW:

Divide the class into crews: Before you come on board, it is mandatory that you divide your class into 5 crews. You know your class, so it is up to your discretion when assigning groups.

Crew Names: Each crew should choose an appropriate naval, maritime or submarine related name.

Name Tags: Each person should wear a nametag. Color-coding the nametags by crew is an effective way to keep crews together in the cramped confines of the submarine.

Rules of Conduct and Safety Rules: Participants are responsible for knowing and following our rules of conduct and safety. Complete rules are in this manual and the Acknowledgement must be signed by all attending adults.

WHAT TO BRING:

- **Medical forms:** No child or adult will be allowed to board the submarine without a completed and legible medical form. Prior to the start of the program, a staff member will collect these.
- **Appropriate clothing:** Each participant should bring weather-appropriate clothing (rain gear and/or warm clothing). Please wear or bring a warm jacket and layers (the sub is warm inside, but days can be chilly on the pier). Comfortable, flat, rubber-soled shoes are recommended.
- **Cameras:** Only adults may use cameras during the program; students may take pictures after the science activities have been completed. ***Suggestion:*** Assign an adult chaperone to function as "Photographer's Mate" to take pictures during the science activities.
- **Important: Your group must bring its own first aid kit!**

CONTRABAND (items not allowed aboard the boat):

- Radios, portable CD players, iPods, etc.
- Handheld electronics/gaming devices
- Cell phones---the teacher and adult chaperones may carry cell phones, but please keep them on silent or vibrate and refrain from using unless absolutely necessary. This will help ensure that everyone is actively participating in the program and that the safety of the students is being observed. Students are not allowed to have cell phones onboard and parents are not allowed to make calls or text during the program.
- Alcoholic beverages and smoking are not permitted onboard.

The San Francisco Maritime National Park Association is not responsible for any lost or stolen articles.

FOOD:

Please have students eat a snack either before leaving school or while en route to the boat as there will be no chance to eat until lunch at 11:15. All participants should bring a bag lunch for the day. Due to heightened nut allergies, no food with nuts (trail mix, peanut butter cookies, etc.) will be allowed on board. There is no refrigeration available, so be sure to bring a cooler if you have perishables.

Crews will eat on the pier or, if it's raining, will be shown to a sheltered space on the pier.

SANITARY FACILITIES (HEADS):

Our restroom facilities are extremely limited on the pier--there is one unisex restroom available, so head calls can take a long time. During lunch students can take shifts eating and using the head for the 45 minute lunch break.

The public restrooms located at the Chowder Hut (2890 Taylor St, San Francisco, CA 94133 is the best location to have the entire class use the restrooms all at once. Ideally the group leaders would use the public restrooms before arrival but Pampanito Education Staff will assist in directing your group after your arrival on the pier.

USS *Pampanito* Map & Directions

From the Golden Gate Bridge (North Bay):

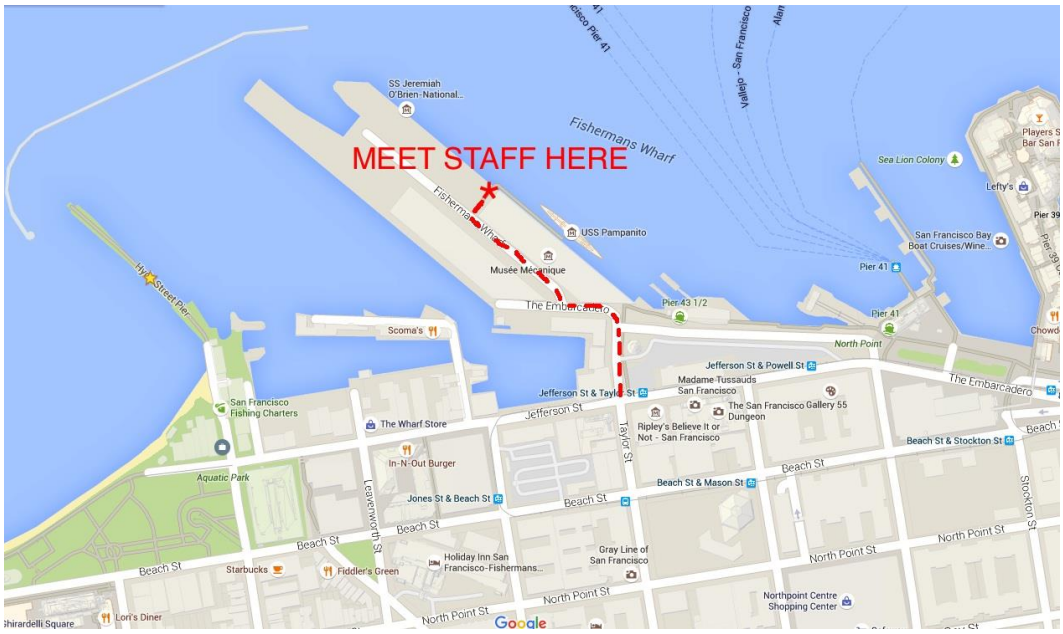
- Coming off the bridge, bear left and look for the Marina off ramp
- Follow Marina Blvd. along the waterfront; it will curve around Safeway, onto Laguna St and up to Bay St
- Turn left on Bay St. and proceed to Taylor St (about 10 blocks)
- Turn left on Taylor St. and go 4 blocks
- Pier 45 and the Pampanito will be directly in front of you, at the foot of Taylor St

From Interstate 80/Bay Bridge (East Bay):

- From West 80/Bay Bridge, take the Fremont/Folsom exit, (very first exit on the right)
- Stay to the right towards Folsom, then turn left onto Folsom.
- Continue on Folsom until it hits the waterfront at Embarcadero; Turn left onto Embarcadero
- Follow Embarcadero around the city waterfront all the way to the Fisherman's Wharf area
- Turn right at Taylor St
- Pier 45 and the Pampanito are at the foot of Taylor St

From Highway 101 (Peninsula):

- Follow Highway 101 up to the split with Interstate 80.
- Bear right onto route 80 towards the Bay Bridge.
- Take the Fourth St./Bryant St. exit---this is the **very last** San Francisco exit, so don't miss it!
- Bear left onto Bryant St. and follow it all the way to Embarcadero (about 6 blocks)
- Turn left onto Embarcadero and continue around the city waterfront until you reach the Wharf area
- Turn right on Taylor St
- Pier 45 and the Pampanito are at the foot of Taylor St



1. At the Corner of Taylor and The Embarcadero, proceed to the left of Shed A down the road between Shed A and Shed B. Do not go inside the front entrance as payment for parking is required. USS Pampanito staff are not responsible for any fees incurred if visitors use the incorrect entrance.

2. Drive straight along this corridor until you see a stop sign to your right.

3. At the stop sign take a right into the gap between Shed C and Shed A.

4. Take another right into the entrance to Shed A. Do not take a left into Shed C.

5. Stop at the yellow chain gate and call 415-775-1943 if it is locked. If it is not locked, park in any available space inside Shed A and an instructor will meet you with the overnight parking passes.

USS *PAMPANITO*

OVERNIGHT PROGRAM

PARKING GUIDE

Welcome to Pier 45 and the USS *Pampanito*! This map will help you to find the parking spaces designated for your group's overnight stay.

The arrows and "X"s on the map will guide you around to the back entrance of "Shed A" where your group's parking spaces are located inside. A staff member will be present at this entrance to assist your group in accessing our parking area.

DO NOT enter through the front of Shed A or take a ticket from the entrance. If you do you will be responsible for paying any parking fees incurred.

Please note: There are a total of 10 parking spaces available for overnight program participants and they are only available from 6:30pm to 8:30am. Extra cars will need to find paid parking at a nearby garage or park on the street.

SAFETY INFORMATION

To ensure your safety, as well as the well-being of the historic submarine, we ask that you please review the following information with the members of your group before your arrival.

Safe Conduct:

Please remember two important points about the USS *Pampanito*: First, *Pampanito* is a naval vessel which was intended to be operated by specially-trained Navy personnel; Second, *Pampanito* is now a museum ship; both of these points dictate that safe conduct be exercised by each and every member of your group. Because of the design and construction of the submarine, special care must be taken while on board. Please adhere to the following:

- **Do not run while on board the submarine or on the pier.**
- Do not attempt to climb on the bridge deck without permission of staff.
- Step through watertight doors one leg at a time while holding on to the handgrip.
- Be aware of low overheads (low hanging equipment or fixtures) in the submarine---there are potential "head knockers" throughout the boat.
- While topside, remain on the special walkway at all times. Do not go outside the wire rope barriers at any time, or out on the bow or stern of the boat. The metal and wooden portions of the deck are usually wet and can be very slippery.
- When going up or down ladders, hold on to handrails with both hands.
- Stay out of any areas of the boat that are secured by locks or screws or are otherwise marked as off limits.
- Do not attempt to operate any equipment, turn switches, open up any control panels or otherwise disturb any equipment on the submarine.

Safety Equipment:

- Telephone: a landline is located in pier office.
- First Aid Kit: each group is required to bring their own First Aid Kit, however we do have a kit located in the office on the pier for emergency use.
- Eye Wash Station: next to the building entrance.
- Life Rings: located on the pier and on the main deck of the submarine.
- Boat Hooks: located against wall in work area behind gangway.
- Life Jackets: on top of the Eye Wash Station.

Fire Emergency Procedure:

Smoke detectors are located on board. If an alarm sounds, please follow the protocol below:

- Exit the boat in a quick and orderly manner---no pushing and shoving---moving in the opposite direction of any smoke towards one of the marked exits.
- Do not close any watertight doors on the submarine.
- Inform staff immediately and call 911.

Emergency Phone Numbers:

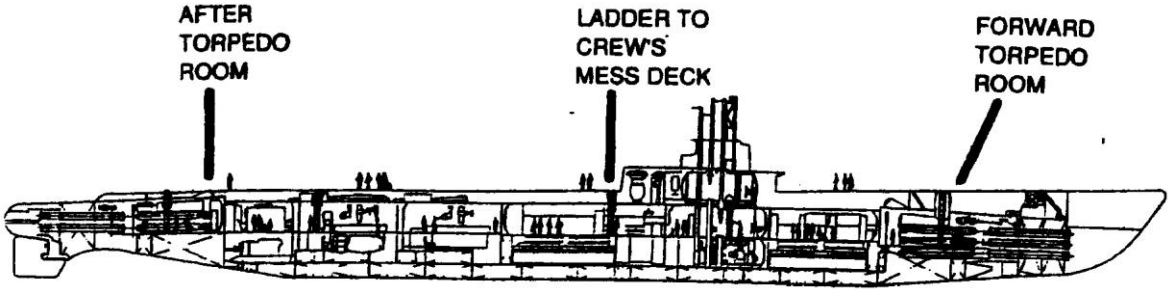
- Ambulance/Fire/Rescue/Police: 911

- Local Police dispatch (emergency): (415) 553-8090
- Police (non-emergency): (415) 553-0123 or (415) 553-1532
- Poison Control: (415)476-6600

USS *PAMPANITO* Emergency Evacuation Plan:

In the event of an emergency it may become necessary to evacuate the submarine. Staff will conduct an evacuation drill with your group to make certain everyone understands what steps to take. The diagram below shows the three main access points into and out of the submarine.

Exit the submarine through one of the following access ways:



Remember:

- Move in the opposite direction of any hazard.
- Use flashlights if necessary.
- Do not push or shove on your way out; walk in single file.
- Do not close any watertight doors.
- If access to both main exits (After Torpedo Room and Forward Torpedo Room) is blocked, you may use the ladder in the Crew's Mess (push aside grate at top of ladder).
- The first person out should notify staff of the problem immediately, and/or call 911 if necessary.
- The rest of the group should line up on the pier and the group leader should take a head count.
- Remain lined up on the pier and wait for further instructions from staff/emergency personnel.

RULES OF CONDUCT FOR GROUPS ABOARD USS *PAMPANITO*

To ensure a safe and pleasant visit, all USS *Pampanito* Program participants are required to abide by the following rules. Group leaders should distribute (or read aloud) the rules to the entire group prior to their visit. Remember: **Discipline is the responsibility of ALL ADULT chaperones and a signed Rules of Conduct form is required from each adult over 18 years of age who will be present during your program.**

1. Absolutely no running or horse play aboard the vessel or on the pier.

2. Adequate adult supervision is required from the visiting group at all times.

3. Do not enter restricted areas without permission of *Pampanito* staff. These areas are well marked. When topside, do not leave the marked walkway. Do not climb on any deck guns or on the periscope and lookout platforms.

4. Do not turn valves, switches, handles or attempt to operate any equipment aboard the submarine. **Everything on board the submarine is an historic artifact and must be treated with respect.** Remember, USS *Pampanito* is a National Historic Landmark (just like the Washington Monument!)

5. None of the following are permitted:
   - Alcohol consumption during your visit, on or off premises
   - Smoking
   - Gum, sunflower seeds or nuts with shells
   - Radios, portable audio devices, handheld electronics/gaming devices, laptop computers, etc.
   - Anything else listed in the Contraband Section of this manual

6. Teachers are to make sure all required paperwork is completed and submitted prior to boarding.

7. **The group must follow all directions and special instructions issued by members of our staff.** Doing so ensures the best possible program and a chance for your school to return!

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ACKNOWLEDGEMENT OF SAFETY GUIDELINES AND RULES OF CONDUCT FOR GROUPS

→ (To be signed by all adult participants age 18 and over) ←

I. the undersigned acknowledge the Rules of Conduct for Groups and Safety Rules for Groups. I have read these rules and agree to abide by them. I also certify that all participants under the age of 18 (if any) have been informed of these rules and I will assist in ensuring they are followed by all participants. Further, I understand that anyone violating these rules may be directed to leave the *PAMPANITO* and its Pier 45 spaces.

SIGNED: _____

PRINTED NAME: _____

DATE: _____

SAN FRANCISCO MARITIME NATIONAL PARK ASSOCIATION

Medical and Liability Form
→ (To be completed by Parent or Guardian of participants under the age of 18) ←

In consideration of my child participating in the programs of the San Francisco Maritime National Park Association (herein "Association") I agree on behalf of myself and my child to assume all risks of injury to my child and agree to waive all claims, actions, damages and agree not to sue the Association, its officers, directors, employees, agents, or assigns for any claims arising out of my child's participation in the Association's programs, the actions of the sponsoring organization or its employees, officers, and agents of the program participants.

Date of Program: _____

Participant's Name: _____

Parent/Guardian's Name: _____

A minor without a duly signed Release Form will not be allowed to participate in the program.

Signature of Parent/Guardian: _____

Date: _____

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SAN FRANCISCO MARITIME NATIONAL PARK ASSOCIATION

→ (To be completed by ALL participants) ←

Date of Program: _____

Group Name: _____

Participant's Name: _____

☐ Adult (over 18) ☐ Minor (under 18)

Address: _____

Emergency Contact: _____

Relationship: _____ Phone Number for Emergency Contact: _____

Do you have any physical or medical conditions, restrictions, or special needs? If so, please describe:

_____

Occasionally photographs of the program are used in publications. If you do *not* want photographs containing your image (or your child's) used in print or online, please indicate here: _____

Signature of Participant _____ Date_____

Signature of Parent/Guardian if under 18 _____

Part II

LESSON PLANS AND ACTIVITIES

The following are in-class activities designed to help you prepare your class for participation in the *Pampanito* Submarine Science program. Feel free to substitute your own lessons if they have similar objectives.

BUOYANCY

Time: 50 minutes

Goal: To gain an understanding of buoyancy

Objectives: Students will be able to:

- Understand the concept of gravity
- Understand the concept of friction
- Understand the concept of gravity and friction as a force
- Understand how these forces effect buoyancy
- Understand what is meant by water displacement
- Design a hull that will maximize its ability to hold cargo

Background:

An object floats or sinks depending upon its ability to displace water. Increasing the volume (area that the object occupies) increases displacement. This increases the buoyancy, or the ability to float. Increasing the volume an object occupies increases its surface area, thus increases the friction it experiences as it moves. Thus, the shape of the object in liquid can serve two purposes: An object designed for speed must have the minimum displacement possible to decrease friction, i.e. a speed boat. An object designed to carry a heavy weight, such as a cargo ship, must be designed to maximize displacement, thus increasing buoyancy and friction.

Water in general is always striving to maintain a level surface. When you place a boat in water, gravity pulls it down and the water is displaced. The water is no longer level. You have two forces at work against the hull of the boat: the pressure of the water pushing up trying to regain a level plane and gravity pulling it down.

The hulls of boats are designed to transfer, or spread out the force of the water over a larger area, thereby decreasing the force at any particular point. If the pressure of the water pushing on the hull is greater than the force of gravity pulling it down, then the boat floats! So, if you take a sea worthy boat hull, break it down and compress it together, and place it in the water, it will no longer float. Why? There is no longer sufficient water displacement to counteract gravity and the desire for the water to maintain a level plane.

Materials:

- Plastine modeling clay or foil
- Small metal nuts or paper clips
- Tub of water

Activity:

Start by demonstrating that when the clay or foil is in the form of a ball it will sink. Discuss the concept of water displacement and buoyancy then give students the following challenges:

Challenge 1: Give each student a ball of clay or foil and challenge them to redesign the ball into a shape that will float. Have a contest to see which design will hold the most cargo (metal nuts or paper clips).

Challenge 2: Have the students think of what hull design would make a hull as frictionless as possible, which could be used as a "race boat"? Why?

Challenge 3: Introduce the concept of positive, neutral, and negative buoyancy. Have the students brainstorm why a submarine uses these three stages of buoyancy.

LIGHT

Time: 50 minutes

Goal: To gain an understanding of how light is reflected.

Objectives: Students will:

- Position mirrors to see objects out of the direct line of sight
- Understand how the position and number of mirrors used will affect the appearance of an image

Background:

Light travels in a straight line unless it is modified or controlled by another object.

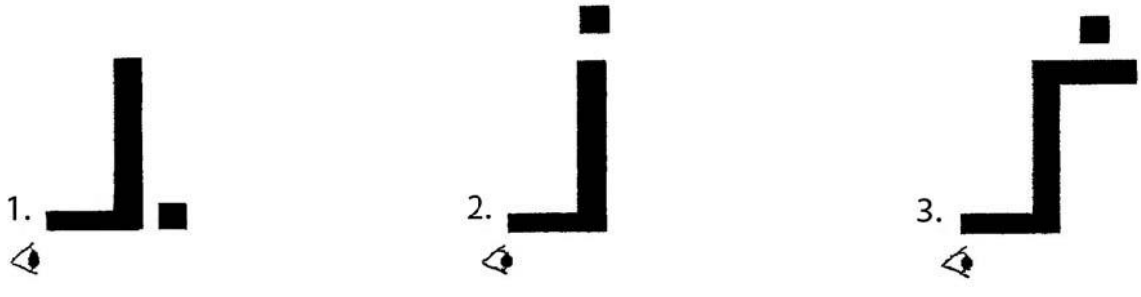
Light can be:

- **Blocked**, such as by a cloud or wall
- **Refracted** (bent) when it passes through another transparent material of a different density
- **Reflected**, in which its path is changed by a mirror

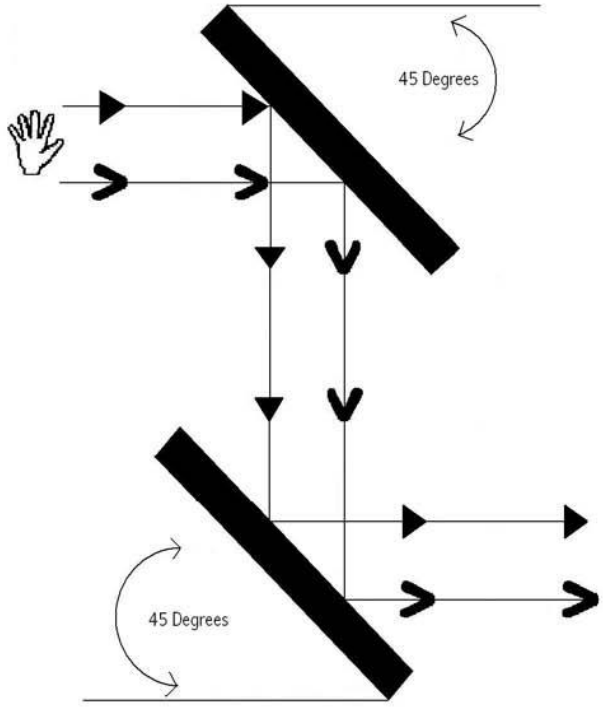
Note on Reflected Light: Light always reflects away from a mirror at the same angle that it hits the mirror. If light hits the mirror at a 10 degree angle it will be reflected at a 10 degree angle away from the mirror.

Activity:

1) Draw lines to represent the location of mirror(s) needed for the eye to see the block. Label the mirror angles needed for the eye to see the block. Any solid line is considered a solid surface and cannot be seen through.

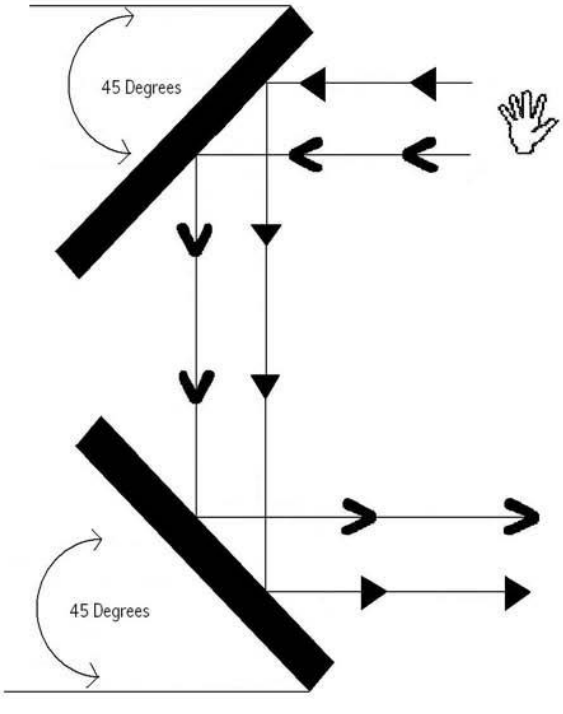


2) Because light travels in a straight line, the position and number of mirrors can change the appearance of the object being reflected. Complete the following exercise, paying close attention to the path of the light from mirror to mirror.



A.

Study the illustration to the left. Draw the hand, as it would appear to the viewer. Explain your answer.



B.

Study the second illustration here. Draw the hand, as it would appear to the viewer. Explain your answer.

PRE-VISIT QUIZ

Buoyancy:

Can 100 pounds of steel float in water? Explain your answer.

Codes:

Decode the following message. YEN IES RGN ODO STS NAT UTW COY ATA NOT OPO VIS EKH DAU IOK

Navigation:

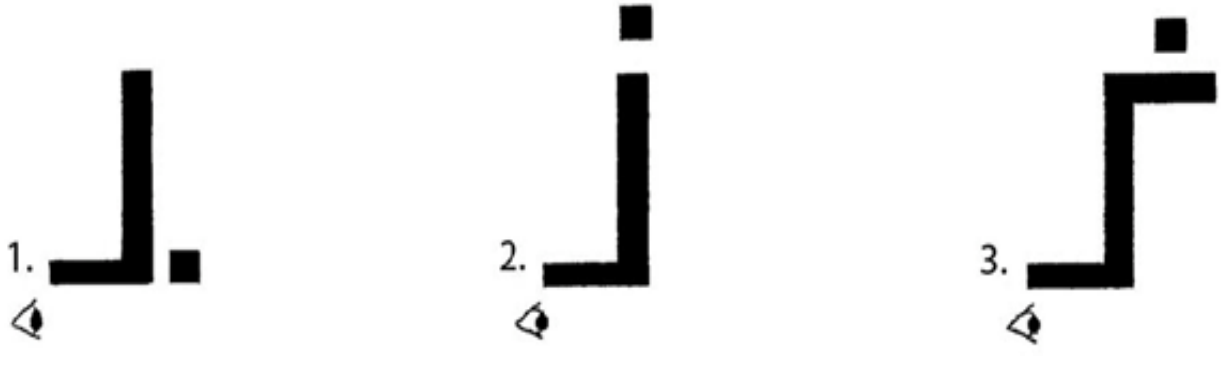
If you travel at 15 knots for 4 ½ hours, how far will you have gone?

How long will this take to travel 30 nautical miles at 6 knots?

If you travel 480 nautical miles in 30 hours, what is your average speed?

Optics:

Where would you position mirrors so you can see the black square? You cannot see through solid lines! Draw the mirror(s) and the path your vision would take.



APPENDIX

TEACHER'S STATION ON BOARD: MAKING A CHEMICAL BATTERY

This is one of the activities students will work on during the program. Please review it carefully, as you, the teacher, will be responsible for supervising this activity. Do not do this activity in the classroom; however, you should review battery principles with your class so students can understand what is happening when they actually make their own batteries during this program activity.

Background:

When submerged, *Pampanito* ran on battery power. The chemical battery you will make changes chemical energy into electrical energy.

The battery is made up of two different metals (the aluminum foil and the copper wire). These are called **electrodes**, which are the parts of a battery where electric current enters or leaves the battery. The electrodes are placed in a liquid containing an **electrolyte**, which is a solution that can conduct electricity.

Atoms in the bleach take electrons from the atoms that make up the copper wire coil . The bleach then transfers them to the atoms that make up the aluminum foil. The electrons can then flow through a second copper wire connected to the foil.

In this sort of circuit, the aluminum is the negative terminal and the copper coil is the positive terminal. Electrons travel from the negative terminal through a connecting wire to the positive terminal and then back to the bleach.

Materials (per group):

- 1 - 16" copper wire safety aprons
- 1 sheet of aluminum foil
- 1 - 2.47 v. lamp
- 1 - 10 oz. plastic cup
- 1 extra wire with alligator clips attached to both ends
- 1/4 sheet of paper towel
- safety goggles
- 1/3 cup of bleach
- propeller motor
- emery cloth
- Voltmeter
- 1 - lamp holder (with wire and alligator clips attached)

Procedure:

1. Line the cup with aluminum foil. Be sure the four corners of foil are sticking out.

2. Using an emery cloth, lightly sand the entire length of the wire. Take this wire and wad it up loosely into a ball. Leave at least four inches of the wire free so another wire may be attached to it.

3. Place the wadded wire in the center of the paper towel and wrap the paper towel around it. Be careful not to tear a hole in paper towel while wrapping.

4. Place the paper towel wad into the cup lined with aluminum foil. Be sure the copper wire extending out of the paper towel does not come in contact with the aluminum foil. If the copper wire touches the aluminum foil, it will cause the cell to internally short.

5. Carefully pour 1/3 cup of bleach on top of towel. Place the red voltmeter probe (+) on the copper wire and the black probe (-) on the aluminum. Record voltage reading. _____ volts.

6. Next, see if your battery will light the lamp. Touch one alligator clip to the copper wire and the other clip to the aluminum foil.

7. How long does your light stay lit? _____sec.

8. Disconnect your leads and let your battery "rest" before reconnecting. What are your observations and why do you think this might be happening?

Group Challenge:

1. Using the batteries you've created with your group, build a series circuit.

    a) Predict the total voltage: _____volts

    b) Using the voltmeter, measure the voltage of the batteries in series: _____volts

    c) How does this voltage compare to the voltage produced by just one battery?

2. Draw a diagram of your design.

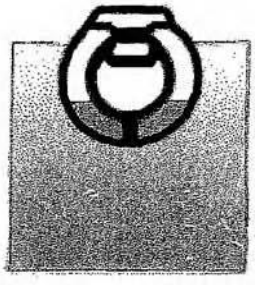
3. With the members from your group, connect the series circuit to make the propeller motor rotate.

BACKGROUND FOR TEACHERS: STATES OF BUOYANCY

By definition, buoyancy is the upward force exerted on a floating, or immersed, body and is independent of the weight of the body. The state of buoyancy refers to the ratio between the weight of the body and the weight of the displaced fluid. In the case of submarines, the displaced fluid is seawater.

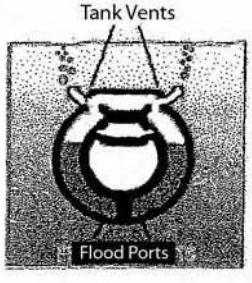
Three states of buoyancy are considered:

- Positive buoyancy
- Neutral buoyancy
- Negative buoyancy.

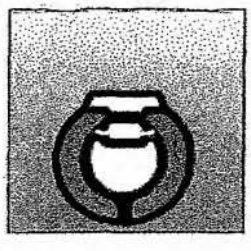


Positive buoyancy exists when the weight of the body is less than the weight of an equal volume of the displaced fluid.

Neutral buoyancy exists when the weight of the body is equal to the weight of an equal volume of the displaced fluid. A body in this state remains suspended, neither rising nor sinking, unless acted upon by an outside force.

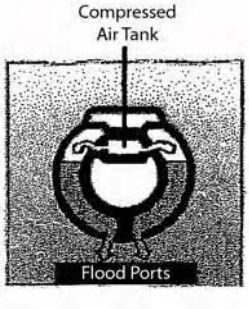


Modern submarines operate on the principle of neutral buoyancy when submerged. In this condition the weight of the submarine is opposed by an equal buoyant force permitting the submarine, theoretically at least, to lie at rest submerged. Not only must weight and buoyant forces be equal, but to keep the submarine on an even keel, they must be in the longitudinal position. This condition must be maintained in seawater of varying density and in different conditions of submarine loading. For the operating submarine, regulating the amount of water in the variable ballast tanks does this. These tanks are for changes in weight and moment necessary to obtain the desired buoyancy conditions. For this purpose they are located at the ends of the submarine (forward and aft trim tanks) and amidships (auxiliary tanks). Water can be transferred from one of these tanks to another, flooded from sea, or pumped overboard.



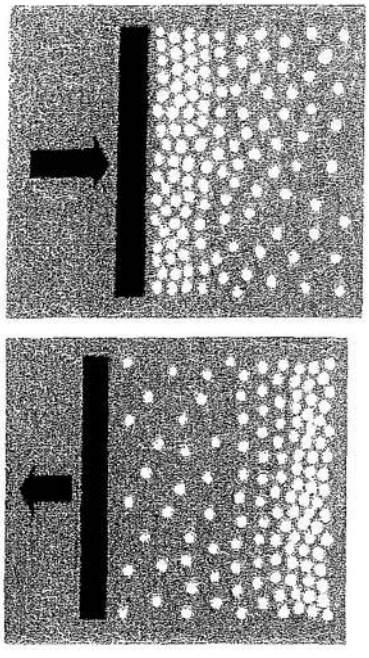
Negative buoyancy exists when the weight of the body is greater than the weight of an equal volume of the displaced fluid and the body sinks.

Theoretically, a submarine is designed with its main ballast tanks of such volume that when they are flooded, the ship is in the state of neutral buoyancy. Negative buoyancy is gained by flooding the negative tank.



BACKGROUND FOR TEACHERS: SOUND IN WATER

Sound can travel through any medium, such as air or steel or water. Submarines are concerned with water as the medium. Imagine an object vibrating back and forth in water. As it moves forward, the molecules of water directly in front of it are pressed closer together. Each molecule then passes this pressure along to the one ahead of it. Thus a state of compression moves away from the object in all directions.



But when the object moves backward, this pressure is removed and the molecules are thinned out. Thus a state of rarefaction follows after each compression.

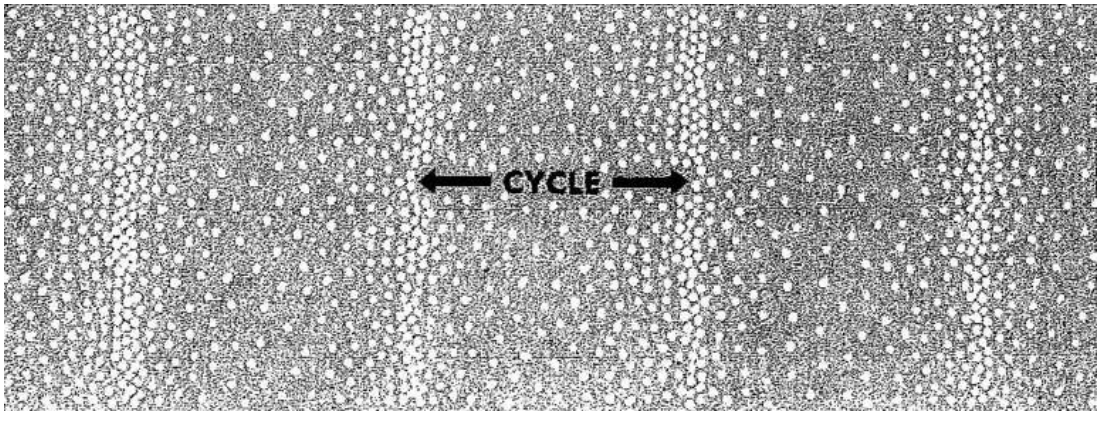
The vibrating object continues to send out compressions and rarefactions one after the other. Each compression - plus -rarefaction is a sound wave.

A single back-and-forth movement of the vibrating object is called a cycle. A single sound wave as shown in this drawing is also called a cycle.

The number of cycles per second is the frequency, and may be expressed in kilocycles (1,000 cycles. For example, a frequency of 16 kilocycles means 16,000 cycles per second.

When sound waves reach our ears through air, the alternating compressions and rarefactions cause our eardrums to move in and out at the same frequency. This vibration is then transferred by tiny bones to the inner ear and then converted to nerve impulses that pass to the brain. Thus the sensation of hearing is produced.

This process includes some additional steps for a submarine sonar operator listening for sounds in water. The sound waves in the water must be picked up by a hydrophone and changed into electric currents. These electric currents are then strengthened and sometimes changed by the use of an amplifier, so that they can be heard through headphones. If the frequency of sound is supersonic (above 15,000 cycles per second or beyond the range of normal human hearing), it must be changed to a sonic frequency (below 15,000 cycles per second) in order to be heard.



Sound traveling in water has its own peculiarities. It travels at a speed of 4,800 feet per second. (It's only 1,100 feet per second in air.) Weak sounds, strong sounds, high frequencies and low frequencies all travel at the same speed. But the temperature, pressure and salinity of the water can affect their speed. These factors can cause sound waves to be bent out of their normal paths. This bending is called refraction. For example, most water is warmer near the surface and cooler at lower depths. Sound waves travel faster in warmer water but are refracted when they hit a patch of cooler water, which alters their speed.

As sound waves move away from their source they grow weaker. There are principally two factors causing this: spreading and attenuation. Spreading is just that, the wave moving from its source spreads out covering a greater area diminishing its strength. Attenuation is the weakening of the sound by other factors, including the friction of water molecules, absorption caused by some underwater objects and scattering caused by others. The effects of attenuation are greater on higher frequencies.

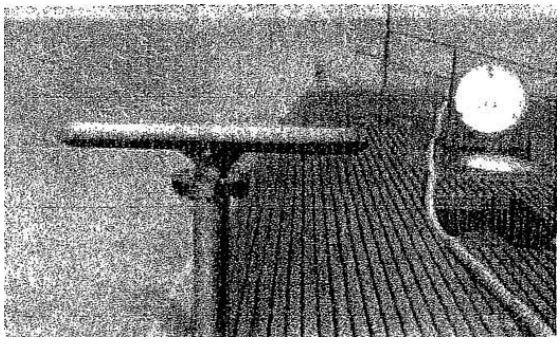
How does this all relate to submarines?

Sounds in water are critical to Navy submarines; both the sounds made by other ships and sounds made by the submarine itself. Sound can give away the location of other ships or your own location. Any ship moving through water makes a certain amount of sound, mostly from the churning of the propellers. Sound also emanates from the various equipment and machinery operating on the ship, as well as the sound of water slapping against the hull. For this reason people are assigned the task of listening for sound on board the submarine.

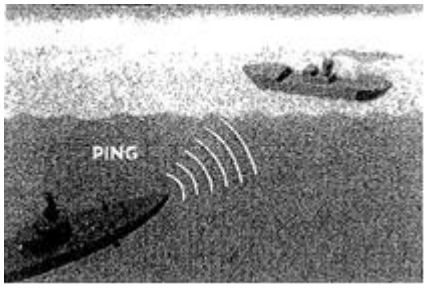
Listening for underwater sounds on a submarine is accomplished through the use of specialized sound equipment, which is generally referred to as **SONAR**. (Like the term RADAR, SONAR is a coined name taken from the first letters of the words SOund Navigation And Ranging.) Listening can be either **passiv**e or **active**.

Passive listening involves using a hydrophone, a type of underwater microphone, to listen for sound. The hydrophone can be turned 360 degrees to permit the listener to sweep the area around the submarine. In this way, detected sounds can be given a bearing so they can know which direction it is coming from.

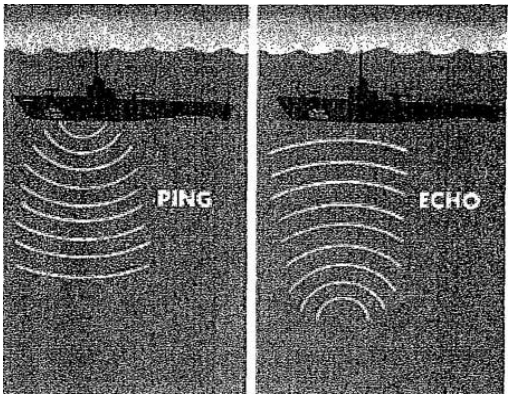
Active sonar involves the sending of a pulse of supersonic sound, called a ping, into the water from a device called a **transducer**. This is also called **echo-ranging**. As its name suggests, echo-ranging permits the user to send a signal with the intent of having it bounce off an object and back to the submarine. The time it takes for the "echo" to return gives a measure of the object's, or possible target's, range. However, besides giving a submarine the bearing of a target, echo-ranging also unavoidably results in giving away the submarine's location to any other ship that may be listening. For this reason, submarines seldom ping, lest the hunter become the hunted.



To determine water depth, submarines also engage in **echo-sounding**. Using a special sound projector, a ping is sent straight down where it will bounce. The returning echo reaches the submarines listening gear, and a depth is shown on an indicator called a **fathometer**. This helps the boat avoid navigation problems in uncharted waters.

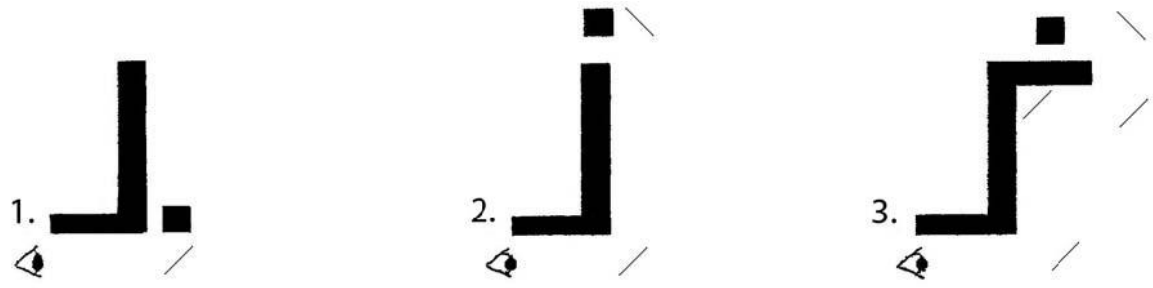


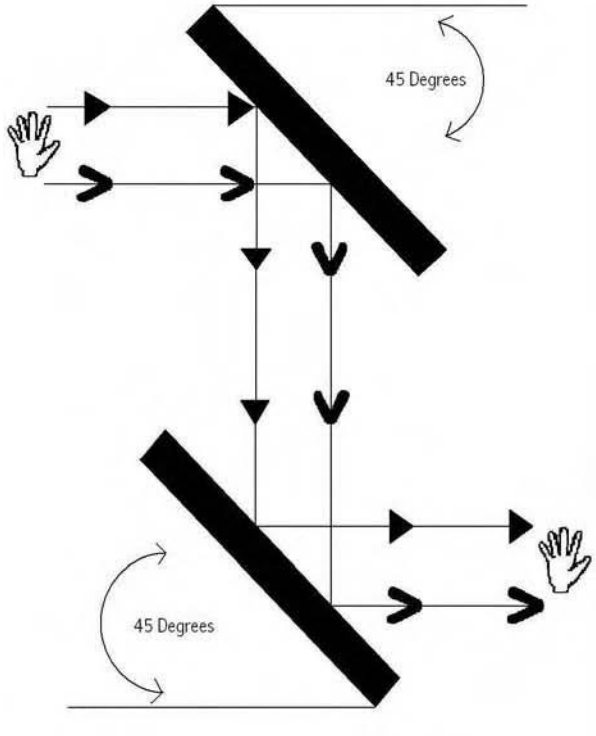
Finally, the effects of refraction of sound waves mentioned earlier could be a great advantage to a submarine evading detection. If a surface ship is echo-ranging in search of a submarine, the submarine can retreat to deeper, cooler waters which may refract the enemy's pings. The enemy ship may simply receive a false echo and never detect the true whereabouts of the submarine. For this reason, submarines are equipped with a special underwater thermometer (bathythermograph) capable of indicating the outside water temperature. This aided in finding a cool place to hide.

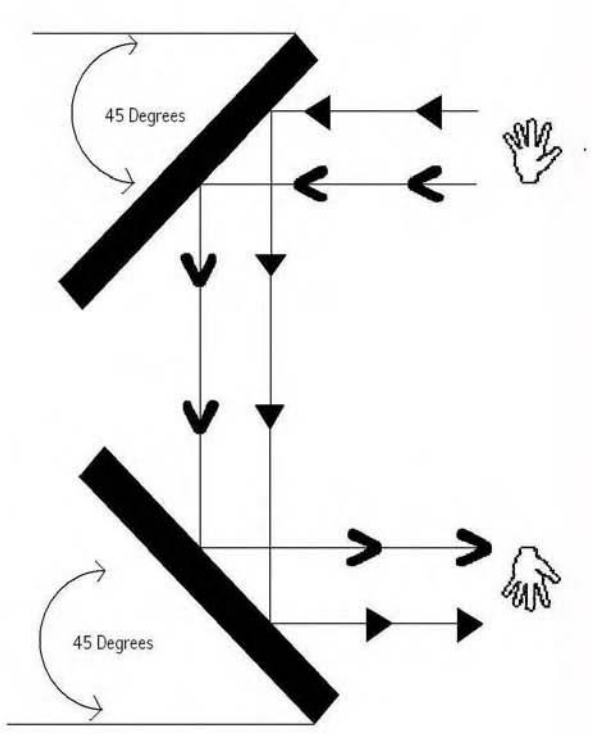


LIGHT WORKSHEET ANSWERS

Mirror Positions:







PRE-VISIT QUIZ ANSWERS:

Buoyancy:

Can 100 pounds of steel float in water? Explain your answer.

Yes, 100 pounds of steel can float if it displaces more than 100 pounds of water. To do this it would need to be spread very thin so it would cover a large amount of surface area.

Optics:

Where would you position mirrors so you can see the black square? You cannot see through solid lines! Draw the mirror/s and the path your vision would take. (/ - denotes mirror position)