By Land, Sea or Air

Unit Topic:	Navigation
Grade Level:	7th grade (with suggestions to scale for grades 6 to 8)
Lesson No.	7 of 10
Lesson Subject(s):	Air and Space Navigation
Key Words:	Nautical Charts, Aeronautical Charts, Dead Reckoning

Lesson Abstract —

In this lesson, students are shown that navigational techniques change when people travel to different places. For example, an explorer traveling by land will use different methods of navigation than a sailor or an astronaut.

The activities include:

- Nautical Navigation – students learn the major features of nautical chart. They look at a real nautical chart and then draw their own.

Lesson Opening Topics / Motivation —

Ask the students what the differences are between traveling in an airplane and traveling on foot. (Possible answers: You are up in the air, you are going faster). Do the students think that using a standard street map would help them navigate an airplane? (Possible answer: No, because you would pass over a city in a couple minutes.) What kind of map would be useful for flying an airplane? (Possible answer: one that covers a much larger area.) Maps for pilots are called aeronautical charts, and we will take a look at them today.

Pose the same questions for traveling by sea. Does a street map help you travel in a sailboat? (Possible answer: No, because there are no street signs on the ocean.) Street maps help you navigate by showing landmarks like street names, but there are not any street signs on the ocean! What kinds of landmarks are on the sea? (Possible answers: Lighthouses, beacons, buoys.) Over the past few millennia, many nations and peoples have created landmarks that are either on land and visible from sea or floating in the water, like buoys. Lighthouses are a great example of landmarks for sailors. They are like big street signs for the ocean. They have a big bright light so sailors can easily see them day or night, in good weather or in storms. These can help you stay clear of hitting land or crashing into rocks. Nautical charts allow sailors to determine where they are on any body of water.

What about traveling in space? How do astronauts have any idea about where they are? There certainly are not any street signs up in space. Luckily, people on the ground can help keep track of satellites by using big telescopes to see them. They are a lot like the common telescope you usually see, except they look for special types of light.

In today's lesson we are going to be talking about the different maps that are used in the different environments—land, sea and air.

Lesson Desired Student Outcomes —

Students will understand the concept of coordinates, cardinal directions, and the importance of using common symbols and methods when making maps.

Science: Students should be able to:

- Predict (hypothesize). (1)
- Evaluate data from other students to formulate conclusions. (1)
- Describe how using and understanding maps and compasses can help determine your location. (5)

Math: Students should be able to:

- Convert from one unit of time, length and speed to another. (6)
- Understand the relation between US customary and metric units. (5)
- Use formulas to calculate time given speed and distance. (5)

Colorado State Standards Met —

http://www.mcrel.org/compendium/search.asp

- Science Standard 1 and 5.
- Math Standard 5 and 6.

Lesson Background & Concepts for Teachers —

Overview

The following topics will be discussed:

- Navigating in different environments,
- Land Navigation,
- Sea Navigation,
- Air Navigation, and
- Space Navigation.

Navigating in Different Environments

Most of us know about navigating on land: we do it everyday when we are walking home or driving to the store. Navigation is used in all sorts of environments, and it is, therefore, always important to know your location. Navigating on land is very different than in the water, in the air, or in space. That is because all three types of navigating require different types of information. For example, a topographical map does not help if you are trying to navigate on the sea. We are going to talk about the different needs of navigating in different environments: land, sea, air and space.

Things Common to All Navigation

Even though traveling in different environments requires different types of information, like maps, some things are common to all navigation. All navigation requires the concept of dead reckoning.

Dead Reckoning

Dead reckoning is the process of navigation by advancing a known position using course, speed, time and distance to be traveled. In other words, figuring out where you will be at a certain time if you hold the *speed*, *time* and *course* you plan to travel. Prior to the development of celestial navigation, sailors navigated by *deduced* (or *dead*) *reckoning.* Columbus and most other sailors of his era used this method. In dead reckoning, the navigator finds his position by estimating the course and distance he has sailed from some known point. Starting from a known point, such as a port, the navigator measures out his course and distance from that point on a chart, pricking the chart with a pin to mark the new position.

Speed, Time, and Direction

How did they know their speed? In Columbus' day, the ship's speed was measured by throwing a log over the side of the ship. There were two marks on the ship's rail a measured distance apart. When the log passed the forward mark, the pilot would start a quick chant, and when it passed the aft mark, the pilot would stop chanting. (The exact words to such a chant are part of a lost oral tradition of navigation.) The pilot would note the last syllable reached in the chant, and he had a mnemonic that would convert that syllable into a speed in miles per hour. This method would not work when the ship was moving very slowly, since the chant would run to the end before the log had reached the aft mark.

$$\text{Speed} \times \text{Time} = \text{Distance}$$

This makes sense when you look at the units:

$$\frac{miles}{hour} * hour = miles$$

The hours cancel to give your distance in miles.

Along with their speed and distance, they needed to know the direction of travel. This was done using a compass. They knew their distance and direction, so they could determine their current location based on their previous location.

So what are the things we need to know so that we can navigate using dead reckoning?

- Speed – we have to know how fast we are traveling.
- Time – we need to know for how long we have been traveling.
- Direction – we certainly need to know where we are going.
- Our previous location – it is good to know our speed, time and direction, but this does not help us unless we know were we at last.

We need to know all these things in order to navigate. Refer to Lesson 2 for more information on Dead Reckoning.

Land Navigation

In previous lessons, we learned how to navigate on land. What types of information do you need to navigate on land?

Traveling by Car:

- Road maps – the first thing you do when you plan a road trip is to get out your road map. This tells you information about what roads you can take, how far it is to some destination, sometimes even what the quickest way is to get there.
- Street signs – a must for traveling in any city.
- Mileage signs – these signs tell you how far it is to the next city or town. These signs are very helpful in finding where you are on a road map.

Traveling by Foot:

- Topographical maps – these maps give you detailed information about the land around you.
- Compass – these help you to determine your direction. Used with a topographical map, you can triangulate to determine your position.

Sea Navigation

We have all traveled by car or on foot. It is very easy to understand. But what about traveling by sea? The sea is open and barren with no distinctive features. Dead reckoning is a very important skill for knowing where you are when on the sea. Because things like sea currents or wind can cause errors when using dead reckoning, it is very important to look for landmarks. But there are not any natural landmarks on the sea. Luckily, people have made landmarks for us.

Aids in Sea Navigation

What other types of information would be helpful to know? What if you are traveling in a bay that is very shallow? You need to know how deep the water is so that you do not run aground and damage your vessel. There are few natural landmarks that can be used. For this reason, people have made landmarks to use for navigating on the sea. These include:

- Buoys – these are floating landmarks. They mark out areas like a bay or a channel
- Lighthouse – a tower with a bright rotating light, located on near shores to tell a sailor that land is close. They are especially useful at night or in bad weather, when you cannot see very well. One could easily run into land if they could only see 20 feet away.
- Beacons – a generic term for some sort of sea landmark, like a buoy or lighthouse.

- Old shipwrecks – ships do sink, and you definitely want to avoid them so that you do not sink also.

Nautical Charts

Land maps are not very useful when you are on the sea. They make special maps for traveling by sea. These are called nautical charts. Some of their features are:

- Depth – Nautical maps show depths in the ocean, just like topographical maps show elevation on the ground. Ship captains are able to use these maps to avoid shallow areas or shipwrecks that can damage their ships.
- Shoreline – Sailors like to know where the shore is so that they can avoid running aground.
- Landmarks – like shipwrecks and beacons.
- Magnetic declination – Sailors need to know the difference between true north and magnetic north so that they can navigate properly.
- Routes – Nautical maps show shipping lanes. Sailors use these lanes just like drivers use city streets. These shipping lanes avoid shallow areas that can damage or even sink ships.
- Currents – Nautical maps show the general direction in which the current flows for various locations.

The map below depicts a section of the nautical chart for the San Francisco Bay in California. We can clearly see some of the common features of the map: there are notes of depths throughout, contour lines, the magnetic declination, landmarks, and various beacons, with purple arrows pointing towards them.

Beacon Nomenclature

The first beacon enclosed in the box is:

Fl R 4s 14ft 4M “4”

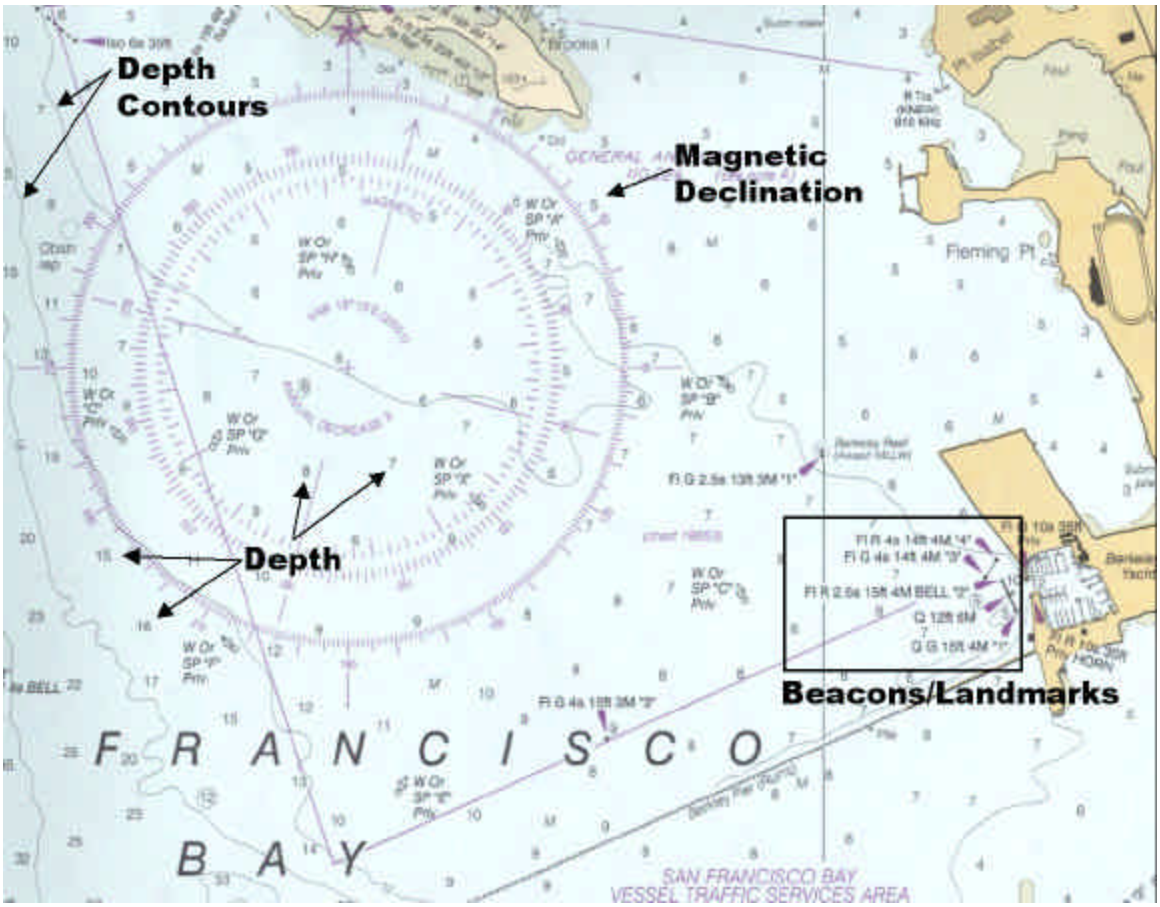
The following nomenclature depends on the type of beacon. The first descriptor, Fl, denotes the type of beacon. In this case, this beacon is a flashing light. Ships use beacons with flashing lights to help navigators identify them in inclement weather. The next descriptor is the color: R for red. The next descriptor shows the period of the flashes. This beacon flashes every 4 seconds. The next descriptor is the height of the beacon, 14 feet. After that is the range that the beacon can be seen from: 4 miles. And finally, the last descriptor is the beacon designator, number 4.

The descriptor changes depending on the type of beacon. There is also a beacon with:

Q 12ft 6M

The Q stands for quick. This is a light that flashes about 60 times per minute, or once per second. Just like above, the 12 ft. tells us that the beacon is 12 ft. high, and the 6M tells us that the beacon can be seen from 6 miles away.

There are many types of beacons. Some flash regularly, and some flash in a pattern. This helps a navigator identify the beacon.



Source: National Oceanic and Atmospheric Association and Federal Aviation Administration

Navigation in the Air

Pilots, like sea captains, need to be able to navigate by dead reckoning. Sadly, this is not too easy to do. What landmarks would you look for if you were a pilot? A street sign? A field? When airplanes were first invented, there were no good landmarks for pilots to use. In fact, many pilots would fly really low and slow and hope to read the signs to see which town it was that they were near.

In the last section, we learned that nautical charts show landmarks that are useful to sailors. What kind of landmarks would be useful for pilots?

- Railroad tracks
- Buildings
- Ranches
- Water or Oil tanks
- Towns
- Lakes
- Rivers
- Highways

These are things that can usually be seen from the sky. A commercial airline pilot would not use these types of landmarks because commercial jetliners fly at about 35,000 ft., much too high to make out most of the above landmarks. Can you imagine trying to make out landmarks from 7 miles away? However, recreational pilots in smaller airplanes that do not fly at such high altitudes find landmarks like these to be quite useful in determining their locations.

Aeronautical Charts

Pilots use aeronautical charts just like sailors use nautical charts. Let's look at some of their features:

- Elevation – Pilots need to know the elevation of landforms in an area. For example, if there is a mountain in your way, you would want to know how high it is so that you can fly above it.
- Airports – Airplanes, like birds, have to land sometime (obviously, there is not enough fuel at once to always keep an airplane safely in the air.) There are a lot of things that help pilots land safely: elevation markers, runways (the road that you land on), flashing lights that show the pilot where to land, buildings and tanks. Anything that can help the pilot figure out where he is and help him land will be listed on the aeronautical chart.
- Landmarks.

Scale of Aeronautical Charts

When we are traveling by foot or even on a boat, we are not going very fast compared to an airplane. Scales of common aeronautical maps are 1:500,000: meaning that an inch on the map is about 10 miles.

In the aeronautical chart on the following page we can see a number of distinct features. There is a maximum elevation for any landform of 4,800 ft.. This is the highest point on that part of the chart, including buildings and natural features like mountains. The chart also has elevation contour lines. We see helpful landmarks, like ranches, a golf course, and a trailer park. Pilots can see all of these things from a normal recreational airplane like a twin engine Cessna. Most importantly, this map shows the two airports in the area. Notice the deep purple circle with two lines that are crossed within it. These are the runways. The purple outline around the whole airport shows that this is the airports airspace. For safety reasons, unless a pilot is landing at that airport, he should not enter this area.

Space Navigation

Navigating in space is very different than all other forms of navigation. Normally, sea drift or wind drift cause us to constantly go off course. But in space, the sources of error are far smaller. Once a spacecraft is in a known orbit, it will travel along that orbit.

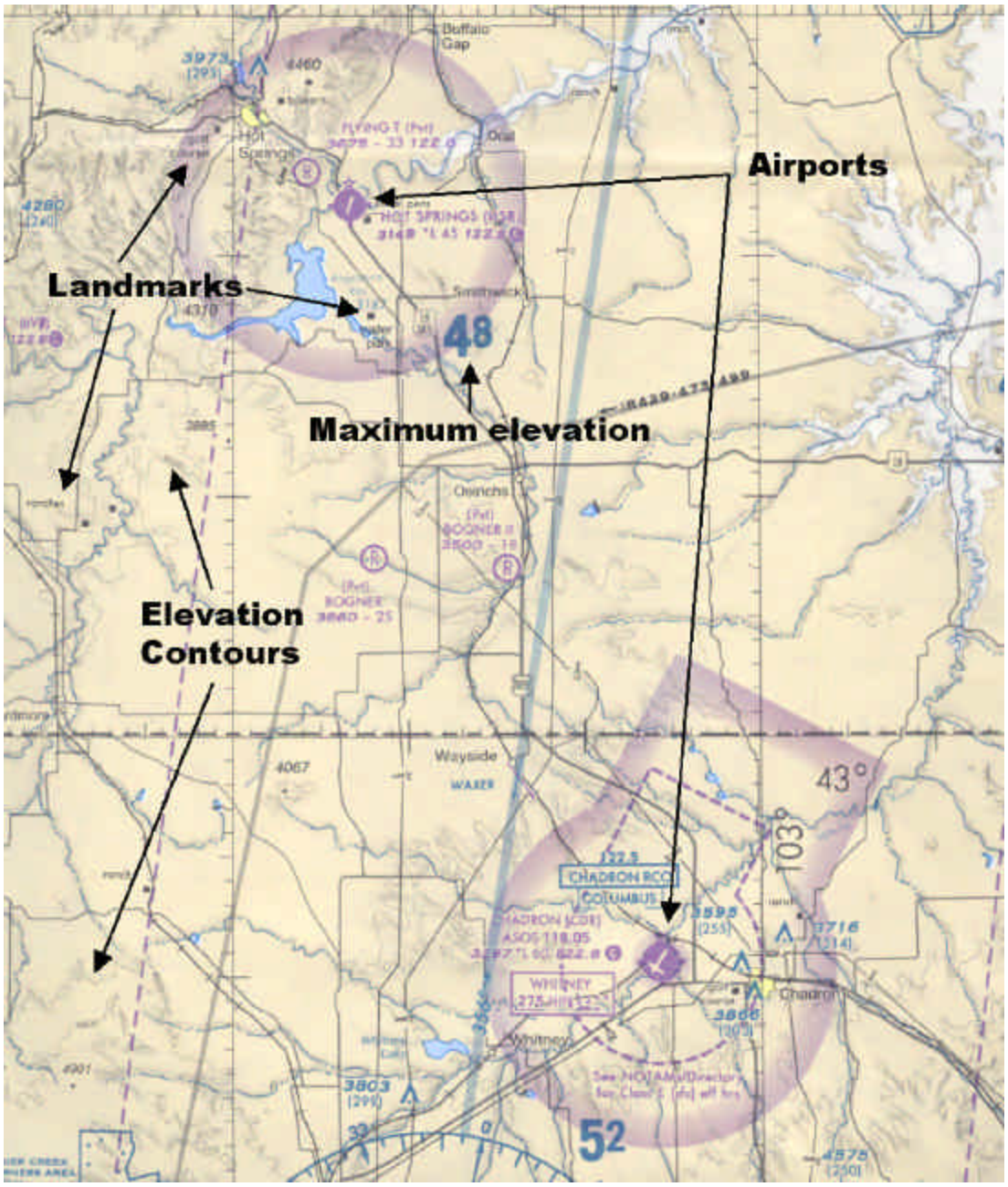
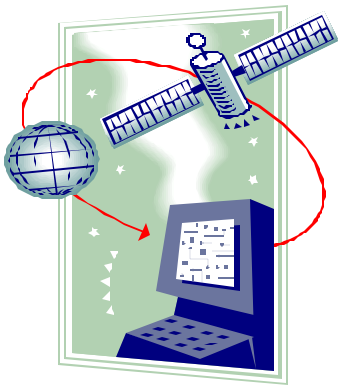


Image source: Federal Aviation Administration

What is an Orbit?



We all know that the Earth travels around the Sun. This happens because the gravity of the Sun is constantly pulling on the Earth. It is just like tying a ball to a string and swinging it around your head. The pull of the string on the ball is like the gravity of the sun pulling on a planet or satellite. Satellites travel around the earth just like the earth travels around the sun. The path that the satellite travels in is called an *orbit*. The satellite will just keep traveling along that orbit because there are not any major sources of drift in space like wind or sea currents. There are a few things that can make satellites drift, like

small changes in gravity or the impact of meteorites, but the probabilities of these events are quite small. Therefore, it can be very easy for knowledgeable people to predict where that spacecraft, moon, or planet will be in an hour or a day. The methods used to predict the position of objects in outer spaces is just like dead reckoning, but there is only a little drift and the speed should be constant.

Some important things that people need to know when they are trying to anticipate the position of objects in space are:

- How fast the object is moving
- What direction the object is moving
- The orbit that it follows

Spacecraft shoot light waves down to the Earth to determine this information. By measuring properties of the light, like the Doppler shift, spacecraft and satellites can calculate where they are and how fast they are going. Once they know how fast they are going and where they are, computers in the spacecraft are able to calculate what orbit they are traveling in. Once the computers determine the orbital path of the spacecraft, a path can be predicted using methods similar to dead reckoning so that people will know the spacecraft will go.

Lesson Vocabulary List —

- **Dead Reckoning** – a method to calculate the location of a person, ship, or spacecraft based upon where it was some time ago. Knowing the speed, direction and how much time has passed since you last knew where it was, you can find out where the person, ship, or spacecraft is at any time in the future.
- **Nautical Chart** – a map used for traveling on the sea.
- **Aeronautical Chart** – a map used for traveling by airplane.
- **Buoy** – floating landmarks that mark out areas like bays or channels.
- **Lighthouse** – a tower with a bright rotating light. They are located on or near shores to tell a sailor that land is close. They are especially useful at night or in bad weather when sailors cannot see very well. One could easily run into land if they could only see things that are 20 ft. away.
- **Beacon** – similar to a floating lighthouse. Beacons have lights that flash in many different patterns and colors to help sailors navigate. A sailor can find his location by looking for a specific beacon and determining which one it is.
- **Airspeed Indicator** – an instrument on an airplane that tells how fast the plane is traveling relative to the wind.
- **Attitude Indicator** – graphical way to see the roll, pitch and yaw of an airplane.
- **Orbit** – the path that a satellite travels around the earth.

Activity Attachments —

Nautical Navigation – students learn the major features of nautical chart. They look at a real nautical chart and then draw their own.

Lesson Closure and Follow-up —

Ask the students if they could use a nautical chart to get home from school or to go hiking in a strange park. (Possible answer: No, because we do not live on the ocean.) Why is a nautical chart not helpful in this situation? (Possible answer: It tells us information about the sea, not the land.) Remind the students that each environment, whether it is land, sea, air, or space, is very different and, hence, requires a different type of map for people to use in navigation.

Ask the students what types of information they need to know to travel on the sea. (Possible answers: depth of the sea, channels or paths, obstacles like shipwrecks, locations of harbors.) What type of information do they need to know if they are traveling in the air? (Possible answers: elevation of landforms, big landmarks that you can see, locations of airports.) These needs are very similar: sailors on the sea need to know about how deep the water is, and pilots need to know how high the land is. Smaller scale land maps are also helpful for hikers who need to know about obstacles so that they can avoid them. Hikers also need to know about landmarks so that they can find their location. Everybody needs to be able to navigate no matter where they are — on land, sea, or air. The navigational methods and maps just need to be adapted to each environment.

Lesson Extension Activities —

None

Lesson Assessment and Evaluation —

Pre-Lesson Assessment

- Discussion Questions: Use questions proposed in "Lesson Opening Topics/Motivation" section to get students to think about the lesson subject. Solicit, summarize, and integrate student answers.

Post-Lesson Assessment

- Question/Answer: Use questions proposed in "Lesson Closure and Follow-up" section to discuss what students learned from the lesson.

Lesson 7: Activity 1 - Nautical Navigation

This activity is planned for 28 students.

Activity Materials List —

- 28 copies of Worksheet 1.
- 28 copies of Worksheet 2.

Activity Equipment and Tools List —

Color Pencils

Activity Cost Estimate —

Less than $5 total

Activity Attachments —

None

Activity Time Estimate —

40 minutes

Activity Procedure —

Background

Sea Navigation

We have all traveled by car or on foot. It is very easy to understand. But what about traveling by sea? The sea is open and barren with no distinctive features. Dead reckoning is a very important skill for knowing where you are at on the sea. Because things like sea currents or wind can cause errors when using dead reckoning, it is very important to look for landmarks. But there are not any natural landmarks on the sea. Luckily, people have made landmarks for us.

Aids in Sea Navigation

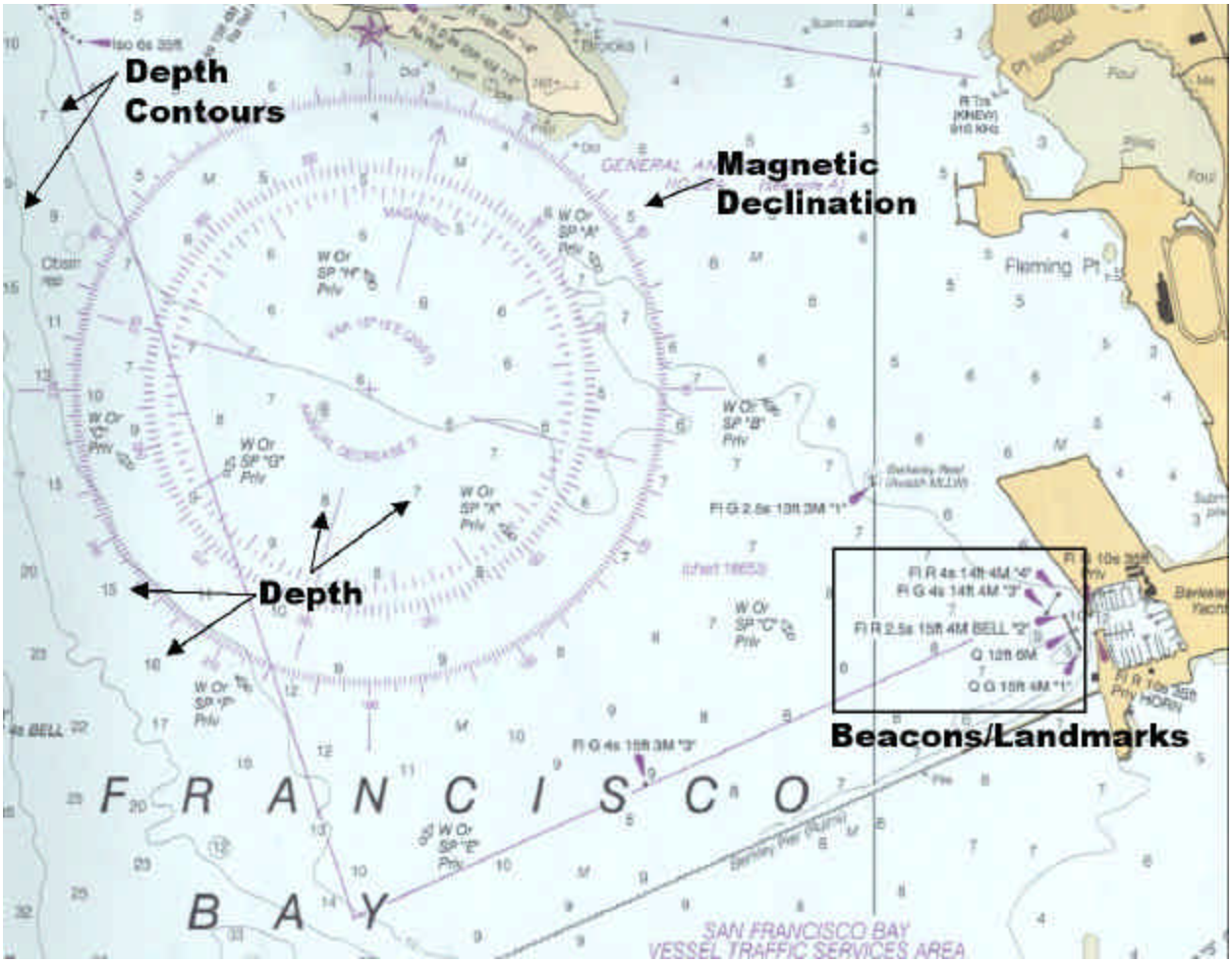
What other types of information would be helpful to know? What if you are traveling in a bay that is very shallow? You need to know how deep the water is so that you do not run aground. There are few natural landmarks. For this reason, people have made landmarks to use for navigating on the sea. These include:

- Buoys – these are floating landmarks. They mark out areas like a bay or a channel.
- Light house – a tower with a bright rotating light. They are located on near shores to tell a sailor that land is close. They are especially useful at night or in bad weather, when you cannot see very well. One could easily run into land if they could only see 20 ft. away.
- Beacons – a generic term for some sort of sea landmark, like a buoy or lighthouse.
- Old shipwrecks – ships do sink, and you definitely want to avoid them so that you do not sink also.

Nautical Charts

Land maps are not very useful when you are on the sea. They make special maps for traveling by sea. These are called Nautical Charts. Let's look at some of their features:

- Depth – just like topographical maps show elevation on the ground, nautical maps show depths in the ocean. If you are traveling through a bay and there is an area that is only 5 ft. deep and your boat has a keel that is 10 ft. deep, you need to avoid that area or you will run aground.
- Shoreline – it is always helpful to know where land is.
- Landmarks – like shipwrecks and beacons.
- Magnetic declination – just like in topographical maps, you need to know the declination at sea.
- Routes – nautical maps show common routes that are used.
- Currents – these show you which way the sea is moving.



Above, we see a section of the nautical chart for the San Francisco Bay. We can clearly see some of the common features of the map. There are notes of depths throughout and even contour lines. The magnetic declination is shown along with its annual change. We also see various beacons, with purple arrows pointing towards them and various landmarks.

Beacon Nomenclature

The first beacon enclosed in the box is: Fl R 4s 14ft 4M "4"

The first descriptor, Fl, denotes the type of beacon. In this case it's a flashing light. The following nomenclature depends on the type of beacon. This is a flashing beacon, so the next descriptor is the color, R for red. The next descriptor shows the period of the flashes. This beacon flashes every 4 seconds. The next descriptor is the height of the beacon, 14 ft.. After that is the range that the beacon can be seen from, 4 miles. And finally, the last descriptor is the beacon designator, number 4.

The descriptor changes depending on the type of beacon. There is also a beacon with: Q 12ft 6M. The Q stands for quick. This is a light that flashes about 60 times per minute, or once per second. Just like above, the 12ft tells us that the beacon is 12 ft. high and the 6M tells us that the beacon can be seen from 6 miles away.

There are many types of beacons. Some flash regularly. Some flash in a pattern. This helps a navigator identify the beacon.

Before the Activity

Complete the activity before hand. Print out Worksheets 1 and 2 for each student.

With the Students

Worksheet 1

1. Talk about nautical charts. Ask students if they have ever seen a map for boaters. Ask students what would make a map for boaters different from one for drivers. Make sure and emphasize, that sea maps are actually called nautical charts, not maps.
2. Give each student Worksheet 1.
3. Tell them to find the deepest and shallowest point on the chart. The deepest is 20 meters, on the far left of the chart. The shallowest is 2 meters on the far right.
4. Describe what a beacon is. Tell them to find all the beacons on the chart and write down how many they find.
5. The next part talks about how beacons are described on the chart. Have them find the beacon marked Fl G 2s 14 ft "1." Talk about what of these numbers each mean. It is described on the worksheet also.
6. Have them find beacon Fl R 2s 14 ft "2." Have them do question 3.
7. Now have them find all the red and green beacons and put an "x" on them with either their red or green pencil. Complete question 4.
8. Now the students should start to see that there is a path that the boats travel in. This is marked on the chart in dotted lines. Have them fill this in with their purple pencil.
9. Ask the students that if there is a big stake or shipwreck in the sea why should they avoid that. Have them identify the obstacles on the chart, which are marked with little circles.
10. Now ask them how shallow the water gets if they have to travel into the harbor. This is labeled on the chart next to the path lines as 6 ft.

Worksheet 2

1. In worksheet 2, the students get to draw their own nautical charts. Give each student Worksheet 2.
2. Have them name their chart.
3. Have them draw an island somewhere on the map. They can also draw other land features.
4. Now have the students draw in depth markers. These are just number (in meters) that show the depth of the sea. Caution them not to make it too shallow (low numbers like 1 or 3) because then no boats could travel through.
5. Describe what a harbor is. Have them draw two harbors on their charts. An example illustration is included.
6. Now have them draw in some obstacles. This should just be a small circle with a label next to it describing it, suck as "stake" or "shipwreck."
7. Now they need to make a path to get to the harbor. Tell them that their boat is 4 meters deep so they need to have at least 5 meters or depth along their path.
8. Have the student draw beacons to guide the boat along the path. Green beacons are on the left side of the boat, traveling inward, and red beacons are on the right. Have them draw these with their green and red pencils.

Math Skills Reinforced —

6^{th}, 7^{th} and 8^{th}: Reading nautical charts.

Activity Troubleshooting Tips —

None

Activity Desired Student Outcomes —

After this activity, students should know how to identify major features of a nautical chart.

Activity Assessment & Evaluation —

Pre-Activity Assessment

- Discussion Question – Ask students if they have ever seen a map for boaters. Ask them how a map for boaters would need to be different than one for drivers.

Activity Embedded Assessment

- Worksheets – Use worksheets 1 and 2 to help students follow along with the activity.

Post-Activity Assessment

- Pairs Check – After completing worksheet number 2, have students pair with one another and compare charts.

Suggestions to Scale Activity for Grades 6 to 8 —

- 6^{th} and 7^{th} grades: Have them do activity as is.
- 8^{th} grade: For Worksheet 2, have the students make detailed labels on the beacons. For example, instead of just red or green have them do a description like "Fl R 4s 16ft "1"."

Lesson 7: Activity 1, Worksheet 1 - Nautical Charts

Name:_____ **Date:** _____

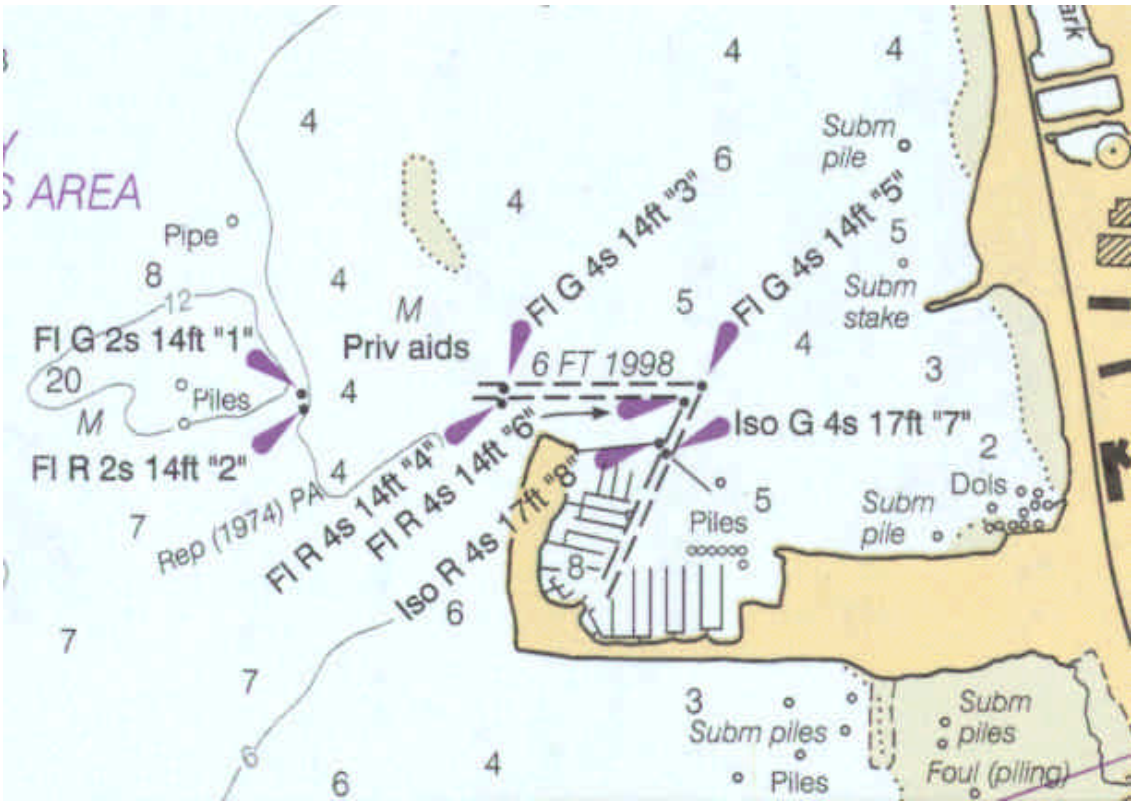


Image: part of an actual nautical chart for the San Francisco Bay.

Question 1: The numbers on the chart above show the depth of the water, in feet. What is the deepest depth of the chart? _____ What is the shallowest depth? _____ Circle those on the nautical chart.

Question 2: All the black dots with the purple (or dark) arrow pointing towards them are beacons. Beacons are like small floating lighthouses. The flash a certain color of light. How many beacons are there? Write the number: _____.

Roads of the Sea

Beacons help sailors figure out where they are and where they should be going. Beacons are like the roads of the sea. If you are traveling to land, a green beacon is like the right side of the road. A red beacon is like the left side of the road. So how do we tell which color the beacons are? Right next to each beacon is a description. On the map above find the beacon that is Fl G 2s 14ft "1." Put an "x" on it with your green pencil. This is actually 5 different things: Fl, G, 2s, 14ft and "1." They each tell us something different about the beacon.

What does all this mean?

Fl – tells us what type of beacon it is. "Fl" stands for flashing, so this is a flashing beacon.
G – tells us what color the beacon is. "G" stand for green, so this beacon flashes green light.
2s –tells us how long between each flash. "2s" stands for 2 seconds, so this beacon flashes every 2 seconds.
14ft –tells us how high the beacon is. "14ft" stands for 14 feet, so this beacon is 14 feet tall.
"1" – tells us what the beacon is numbered. This is beacon number one.

Question 3: Find the beacon that says Fl R 2s 14ft "2." Put an "x" on it with your red pencil.

What type of beacon is this? _____ How often does it flash? _____

What color is this beacon? _____ How high is this beacon? _____

What number is this beacon? _____

Question 4: Now find all the green beacons and put an "x" on them with your green pencil. Now find all the red beacons and put an "x" on them with your red pencil.

How many green beacons are there? _____

How many red beacons are there? _____

Question 5: These beacons form a road in the sea. If you are going to land, or to dock your boat, the green beacons are markers for the left side of the road, and the red beacons are markers for the right side. Looking at the nautical chart above, there is a dotted line that show shows the "road" to get into the harbor. Mark this "road" with your purple pencil.

Question 6: There are all kinds of things sailors have to watch for and avoid, like stakes and piles, and pipes. These are usually marked with little circles. Circle all the landmarks that sailors should avoid with your red pencil.

Question 7: Boats come in all different shapes and sizes. Some of them might go 10 meters down in the water. If you were sailing into the harbor, what would be the deepest your boat could be? _____

Lesson 7: Activity 1, Worksheet 2 - Make your Own Nautical Chart

Name:_____ **Date:**_____

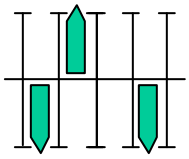
Now you get to make your OWN nautical chart!

Step 1: Give your nautical chart a name, such as “Igor’s Island” or “Holly’s Hideaway.”

Step 2: Now draw an island somewhere on your chart. Do not make it too big, as you still have to have some sea to navigate through.

Step 3: Now give your chart some depths. Write down the depth of the sea. Make sure you do not make it too shallow (like, 1 or 3) or no boats will be able to get through.

Step 4: Now draw a harbor. A harbor is a place where they park boats, just like a parking lot to park cars. They usually look like the diagram below. This harbor has 3 boats parked in it.



Step 5: Draw another harbor somewhere else on the chart. Most water areas have many harbors. The San Francisco Bay has over 20.

Step 5: Now that you have an island and a harbor, make some obstacles (stakes, large rocks, or a shipwreck). Make this with a small circle, and right next to it tell us what it is (label it).

Step 6: Now that you have a harbor and some obstacles, find a path that a boat can travel to go to the harbor. Do not put any obstacles in the path. Also, let us say that this boat goes down 4 meters in the water. This means that the boat can travel only in places with at least 5 meters of depth.

Step 7: How is the boat going to know how to get to your harbor? Draw in beacons to help the boat navigate into your harbors. Remember that beacons are like the roads of the sea. On the left side of the road, there are green beacons. On the right side of the road there are red beacons. Make sure and color these in with either your green or red pencil.

Chart Name: