6^{th} Grade

Spring 2019 Lesson Plans

Vanderbilt Student Volunteers for Science

http://studentorg.vanderbilt.edu/vsvs/

VOLUNTEER INFORMATION

Team Member Contact Information

Name:____ Phone Number:________________________

Name:____ Phone Number:________________________

Name:____ Phone Number:________________________

Name:____ Phone Number:________________________

Name:____ Phone Number:________________________

Teacher/School Contact Information

School Name: ____________________________________ Time in Classroom: ____________________

Teacher's Name: __________________________________ Phone Number: ______________________

VSVS INFORMATION

VSVS Educational Coordinator:

Paige Ellenberger 615-343-4379

paige.ellenberger@vanderbilt.edu **VSVS Office:** Stevenson 5234

Co-Presidents:	Eric Zhang	eric.zhang@vanderbilt.edu
	Vineet Desai	vineet.desai@vanderbilt.edu
Secretaries:	Gabriela Gallego	gabriela.l.gallego@vanderbilt.edu
	Emily Chuang	emily.a.chuang@vanderbilt.edu

Vanderbilt Protection of Minors Policy: As required by the Protection of Minors Policy, VSVS will keep track of the attendance – who goes out when and where.
https://www4.vanderbilt.edu/riskmanagement/Policy_FINAL%20-%20risk%20management%20v2.pdf

Before You Go:

- The lessons are online at: http://studentorg.vanderbilt.edu/vsvs/
- Email the teacher prior to the first lesson.
- Set a deadline time for your team. This means if a team member doesn't show up by this time, you will have to leave them behind to get to the school on time.
- Don't drop out from your group. If you have problems, email Paige or one of the co-presidents, and we will work to help you. Don't let down the kids or the group!
- If your group has any problems, let us know ASAP.

Picking up the Kit:

- Kits are picked up and dropped off in the VSVS Lab, Stevenson Center 5234.
- The VSVS Lab is open 8:30am – 4:00pm (earlier if you need dry ice or liquid N_2).
- Assign at least one member of your team to pick up the kit each week.
- Kits should be picked up at least 30 minutes before your classroom time.
- If you are scheduled to teach at 8am, pick up the kit the day before.
- There are two 20 minute parking spots in the loading dock behind Stevenson Center. Please do not use the handicap spaces – you will get a ticket.

While you're there – Just relax and have fun!

February						
SUN	MON	TUES	WED	THU	FRI	SAT
					1	2 New member training
3	4	5 New member training	6	7 Team leader training	8	9
10 Team leader training	11 Team training Lesson 1 / 5th-7th Alt training	12 Team training Lesson 1 / 5th/7th Alt training	13 Team training Lesson 1 / 5th/7th Alt training	14 Team training Lesson 1 / 5th/7th Alt training	15 Team training Lesson 1 / 5th/7th Alt training	16
17	18 Teams go out (Lesson 1) / Alt 6th-8th team training	19 Teams go out (Lesson 1) / Alt 6th-8th team training	20 Teams go out (Lesson 1) / Alt 6th-8th team training	21 Teams go out (Lesson 1) / Alt 6th-8th team training	22 Teams go out (Lesson 1) / Alt 6th-8th team training	23
24	25 5th-7th team training / Alt Teams go out (Lesson 1)	26 5th-7th team training / Alt Teams go out (Lesson 1)	27 5th-7th team training / Alt Teams go out (Lesson 1)	28 5th-7th team training / Alt Teams go out (Lesson 1)		

March						
SUN	MON	TUES	WED	THU	FRI	SAT
					1	2
3	4	5	6	7	8	9
10	11 6th-8th team training	12 6th-8th team training	13 6th-8th team training	14 6th-8th team training	15 6th-8th team training	16

17	18 Teams go out (Lesson 2)	19 Teams go out (Lesson 2)	20 Teams go out (Lesson 2)	21 Teams go out (Lesson 2)	22 Teams go out (Lesson 2)	23
24	25 Teams go out (Lesson 3)	26 Teams go out (Lesson 3)	27 Teams go out (Lesson 3)	28 Teams go out (Lesson 3)	29 Teams go out (Lesson 3)	30

April						
SUN	MON	TUES	WED	THU	FRI	SAT
31	1 Teams go out (Lesson 4)	2 Teams go out (Lesson 4)	3 Teams go out (Lesson 4)	4 Teams go out (Lesson 4)	5 Teams go out (Lesson 4)	6
7	8 Make-up week	9 Make-up week	10 Make-up week	11 Make-up week	12 Make-up week	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

CLASSROOM ETIQUETTE

Follow Metro Schools' Dress Code!

- No miniskirts, shorts, or tank tops.
- Tuck in shirts if you can.
- Please dress appropriately.

Metro student standard attire guideline:
http://jtmoorems.mnps.org/pages/JohnTrotwoodMooreMiddle/About_Our_School/8998762518461552450/Dress_Code

COLLEGE Q&A SESSION

VSVS members should be candid about their experiences and emphasize the role of hard work and a solid body of coursework in high school as a means to get to college.

- Email the teacher prior to the first lesson.
    - They may want to have the students write down questions prior to your lesson.
    - They may also want to have a role in facilitating the discussion.
- Finish the experiment of the day and open up the floor to the students.
- Remind them of your years and majors and ask if they have specific questions about college life.
- If they are shy, start by explaining things that are different in college.
    - Choosing your own schedule, dorm life, extracurricular activities, etc.

  - Emphasize the hardworking attitude.

The following are some sample questions (posed by students):

- When is bedtime in college? Does your mom still have to wake you up in college?
- How much does college cost?
- What do you eat in college and can you eat in class in college?
- How much homework do you have in college?

DIRECTIONS TO SCHOOLS

H.G. HILL MIDDLE SCHOOL: 150 DAVIDSON RD **615-353-2020**

HG Hill School will be on the right across the railroad lines.

HEAD MAGNET SCHOOL: 1830 JO JOHNSON AVE **615-329-8160**

The parking lot on the left to the Johnston Ave.

J.T. MOORE MIDDLE SCHOOL: 4425 GRANNY WHITE PIKE **615-298-8095**

From Lone Oak, the parking lot is on the right, and the entrance into the school faces Lone Oak, but is closer to Granny White.

MEIGS MIDDLE SCHOOL: 713 RAMSEY STREET **615-271-3222**

Going down Ramsey Street, Meigs is on the left.

ROSE PARK MAGNET SCHOOL: 1025 9th AVE SOUTH **615-291-6405**

The school is located on the left and the parking is opposite the school, or behind it (preferred).

WEST END MIDDLE SCHOOL: 3529 WEST END AVE **615-298-8425**

Parking is beside the soccer field, or anywhere you can find a place. Enter through the side door.

EAST NASHVILLE MAGNET MIDDLE SCHOOL: 2000 GREENWOOD AVE **615-262-6670**

MARGARET ALLEN MIDDLE SCHOOL: 500 SPENCE LN **615- 291- 6385**

From West End down Broadway, take 1-40E to exit 212 Rundle Ave. Left on Elm Hill to Spence Lane.

VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
http://studentorg.vanderbilt.edu/vsvs

Potato Power

Mini Lesson for Spring 2019

Goal: To learn about the energy conversion from chemical energy to electrical energy.
To understand how a battery is made.
Fits TN State Standards: 6.ESS3 6PS3.1

Lesson Outline

I. Introduction
Discuss different sources of electrical energy.

II. Chemical Energy → Electrical Energy – Potato Battery Demonstration
Use a potato clock to demonstrate that potatoes and 2 different electrodes can provide enough electrical current to run a digital clock. This current is produced by the difference in activity of the copper and zinc electrodes that are inserted in the potatoes. This provides an example of chemical energy being converted to electrical energy.

III. Making a Battery
Demonstrates how a wet cell battery produces electricity

IV. Review

Students will work in groups of 3 or 4. There are 10 sets of materials, so divide the class into enough groups to use all the materials.

Fun Facts!

1) Lightning is a potent example of electrical energy being discharged. Bolts can travel up to 130,000mph and can reach 30,000^{o}C!
2) Electricity travels at the speed of light – more than 186,000 miles per second! If you traveled as fast as electricity, you could go around the world 8 times in the time it takes to turn on a light switch.
3) When you scuff your feet against carpet the electrons travel through your bloodstream and collect in your finger, where they form a spark between another conductor.
4) Electric eels can produce strong electric shocks for both self-defense and hunting.
5) Electricity can be made from wind, water, the sun, and even animal poop!

Complete teacher/school information on first page of manual.

1. Make sure the teacher knows the VSVS Director's (Paige Ellenberger) office number and email (in front of manual).
2. Exchange/agree on lesson dates and tell the teacher the lesson order (**any changes from the given schedule need to be given to Paige in writing (email)**).
3. Since this is your first visit to the class, take a few minutes to introduce yourselves. Mention you will be coming three more times to teach them a science lesson.
4. Do the experiment with the classroom, and leave 10 minutes at the end to discuss aspects of college life with them. Some topics that could be included are in the manual.
5. **While one team member starts the Introduction, another should write the following vocabulary words on the board:**
   fossil fuels, turbine, generator, voltage, amperage, solar energy, wind energy, battery, LED

Materials
1 potato "battery" clock
2 potatoes
10 green liquid battery holders with zinc and copper electrodes
10 containers of distilled water (we use DI water)
10 containers sodium bisulfate (containing mini spoon)
10 coffee stirrers
10 M6 meters
10 green snap wires
10 yellow snap wires
10 LED's (black, D6)
10 snap circuit digital clocks
16 instruction sheets
32 observation sheets

Unpacking the Kit

Part II. Chemical energy → Electrical energy
1 potato "battery" clock
2 potatoes

Part III. Making a Battery
Divide the class into 10 groups, and give each group a set of materials:
A. Experiment give to each group:
- 1 green container outfitted with copper and zinc electrodes
- 1 M6 meter
- 2 connecting wires (1 yellow and 1 green)
- 1 container of sodium bisulfate powder plus mini spoon
- 1 bottle distilled water (we use DI water)
- 1 coffee stirrer

B. What could this battery power do?
Give to each group:
- 1 LED (black, D6)
- 1 snap circuit digital clock

I. INTRODUCTION

A. Sources of Electricity

Where does electricity come from?
Ask students if they can tell you some different ways that electrical energy can be generated.

1. **Power plants burn fossil fuels** such as coal, oil, and gas. The burning of these fuels is used to create heat to convert water into steam. The steam turns a turbine which acts to convert mechanical energy into electrical energy.
2. **Nuclear power plants** produce heat energy by splitting apart atoms such as uranium and plutonium. The heat energy is used in the same way as in Fossil fuel plants.
3. **Hydroelectric power plants** use the force of falling water to turn a water turbine which powers a generator.
4. **Solar**: The light of the sun can be used to convert light energy to electrical energy via solar panels made up of thousands of solar cells.
5. **Wind**: Wind turns large blades on a windmill to produce mechanical energy which drives an

Your Notes:

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electric generator.

6. **Batteries**: Batteries store energy and convert chemical energy to electrical energy: A battery is also known as an electrochemical cell.

This lesson will demonstrate the use of a chemical battery as a source of electrical energy.

II. Chemical energy → Electrical energy: Potato Battery Demonstration

Materials

1 potato "battery" clock
2 potatoes

Hold the potato battery clock so that students can see that it is working. (If it's not working, make sure each potato has a copper and a zinc electrode inserted in it.)

- Ask students: What is causing the clock to run? *Some students might say a battery*.
- Ask students if they see a battery? *There is no traditional battery*.
- Show students the clock and point out the parts. Have them look at the picture of the clock on their instruction sheet. :
  - There are 4 metal probes, 2 zinc and 2 copper. These are called electrodes. Electrodes are electrical conductors that can carry a current. Point out the 2 different metals (zinc is silver-colored, copper is orangish).
  - The electrodes have wires attached to them. The wires carry the electric current.
  - The potato provides the acid (phosphoric acid) which reacts with the zinc electrode to produce excess electrons. There is no electricity in the potatoes.
  - The electrons flow from the zinc to the copper metal. The flow of electrons produces electricity.
  - The electricity powers the digital clock.
- Tell the students that the digital clock needs 2 potatoes and 2 sets of electrodes to make it work well:
  - Pull one of the metal electrodes out of one potato to show that this causes the clock to stop working (the circuit is broken).
  - Put the 2 electrodes connected to the clock into 1 potato – the clock may work faintly, or not at all. 1 set of electrodes does not produce enough electricity to power the clock.
- Tell the students that the digital clock will also work with fruits such as apples, oranges, lemons, and limes.
- Ask the students to decide which energy they believe the chemical energy was converted to. Answer: ***Electrical Energy***

For VSVS Information Only: Although the chemistry is too advanced for middle school students, this is an oxidation-reduction reaction in which the zinc metal is being oxidized, the phosphoric acid solution in the potatoes is acting as the electrolyte, water is being reduced around the zinc electrode to give hydrogen gas (very small amounts which aren't visible), and the potato matter is serving as a membrane for ion flow between the electrodes

Your Notes:

III. Making a Battery

Tell students that they are going to make a **wet cell**. It is similar to the one first created by Alessando Volta in 1880.

Divide the class into 10 groups, and give each group a set of materials:

1 green container outfitted with copper and zinc electrodes
1 M6 meter
3 connecting wires (1 yellow and 1 green)
1 container of sodium bisulfate powder plus mini spoon
2 bottle distilled water (we use DI water)
1 stirrer

Give each student an observation sheet

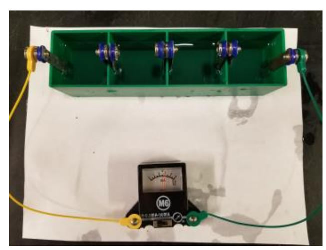
Explain that the M6 meter can measure both voltage and current. Point out the 3 different settings and tell students to turn the switch to the left, for the 5V setting.

The voltage measurement (V) tells you how much pressure is present to move the electrons being pushed through the circuit.
The electric current measurement (A or mA) tells you how much electricity is flowing through the wires each second.

A. Experiment:

Tell students to fill each compartment of the green container with DI water (about 1/2 full).

Tell them that the green container is now a liquid battery, with zinc and copper electrodes. Help students identify the **copper (orange colored) and zinc (silver colored)** electrodes. Point out the arrangement of the electrodes – the metals alternate.



1. Orient the green container so that the zinc electrode is on the left and the copper electrode is on the right.
2. Place the M6 meter below the green container. Tell students to follow the diagrams to connect the cables, meters, and green container.
3. Connect the green jumper cable from the RHS (+) terminal of the M6 meter, to the RHS of the container (the end that has the orange-colored copper electrode) and the yellow jumper cable from the LHS (-) terminal of the M6 meter to the lighter zinc electrode on the LHS end of the green container.
4. Make sure the black switch on the M6 meter is to the <u>**left**</u> for the <u>**5V setting**</u>, and then measure and record the voltage.
   Since the liquid used is distilled water, there should be **little to no voltage recorded**. **Distilled water** does not contain ions and thus does not conduct electrical currents.
5. Tell students to add 2 scoops of the sodium bisulfate powder to each compartment. Stir with a coffee stirrer. Students should see the voltage increasing as the sodium bisulfate is added and stirred.
6. Record the voltage. **The voltage should read around 3V**
7. Now change the green jumper cable from the right end of the green box to the copper electrode at the end of the 1st compartment and measure the voltage (0.75V)

Your Notes:

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8. Repeat by changing the green jumper cable from right end of the green box to the copper electrode at the end of the 2nd and then 3rd compartments. Record the voltage for both arrangements (1.5V and 2.3V).

Discussion:
Ask students what arrangement gave the highest voltage?
How did the voltage change with fewer compartments?
Each compartment produces about 0.75V. The 4 compartments are connected in series, so the voltages add together.

B. What could this battery power do?

Is this battery strong enough to make a digital clock run, as did the potatoes in the potato clock apparatus?

Remove the jumper wire snaps from the meter and set the meter aside. Leave the wires attached to the battery tank.
Place the LED in front of the battery tank so that the arrow is pointing from right to left (words are upside down). Snap the leads into the LED, connecting the green jumper cable to the positive end and the yellow jumper cable to the negative end.
Does the LED light? Repeat the steps 7 and 8 above to find out how many compartments in the battery tank are needed to make the LED glow. (At least 2 are needed).
Replace the LED with the digital clock and check to see how many compartments are required to make it work.
Tell students that both these devices require very little voltage to work.
Note: but not all LED's will light up.

Household Batteries.

Tell students: The most common household battery is a dry cell battery:
It has 2 electrodes, zinc and carbon. Zinc likes to give up its electrons.
The electrolyte is ammonium chloride or zinc chloride.
Electrolytes move or conduct an electric current.
An alkaline battery has manganese dioxide and zinc powder as the electrodes and potassium hydroxide as the electrolyte.

Ask: What kind of battery have we produced (nuclear, biofuel, or chemical)?

Clean – up: Empty green boxes into the sink, making sure the electrodes do not fall out. Collect all snap circuit pieces, sodium bisulfate powder, coffee stirrers and mini spoons and return them to the kit.

Lesson written by Pat Tellinghuisen, VSVS Program Coordinator, 1998-2018, Vanderbilt University
References: Snap Circuit Green Chemistry Manual.

Your Notes:

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Potato Power Observation sheet
Name____________________

Circle the correct answers:

1. What color are the copper electrodes   orange   silver
2. What color are the zinc electrodes   orange   silver
3. What kind of energy was the chemical energy in the clock converted to?
   : electrical   mechanical   light

4. Add 2 scoops of sodium bisulfate to each compartment and stir with a coffee stirrer. Measure and record the voltage from 4 compartments, then 1, 2, and 3.

Voltage Measurements:

Voltage measurement from 4 compartments using distilled water	Voltage measurement from 4 compartments after sodium bisulfate added.	Voltage measurement from 1 compartment	Voltage measurement from 2 compartments	Voltage measurement from 3 compartments

5. What arrangement gave the highest voltage? ________________

6. How many compartments does it take to light up the LED? ________________

7. How many compartments does it take to make the clock work? _____________

Potato Power Observation Sheet - Answers
Name____________________

Circle the correct answers:

1. What color are the copper electrodes *orange*
2. What color are the zinc electrodes *silver*
3. What kind of energy was the chemical energy in the clock converted to? *electrical*

4. Add 2 scoops of sodium bisulfate to each compartment and stir with a coffee stirrer. Measure and record the voltage from 4 compartments, then 1, 2, and 3.

Voltage Measurements:

Voltage measurement from 4 compartments using distilled water	**Voltage measurement from 4 compartments after sodium bisulfate added.**	**Voltage measurement from 1 compartment**	**Voltage measurement from 2 compartments**	**Voltage measurement from 3 compartments**
0 or very small	*About 3V*	*0.75V*	*1.5V*	*2.3V*

5. What arrangement gave the highest voltage? *4 compartments*

6. How many compartments does it take to light up the LED? *At least 2*

7. How many compartments does it take to make the clock work? *At least 2*

VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
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Deep Ocean Currents

Spring 2019

Goal: To teach students about deep ocean currents by allowing them to visualize and understand how and why the currents form.
To introduce students to convection in liquids .
Fits Tennessee standards 6.ESS2.1, 6.ESS2.2

VSVSer Lesson Outline:

________ **I. Introduction to Ocean Currents**

________ **II. Density Background Information:**

a. Demonstration – students will observe that a liquid with lower density (oil) will float on water.

_______ **III A. Saltwater in the Ocean:**

a. The VSVS team will share some information about oceans with the students.
b. Saltwater demonstration: Students will add colored salt water to one side of a partitioned rectangular container and fresh water to the other side. Plugs in the partition will be removed and students will watch the flow of water. Pepper will be added to the surface of the water on both sides and students will observe the circulation.

B. Cold Water in the Ocean

Students will observe the flow of cold water into warm water.

________ **IV. Where Are The Deep Ocean Currents?**

a. Students look at a map of deep ocean currents.

________ **V. Review**

LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM
https://studentorg.vanderbilt.edu/vsvs/lessons/
USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.

1. Before the lesson:

In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.

Deep Ocean Currents & Air Convection Currents Lesson Quiz

1) Which ocean current is driven by the temperature and density of the water? (Deep vs surface)
2) Which is denser? Pure water or salt water?
3) Why does the sea contain so much salt, but lakes, streams, and rivers do not have much salt at all?
4) True or False? With time, the seas have gotten less salty.
5) Why was pepper used in one of the experiments?
6) Where does deep water formation occur?
7) True or False? When ocean water freezes into icebergs and ice sheets, the ice is made up of water with no salt.
8) Which is denser? Cold water or warm water?

2. During the Lesson:

Here are some Fun Facts

- A. well-known density-driven current occurs where the saltier Mediterranean Sea empties into the Atlantic Ocean. During World War II submarines used this current to enter and leave the Mediterranean without even turning on their engines http://sciencehowstuffworks.com/

- If the salt in all of the earth's seas could be removed and spread evenly over the Earth's surface, it would form a layer more than 500 feet thick – that's about as tall as 2.5 Batman buildings (in Nashville)!
- The oceans move 1.4 trillion cubic kilometers of water each day!
- Radioactive tritium is used to trace the world's currents because it is easily detected and it travels at the same speed as the water carrying it.
- It takes a minimum of 500 years and up to 1,000 years for the oceans' water to cycle itself globally.

<u>Unpacking the Kit– What you will need for each section:</u>
Divide the class into 10 groups (of 3).

For Part II. Density Background Information and Demonstrations
10 oil/salt water bottles (1 per 3-4 students)

For Part III. Movement of Saltwater in the Ocean
10 containers of salt, 10 spoons, 10 rectangular containers, 10 16oz/500 mL bottles water
20 16oz cups with marked water level [~250mL]
2 blue food coloring dropper bottles
1 pair plastic gloves (for VSVS members to wear when using food coloring)
2 pepper container
10 oval plates

For Part IIIB. Cold Water in the Ocean
20 2oz jars with holes in lids
2 16oz styrofoam cups containing ice
2 L water
Food Coloring from Part III
10 plastic plates
10 Clear plastic squares

<u>Set-up:</u>
<u>VSVSers will put 2 drops of blue food coloring in 10 of the jars and then pack with ice.</u>
<u>(*Just before the students do this experiment, VSVSers will pour room temperature water into all containers so they are FULL.*)</u>

For Part IV. Where Are The Deep Ocean Currents?
32 World Maps with Ocean Salinity

I. Introduction to Ocean Currents

Learning Goals: Students understand the two types of ocean currents

Why is the science in this lesson important?
The movement of deep ocean currents are partly responsible for global temperatures, as they cycle cold water to different areas of the globe. Changes in deep ocean currents due to climate change can alter ecosystems around the world.

Ask students if they know the names of the 2 types of ocean currents?
Ocean currents are divided into 2 types - **surface** and **deep**.

Your Notes:

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Surface currents are driven by the wind blowing over the ocean, the earth's rotation, and large land masses.

Surface currents occur at the surface of the ocean.

They are only about 400m (1300ft) deep (occur in the top 400m of the ocean).

That's about that the height of two Batman Buildings! (192m (630.5ft))

Deep ocean currents are driven by the temperature and density of the water.

Sometimes they are called submarine rivers.

90% of the ocean water is moved by deep ocean currents.

Ocean water becomes denser when it is colder and has more salt dissolved in it.

Tell students they will investigate the behavior of dense salt water, which is similar to that found in the deep ocean waters AND the behavior of cold water compared with room temperature water

II. Density Background Information

Learning Goals: Students observe how manipulations of mass and volume affect density.

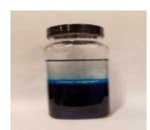
- Ask the students if they know what density is. Tell them that they can think of density as how much mass there is in a given fixed volume. A good example would be the different densities of a golf ball and ping pong ball. They have the same volume but different mass.

A. Density of Liquids - Demonstration

Learning Goals: Students investigate solutions with different densities and find that a lower density solution layers on top of a solution with higher density.

Materials

10 oil/salt water bottles (1 per 3-4 students)



Pass out the oil/salt water bottles. Tell students that the water was colored blue to make the layers easier to see.

Share that density is a **property** of solids, liquids, and gases.

- Ask students: what do you notice? *There are two separate layers, the saltwater is on the bottom and the oil is on the too*
- Ask students: why do you think the two liquids layer? *Saltwater is more dense than oil, so the oil floats on top of the saltwater*.

Write these facts on the board:

Pure water has a density of 1g/cm^3.

Ocean water at the sea surface has a density of about 1.027 g/cm^3.

Oil has a density of 0.83g/cm^3 (depends on type of oil – we used baby oil).

Tell students that a liquid with low density will float on top of a liquid with a high density.

III. Saltwater in the Ocean

Learning Goals: Students understand and observe how density drives deep ocean currents.

Why does ocean water have a higher salinity?

- Ocean water is saltier than fresh water.
- Ask students why they think the sea contains so much salt but lakes, streams, and rivers do not have much at all.

Your Notes:

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    - The salt in the ocean comes from the gradual process of weathering and erosion of the Earth's crust, as well as the wearing down of mountains.
    - Rain and streams then transport the salt to the sea.
- Some salts may have come from volcanic emissions when earth was being formed.
- Some salts also come from the magma at the mid-ocean ridges.
- As time has passed, the seas have actually gotten saltier. Evaporation of water from the ocean leaves salts in the ocean while weathering continues to add salts.

What kind of salts are in the ocean?

- Seawater is actually very complex and contains salts made up of combinations of at least 72 elements, most in very small amounts. Salts of sodium, chloride, magnesium, sulfate and calcium are the most abundant.

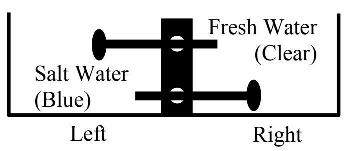
Divide the class into 10 groups (of 3).

Tell students they will make their own salt water and observe what happens when it "meets" fresh water.

Pass out the following materials to each group:

1 16oz bottle water
2 16 oz cups marked at the 250ml level
1 2 oz container of salt
1 spoon
1 plastic container with divider in middle and holes punched at bottom & top with plugs (aka nails) inserted
1 oval plate

1. Tell students to add water to ONE of the cups and add 3 full spoons of salt to it. Set this cup aside until the VSVS member comes to your table.
2. A VSVS member will add a squirt of blue food coloring to the SAME salted water cup until the solution is **dark blue**. **This is your salt water cup.**
3. Now add water to the second cup to the 250 mL mark. **This is the freshwater cup.**
4. Make sure the students understand the differences between the 2 waters. *The salt water (blue) is denser than the "fresh" water (clear).*
5. **VSVS members:** Draw a sketch of the container with the divider on the board. Tell students they will be adding the salt water to the LEFT side and fresh water to the right side **BUT NOT YET!** (point out that the sides of the container are labeled & make sure they have it turned the correct way)



6. Ask the students to predict what will happen when the 2 waters are added and plugs are removed.
   Accept all answers and write them on the board. Students may not have the correct answer at this time! **Do not correct them.**
7. Have one student per group be responsible for the salt water and another responsible for the fresh water. Tell these students to pour their water solutions into the correct sides **AT THE SAME TIME**

Your Notes:

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Check that the water level on both sides is above the top nail. If it is not, add water so that the level is above the nails. Do not proceed until this is done.

8. Tell the students that they are going to be removing the plugs and that they ALL need to be ready to observe the water from the sides of the container once the plugs have been removed.
   Have one student be in charge of the top plug on the salt water side and another student in charge of the bottom plug on the fresh water side.
   Tell them they will remove both plugs on the count of 3. **Count to 3 loudly, so everyone can hear.**
9. Have VSVS members go to each group to sprinkle pepper on the top of the water on BOTH sides. Once this is done, the students should also observe the water from the top.
   The other VSVS members should be circulating the room helping students.
10. Students should make their observations through of the sides and from the top of the container for about 5 minutes and record their observations on their observation sheet. Students may need to have their eyes at the level of the lowest nail to see what is going on.

11. Ask students what happens to the salt water.
    It moves through the bottom hole underneath the clear fresh water.

12. Ask the students what happens to the fresh water.
    It moves through the upper hole and layers on top of the blue salt water.

13. Ask the students what they noticed when the pepper was added.
    The pepper/water on the right (originally just clear water) seemed not to move much, but the pepper/water on the left side (originally blue salt water) is moving away from the hole and is circling around that side.

Explain to the students they have just created currents, similar to those in the ocean. The blue salt water is more dense than the fresh water, so it acts like the colder, saltier water of the ocean while the fresh water acts like the warmer, less salty water of the ocean. Deep ocean currents are formed when denser water sinks/flows beneath less dense water, which in turn flows on top of the denser water, as they observed in their experiment.

You can also mention that when the pepper water hits the side of the container and circles around the left side, the effect is similar to that of water hitting large landmass – one of the causes of surface currents.

Set aside the model – the students can refer to it as they look at the map of ocean currents. They will observe the model again before the end of class to see that there are 2 distinct layers that do not seem to be mixing.

IIIB. Movement of Cold Water in the Ocean

Learning Goals: Students understand and observe how temperature drives deep ocean currents.

Your Notes:

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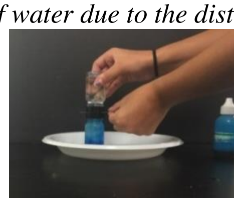
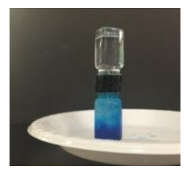
Materials
20 2oz jars with holes in lids
Ice
Water
Food Coloring
Plates
Plastic squares

Set-up:

VSVSers will have already put 2 drops of blue food coloring in 10 of the jars packed with ice.
Now pour room temperature water into all containers so they are FULL.
Tell students that the blued water tells them that the water is COLD.

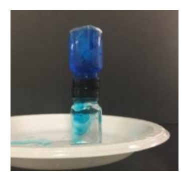
Students must do the following in this order:

1. Take one bottle of cold and one of room temperature. Place the plastic square on top of the ROOM TEMPERATURE bottle. Hold the square securely to keep water from pouring out, turn it upside down and place on top of a bottle of blue cold water. Once in place, have one member of the group (or VSVSer) hold the 2 bottles securely and slide the plastic square out. Observe what happens. *Not much! There may be some initial movement of water due to the disturbance created when the plastic is removed.*

2. Separate the 2 bottles (a little water will spill, so keep on the plate. "Top" up the bottles with water if needed. (It is important to have both bottles full to the top.)

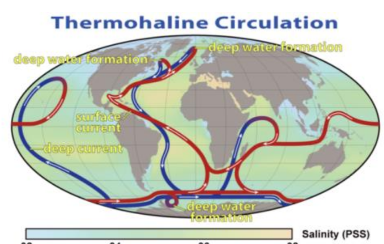
3. Place the plastic square on top of the COLD bottle, turn it upside down and place on top of the room temperature water bottle. Once in place, have one member of the group (or VSVSer if needed) hold the bottles securely and slide the plastic square out. Observe what happens. *The cold water will flow, and continue to flow, into the bottom warmer bottle.*



Explanation: Cold water is denser than warm water and so will sink to the bottom. Warm water will rise up through cold water. Cold water will sink below warmer water.

IV. Where Are The Deep Ocean Currents?

Tell students to look at the map of ocean currents (pass this out if you haven't already).
Have the students notice where **deep water formation** occurs (*3 areas in the Arctic & Antarctic)*.



Robert Simmon, NASA
http://earthobservatory.nasa.gov/Features/Paleoclimatology_Evidence/paleoclimatology_evidence_2.php

Explanation:

- The biggest source of deep water is highly saline surface water from the Gulf Stream in the North Atlantic. This water is cooled by the polar air and sinks to the bottom. It flows south to Antarctica.

Your Notes:

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- The densest water is in the Weddell Sea of Antarctica. It forms in the southern winter when sea ice forms, leaving more salt in the water below the ice. This water sinks to the bottom of the ocean and flows north.

- The average temp of **surface** sea water is 17.5 ºC (63.5 ºF). 75% of **all** ocean water has a temperature of between 0 ºC (32 ºF) and 5 ºC (41 ºF). So most of the water that fills the oceans is much colder than surface water.

- When ocean water freezes into icebergs and ice sheets, the ice is made of pure water with no salt. That salt is left in the water, so the ocean becomes saltier and denser. (This can be related to the marble demonstration **-** if all of the salt remained but a few marbles were removed, (became ice) then there would be more salt per marble).

- Have them trace the paths of the current with their fingers, following the arrows. Start at the northern-most point. Tell students that the entire trip for the current to return to its starting point can take over 1000 years!

- Have students look at where the water appears to warm up (blue changes to red). *This happens in warm areas of the world, near Hawaii and off the coast of Africa*.When the blue line turns red, the water has become less dense by warming up and/or becoming less salty, and hence rises above the denser water.

Have students look once more at their water experiment to notice the layering effect of the salt water and fresh water. Explain to them that these layers will remain separated for several hours

V. Review

- Ask students why saltwater is more dense than freshwater? *For the same volume of saltwater and freshwater, saltwater is more dense because it has a higher mass*.
- Ask students: What can we say about cold water versus warm water?
  Cold water sinks.
  Warm water rises.

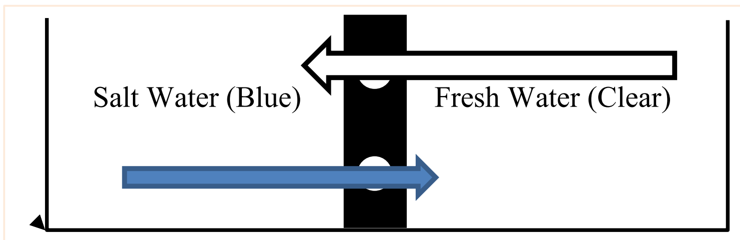
Lesson written by: Patricia Tellinghuisen, Program Coordinator of VSVS 1998-2018, Vanderbilt University
Courtney Luckabaugh, VSVS Lab Assistant, Undergraduate, Vanderbilt University

Your Notes:

Deep Ocean Currents Answer Sheet

Name ______________________________

1. **Draw arrows on the diagram below showing the movement of the blue salt water and the clear fresh water.**

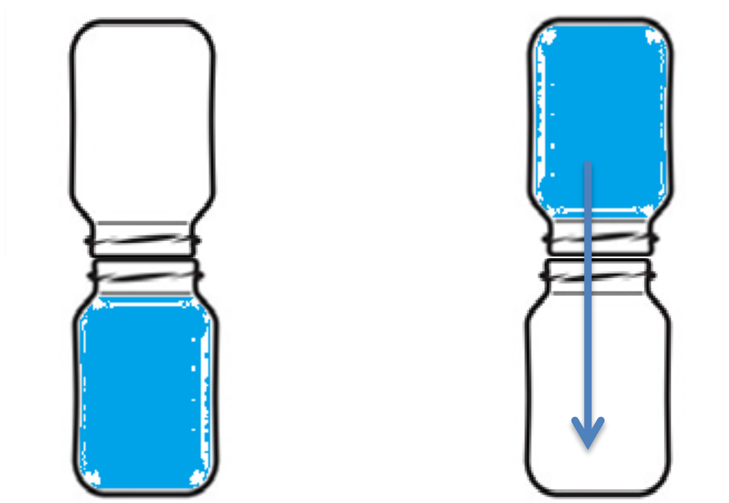


What happens to the salt water? *Moves through the bottom hole and stays below the fresh water*

What happens to the fresh water? *Moves through the top hole and stays above the salt water*

What happens to the pepper? *The pepper/water on the right (originally just clear water) does not move much, but the pepper/water on the left side (originally blue salt water) moves away from the hole and is circling around on that side.*

2. **Draw arrows on the diagram to show the movement of blue cold water and the clear room temperature water.**



Look at the map of ocean currents to answer the following questions.

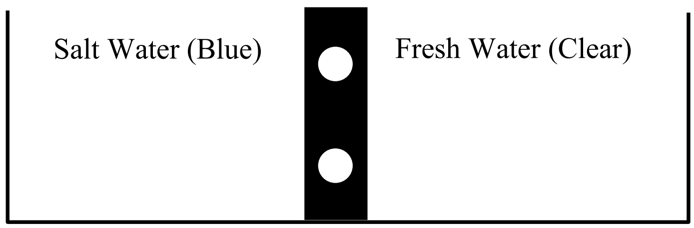
In what parts of the Earth does deep water formation occur? *3 areas in the Arctic & Antarctic*

Why does deep water formation occur in these regions? *Cold temperatures and salty water.*

Deep Ocean Currents Observation Sheet

Name ______________________________

1. **Draw arrows on the diagram below showing the movement of the blue salt water and the clear fresh water.**



What happens to the salt water? ____

What happens to the fresh water? ____

What happens to the pepper? ____

2. **Draw arrows on the diagram to show the movement of blue cold water and the clear room temperature water.**

3. **Look at the map of ocean currents to answer the following questions.**

In what parts of the Earth does deep water formation occur? ______________________

Why does deep water formation occur in these regions? __________________________

Your Notes:

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VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
http://studentorg.vanderbilt.edu/vsvs

Saltwater Density

Spring 2019

Goal: To demonstrate the concept of density using saltwater, and to share some information about the salinity of oceans.
Fits Tennessee standards 6.ESS2.1

VSVSer **Lesson Outline:**

________ **I. Introduction - Saltwater in the Ocean:**
The VSVS team will share some information about oceans with the students.

________ **II. Density Information and Activities**

A. Density Background Information: VSVS team members will explain the concept of density.
B. Density Demonstration: VSVS volunteers will show students how salt packs around water molecules using a jar of marbles and salt.
C. Polydensity bottle
D. **Floating Solids Demonstration**: Students will observe two vials: one with saltwater and one with freshwater. A plastic bead will float in the saltwater but not in the freshwater, this illustrates the concept of density and floating..

________ **III. Separation Challenge**: Students will separate a mixture of beads using the concept of density. There are four types of beads with differing densities. As students add salt to the water, the density changes, the beads will float according to their densities.

________ **IV. Review**

LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM (https://studentorg.vanderbilt.edu/vsvs/lessons/)
USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.

1. Before the lesson:
In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.
1. What's the difference between density and mass?
2. What region of the globe is home to densest salt water?

2. During the Lesson:
Here are some Fun Facts for the lesson
Density of salt water: 1020 kg/m^3
Density of the human body: 1062 kg/m^3
Density of the Dead Sea: 1240 kg/m^3
Least dense? The universe: estimated at 10^{-27} kg/m^3
Most dense? A black hole; "infinitely" dense

Draw an analogy to a pinhole and a football field. If you compress a football field into the size of a pinhole, the football field would have a very high density. If you shrank the football field into a tiny, tiny space, just a little more than nothing, you'd have the density of the singularity of a black hole. A singularity of a black hole is a one-dimensional point that contains infinite mass

Your Notes:

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in an infinitely small space (this example may be too advanced for the class, so share accordingly).
Refer to Disney's Despicable Me. In Despicable Me: when Gru shrank the moon, he decreased the volume, without altering the composition of the moon (i.e. the mass did not change). So the density would have increased. So it would be impossible for Gru or a spaceship to lift the moon.

<u>Unpacking the Kit – What you will need for each section:</u>

For Part I: Introduction - Saltwater in the Ocean
32 Observation Sheets, 16 Instruction Sheets, 16 World Maps with Ocean Salinity and Density Graphs

For Part II. Density Information and Activities
B. Density Activity

6oz container of salt, 1 6oz jar containing marbles

C. 1 Polydensity bottle

D. Floating/Sinking Beads

16 bags with1 vial of saltwater and a plastic bead (#1), 1vial of regular water and a plastic bead (#2)

For Part III: Separation Challenge – Changing the Density of Water to Make Beads Float
16 containers of kosher salt, 2L bottle of water, 16 100 mL plastic jars containing several beads of 4 different colors/shapes filled with water.

a. Ziploc bags containing:1 measuring spoon, 1 coffee stirrer, 16 plates

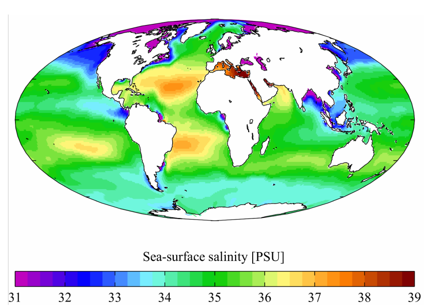
I. Introduction - Saltwater in the Ocean

Learning Goals: Students learn about salinity differences in the ocean.

Why is the science in this lesson important?
The density of saltwater can impact global currents that wildlife use to migrate around the ocean. Thus an understanding of saltwater density is relevant to oceanologists, fishermen, and anyone who relies on the sea for a living.

Tell students that:

- Oceans and seas contain considerably more salt than freshwater. Ask students why they think the sea contains so much salt but lakes, streams, and rivers have very little.
- The salt in the ocean comes from the gradual process of weathering and erosion of the Earth's crust, as well as the wearing down of mountains.
- Salinity is the amount of dissolved salts in water.



http://en.wikipedia.org/wiki/Salinity

Have students look at the map of the world handout.

- As students can tell from the map, the oceans vary widely in salt concentration.
- The numbers in the key (at the bottom) are measures of salinity. 35 means there are 35 grams of salt per 1000 grams (1 kilogram) of water. The higher the number, the more salt that ocean contains.
- Ask students if they can point to the saltiest area. The saltiest water occurs in the Red Sea and the Persian Gulf.

Your Notes:

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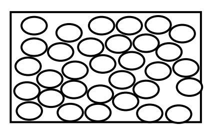
- The average salinity of water in the ocean is 35 PSU.

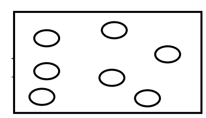
II. Density Information and Activities

Learning Goals:
Students learn the definition of density, and that density is a physical property of matter.
Students observe that solids (beads) of different densities float or sink depending on the density of the liquid they are in.

A. Density Background Information

- Ask the students to explain the property of **density**.
  - **Density** is a physical property of matter.
  - Each element and compound has a unique density associated with it.
- Ask students to give you some examples of high density objects and low density objects. Some examples might be:
  - Regular coke can vs. Diet coke (diet floats in water, regular sinks)
  - Oil (less dense) vs. water (more dense)
  - 1 golf ball (more dense) vs. 1 cotton ball (less)
- Sum up the difference between high density and low density with these generalizations:
  - **High density** means there is a **lot of material** in a **given space** (volume)
  - **Low density** means there is **little material** in a **given space** (volume).
- Have students look at the pictures on their Instruction Sheet. The circles represent material. Both pictures have the same space (area), but the high density picture has much more material (circles).





High Density

Since D = m/V, more mass (circles) in a given volume increase in density.

Low Density

B. Demonstration

Materials:
1 6oz container of salt
1 6oz jar containing marbles

- Show students the jar with marbles in it.
- Tell the students that the marbles represent water molecules.
- Pour the container of salt into the jar.
- Explain to the students that the salt packs around the marbles like it does around water in salt water.
- Ask students why they think saltwater is denser than regular water. *Saltwater has a higher mass because of the added salt, and hence is denser.*

C. Polydensity Bottle Demonstration

- Have students observe the polydensity bottle. Shake the bottle gently and let the students observe what happens (the 2 liquids gradually separate).
- Ask students what happened? *First the white beads moved to the top and the blue beads moved to the bottom of the liquid (refer to background*

Your Notes:

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information). Then the white beads floated down and the blue beads floated up and met in the middle.

- Ask students why they think this happened?
  - *The two liquids have different densities.*
  - *One of the liquids is denser salt water (lies below the beads on the bottom).*
  - *The other liquid is less dense rubbing alcohol (lies above the beads on the top).*
  - *These 2 liquids do not mix, they form layers (salt water on the bottom & rubbing alcohol on the top)*

  - *The beads also have different densities:*
    - *The blue beads are denser than the white beads and less dense than the salt water (they float on the salt water).*
    - *The white beads are less dense than the salt water and blue beads, but denser than the rubbing alcohol (they float on the blue beads but not on the rubbing alcohol).*

For VSVS background information only: The bottle contains a mixture of isopropyl alcohol and saltwater. All of the liquids and beads have different densities. The rubbing alcohol is the least dense followed by the white beads, then the blue beads, with salt water being the densest. <u>When the two liquids are forced to temporarily mix by shaking, the liquid formed has a density somewhere between those of rubbing alcohol and saltwater.</u> As the two liquids separate once more (due to their different densities), the initial layering reoccurs: the blue beads float to the top of the saltwater layer because they are less dense than saltwater, and the white beads float to the bottom of the isopropyl alcohol layer because they are more dense than the isopropyl alcohol.

D. Floating/Sinking Beads

Learning Goals: Students observe how density of a liquid impacts beads' ability to float.

Materials:
16 bags containing
1 vial with saltwater and a plastic bead (#1)
1vial with regular water and a plastic bead (#2)

Pass out the bags containing the vials with the beads to pairs of students. **Make sure that students do not remove the tops of the vials. Tell students that the 2 liquids have different densities.**

Explain to students that:

- solids that are less dense than a liquid will float in that liquid.
- solids that are denser than a liquid will sink in that liquid.

Tell students that the beads in all of the vials have the same density.

Ask students why the bead floats in vial 1 but not in vial 2.

- *Vial #1 has a liquid that is denser than the bead.*
- *Vial #2 has a liquid that is less dense than the bead.*
- *Tell students that the liquid in vial #1 is salt water and in vial #2 is regular water.*

Point to the facts on the board:
Pure water has a density of 1g/ml.
Ocean water at the sea surface has a density of about 1.027 g/ml.
Saturated salt solution has a density of 1.202 g/ml.

Ask students why they think **saltwater is denser than regular water.**
Saltwater has a higher mass because of the added salt but still occupies the same amount of space in a container that regular water would, and hence is denser.

Your Notes:

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Ask students if the bead is more or less dense than regular water. *More*
Ask students if the bead is more or less dense than saltwater. *Less*

III. Separation Challenge – Changing the Density of Water to Make Beads Float

Learning Goals: Students observe how density of a liquid impacts beads' ability to float.

Distribute to each **pair** of students:

1 plate
1 100mL jar containing water and several colored beads
1 measuring spoon (pink 1/4tsp)
1 Coffee Stirrer
1 container of salt
32 Density Graphs (Handouts)

Tell students to:

1. Observe that there are 4 different beads. Tell students that the beads have different densities. They are (see student handout):

Bead	**Approximate Density**
#1, white, oval	**< 1.00g/mL**
#2, blue, cylindrical	**1.05-1.07g/mL**
#3, yellow, cylindrical	**1.13-1.16g/mL**
#4, clear, cylindrical	**> 1.276g/mL**

2. **Pure water has a density of 1g/mL**
3. **A saturated salt solution has a density of 1.202 g/ml**
4. Ask students to explain why the white oval beads are floating? *Their density is less than that of pure water.*

Tell students that we can gradually change the density of the water by adding salt to it.

5. Tell students to look at the Density of Salt Water graph and explain that the density of water increases as more salt is added.
6. Ask students: What do you think will happen to the beads when salt is added to the water?
   Since the beads have different densities, they will float in different densities of salt water.
7. Ask students to predict the order that the beads will float.

For VSVS Information: The density of the salt water has been calculated using a mass of 1.63 g for one ¼ teaspoon of salt and 100mL for volume.
The density of regular (fresh) water is 1g/mL. 100mL = 100g
(Since D = m/V, the density of water is 100g/100mL, = 1g/mL)
The density of the saltwater is calculated using:
100g of water + (1.63 grams X # of 1/4-teaspoons of salt added) / 100mL

Tell students to:

1. Stir the beads and water, using the **coffee stirrer (not the spoon)**.

Your Notes:

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2. Tap all of the floating beads gently to see which ones float and which beads sink to the bottom.

Share the following explanation with the students: some of the beads float initially because water has a high surface tension. This surface tension is mostly due to the high intermolecular forces between water molecules making it possible for some things that would normally sink to float. Tapping the bead exerts enough force to break the surface tension. Stirring the water may also break the surface tension.

3. Record on their observation sheets, which beads are floating and which are at the bottom of the cup. *The round whitish beads should be the only ones floating at this point.*
4. Fill the spoon with salt (do not overfill).
5. Add one level spoon of salt and then stir the water until they can no longer see salt particles.
6. Record what happens. Are any more beads floating on top?

There shouldn't be any beads floating on top.

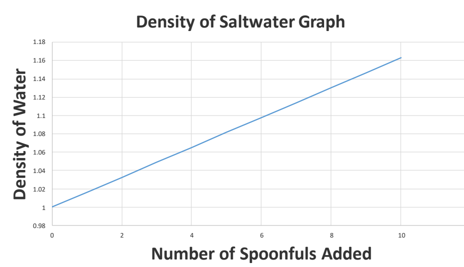
7. Have students repeat this step. Record what happens after each spoon is added.
8. Students can add several more spoons; but tell them not to go higher than 10 spoons of salt total.
9. After 10 spoons, have students screw lid on jar. Make sure it cannot leak. Place jars in kit box so that NO water will leak into box – ie upright!

Note: In the lab, 3 or 4 1/4- teaspoons of salt were required for the blue beads to float and 7-9 spoons were necessary for the yellow beads to float. This may vary depending on students' "level teaspoons". The clear beads will not float at all. Their density is greater than that of a saturated salt solution. Students can add several more spoons; tell them not to go higher than 10 spoons of salt total. The salt solution eventually becomes saturated and no more salt will dissolve.

V. Results

Ask students if their predictions were correct.

- The white beads floated initially, because their density is less than one.
- The beads floated in the order of their densities, white, then blue, then yellow.
- The clear beads never floated. The students should have noticed that salt stops dissolving in the water. This is called a saturated solution.



- Ask students if they can think of a way to make the clear beads float.
  - *We could use liquids more dense than saltwater for the clear beads.*

Tell students to look at the Density Table for Recyclable Plastics (on their Handout) and determine what kinds of plastics might have been used in this lesson.

Density Table

Substance	Density (g/mL)
Water	1.00
(1) PETE	1.38-1.39
(2) HDPE	0.95-0.96
(3) PVC	1.16-1.35
(4) LDPE	0.92-0.94
(5) PP	0.90-0.91
(6) PS	1.05-1.07

IV. Review

- Ask students: If a solid floats in a liquid, is it denser or less dense than the liquid? – *Less* If it sinks -*more*
- Ask students why saltwater is more dense than freshwater?

Your Notes:

Saltwater has a higher mass than the same volume of freshwater.

- Ask students: what is one way to separate mixtures? *Density*

References: Educational Innovations Mixture Separation Challenge, and Polydensity Bottle.

Lesson written by: Patricia Tellinghuisen, Director of VSVS 1998-2018, Vanderbilt University
Michael Gootee, VSVS Lab Assistant

Your Notes:

Observation Sheet - Saltwater Density

IIC. Floating/Sinking Beads in Vials

Is the bead more or less dense than freshwater? ___________

Is the same bead more or less dense than saltwater? ___________

III. Separation Challenge

Look at the table of bead densities and predict the order in which they will float as spoons of salt are added to the water.

1.____

2. ____

3. ____

4. ____

Bead	**Approximate Density**
#1, white, oval	**< 1.00g/mL**
#2, blue, cylindrical	**1.05-1.07g/mL**
#3, yellow, ylindrical	**1.13-1.16g/mL**
#4, clear, cylindrical	**> 1.276g/mL**

Write down what happens to the beads after each addition.

Number of Spoons Added	**Density salt water**	**What Happened to the Beads?**
0	1.00	
1	1.0163	
2	1.0326	
3	1.0489	
4	1.0652	
5	1.0815	
6	1.0978	
7	1.114	
8	1.1304	
9	1.1467	
10	1.163	

Look at the Density Table for Recyclable Plastics (on your Handout) and determine what kinds of plastics might have been used in this lesson.

white, oval = __________________ **blue, cylindrical =** ____________________

yellow, cylindrical = __________________ **clear, cylindrical =** ____________________

Observation Sheet Answers - Saltwater Density

IC. Floating/Sinking Beads
Is the bead in the vial more or less dense than freshwater? **More**_____
Is the same bead in the vial more or less dense than saltwater? **Less**______

III. Separation Challenge
Look at the table of bead densities and predict the order in which they will float as spoons of salt are added to the water.
1.**white, oval** will float in pure water, since its density is less than the density of water

2.**blue, cylindrical**

3. **, yellow, cylindrical**

4. **clear, cylindrical**

Bead	**Approximate Density**
#1, white, oval	**< 1.00g/mL**
#2, blue, cylindrical	**1.05-1.07g/mL**
#3, yellow, cylindrical	**1.13-1.16g/mL**
#4, clear, cylindrical	**> 1.276g/mL**

Write down what happens to the beads after each addition.

Number of Spoons Added	**Density salt water**	**What Happened to the Beads?**
0	1.00	
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3	1.0489	
4	1.0652	
5	1.0815	
6	1.0978	
7	1.114	
8	1.1304	
9	1.1467	
10	1.163	

Look at the Density Table for Recyclable Plastics (on your Handout) and determine what kinds of plastics might have been used in this lesson.
white, oval = HDPE, LDPE, PP **blue, cylindrical = PS**
yellow, cylindrical = PVC **clear, cylindrical = PETE, PVC**

VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
http://studentorg.vanderbilt.edu/vsvs

Vacuums and Air Pressure

Spring 2019

Goals: To introduce students to atmospheric pressure and vacuums
https://www.youtube.com/watch?v=Ssqi-CkysvQ
Fits TN Standards: 6.ESS2.6

VSVSer Lesson Plan

______ **I. Introduction to Air Pressure**

A. What is the Atmosphere?

B. What is Air Pressure?

- Activity: Water in a jar held upside-down remains inside when covered by a card.

C. Atmospheric Mat: How can we Prove Air Pressure Exists?

- Activity: Pressure acting on a mat prevents it from being picked up in the center.

______ **II. What is a Vacuum?**

A. Investigating the Action of a Vacuum Pump: How does a Vacuum Pump Work?

- Activity: The force required to pull a piston increases as more air is removed.

B. Does Air have Mass?

- Activity: The mass of a jar previously held under vacuum increases when air enters it.

C. Demonstration: How Much Air is Being Removed from the Bell Jar?

- Activity: Water rushes into a jar held under vacuum because no air is inside that jar.

______ **III. What Happens when Air Pressure is Decreased?**

A. Balloon in Jar: Pressure is All About Balancing the Inside and the Outside!

- Activity: A deflated balloon inflates when placed in a vacuum.

B. Marshmallow: How are Marshmallow Bubbles like Balloons?

- Activity: A marshmallow expands when placed in a vacuum.

C. The Suction Cup (Optional)

- Activity: Removing atmospheric pressure causes suction cups to fall.

______ **IV. Use Magdeburg Hemispheres to Illustrate Air Pressure (Optional)**

- Activity: Atmospheric pressure acting outside a hemisphere holds it in place.

______ **V. Review**

Materials

1 Atmospheric mat
1 bag containing 15 Madgeberg hemispheres – change if can to increase from 10-15
11 plastic bags with a 1bell jar, syringe and tubing (10 for students, 1 for VSVS members
1 bag containing 10 balloons, slightly inflated (about 3-4 cm in diameter). The balloon should easy to put into bell jar
1 bag containing 10 large marshmallows
1 bag containing 10 suction cups
1 plastic container with 10 scales
1 tub about 3L, large enough to immerse bell jar into it
3L water to fill above container
1 plastic box containing:
  1 jar (2oz) and 1 laminated card
  100 mL water in bottle
16 handouts
32 observation sheets

1 box of goggles (for all to wear)

Before the Lesson: In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.

Lesson Quiz

1. How does the atmosphere cause atmospheric pressure?
2. If you squeeze a marshmallow, the pressure from your hand crushes it. Why does air pressure not crush humans?
3. What is the purpose of a check valve?
4. True of False: The inside of a deflated balloon is completely empty.
5. Why does a deflated balloon inflate when it is placed in a vacuum?

Divide students into groups of 3-4 (there are 10 sets of bell jars).

Unpacking the Kit

I.B What is Air Pressure?

Pass out student handouts and observation sheets.

1 plastic box containing:

1 jar (2oz) and 1 laminated card

100 mL water in bottle

I.C. Atmospheric Mat

1 Atmospheric mat

II. What is a Vacuum?

A. Investigating the Action of a Vacuum Pump

Distribute the bell jar apparatus – there are 10 per class (plus one for VSVS members to use), so divide students into groups of 3-4. D

Distribute goggles to all students.

B. Does Air have Mass?

Distribute the10 scales to groups.

C. Demonstration: How Much Air is Being Removed from the Bell Jar?

1 tub large enough to immerse bell jar into it

3L water to fill above container

Fill the plastic tub with water

III. What Happens when Air Pressure is Decreased?

A. **Balloon in Jar**

Pass out 10 slightly inflated balloons

B. **Marshmallow**

Pass out 10marshmallows

C. **Suction Cup (optional, time permitting)**

Pass out 10 suction cups

IV. Use Magdeburg Hemispheres to Illustrate Air Pressure (Optional)

Distribute 15 Madgeberg hemispheres

Students and volunteers must wear goggles at all times

Your Notes:

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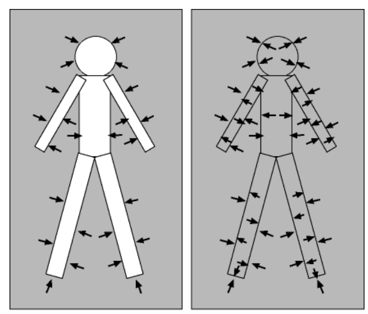
I. Introduction

Learning Goals:
Students understand that gases in the atmosphere create an atmospheric pressure that acts in all directions.
Students understand that vacuums decrease pressure within an enclosed region. Students understand that air, which consists of elemental and small molecular gases, has mass.
Students understand that pressure acts both within and outside a region, and that these two forces must be in balance. Students can conceptualize that decreases in pressure cause increases in volume.

A. What is the Atmosphere?

Our planet is wrapped in a blanket of air called the atmosphere. The atmosphere is a thin layer of gases as well as liquid and solid particles.
Ask students if they know what gases are in the atmosphere? – Nitrogen, Oxygen, carbon dioxide, argon plus very small amounts of "trace" gases.
What are other particles in the atmosphere? Water vapor, dust, smoke, chemicals….

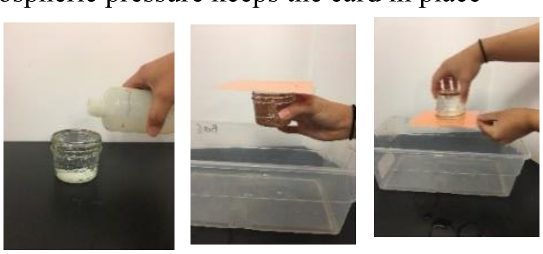
B. What is Air Pressure?



Gravity acts on the air
All of these gases and particles have mass. The weight of the air above earth presses down on us - we call this atmospheric pressure.
Can you feel the atmosphere? Why don't we get crushed?
Because at the same time as the atmosphere is pushing down on us, pressure is being applied equally in all directions outside and inside our bodies.

Demonstration:

Materials: 1 plastic box containing ar of water plus card
Fill the glass jar with water and cover it with a card. Hold jar over plastic box. Invert jar (slowly) while holding on to card. Carefully remove hand from card.
The card remains "attached" to the jar, and the water stays in the jar.
Atmospheric pressure keeps the card in place



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C. **Atmospheric Mat**

If you can't feel the atmosphere, how do you know it is there?
Demonstration:

Place the mat on a **flat-topped** desk or table. Move it around the table to show students that it is not glued down.
Pick it up by its edge. Easy!
Ask a volunteer, or the teacher, or another VSVS member to try to pull the mat up, using the hook.

Put it down again and lift it by the hook. Impossible!
Release the hook, and lift it by the edge again to show that it is not stuck at all.

Attach it to a free-standing object (a stool, book,….) and demonstrate that you can lift the object

Explanation:
The mat is held down by atmospheric pressure, which is approximately 15 pounds per square inch.
The area of the mat is about 100 square inches (10.5 x10.5).
A quick calculation leads to a total pressure of over 1500 lbs pushing down on the mat (assuming no air at all is under the mat).
Note **-** Imperfections in the rubber can lead to bumps and leaks, breaking the seal.

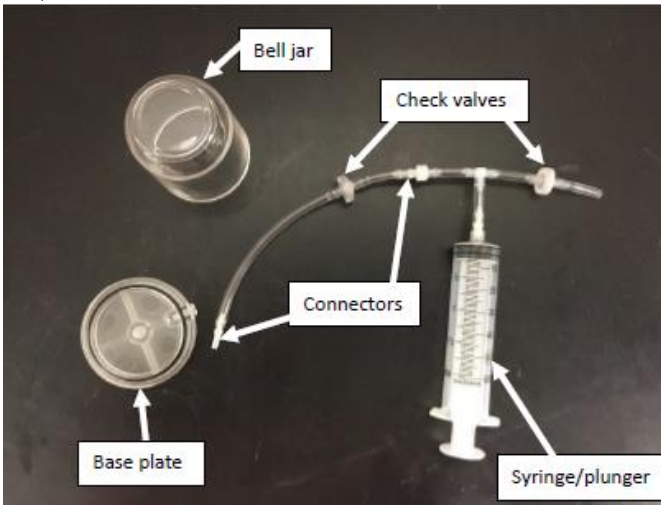
The Atmospheric Mat is unique in that you don't need to apply any force to make it work.
(Suction cups, for example, also stay put because of atmospheric pressure, but the way they are applied may make it seem like they adhere to the surface, rather than being pushed there from outside.)

II. What is a Vacuum?

A. Investigating the Action of a Vacuum Pump

Distribute the bell jar apparatus – there are 10 per class, so divide students into groups of 3-4.

Show students the handout of the apparatus. Point out the parts: a bell jar and its base, syringe/plunger, tubing with 2 check valves, connectors



Your Notes:
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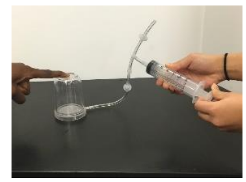
1. **Ask** students what is in the bell jar? *Air is present - nothing is not the correct answer*.
2. Have one team member pull the syringe to the top. Team members take turns listening to the "short" tubing end while the piston is pushed back in. They will hear air coming out.
   Point out the check valves. The check valves will allow air to flow in one direction but not in the other. See diagram.



3. Tell one person in each group to push down on the bell jar to make certain that the bell jar is pressing against the "O" ring. Another student should pull the syringe out to the 60 mark.
   Ask students where does the air come from that fills the syringe?
   The air comes from the bell jar (so there is now less air than in the bell jar than before).
   How hard was it to pull out the piston? (*Not very*).

4. Let go of the piston and watch what happens. Now push the piston all the way back into the syringe. Where did the air go (hint – listen for the sound of moving air at the end of the open tube*). Air moves out of the open end at point E*.
5. Repeat the following steps five times in rapid succession:
   a. Pull the piston out to the 60ml mark;
   b. Let go of the piston, and see what happens;
   c. Push the piston all the way in.

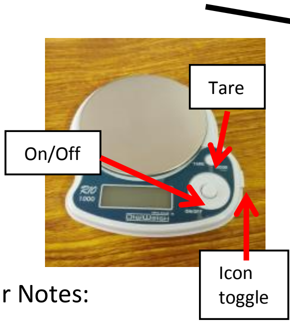
Ask students: what happened to the amount of force required to pull out the piston? (*The force needed increased*.*)*
Explain why. (Less air pressure inside the jar, which used to initially helped push the piston out)

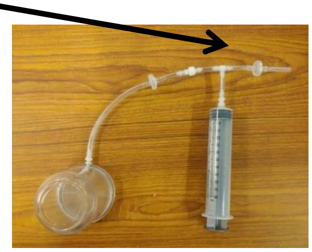
6. Repeat the steps in #5 another 10 -15 more times until it is very difficult to pull the piston out.
7. What has happened towards the end of the pull/pushes? What is in the bell jar now? (*Very little air will be in the jar = partial vacuum)*

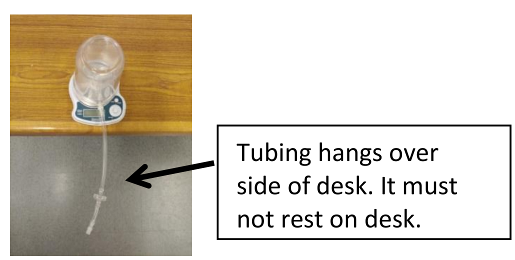
8. Tell students to keep the vacuum in the jar for the next experiment.

B. Does Air have Mass?

1. Tell students to place the scale on flat surface, remove any protective cover, and turn it on.
2. Press the on/off button to switch on and wait until "0.00" is shown on the screen. .
3. Make sure it is zeroed by pressing the button labelled T,- this is called taring.
4. The icon in the screen should read "g". If it does not, toggle the "mode" button (on the side) until it does. There are other icons – oz, ozt and ct. We want to measure the mass of the bell jar plus its air in grams.
5. Detach tubing where tubing couples into syringe assembly. Do this by twisting gently.





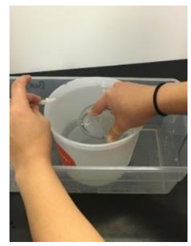


Your Notes:

6. Place bell jar apparatus with this remaining small piece of tubing on the scale. Place the scale close to the edge of the table, the tubing can hang over the edge (you do not want the tubing to rest on the table.)
7. Mass the above set-up. and record the value.
8. Remove the tubing from the bell jar so that the air rushes in.
9. Replace the tubing and mass the apparatus again.

Was there any difference? (In the VSVS lab, *we found it about .1-.3 g lighter*)

Demonstration: How much air is being removed from the bell jar?



Fill the plastic tub with water.
Repeat the procedure for evacuating the jar: pull the piston of the syringe to the 60 ml mark and push it all the way back in. Do this 24 times in rapid succession.
Detach tubing where D tubing couples into syringe assembly. Do this by twisting gently.
HOLD THE BELL JAR UPSIDE DOWN and immerse it in the bucket of water. While the jar is immersed, detach the tubing from the bell jar. Water will fill the chamber. CAREFULLY lift the bell jar out, keeping the jar and its bottom intact. Turn upright and show students how much water and air is in the jar.

D. What Happens when Air Pressure is Decreased?

What happens to the volume of an object when the pressure is changed?

VSVS Information only: Use the equation PV=nRT If you decrease the pressure, the volume will increase.

Ask students if they have noticed what happens to a plastic bottle if it is carried up to a higher altitude (such as going up a mountain)?

As air pressure decreases, the density of the contents decreases as well. The plastic bottle may feel "tighter" as the gas expands.
On the other hand, a plastic bottle will look "crushed" if it is taken from high altitude (lower air pressure) to sea level where the pressure is greater.

A. Balloon in Jar:

Show students the slightly inflated balloon (about 3-4 cm in diameter). The balloon should be tight.
Ask students to hypothesize what will happen to the volume of the air in the balloon if the pressure is decreased?
Tell students to place the balloon in the bell jar and make sure that no part of the balloon touches the black O-ring of the bell jar.
Tell one person in each group to push down on the bell jar to make certain that the bell jar is pressing against the "O" ring. Another student should pull the syringe out to the 60 mark and start pumping the piston:

What happens to the balloon after a few pumps? *It grows larger*.

Your Notes:

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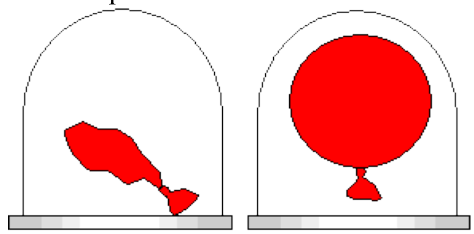
Why? *The pump removed air surrounding the balloon that had been pressing inward. The air inside the balloon wants to stay at the same pressure as the air around it. The air inside the balloon is still pressing outward, so the balloon expands.*

What do you think will happen when the chamber is re-pressurize?

Loosen the end connected to the bell jar. What do you hear, and what happens to the balloon*? Air moves back into the bell jar and crushes the balloon.*

Explanation:

If you put a partly blown up balloon in a bell jar and then pump out the air from the bell jar the balloon will slowly expand. This is because the air inside the balloon is at a room pressure and when the air outside the balloon is removed there is a bigger pressure difference between the inside and outside of the balloon. The balloon therefore expands to balance this difference.



This is how our lungs fill with air. A muscle called the diaphragm contracts downward to increase the space in your chest. As volume increases, pressure decreases. Imagine the balloons represent your lungs. Since there is now less pressure pushing against your lungs, they begin to expand as outside air rushes inside.

B. **Marshmallow** . Repeat with a marshmallow. Predict what will happen. Marshmallows have small bubbles of air trapped inside them. These bubbles are at atmospheric pressure. When the air inside the container is sucked out the pressure is reduced. The air bubbles inside the marshmallows are therefore at a much higher pressure than the air surrounding the marshmallows, so those bubbles push outwards, causing the marshmallows to expand. When air is let back into the container, the surrounding pressure increases again, and the marshmallows deflate back to their normal size.

Note that the marshmallow now looks funky.

Some of the gas inside the marshmallow was also drawn out of the chamber so there is now less air in the marshmallows than before. What happens if you try it again with the same marshmallow?

VSVS Information only: This illustrates <u>Boyle's Law</u> (as the pressure on a gas decreases, its volume increases).

C. The suction cup – optional if time permits

Stick the suction cup firmly to the stop of the bell jar.

a. Why does the suction cup stick to the jar? *Atmospheric pressure of 15lb per square inch pushes on the suction cup (and us)*

b. What do think will happen when some of the pressure is removed?

Your Notes:

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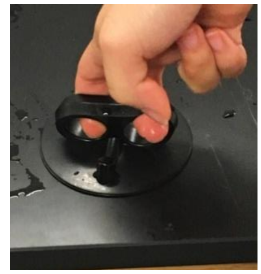
Pull the piston of the syringe to the 60 ml mark and push it all the way back in. Repeat until something happens to the suction cup.
The suction cup eventually falls off because the pump has removed the outside pressure that held the cup on the surface.



IV. Optional – If Time Permits Use Magdeburg Hemispheres to Illustrate Air Pressure

Background Information:

Historically, the Magdeburg hemisphere is a pair of copper hemispheres that can be sealed together, by applying grease around the rim, then connected t a vacuum pump so as to create a near "perfect vacuum" inside of the sealed sphere. In this vacuumed-out state, the pressure of the weight of surrounding atmosphere, (piled upwards of 62-miles above the sphere), acts to hold the spheres together tightly with great force by pressing inward on the outer casing.
The Magdeburg hemispheres were invented by German engineer Otto Guericke who became mayor of Magdeburg (hence the name), from 1646 to 1676.

Activity:

1. Each student /pair will use one half a hemisphere.
2. Tell students to press the hemisphere down onto a flat desk top and then try to lift it up.

Explanation:

When the hemisphere is pressed against a flat surface, most of the gas molecules in the air are forced out. There are a lot of air molecules on the outside of the hemisphere. This results in the atmospheric pressure being much greater on the outside, so that it pushes the hemisphere down and forms a seal with the surface.

Lesson ideas taken from Educational Innovations “Bell Jar and Vacuum Pump Set”

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Your Notes:
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Vacuums and Air Pressure Observation Sheet

Name:____

Part 1 – What is Atmospheric Pressure? Circle the correct italicized answer
In both the water jar and atmospheric mat experiments, what force caused the results we observed?
Atmospheric pressure *atmospheric clouds* *vapor pressure*

In which direction does this force point? *Up* *outwards* *inwards* *all directions*

Part 2 – What is a Vacuum? The Bell Jar
(a) As you pull-out the piston, what are you removing from the bell jar? *air* *nothing*

(b) Over time, the piston becomes *easier* *harder* to pull-out.

This happens because, over time, the air pressure inside the bell jar (*decreases,* *increases,* *remains the same*) while the atmospheric pressure (*decreases,* *increases,* *remains the same*).

(c) We made a vacuum inside the bell jar. This means the air pressure inside the bell jar was (*less than,* *greater than*) the atmospheric pressure pushing on the outside of the jar.

(d) When the vacuum is released from the bell jar, what happens to the jar's mass? *increased* *decreased*

Why?____

(e) In the last demonstration, the amount of water that entered the bell jar was equal to the amount of _____________________ that was removed from the bell jar.

Part 3 – What Happens when Air Pressure Decreases?
A. & B. The Balloon and Marshmallow
As air is taken out of the bell jar, the pressure in the jar drops. What happens to the balloon and marshmallow?
The balloon and marshmallow *inflate* *deflate* *do not change*
Why? ____

C. The Suction Cup (If Time Permits)
What force causes suction cups to stick to walls? *Atmospheric pressure* *vapor pressure*

IV. The Magdeburg Hemisphere (If Time Permits)

Do you think the Magdeburg hemisphere would work if we used it on a bumpy surface, like sandpaper, instead of a flat surface? Why or why not?
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Vacuums and Air Pressure Observation sheet = Answers

Part 1 – What is Atmospheric Pressure?

In both the water jar and atmospheric mat experiments, what force caused the results we observed? ***atmospheric pressure***
In which direction does this force point? ***all directions***

Part 2 – What is a Vacuum?

The Bell Jar

(a) As you pull-out the piston, what are you removing from the bell jar? ***air***

(b) [Circle the correct *italicized* answers]. Over time, the piston becomes (***harder***) to pull-out.
This happens because, over time, the air pressure inside the bell jar (***decreases***,) while the atmospheric pressure (***remains the same***).

(c) We made a vacuum inside the bell jar. This means the air pressure inside the bell jar was (***less than***) the atmospheric pressure pushing on the outside of the jar.

(d) When the vacuum is released from the bell jar, what happens to the jar's mass? Why? **The bell jar's mass *increases because air rushes inside the jar once the vacuum is released. This shows that air has mass.***

(e) In the last demonstration, the amount of water that entered the bell jar was equal to the amount of ***air*** that was removed from the bell jar.

Part 3 – What Happens when Air Pressure Decreases?

A & B The Balloon and Marshmallow

As air is taken out of the bell jar, the pressure in the jar drops. What happens to the balloon and marshmallow?
The balloon and marshmallow ***inflate***

C.The Suction Cup (If Time Permits)
What force causes suction cups to stick to walls? ***atmospheric pressure***

IV. The Magdeburg Hemisphere (If Time Permits)

Do you think the Magdeburg hemisphere would work if we used it on a bumpy surface, like sandpaper, instead of a flat surface? Why or why not? ***The Magdeburg hemisphere would not work. On a bumpy surface, the hemisphere would not be able to form a tight seal with the ground. Air from the atmosphere could then enter the hemisphere, resulting in atmospheric pressure within the hemisphere.***