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ABSTRACT

This instructional guide, intended for student use, develops the subject of water and its effects on our lives through a series of sequential activities. A technical development of the subject is pursued with examples stressing practical aspects of the concepts. Included in the minicourse are: (1) the rationale, (2) terminal behavioral objectives, (3) enabling behavioral objectives, (4) activities, (5) resource packages, and (6) evaluation materials. This unit is one of twelve intended for use in the second year of a two year vocationally oriented physics program. (CP)

CAREER ORIENTED PRE-TECHNICAL PHYSICS

Water, Water Everywhere!

Minicourse

ESEA Title III Project

1974

dallas independent school district

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October 8, 1974

Nolan Estes
General Superintendent

This Minicourse is a result of hard work, dedication, and a comprehensive program of testing and improvement by members of the staff, college professors, teachers, and others.

The Minicourse contains classroom activities designed for use in the regular teaching program in the Dallas Independent School District. Through minicourse activities, students work independently with close teacher supervision and aid. This work is a fine example of the excellent efforts for which the Dallas Independent School District is known. May I commend all of those who had a part in designing, testing, and improving this Minicourse.

I commend it to your use.

Sincerely yours,

Nolan Estes

General Superintendent

NE:mag

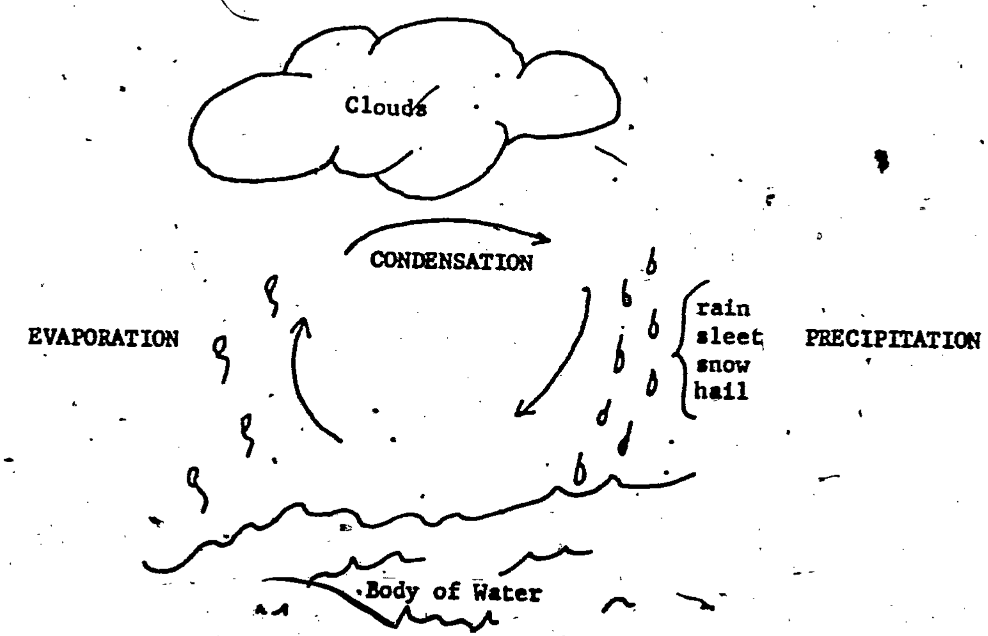
CAREER ORIENTED PRE-TECHNICAL PHYSICS

WATER, WATER EVERYWHERE!

MINICOURSE

RATIONALE (What this minicourse is about)

Everyone is familiar with the lines: "Water, water everywhere, and not a drop to drink!" * But lately, more and more people are saying, "Water, water everywhere; but will it be fit to drink?" Water is not an inexhaustible resource. We must conserve water. To conserve water, we must understand something of its role in nature. Part of this essential understanding concerns the so-called water cycle:



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* From The Rime of the Ancient Mariner by Samuel Taylor Coleridge.

Next, consider that probably the single most important substance to you is water. You may not be aware of this, but the chemical make-up of your body is such that it is dependent on solutions, with water as the solvent. There is no other possible substitute for this solvent in your body!

In addition to your body's needs for water, you must have it to dissolve various bits of foreign matter on your skin to remain clean; and it is used to carry many waste materials from your home. Water is also a major resource for recreational activities (fishing, water skiing, surfing, swimming, etc.). But whether for drinking or recreation, we all need water--good, clean, pure water.

The maintenance of adequate sources of pure water for our needs and desires is big business, touching upon a great many people in related occupations in every geographic area of the country. These "water maintenance" people range from the game warden (who may issue you a citation for dumping your garbage in a lake) to the engineer who designs a sewage disposal plant. Also included are chemists, water meter readers, plumbers, biologists, fishing tackle manufacturers, pleasure boat manufacturers, and a virtual host of other related workers.

These "maintenance" people may find employment everywhere, including university research departments, municipal water departments, state fish and game departments, etc. Employment is also found in private industry, catering to recreational activities and engineering projects. Land development and sales around lakes, primarily for recreational purposes, has become a multi-billion dollar business. This has opened employment possibilities ranging from real estate sales to engineering.

You are expected to keep a notebook during this minicourse. The notebook is to contain all problems, notes, experiments, and exercises. Your grade for this minicourse will be determined partially by the content and quality of the materials in this notebook.

In addition to RATIONALE, this minicourse contains the following sections:

1) TERMINAL BEHAVIORAL OBJECTIVES (Specific things you are expected to learn from this minicourse)

2) ENABLING BEHAVIORAL OBJECTIVES (Learning "steps" which will help you to reach the terminal behavioral objectives)

3) ACTIVITIES (Specific <u>things to do</u> to help you learn)

4) RESOURCE PACKAGES (Instructions for carrying out the learning activities, such as procedures, references, lab materials, etc.)

5) EVALUATION (Tests to help you learn and to determine whether or not you satisfactorily reach the terminal behavioral objectives) These tests include:

   a) Self-test(s) with answers, to help you learn more.
   b) Final test, to measure your overall achievement.

<u>TERMINAL BEHAVIORAL OBJECTIVES</u>

Upon completion of this minicourse, you will be able to:

1) explain the water cycle and tell how man uses water in his home and community.

2) demonstrate a knowledge of the processes by which water is purified (made safe for human consumption) and analyzed to determine what is dissolved in the water.

3) demonstrate an understanding of Archimedes' principle, especially as it applies to swimming, boating, and fishing.

4) be able to explain how the evaporative process serves to cool our bodies and how it may be used to cool living areas in low humidity areas.

5) list the types of terrain and watershed that one would look for when planning to build a lake or pond.

<u>ENABLING BEHAVIORAL OBJECTIVE #1</u>:	<u>ACTIVITY 1-1</u>	<u>RESOURCE PACKAGE 1-1</u>
Make a list of the steps in the water cycle, including modern man as a part of this. Explain what part taking care of the watershed plays in this cycle.	Complete Resource Package 1-1.	"The Water Cycle"
	<u>ACTIVITY 1-2</u>	<u>RESOURCE PACKAGE 1-2</u>
	Listen to tape.	Tape, "The Trouble with Water"
	<u>ACTIVITY 1-3</u>	<u>RESOURCE PACKAGE 1-3</u>
	Complete Resource Package 1-3.	"Watershed Investigation"
<u>ENABLING BEHAVIORAL OBJECTIVE #2</u>:	<u>ACTIVITY 2-1</u>	<u>RESOURCE PACKAGE 2-1</u>
Examine how water is used in the home and the community.	Complete Resource Package 2-1.	"Water Use in the Home"
	<u>ACTIVITY 2-2</u>	<u>RESOURCE PACKAGE 2-2</u>
	Complete Resource Package 2-2.	"Community Water Consumption"

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Enabling Behavioral Objective	Activity	Resource Package
ENABLING BEHAVIORAL OBJECTIVE #3: Be able to demonstrate the skills required to test and prepare water for human consumption.	**ACTIVITY 3-1** Complete Resource Package 3-1.	**RESOURCE PACKAGE 3-1** "Water Testing"
	ACTIVITY 3-2 Listen to tape.	**RESOURCE PACKAGE 3-2** Tape, "Pure Oxygen for Polluted Water"
	ACTIVITY 3-3 Complete Resource Package 3-3.	**RESOURCE PACKAGE 3-3** "Methods of Water Purification"
	ACTIVITY 3-4 Listen to tape.	**RESOURCE PACKAGE 3-4** Tape, "The Slick Factor in Ocean Pollution"
ENABLING BEHAVIORAL OBJECTIVE #4: Demonstrate an understanding of the application of Archimedes' Principle, especially as it applies to recreational activities, such as boating, swimming, and fishing.	**ACTIVITY 4-1** Complete Resource Package 4-1..	**RESOURCE PACKAGE 4-1** "Why Does It Sink?"
	ACTIVITY 4-2 Complete Resource Package 4-2.	**RESOURCE PACKAGE 4-2** "Choosing a Boat"
ENABLING BEHAVIORAL OBJECTIVE #5: Demonstrate an understanding of the evaporative process and how this serves to help make man more comfortable.	**ACTIVITY 5-1** Complete Resource Package 5-1.	**RESOURCE PACKAGE 5-1** "Evaporation and Cooling"

RESOURCE PACKAGE 1-1

THE WATER CYCLE

Whether we like it or not, the earth has a single water system; and all living things on earth have to use that single system. We do not produce any new water, and the water we use now has been here as long as the earth. We use this water, and nature cleans it and gives it back to us to use again. Nature's process for this is called the water cycle. As it is probable that you have been exposed to this before, we will not spend a great amount of time on it; but to be sure that you know what the water cycle is, let's do a short assignment on it. Get a "W" volume of the <u>World Book Encyclopedia</u> and list the steps or processes involved in the water cycle. Be sure that you know where you fit in this cycle.

RESOURCE PACKAGE 1-3

WATERSHED INVESTIGATION

When rain falls, it strikes a given earth surface. Part of the rain water goes into ground storage, part of it evaporates, and part of it runs off by way of streams and rivers. The surface or stretch of high land dividing the areas drained by a river or stream which supports a lake, stream, or river is commonly called a watershed. The condition of the land, amount of trees and grass, and the slope of the land determine the ratio between stored water and runoff.

A paved parking lot, for example, would have 100% of its rainfall distributed between evaporation and runoff. On the other hand, a level area with an abundance of vegetation would store a great deal of the falling rain. In this exercise you will investigate a watershed. The following diagram (on next page) is an example of a watershed map.

For this investigation you will need a map. You may use a common road map or a scaled area <u>topographic</u> map.

<u>Instructions</u>:

1) On your map choose the creek or river you wish to study and draw a line around the watershed.
2) How many tributaries supply the creek or river?
3) What are the dimensions (metric) of the watershed?


Warm springs creek
Watershed
Stream

4) Calculate the area of the watershed in square meters.

5) What would be the effects of removing all vegetation from the area of the watershed?

Problems:

1) During a storm an amount of rain equal to 1 centimeter in depth falls over your entire watershed. This would be equivalent to how many liters of water? Approximately 3.8 liters equal 1 gallon. How many gallons of water fell during the storm?

2) Half of all the rainfall in Problem 1 goes into storage in the soil, one-half of what remains is evaporated, and the rest is available for stream runoff. Find the number of liters that will run off your watershed.

RESOURCE PACKAGE 2-1

WATER USE IN THE HOME

Studies of water consumption show that the average person uses about 50 gallons of water per day. This seems like a large amount of water and indicates the importance for large water supplies as well as for water conservation. The rate at which one uses water varies from day to day and month to month. In this exercise you will be asked to determine the amount of water your family uses during a 24-hour period.

In order to do this, you will have to make some measurements of the rate at which water is used for various things--for example, a shower. Take a container, such as a 1-gallon bucket, and place it under the shower head. Then determine how long it takes to fill it at the normal rate for the shower. Finally, you can multiply the gallons per minute times the number of minutes for the shower to find the total water usage.

For a rectangular bathtub you could calculate the volume of water used by simply multiplying its length times its width times the depth of the water. If you are unable to figure out how to measure the volume of something, ask your teacher.

Make a table like the following one (on next page) and list as many different items as possible to determine your family's usage of water during a 24-hour period.

PLEASE DO NOT WRITE ON THIS PAGE!

Item	Times Used	Amount of Water Per Time	Total Water
Cooking			
Toilet			
Drinking			

Questions:

1) How many people are in your family?

2) What is the use of water for your family in gallons per person?

3) Would you expect the water consumed by your family to be the same from month to month? If not, why not?

RESOURCE PACKAGE 2-2

COMMUNITY WATER CONSUMPTION

In Dallas, Texas, for the year 1973, there were 195,299 residential accounts with the City Water Department. Each account used an average of 10,264 gallons per month for the year. The average water usage by the city for the same year was 177.22 million gallons per day, for both residential and commercial customers. One finds it difficult to understand numbers of this magnitude; but, hopefully, you will begin to get some feeling for community water consumption by the time you finish this unit.

Using information as gathered by others in your group or class from their charts for Resource Package 2-1, complete the following steps:

1) Make a chart similar to the following:

Student's Name	Number in Family	Water Consumption		
		Gal/Day	Gal/Month	Gal/Year
Total				

2) Allow a space on your chart for each member of your group or class.

3) List each student's name.

4) For each student, find out how many are in the family and include this on the chart.

5) List information for gallons per day, month, and year, using charts from Resource Package 2-1 and the water bills for each student's family.

6) Total each column.

7) Compute the average family size for your chart.

8) Compute the average number of gallons of water for each column.

9) From these averages compute what should be the community (city) residential usage.

10) Subtract to find the difference in this and the given residential usage for Dallas.

11) Compute the percent difference. Why do you think there is a difference?

RESOURCE PACKAGE 3-1

WATER TESTING

Is the drinking water in your home pure? Of course not. Is it polluted? Well, maybe or maybe not. Is it harmful for you to drink? No. When applied to water, these terms are all relative (not absolute): pure, polluted, safe, and harmful.

In Texas, the State Department of Health is the organization that certifies public water supplies to be safe for human consumption; but this does not mean free from any sort of dissolved materials or the like. Whether water is called "hard" or "soft" has to do with the amount and type of foreign materials in the solution. Can you see why hard water requires more soap for you to wash than soft water?

The purpose of this experiment is to determine qualitatively the impurities in tap water and in water taken directly from a river, stream, or pond.

<u>Materials Needed</u>:

1) tap water
2) river, stream, or pond water
3) eye dropper
4) ammonium chloride (NH_4Cl)
5) ammonium hydroxide (NH_4OH)
6) ammonium oxylate ($(NH_4)_2C_2O_4$)
7) Bunsen burner
8) hydrochloric acid (HCl)
9) potassium ferricyanide ($K_3Fe(CN)_6$)
10) copper wire

11) sodium iodide (NaI)
12) silver nitrate ($AgNO_3$)
13) sulfuric acid (H_2SO_4)
14) ferrous sulfate ($FeSO_4$)
15) nitric acid (HNO_3)
16) ammonium molybdate $(NH_4)_2MoO_4$
17) pH paper
18) sodium hydrogen phosphate (NaH_2PO_4)

Special Instructions:

CAUTION: DO NOT TASTE, SPILL, OR OTHERWISE EXPOSE YOURSELF UNNECESSARILY TO CHEMICALS AND WATER USED IN THIS EXERCISE. TREAT CHEMICALS AND POLLUTED WATER WITH RESPECT.

1) For all tests in this activity, use 1-2 ml of water in a test tube. Record all data in a table like the one after the tests (See page 18).

2) Analyze the tap water either from your school or your home.

3) Analyze a sample of water from a local river, stream, lake, or pond. Identify the source of water as precisely as possible.

4) Analyze rain water "straight from the sky."

5) Analyze "run-off" water from the same rain storm in number 4 above.

Tests

I. Calcium Test

Add 3 to 5 grams of NH_4Cl (ammonium chloride), $(NH_4)_2C_2O_4$ (ammonium oxylate), and a few drops of NH_4OH (ammonium hydroxide) to the sample. Boil gently for one minute. A white precipitate (solid) indicates calcium in the sample. Save this sample for Test II.

II. Magnesium Test

Filter the calcium precipitate from the sample from Test I. Add a few grams of NH_4Cl (ammonium chloride) and NH_4OH (ammonium hydroxide) to the remaining solution. Next, add a few grams of NaH_2PO_4 (sodium hydrogen phosphate) and shake well. A white precipitate indicates magnesium presence in the sample.

III. Iron Test

To a fresh sample add a few drops of HCl (hydrochloric acid) and $K_3Fe(CN)_6$ (potassium ferricyanide). A dark blue precipitate indicates iron in the sample.

IV. Mercury Test

Add a small piece of shiny copper wire to the sample and let stand for one to two minutes. A silvery coating on the wire indicates mercury is present. To confirm the presence of mercury, add a few grams of NaI (sodium iodide) to the solution. A yellow-orange precipitate indicates mercury.

V. Chlorine Test

Add a few drops of $AgNO_3$ (silver nitrate) solution to a new water sample. A cloudy white precipitate indicates chlorine in the sample.

VI. Nitrate (NO_3) Test

Add 5 drops of concentrated H_2SO_4 (sulfuric acid) to the sample. (CAUTION: IF YOU HAVE NOT BEEN INSTRUCTED IN THE CARE OF HANDLING H_2SO_4, ASK YOUR TEACHER FIRST.) Carefully and without mixing, pour a strong solution of $FeSO_4$ (ferrous sulfate) down the side of the sample test tube. A brown ring where the two liquids join indicates a nitrate. A positive test hue may mean contamination by animals or man, since body waste products are high in nitrogen compounds.

VII. Phosphate Test

Add several drops of HNO_3 (nitric acid). Using pH paper as an indicator, neutralize the solution with NH_4OH (ammonium hydroxide) if it is acid, and with HNO_3, if it is basic. Now add 2 ml of $(NH_4)_2MO_4$ (ammonium molybdate) solution and warm but do not boil. A bright yellow precipitate indicates phosphate in the sample.

TABLE

	Tap Sample		River, Stream, Lake, Pond	
	Positive	Negative	Positive	Negative
Test I				
Test II				
Test III				
Test IV				
Test V				
Test VI				
Test VII				

NOTE: These tests are very sensitive, and a positive test result for one or more of these elements does not mean that the H_2O is unsafe. It simply means that you have made qualitative tests which are merely possible indicators of unsafe water.

RESOURCE PACKAGE 3-3

METHODS OF WATER PURIFICATION

Before 1940 it was possible to go almost anywhere out of an urban area and take water from a spring, creek, or well and to be virtually certain that it was free from harmful bacteria. This, unfortunately, is no longer the case.

Dallas has to dispose of more than 150 million gallons of waste water per day. This waste water contains detergent, acid, alkaline, insecticide, human and animal waste material, infected materials from hospitals, ground-up garbage produced by garbage disposal units, and many other things. Until recently, standards for waste water discharge were almost non-existent. One can readily see what a discharge of this magnitude could do to the environment for areas around urban centers.

Today, as people become increasingly aware of these problems, controls for the standards of purity of effluent discharge are becoming increasingly more rigid. However, it will be many years, if at all, before one can be confident of untested water in nature.

The exercises included in this resource package are designed to familiarize you with the processes used in making water safe to drink and use for other things.

EXERCISE #1: BOILING

When cases of typhoid fever, diptheria, and other water-carried diseases happen or when floods contaminate the water supply, health authorities will send out a warning to people to boil the water before they drink it; or if when camping, you do not have water purification tablets (halozane), you may use water you are not sure about if you boil it first.

When water is hot enough to boil, most living bacteria will be killed! Since bacteria cannot be seen without a microscope, the water will not change in appearance. The behavior of egg white in water is about the same as the behavior of bacteria in water since both are organic compounds, and this experiment may help you to be convinced that boiling water really helps.

Materials Needed:

1) egg white
2) eye dropper
3) Bunsen burner
4) test tube
5) test tube holder
6) dictionary
7) water
8) lake water
9) microscope
10) slides
11) cover slips

Instructions:

1) Fill a test tube half full of tap water and bring to a boil.
2) Remove from heat and add several drops of egg white.
3) Observe pond water under a microscope and record your observations.
4) Boil water from a pond sample.
5) Observe this boiled water under a microsoope and record your observations.

Questions:

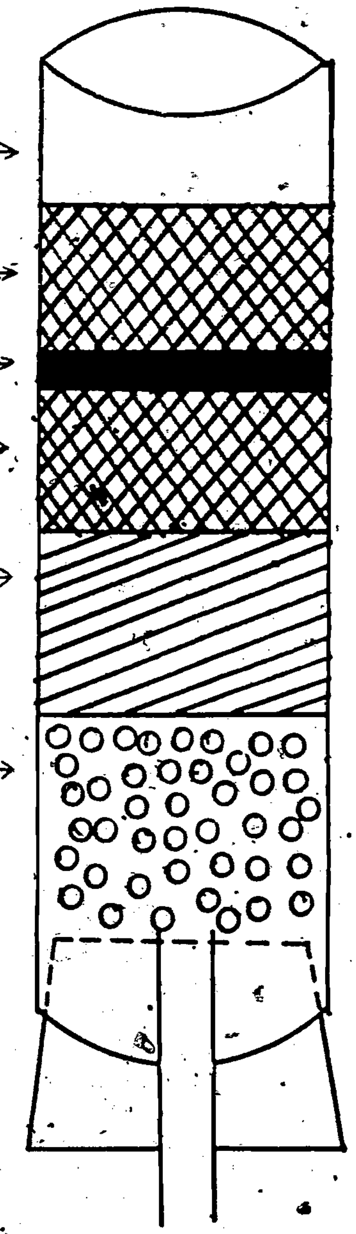
1) Describe what happened to the egg white. Discuss color, texture, etc.

2) The egg white coagulated. What does this mean?

3) What is the difference between sterilizing and purifying? (Use a dictionary, if necessary.)

4) Describe and sketch what you observed in the untreated pond water.

5) Describe the changes you observed in the pond water after boiling.



EXERCISE #2: FILTRATION

Filtration aids in the preparation of drinking water, but probably filtration alone will not make it safe to drink. It removes the solid particles of soil and debris and perhaps might trap some of the larger bacteria, but that is all. Filtration is important because no one wants to drink muddy or murky water. Also, when water is not clean, there is probably some culture medium in it that could support some bacteria growth if bacteria were introduced.

In this exercise, you will make a filter and clean some dirty water.

Materials Needed:

1) dirty water
2) plastic or glass cylinder
3) stopper
4) glass tubing (4")

5) coarse pea gravel
6) coarse clean sand
7) fine sand
8) powdered charcoal
9) 500-ml beaker
10) ring stand
11) tube clamp

Instructions:

1) Set up the filtering system according to the following steps. Observe diagram of filter as you construct it (on previous page).

   a) Insert a stopper with glass tubing into cylinder.

   b) Place on top of stopper 2" of pea gravel, 2" coarse sand, 2" fine sand, ½" charcoal, and 1" fine sand.

   c) Pour dirty water into top of filter, taking care not to wash a hole in the sand. Collect about 100 ml of filtered water.

Questions:

1) Describe the difference in appearance of the filtered water and the unfiltered water.

2) If your filtered water is still dirty, what might be the possible causes?

3) Has there been a change in the smell of the water?

4) Is the filtered water ready for human consumption? Give a reason for your answer.

5) Could a community filter its waste water for re-use? Why or why not?

EXERCISE #3: CHEMICAL STERILIZATION

Many people who go camping take along some special chemicals in the form of small tablets to purify water for drinking. These tablets usually contain iodine or chlorine which kill bacteria in water.

Bacteria are mostly made of protein similar to that of egg white. Because most bacteria are invisible to the unaided eye, you have to assume that the tablet has killed them. This experiment will help you to have greater faith in the purifying of water with the aid of chemicals.

Materials Needed:

1) water
2) tincture of iodine
3) egg white
4) eye dropper
5) test tube

Instructions:

1) Fill the test tube half full of water.

2) Add two or three drops of iodine solution so that the water is a light amber color.

3) Add five or six drops of egg white.

4) Allow this mixture to stand for half an hour.

5) (Optional) Other chemicals will cause the same reaction. Check with your teacher or bring some from home. CAUTION: ALTHOUGH OTHER CHEMICALS MAY CAUSE SIMILAR REACTIONS, DO NOT DRINK THE WATER. For sterilizing water for human consumption, use only recommended chemicals.

Questions:

1) Was there any change in the egg white? What was it?

2) Why is tincture of iodine used on cuts and scratches?

3) What does sterilize mean?

4) (Optional) What other chemicals did you find which caused a similar reaction to the egg white?

EXERCISE #4: DISTILLATION

When water is changed into the vapor state, the minerals that are dissolved in it do not go with the water vapor. Instead, they remain in the container in which boiling is taking place. Therefore, this is the only method with which water can be completely purified. This, of course, is the most expensive method, since enough energy must be expended to change the water into the vapor state (540 calories per gram), and then it must be removed to change it back into the liquid state.

Because of the considerable expense involved in this process, distilled water is used mostly in chemical laboratories where the water that is used in chemical reactions must be completely pure. Distilled H_2O is also used by persons who must not take any minerals into their system.

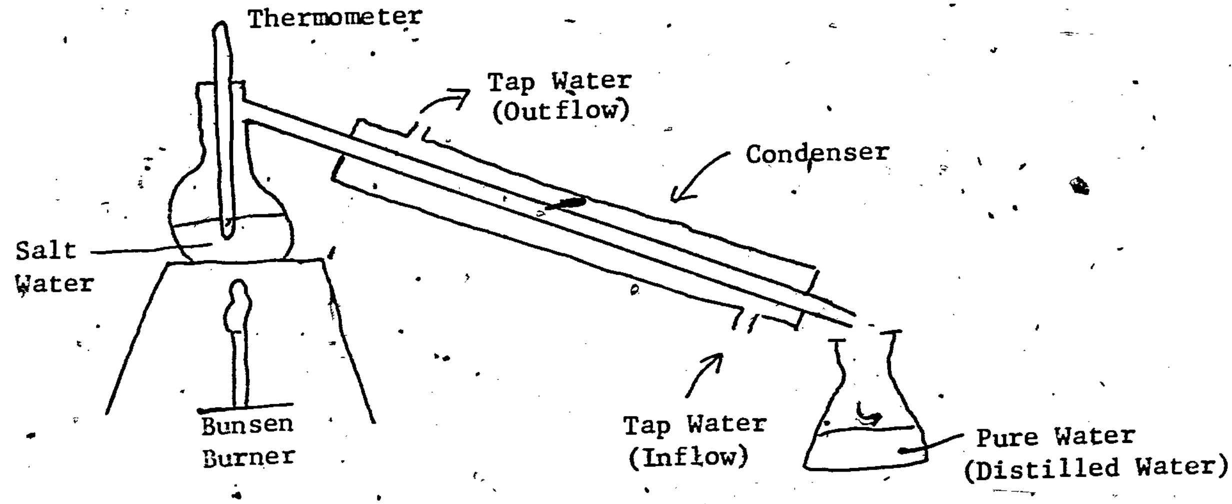
Materials Needed:

1) thermometer
2) distilling flask
3) condensing tube
4) erlenmeyer flask
5) Bunsen burner
6) ringstand
7) salt water
8) rubber tubing
9) rubber stopper

Instructions:

1) The drawing shown on the next page is a distillation apparatus. Set one up similar to the one in the drawing.

2) Light the burner and heat the salt water gently to the boiling point.



3) Have tap water circulating through the water jacket of the condenser tube in order to carry the heat away from the vapor.

4) After you have collected a sample of distilled water, test it to see if the salt is in the water.

Questions:

1) Was any salt found in the distilled water?

2) If so, can you account for it?

3) Look up the definition of a calorie. Use the equation, $\Delta Q = mC\Delta T$, to find out how much heat energy would be required (assuming no heat loss) to distill a liter of tap water at 20^{o} C. In the equation, Q is the heat energy in calories; m is the mass value of 1 liter of water; C is the specific heat of water; and ΔT is the temperature change from 20^{o} Celsius to the normal boiling point of 100^{o} Celsius.

RESOURCE PACKAGE 4-1

WHY DOES IT SINK?

If you have had the opportunity to visit the San Jacinto Battleground just east of Houston, you have probably gone on the battleship, "Texas," and had the opportunity to see all the things that are there. You may not have been made aware of the fact that the ship is constructed of steel reinforced concrete; yet it was used during World War I, and it actually floated. Upon first considering this and knowing that chunks of concrete and steel will not float at all, one might think that it should not float at all, but it will.

We may begin with a consideration of Archimedes' Principle to help us account for this. There are several interesting legends pertaining to how Archimedes came to discover his principle, but we will not go into them at this time. The principle says that when a body is immersed in a fluid, it will be buoyed up (supported) by a force equal to the weight of the fluid displaced. This tells us that in order for a one-pound object to float, it must have sufficient volume to push one pound of water out of the way ("displace one pound of pond water"). Otherwise, it will sink.

Consider a metal can like you would get vegetables in at the store. If it is empty and you set it in water, it will float. Now, take the same can and with the aid of a hammer, crush it until it is the smallest possible ball of metal. When placed in water, the small ball of metal will quickly sink. A ship or object made from materials more dense than water will float because the inside is empty so that the density of the whole thing is less than the density of water. Density is defined as mass volume *. One can readily see that if the volume increases in the mathematical relationship, it would reduce the density and could thus make the effective density of a ship less than water (even though the ship is made of materials that are more dense than water!).

If you ever have the opportunity to visit a port where goods are being loaded onto a ship, you can watch as the ship sinks deeper and deeper into the water. Every time one pound of goods is loaded, the ship will sink deeply enough in the water to displace another pound of water.

The manufacturers of pleasure boats tell the purchaser how many people can safely be carried in a boat. If this capacity is exceeded, the top of the boat will be too close to the surface of the water, and it would be relatively easy to swamp the boat and sink it. One should choose the proper size boat for the number of people and amount of cargo that he intends to carry. Each year many people who are out to have a good time during a vacation or weekend outing drown; but even with relatively little education, training, and study of water safety, there is almost no justification for an individual to lose his life in the water. First, the density of the body is about the same or just slightly less than water, so that most people can float unaided if they know how. When an individual is floating

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* Mass density definition. Weight density is defined as weight/volume.

properly, little energy need be expended, so that this activity can be sustained for hours. Life preservers for boaters are required by law to be within reach of everyone on the boat and must be fastened onto any child twelve years of age or younger. With the aid of a properly designed coast guard approved life preserver, there is no limit to the length of time an individual can stay afloat. The density of the life preserver is much less than that of water so that the combination of the life preserver and the individual is such that it is impossible to sink.

<u>EXERCISE #1: DENSITY</u> (Why some things float, sink, "weigh less" when in a fluid, etc.)

<u>Materials Needed</u>:

1) rectangular block of wood
2) metal cylinder
3) irregular shaped object (stone)
4) water
5) balance
6) meter stick
7) vernier caliper
8) graduate (large enough for stone)

<u>Procedure</u>:

1) Measure the length, width, and thickness of the block of wood with the vernier caliper (if possible).

2) Calculate volume by multiplying length x width x height.

3) Weigh block of wood for weight (w)*.

4) Calculate weight density (D) by formula, $D = \frac{w}{V}$.

5) Measure length and diameter of the metal cylinder with vernier caliper.

6) Calculate volume by formula, $V = \pi r^2 L$, when r is radius of cylinder and L is length of cylinder.

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* w = mg. Ask your teacher about this!

7) Weigh metal cylinder.

8) Calculate weight density of metal cylinder by formula, $D = \frac{W}{V}$.

9) Weigh the graduate.

10) Measure a volume of water in the graduate.

11) Weigh graduate and water.

12) Calculate weight of water.

13) Determine density of water by formula, $D = \frac{W}{V}$.

14) Weigh the stone.

15) Pour sufficient water into the graduated cylinder (graduate) to cover the stone when placed in the graduate, but not enough to overflow.

16) Determine the volume of water in the graduate.

17) Then carefully place the stone in the water in the graduate and determine the volume of the stone and water together.

18) Calculate the volume of the stone by subtracting the volume of the water from the volume of the water and stone together.

19) Calculate the density of the stone by the formula, $D = \frac{W}{V}$.

20) Calculate percent difference for those objects whose densities are in the tables provided.

Data: (Record on an answer sheet, please--NOT IN THIS BOOK!)

Block of Wood

length = ______ cm

width = ______ cm

thickness = ______ cm

V = ______ cc

w = ______ mg *

D = ______ w/cc

Accepted D = ______ w/cc

% difference = ______ %

Water

V = ______ cc

w of graduate = ______ mg *

w of graduate + water = ______ mg *

w of water = ______ mg *

D = ______ w/cc

Accepted D = ______ w/cc

% difference = ______ %

Metal Cylinder

length = ______ cm

diameter = ______ cm

radius = ______ cm

V = ______ cc

w = ______ mg *

D = ______ w/cc

Accepted D = ______ w/cc

% difference = ______ %

Stone

V of water = ______ cc

V of water + stone = ______ mg *

V of stone = ______ cc

w of stone = ______ mg *

D = ______ w/cc

Accepted D = ______ w/cc

% difference = ______ %

----

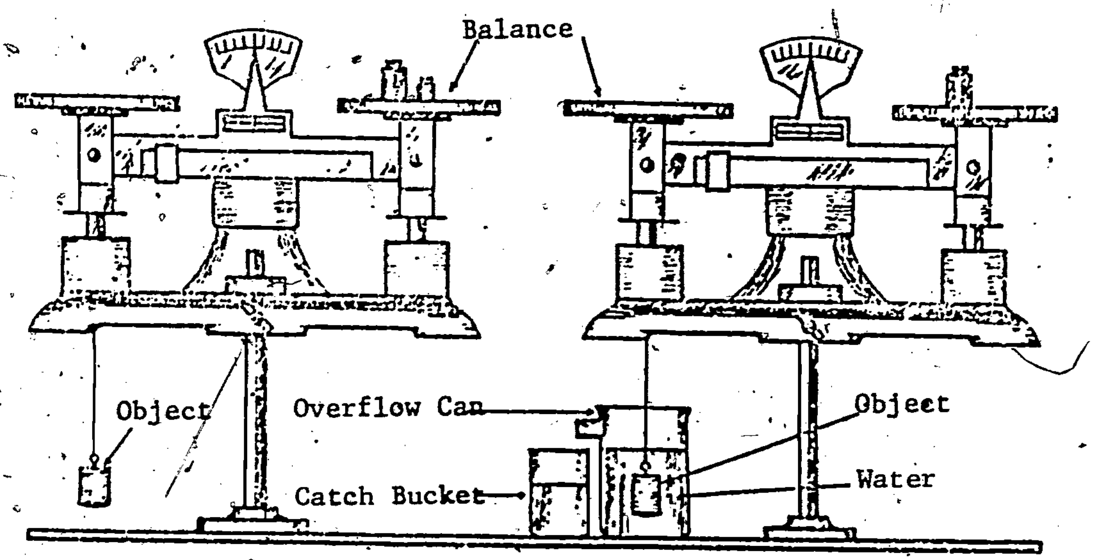
* g is the acceleration of gravity value (Ask your teacher about this!)

EXERCISE #2: ARCHIMEDES' PRINCIPLE

Materials Needed:

1) three objects which will sink in water
2) overflow can
3) catch bucket
4) strong string
5) balance
6) rod to support balance above table
7) table clamp

Diagram:



Procedure:

1) Weigh one of the objects in air.

2) Weigh empty catch bucket.

3) Fill overflow can with water. Add a few drops of liquid detergent to water to counteract surface tension (Look up the meaning of surface tension).

4) Place catch bucket under the overflow spout.

5) By means of a string, lower the object slowly into the overflow can, being careful that all displaced water overflows through spout into catch bucket.

6) Weigh the object in the water.

7) Weigh the catch bucket and water.

8) Calculate the weight of the displaced water and apparent loss of weight by the object (force of buoyancy). They should be equal.

9) Repeat, using the other two objects.

10) (Optional) See procedure #3 above. Can the effects of "cleansing" hard water and soft water be related to surface tension?

Data: (PLEASE DO NOT WRITE IN THIS BOOK.)

OBJECT	Wt. in Air	Wt. in Water	Wt. of Empty Bucket	Wt. of Bucket + Water	Wt. of Displaced Water	Force of Buoyancy
1						
2						
3						

Questions:

1) Why does the human body ordinarily float in fresh water? Will it float with greater ease in salt water? Why or why not?

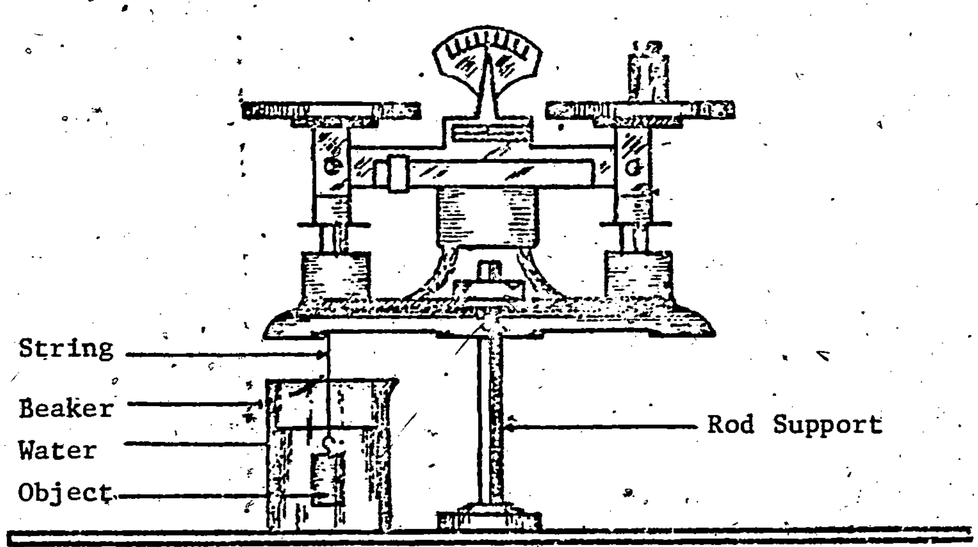
2) Why does one often feel heavier on his feet and legs when he first leaves the swimming pool after a lengthy swim?

EXERCISE #3: ARCHIMEDES' PRINCIPLE AND THE SPECIFIC GRAVITY OF A SOLID OBJECT

Materials Needed:

1) balance
2) rod to support balance above table
3) metal object
4) large beaker
5) water
6) string
7) table clamp

Diagram:



Procedure:

1) Set up apparatus as shown in diagram on previous page.

2) Suspend the object by string from the balance scales so that it is about 2 inches from the table.

3) Weigh object in air.

4) Pour water into beaker to a level of about 4 inches or more.

5) Place the beaker and water under the scales so that object hangs in water completely submerged.

6) Weigh object in water.

7) Subtract the weight of object in water from the weight of object in air. The loss of weight in water is the force of buoyancy, which equals the weight of displaced water, according to Archimedes' Principle.

8) Since the volume of water displaced is equal to the volume of object, the specific gravity (sp. gr.) of the object is determined by the formula:

$$\text{sp. gr.} = \frac{\text{wt. of object in air}}{\text{wt. of displaced water}}$$

9) Determine the percent of difference if the accepted value for specific gravity of the object is known.

Data:

Wt. of object in air ______ mg

Wt. of object in water ______ mg

Loss of wt. of object in water (wt. of displaced water) ______ mg

Data (cont.)

Calculated sp. gr. ______

Accepted sp. gr. ______

% difference ______ %

Problem:

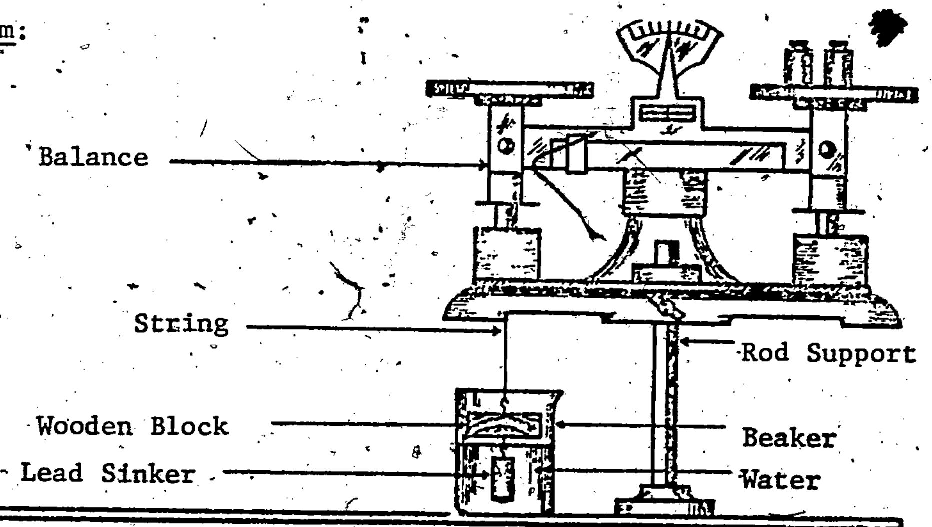
Relate Archimedes' Principle to this method of determination of the specific gravity of an object that will sink in water.

EXERCISE #4: ARCHIMEDES' PRINCIPLE APPLIED TO FLOATING OBJECTS

Materials Needed:

1) balance
2) rectangular block of wood about 10 cm x 10 cm x 5 cm
3) lead sinker
4) large beaker
5) string
6) rod to support balance above table
7) meter stick
8) table clamp

Diagram:



Procedure:

1) Weigh wooden block in air.

2) Place balance scales on rod support so that weights can be hung from the bottom.

3) Suspend wooden block from balance scales and the lead sinker from bottom of wooden block.

4) Place beaker under the lead sinker with enough water to submerge the lead sinker.

5) Weigh with lead sinker in water and wooden block in air.

6) Submerge both wooden block and lead sinker in water by adding water to the beaker and weigh both in water.

7) Calculate loss of weight of wooden block in water (force of buoyancy) which equals the weight of displaced water (Steps 5-6).

8) Determine specific gravity (sp. gr.) of the wooden block by the formula below and by overflow method to get the weight (volume) of the displaced water.

$$\text{sp. gr.} = \frac{\text{wt. of wooden block in air}}{\text{wt. of displaced water}}$$

9) Calculate the weight density (D) of the block by the formula, $D = \frac{W}{V}$.

10) Calculate specific gravity of the wooden block by the formula,

$$\text{sp. gr.} = \frac{\text{D of wooden block}}{\text{D of water}}$$

Data: (PLEASE DO NOT WRITE IN THIS BOOK.) Keep your units of measure consistent.

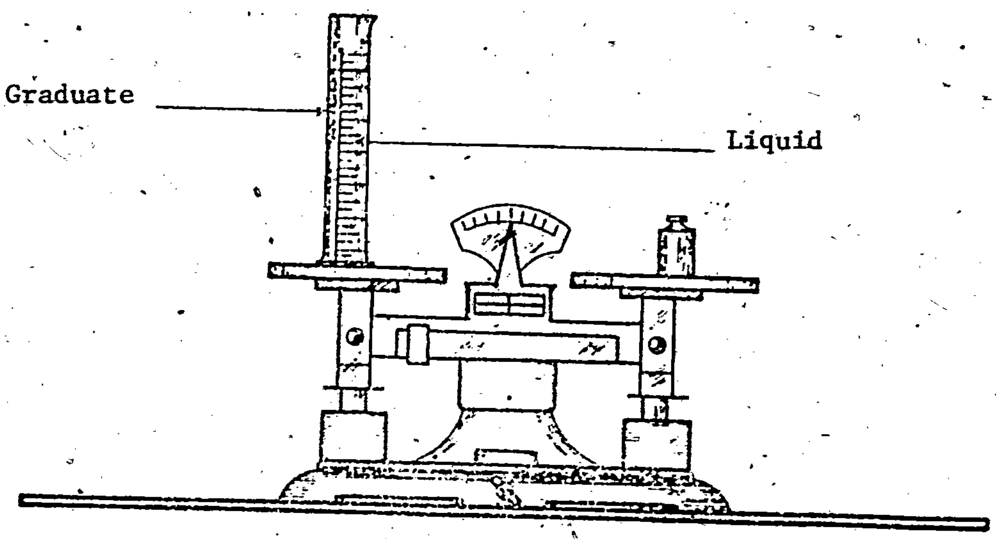
Wt. of wooden block in air	________
Wt. of wooden block in air and sinker in water	________
Wt. of both wooden block and sinker in water.	________
Wt. of displaced water	________
Sp. gr. of wooden block	________
Dimensions of wooden block:	
Length	________
Width	________
Thickness	________
Volume	________
Density of wooden block	________
Sp. gr. of wooden block	________
Percent difference	________

EXERCISE #5: SPECIFIC GRAVITY OF LIQUID

Materials Needed:

1) liquid, such as alcohol
2) water
3) balance
4) graduate

Diagram:



Procedure:

1) Weigh the graduate.

2) Measure a volume of the liquid in the graduate (V_L).

3) Weigh both liquid and graduate.

4) Calculate weight (w_L) of liquid.

5) Determine density (D_L) of liquid by the formula, $D_L = \frac{w_L}{V_L}$.

6) Remove liquid from graduate and dry as much as possible.

7) Measure a volume (V_w) of water in graduate equal to the volume (V_L) of liquids.

8) Weigh both graduate and water.

9) Calculate weight (w_W) of water.

10) Determine (V_W) of water in Step 9.

11) Determine the specific gravity (sp. gr.) of the liquid by the following formulas:

$$\text{sp. gr.} = \frac{D_L}{D_W}$$, in all cases, where D_W is density of water

$$\text{sp. gr.} = \frac{w_L}{w_W}$$, when volumes are equal.

12) If the specific gravity of the liquid used is in the tables provided, determine the percent difference.

<u>Data</u>:

w_L	________	w
V_L	________	cc
D_L	________	w/cc
w_W	________	w
Sp. gr. = $\frac{D_L}{D_W}$	________	
Sp. gr. = $\frac{w_L}{w_W}$	________	

Data (cont.)

Average sp. gr. from the two previous values ________

Accepted sp. gr. ________

% difference of average sp. gr. and accepted sp. gr. ________

Problems:

1) When a liquid has a specific gravity of .82, what does the figure .82 mean?

2) A certain liquid has a specific gravity of 1.25 and weighs 25 lbs. How much would an equal volume of water weigh?

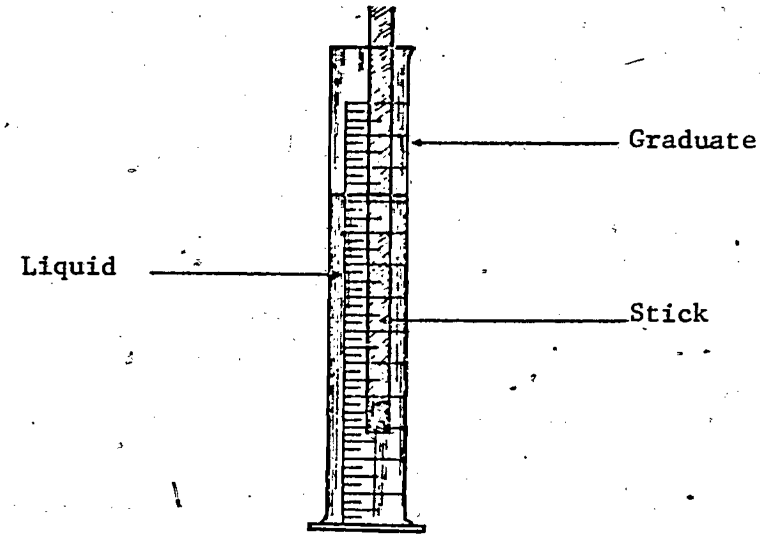
3) One liquid has a specific gravity of .58 and weighs 8 lbs. How much does one equal volume of another liquid weigh if its specific gravity is .76?

EXERCISE #6: ARCHIMEDES' PRINCIPLE APPLIED TO FIND SPECIFIC GRAVITY OF LIQUIDS

Materials Needed:

1) two large graduates
2) a liquid, such as alcohol
3) water
4) a stick weighted at one end so that it sinks about half its length in water
5) meter stick
6) two hydrometers--one for lighter than water and one for heavier than water

Diagram:



Procedure:

1) Fill one graduate with water and the other with the liquid to approximately 2 inches of the top.

2) Place the prepared stick in the water.

3) Place the meter stick along the outside of the graduate parallel to the stick in water and measure the length of the stick that is below the water surface.

4) Then place the stick in the other liquid and measure the length of the stick that is below the surface.

5) Since the stick sinks until it displaces its own weight, the specific gravity may be calculated by the formula,

$$\text{sp. gr.} = \frac{\text{length of stick in water}}{\text{length of stick in liquid}}$$

6) Check the results in Step 5 by placing a hydrometer in the liquid.

7) Check the specific gravity of water with the hydrometer.

8) Calculate the percent difference if the accepted value for specific gravity of the liquid is known.

Data:

Length of stick in liquid	______	cm
Length of stick in water	______	cm
Calculated specific gravity of liquid	______	
Hydrometer specific gravity of liquid	______	
Hydrometer specific gravity of water	______	
Percent difference with stick as compared to hydrometer	______	

Problem:

What do you consider to be the most convenient means to determine the specific gravity of a liquid?

RESOURCE PACKAGE 4-2

CHOOSING A BOAT

Before you complete this resource package, plan to visit a pleasure boat dealer who has a wide selection of boats for sale, both of the power type and the sail type. While you are there, pick up whatever sales literature he has available that discusses how to choose a boat and what one should look for.

You will find that there are many different shapes of hulls and types of power plants (motors) to choose from. Some of the boats you will see are designed for appearance rather than function. Some are designed so that they will not sink even though filled with water, some upright, and some upside down. The shape of the hull has a great deal to do with the efficiency and riding comfort of the boat.

Take a few minutes to look through the publication, "How to Buy the Right Boat," published by the Chrysler Corporation. As you read through this publication, take notes to include in your notebook on the section on hull design, construction and construction materials, powering the boat, and financing the purchase and maintenance of a boat.

Next, go through the boat buyer's checklist and determine what kind of boat you might like to purchase. Make a photocopy of the checklist to place in your notebook if your school has photocopy equipment available. If this is not possible, you might like to make yourself a copy at the public library or somewhere else where this equipment is available.

RESOURCE PACKAGE 5-1

EVAPORATION AND COOLING

When water changes from one state to the other, there is an increase or decrease in the amount of heat energy that it contains. At 100° C., the boiling point of water, 540 calories of heat is required to affect the change from the liquid to the vapor state for one gram of liquid water. As the temperature at which evaporation takes place becomes less than 100° C., the amount of heat required to cause the transformation becomes less than the 540 calories per gram; but the water still must absorb a large amount of heat per unit volume to cause evaporation to take place.

Your body makes use of this process in order to help regulate its temperature. You have probably noticed that the perspiration on your body evaporates quickly and makes you feel cool on days when the relative humidity is low; but when the relative humidity is high, your perspiration does little to make you feel more comfortable, since it does not evaporate efficiently (rapidly).

In areas such as West Texas, Arizona, and New Mexico, where the relative humidity is usually very low, evaporative coolers are used almost exclusively to cool the homes. This does an excellent job of cooling because evaporation takes place rapidly and heat present in the air is removed.

The evaporative process works like this. If you fill a bottle half full with water and stopper it, the liquid water in the bottle and the water vapor in the air above the liquid surface will reach a state of equilibrium. That is, the rate at which water molecules are leaving the liquid state and the rate at which water molecules are leaving the vapor state and returning to the liquid state will be equal, and the air above the water will contain as much water vapor as is possible at that temperature. The reason that water evaporates is that the process by which the molecules are constantly in motion, bumping into each other and transferring energy from one to the other, frequently causes one molecule near the surface to have a velocity equal to the escape velocity from the surface, and it leaves. When it does, the energy it had absorbed leaves with it, and the liquid is cooler than it was. When a molecule re-enters the surface of the liquid, the energy it contains serves to warm the liquid.

Cooling by evaporation is achieved by upsetting the equilibrium condition that might exist. When you perspire, the moisture evaporates into the air. If the air around you is in motion, then the evaporated molecule of water is carried away so that it does not have the opportunity to recondense on you, and that amount of heat is taken away. Moving air also helps to hasten the evaporative process, in that a water molecule at the surface of the liquid may have just slightly less energy than that required to escape and the moving air molecule may give it just enough additional energy to escape and to take its energy with it.

The evaporation process, as described above, indicates the reason that an evaporative cooler will effectively cool in a climate when the air has low humidity and will not be very effective in a climate when the humidity is high.

In this exercise you will investigate the effect of evaporation on the temperature of several containers of water.

Materials Needed:

1) three thermometers
2) two collecting bottles
3) pie plate
4) rubber stopper to fit collecting bottle

Instructions:

1) Place 200 ml of water in each container.

2) Place the thermometer through the stopper and place it in one of the bottles.

3) Place the other two thermometers in the other two containers of water.

4) Record the temperature of each. They should all begin at the same temperature.

5) Allow each of the three samples to sit in front of a fan for thirty minutes and record the temperature at the end of that period of time.

Questions:

1) If there was a difference in the final temperature of the three solutions, explain the reasons for this.

2) In an area like Dallas where the usual summertime relative humidity ranges from 50% to 90%, would evaporative cooling be practical? Justify your position.

WATER, WATER EVERYWHERE!

SELF TEST

1) Draw a diagram of the various steps in the water cycle and label each step.

2) Improper care of our watershed upsets the operation of the water cycle. Explain why this is the case.

3) List the steps in preparing water for human consumption for a city like Dallas.

4) State Archimedes' Principle.

5) List the six basic hull shapes for boats and tell the advantages and disadvantages of each.

6) You can physically place more people and equipment in your boat than it is designed to carry. Why is this a bad practice?

7) Describe the boat you would choose for yourself and tell why you selected the various features.