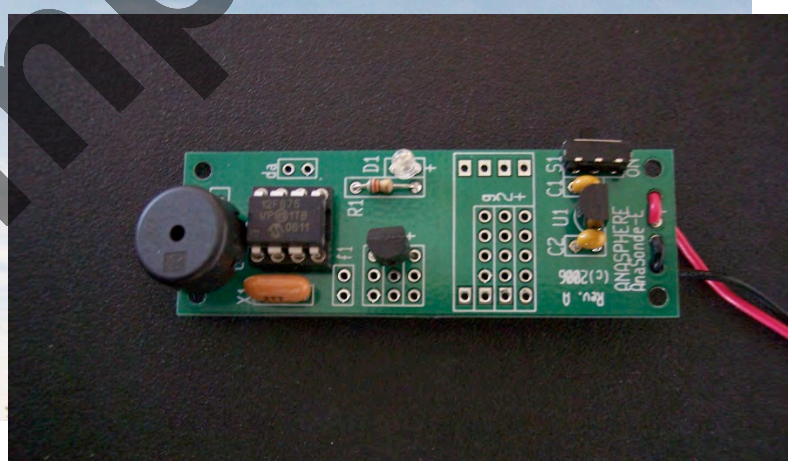
AnaSonde Student Guide



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Foreword

The implications of learning about weather and climate research in society are great. When society as a whole understands the concepts of weather, the atmosphere and climate change, we will have a culture that understands the consequences of many important topics such as greenhouse gases and their effects on the environments. When we are a fully educated people, we make better decisions about the laws concerning some of the topics involving thins such as global warming.

Also, technology is an integral part of our culture today. In order to become a fully productive member of the general public, one must understand what technology can do for society. With increasing technology, we can better predict the storms that cause so much damage and possibly save lives.

In science, everything is connected. Earth science, biology, chemistry, and physics are all continuous with each other and rely very much on one another. A strong foundation in earth science, physics and math is essential to continue into most other disciplines in life. When we get up in the morning we look outside to get the weather to decide what to wear for the week. Next, we use weather forecasts to determine what we will and will not be doing that week. Earth science is necessary in determining the biology and the factors affecting the biology of previous life forms. It is also an integral in determining the chemistry of the atmosphere and soils and how it depends on the earth science of minerals, layers, etc. present. With the knowledge that we can get from the atmosphere, we can predict weather, predict what will happen to the climate in years to come, determine what the climate was like centuries, even millennia ago, and determine the chemistry of the environment today and a long time ago.

Overview

AnaSonde is an instrument developed by Dr. John Bognar, founder of Anasphere, originally as a family of digital radiosondes for research purposes. They are simple and inexpensive probes used to gather atmospheric profiles for numerous parameters such as temperature, pressure, and humidity. When flying an AnaSonde on a common 3-foot helium-filled balloon, AnaSondes are capable of gathering measurements in the lower atmosphere (troposphere) up to altitudes of approximately 35,000 feet! Since then, Anasphere has recognized the increasing potential of the AnaSonde to educate students in the areas of earth science, math, physics, atmospheric chemistry, technology, and science and technology impacts on society. This realization has resulted in the following curriculum unit. The curriculum starts out by teaching students the basic principles of weather, the greenhouse effect, the atmosphere and its layers, weather predictions, and then it moves on to go into to detail about science investigations, radio communications, and relevant, science experience. The program includes learning to use a Morse code key to determine what the data coming back from the AnaSonde is, soldering a working circuit, and studying on microclimates. It concludes with the students sending an AnaSonde into the atmosphere and receiving real time data, graphing and analyzing that data.

Please make sure all safety procedures are followed in the following lessons. Anasphere is not liable for any injury that results from performing the procedures.

Lesson # 1 What is Weather?

Content Background:

Weather. According to Webster's Dictionary, ***weather*** is "the state of the atmosphere with respect to heat or cold, wetness or dryness, calm or storm, clearness or cloudiness". Weather is an important factor in everything that we do. It can decide what you are going to do that day (if it is raining out it may cancel that trip to the beach) or what you are going to wear that day (do you need that winter coat?). Because of the necessity of knowing the weather to make plans, it is increasingly important to know more about the weather, this thing of which we have no control.

Pressure Systems. One of the factors in predicting weather is high and low pressure systems appearing in the region. A region where the air is sinking is called a ***high pressure*** region. In a high pressure region (anticyclone) there is clear skies and fair weather. This is because the sinking cold air warms as it does so and becomes stable. In general, they cover a greater area and last longer than a low pressure system. A ***low pressure*** region (depression or cyclone) is caused by rising air and often occurs in conjunction with clouds, rain and very strong winds. As the air rises, clouds form and air instability produces vertical development of clouds such as cumulonimbus clouds. In the Northern hemisphere, air sinking spirals in a clockwise direction and rising air in a counterclockwise direction.

Clouds. Clouds are another way that we can tell what the weather will be like. They are created when the water in the air is saturated and there are ***condensation nuclei*** present in the air for the water to collect on (such as smoke, pollution, or dust). Cirrus clouds are high altitude wispy clouds composed mostly of ice. They are usually white and predict fair weather. Watching how these clouds are moving can predict which direction weather is approaching from. Usually they mean a change in weather within the next 24 hours. Cirrostratus clouds usually cover the sky in thin sheets meaning that the sun or moon can shine through. These clouds usually mean that there will be a rain or snow storm. Cirrocumulus clouds appear to be in rows of cotton. They can vary from white to gray. In winter they predict cold but fair weather. In the tropical regions, however, they predict that a hurricane may be on its way.

Alto clouds are mid-level clouds that predict changes in the next 6-12 hours. ***Altostratus*** clouds cover the sky and are a grayish color. It usually makes the surrounding area appear hazy and is foreboding of rain or snow. ***Altocumulus*** are a lighter gray and look like cotton balls strewn across the sky. If they are seen in the morning they indicate afternoon thunderstorms.

Stratus clouds are the lowest in the sky. They are uniformly gray and cover the entire sky. When this cloud gets close enough to the ground it is just called fog. These usually indicate a drizzle throughout the day. ***Stratocumulus*** clouds are puffy gray clouds that form with the blue sky still visible. These rarely mean rain unless they become nimbostratus. ***Nimbostratus*** clouds are dark gray and usually mean rain or snow.

Cumulus clouds are puffy clouds that develop vertically. These usually indicate fair weather unless they become very tall. In this case, they have become ***cumulonimbus*** clouds and are indicative of thunderstorms. They also can predict hail, tornadoes and snow. When they are shaped like an anvil, it points in the direction that the storm is headed.

Increasingly lower altitude of the cloud formations usually means that a storm is approaching. Cumulus clouds developing upward indicate stormy weather as well. In general, weather changes come from the west or southwest. If winds change or temperature and/or pressure drop suddenly, a storm should be watched for as well.

All of the main things involved in weather are involved in the creation of clouds (temperature, pressure, and humidity). Water condensation above the earth's surface on little particles creates clouds. This is generally because the air is ***saturated*** with moisture. Saturation occurs when the temperature cools an air mass to its ***dew point*** or air is forced to rise.

Air can be forced to rise in several different ways. One way is when it meets elevated land forcing the air upward (***orographic uplift***). Another way is associated with the surface hearting the air. When enough heating has occurred, the air mass becomes hotter and lighter and it begins to rise, expand, and cool. Once it has cooled enough the air becomes saturated with moisture because of the air's decreased capacity to hold water when cooled. ***Convergence*** occurs when two air masses come together. The warm, moist air mass gets lifted over the cold, dry one. The warm one is cooled as it is lifted over the cold and this once again results in saturation of the air.

Finally, there is ***radiative cooling***. This occurs when the sun is not heating the air and ground (this occurs at night). The earth begins to lose the heat and this causes the ground and air above it to cool saturating the lower and producing a fog.

Temperature, pressure and humidity all work as a team to produce weather. Temperature describes how warm the air is. Pressure describes how much air is in the area. Humidity describes how much water is in the air.

Temperature. When looking at temperature, it is obvious how it works when looking at the air. When they are place closely to each other, the air masses exchange heat until the cool object has warmed and the higher temperature object has cooled enough that they are at roughly the same temperature. This is called thermal equilibrium. Air higher in pressure is usually cooler air and air lower in pressure is usually warmer air. When the two meet, the air becomes uniformly dispersed and the cooler air warms and the warmer air cools.

Humidity. Humidity that we talk about most of the time when we talk about weather is ***relative humidity***. Many people have misconceptions about what relative humidity is. It is not how much water the air can hold it is how much water is in the air over how much water could fit in the air before maximum capacity is reached (right before the water begins to condense out of the air). The temperature at which the moisture saturates the air is the dew point. If the air were to drop in temperature further, the moisture would begin to condense out of the air.

Wind. Wind is caused by the earth's surface being heated unevenly by the sun because of the tilt in the earth's axis. Also, the different things that make up the earth's surface hold heat differently. Warm air is less massive than cool air and as it rises, the cool air moves in and replaces the warm air. This movement makes the wind blow.

Thunderstorms. Thunderstorms are a type of storm produced by cumulonimbus cloud. They usually consist of gusty winds, heavy rain and hail. The basic things that create a thunderstorm are moisture, unstable air and lift. The moisture is needed to form rain and clouds. Unstable air that is relatively warm can rise rapidly causing lift. They can occur at any point in time but are most likely to happen in the spring and summer months later on in the day.

Lightning. Lightning is the partner of thunder and an electric current. Lightning is the bright flash of light before the sound of that flash (thunder). Therefore, lightning must be present for the storm to be a thunderstorm. Just because thunderstorms are small does not mean that they are not dangerous. It is estimated that more people are killed each year due to lightning than tornadoes.

For lightning to occur there must be a build-up of electric charge in the cloud caused by the water particle bumping into each other. The charges in the cloud separate with the positively charged protons at the top and the negatively charged electrons at the bottom. With charges, opposites attract, this means that since the bottom of the cloud is negatively charged, the ground get all of the positive charges moving toward the surface and collects wherever there is something that is higher in elevation than the ground, such as a tree. When the charge from the tree meets the charge coming down from the cloud it causes a giant spark (lightning). This is the same as when you drag your feet across the floor and then turn on the light switch. The switch can shock someone even before they touch it because of the attraction between the charges when close to the other. The little zap that can be heard when this occurs is comparative to the thunder only not as loud because the shock is not as big. The zap or the boom is caused by a hole in the air that opens when the electricity travels through the air. When the lightning bolt is gone, the air collapses back into the hole

Greenhouse Gases and Climate. ***Greenhouse gases*** include several gases such as carbon dioxide, methane, water vapor, nitrous oxide, and fluorocarbons. These gases are naturally part of the atmosphere. They are what keeps the Earth at a temperature that we can live in. If it were not for them, the Earth would be about 33 degrees Celsius cooler. These gases help to retain the heat through a process called the Greenhouse effect. This process begins when the Sun's short wave rays enter the Earth and the Greenhouse gases allow them to pass through the atmosphere to get in. Once they get to the ground, they are either absorbed or reradiated back to the atmosphere. When they bounce off the Earth, the waves changed into long wave infrared radiation and the gases do not allow the rays to leave. This keeps the Earth warm.

In the last century, however, the Earth's temperature has increased by about 0.5 degrees Celsius. Scientists believe that this increase in temperature is caused by the increase in greenhouse gases caused by humans. This is being called climate change. (***Climate*** is the weather of a place over a long period of time.) It is theorized that such an event will cause catastrophic events for nature such as rising sea levels and melting polar ice caps. This will also cause economic damage. Other scientists say that this is just the natural cycle of the Earth.

Atmosphere. The atmosphere consists of several different layers. The gases in the atmosphere and the conditions of it change from the ground up. The five distinct layers are classified by using temperature, chemical composition, air density, and movement. The boundaries of the layers are where the maximum variances in the above characteristics occur.

The layers, in order from the ground up are described below. The ***troposphere*** begins at the surface of the earth and extends up to about 10 miles in height varying around the equator and the poles. This is where we live and where most of the weather occurs. The temperature decreases with height in this layer. It is often windy in this layer (there is much movement). The boundary between the next layer and the troposphere is called the ***tropopause***.

The ***stratosphere*** comes next. This layer goes from the tropopause up to around 30 miles above the surface. This is where 19% of the atmosphere's gases reside, however, there is very little water vapor here. This is also where we would find the ozone layer, the layer that protects us from the sun's harmful rays. The temperature increases in height in this layer because the gases in this layer absorb the radiation from the sun. This is what causes the formation of ozone. The layer that separates this from the next is the ***stratopause***.

Next, we have the layer called the ***mesosphere***. This layer extends up to around 53 miles above the earth. The density of the gases in this layer is low. Because of this, there is less radiation from the sun absorbed in this layer making the temperature decrease with height once again. This is where most meteorites burn up. The ***mesopause*** separates this from the next layer. The ***thermosphere*** is the next layer. In this layer, the gases of the thermosphere are increasingly thinner than the previous layers. This is where all of the high energy rays from the sun are absorbed and therefore this is where the temperatures in the atmosphere are the hottest.

Finally, the exosphere is the outermost layer of the atmosphere. The barrier between this and the thermosphere is called the ***thermopause***. This is the layer where molecules from our atmosphere begin to escape into space. This is also where our satellites orbit the earth.

Greenhouse Effect Lab

Name ___________________

Procedures: Assign a recorder, a reader, and a timer within each group. The recorder will record the data, the reader will read the temperatures and the timer will tell the reader when to read.

1) Read the procedure and hypothesize what you think will happen and why.

____

____

2) Obtain the following materials for your group: 1 Thermometer, 1 Alka-Seltzer tablet, 2 half-gallon Ziploc bags, a 250 mL beaker, tape, stop watch and a permanent marker.

3) Fill both bags with 250 mL of water. Place the thermometer in one of the bags containing water and close it (this is your control). **Important:** *Make sure to hold the thermometer up out of the water while sealing the bag and during the entire experiment. The temperature that we want to know is of the atmosphere and not of the water.*

4) Place the thermometer (and the bag) under a heat lamp, or under direct and VERY warm sunlight. Record the measurements from the thermometer at time 0 and then every 30 seconds after that for the next 2 minutes in the following data table using a stop watch to ensure equal time intervals. Record the temperature readings to the nearest half degree.

5) In the other bag of water, place the thermometer, once again keeping it out of the water AT ALL TIMES. Put the Alka-Seltzer tablet into the bag, but do not drop it into the water yet. Once the bag is sealed, place it under the same heat source in the same spot that was used for the control. Drop the Alka-Seltzer tablet into the water and begin taking measurements. Repeat the same methods for the experimental group that was used in the control.

Greenhouse Gas Data

Time (s)	Temperature of Control (F)	Temperature of Experimental (F)
0		
30		
60		
90		
120		

Total Change in Temperature		

Discussion: Write a short paragraph discussing the following things. What do you notice about the data? What do you think this means? What are possible sources of error? How is the study relevant (what are the practical applications)? If you did a follow up study, what would you do?

Lesson # 2 Forecasting the Weather

<u>Content Background:</u>

Weather prediction has become highly evolved in the last half a century. However, people have been doing it for ages. Some of these methods still work great. The Native Americans used things such as flight patterns of birds, thickness of the skin of an onion, etc. Settlers used many things such as pine cones, wool, and sea weed.

Starting with pine cones, when the cone is open the weather will be dry. They retain their original shape when the weather begins to become wet. This is one of the most reliable indicators. Next, wool is used as a humidity indicator as well. When the weather is dry, it shrinks and curls up; when it is wet, it swells and straightens out. Another humidity indicator is sea weed. When rain threatens, it swells and feels damp.

In order to keep things straight, many sayings were invented to represent how people used to predict the weather. A few are listed below:

> If the crows fly low, the wind's going to blow. If crows fly high, the wind's going to die.
> A sunshiny shower won't last half an hour.
> Clear moon, frost soon.
> When sea birds fly to land, there truly is a storm at hand.
> Onion skin is very thin, mild winter coming in. Onion skin is thick and tough, winter will be cold and rough.
> Rainbow in the east, sailors at peace. Rainbow in the west, sailors distress.
> Red at morning, sailors take warning. Red at night, sailors delight.

These next few predictors have the logic behind the reasoning written below it:

> If a muskrat builds his house toward the edge of the lake it means we will have a mild winter. If a muskrat builds his house toward the middle of the lake, we will have a long winter.
> Logic: A muskrat needs open water to get out of his house. So if he builds near the edge of the lake, it means he knows that there won't be a long hard freeze. If there was, he could not get out of his house.
>
> If snakes stay around in late fall, we will have a long fall.
> Logic: Snakes hibernate in the winter, so this can be used as an indicator of the length of the fall.
>
> If rabbits keep their gray colors unusually long, we will have a long fall. If rabbits turn white early, we will have an early winter.
> Logic: Since they turn white in winter, we can use them as an indicator of when winter is coming.

If crows are seen in February there will be an early spring.
Logic: Birds migrate instinctively at various times of the year.

When leaves on the ash trees turn upward it will rain.
Logic: Moisture in the air affects the position of some types of leaves.

A chattering squirrel is a call for rain.
Logic: This is more of a sign that it will rain than a call for rain. Squirrels will chatter while gathering or eating food. They eat and store food before a rainstorm.

If the quarter moon starts to tip downward it will rain. If the quarter moon tips upward we will have dry weather.
Logic: The moon affects the weather of the earth. When it is tipped down this signifies the dumping of rain.

Even though the technology we use today is great, we still use the old standby sayings as well to ensure the most accurate forecast possible. The instruments used today consist of several things that have been around for decades. These examples include (but are not limited to) thermometers, barometers, and sling psychrometers. ***Thermometers*** are used to measure the air temperature. A thermometer works using a liquid center in a glass tube. Once the liquid in the tube is filled up, the temperature is determined. A ***barometer*** measures the pressure in the air. If the pressure is rising, the weather is going to sunny and dry. If it is falling it will be stormy and wet. A sling ***psychrometer*** measures the relative humidity through evaporation. Two thermometers are used to make this psychrometer. A regular one and one with a wet "sock" on. It is swung around in the air a few times and the water evaporates causing the temperature on the one with the "sock" to drop.

Newer technologies that we use in predicting weather are things such as maps, satellites, and balloons. Weather maps are used to put all of the conditions of a particular region together and watch the movement of the conditions to determine when and if that weather will hit the location being watched. Weather balloons are used to measure the weather conditions higher in the atmosphere to determine what the conditions could be like if changes occurred in the atmosphere. These balloons usually go only as high as the top of the troposphere because that is where most of the weather occurs. Finally, weather satelllites are used to photograph and track larger scale air mass movements. These are compiled onto the weather maps and then with the help of computers the data is analyzed.

Lesson Wrap-up:

Use your cloud finders and the information you have learned about weather so far to predict the weather. You will need to record your prediction, what the actual weather was like that afternoon, and what other conditions may have existed that may have contributed to their predictions being wrong or right.

Forecasting Weather

Name___________________

Not only do meteorologists predict weather using clouds, they can collect data about the earth's weather using things such as weather balloons (like we will use) and then use that data to construct maps of the conditions of an area. These maps can be used to predict what the weather will be like over the next couple of days. In this activity, you will use the given information to create a weather map of an area and then forecast the weather for the next couple of days.

Fill in the blanks to help give you a guide for weather conditions.

Things to know:

A cold front is a mass of cold air that moves in and replaces warm air. Warmer air is __________ dense than cool air so it ___________. Since the warm air can hold ________ water, when the air cools, it condenses and forms a big column of clouds. This type of front also causes ___________ temperatures.

A warm front is a mass of warm air that moves in and replaces ___________ air. This type of front causes __________ temperatures. Since more surface area of the two masses touch in this situation, it causes more water to condense and form _________. These conditions last longer.

Use the following information and the key for weather maps to draw in the conditions listed below on the map of the United States.

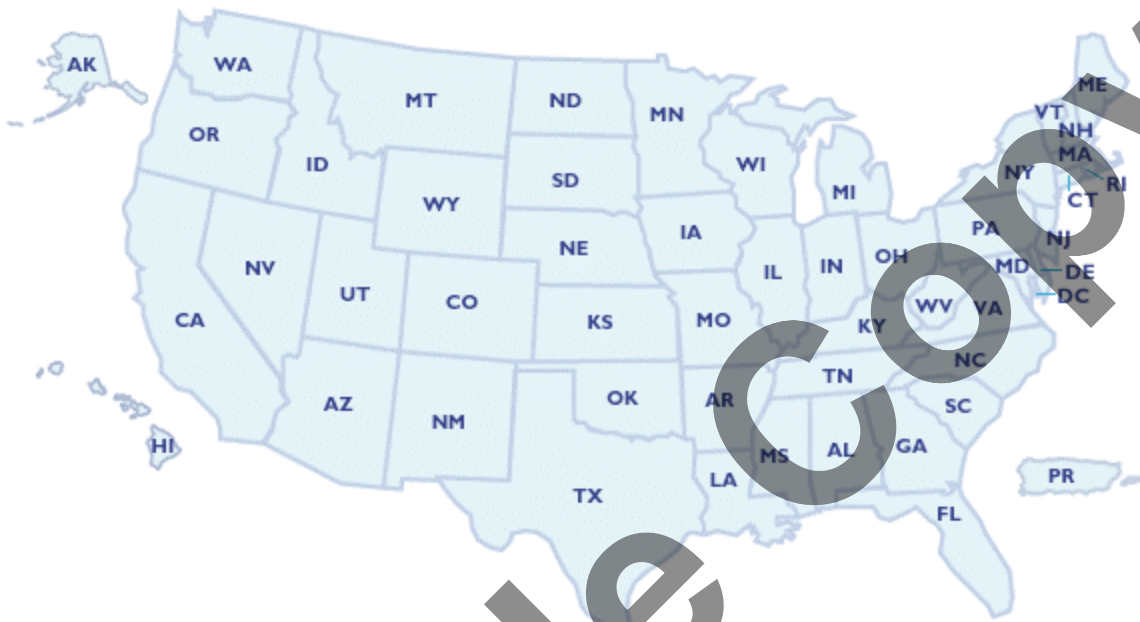
Information Received from Weather Satellite:

****Remember****: *In general, the wind blows weather across the United States in a south eastern direction. Warm fronts tend to move north east, however.*

-- A warm front stretches from Indiana to Ohio.
-- There is precipitation along the warm front.
-- A low pressure system is over Texas and Maine.
-- A cold front stretches from the top left corner to the bottom right corner of Montana.
-- A high pressure system is over Nebraska and Georgia.
-- There is a hurricane off the coast of Louisiana.
-- There are some severe thunderstorms with high winds in Kansas that look like they may turn into tornadoes.

Key for Weather Maps:

<u>**Weather**</u>	<u>**Symbol**</u>	<u>**Associated Weather**</u>
Precipitation		Rain, snow, fog, etc.
Cold Front		Cooler temperatures with a chance of precipitation
Warm Front precipitation		Warmer temperatures with a chance of
Low Pressure		Cloudy skies with a chance of precipitation
High Pressure		Clear skies
Hurricane		Damaging winds and rain with flooding
Tornado Watch		Area where with a good chance of a tornado or severe thunderstorms
Tropical Storm		Heavy rain with strong winds



<u>Use the above map as today's weather. Predict (and justify) tomorrow's weather for Kansas below:</u>

____

____

____

Predicting Weather

Fill in the table every morning this week. Make sure to compare your predictions to the actual weather in the afternoon.

Date/Time	Cloud Type	Weather at Class Time	Predicted Weather Later	Weather/Time

Lesson # 3 Radio Waves and the Electromagnetic Spectrum

<u>Content Background:</u>

Wavelength, frequency and energy are the first very important things to know to understand the electromagnetic spectrum. ***Wavelength*** is the distance from crest to crest or trough to trough. Wavelength is measured in meters. ***Frequency*** is how many crests or troughs (whichever you pick) goes by every given unit of time (cycles/second or Hertz). Energy is measured in electron volts.

The ***electromagnetic spectrum*** is the full spectrum of radiation. This includes visible light, radio waves, microwaves, infrared and ultraviolet light, x-rays, and gamma rays. The highest energy forms of radiation (x-rays and gamma rays) are caused by extremely hot bodied objects. These forms of radiation have the shortest wavelengths and also the highest frequency. Starting with the lowest energy and working the way up to the highest in order, the following is the electromagnetic spectrum.

Radio waves are emitted by many other things besides the radio. These things include stars and gases in space. These waves can be studied by scientists to learn what the stars are made of or what the gases are. When we talk about the radio waves as we know them we see that the lowest energy/ lowest frequency magnitudes are reserved for aircraft and ship radio contacts. Next, come the AM, then shortwave radio, and finally the waves that produce the picture on your TV and FM radio. Radio waves have a very long wavelength and a low frequency. These waves are the ones used by the AnaSonde to transmit the data from the atmosphere to the ground. If it were not for these waves, we could only get data from the AnaSonde up to the point that we could not hear it anymore.

Microwaves are just as they sound, the waves the can make your food very quickly. Not only this, but microwaves can be used by astronomers to learn about the structure of nearby galaxies.

Infrared waves are often confused as heat. These are the rays that night vision goggles use to allow to us see at night. When we can see this heat, we can find warm bodies like animals or humans. These also help to map the dust between stars.

Visible waves of light are next. This is the part of the electromagnetic spectrum that we can see. This includes “ROY G BIV”.

Ultraviolet light is the light that comes from the sun (UV radiation). Because of the hot body that it comes from, it is high energy radiation. This radiation can cause damage to our skin (sun burns and skin cancer).

X-rays are increasingly more dangerous than UV radiation, but are also very useful in looking at bones and teeth. These are very high energy waves and can cause mutations if a person is exposed to them too much. Hot gases in space also emit X-rays, so even if we did not get X-rayed by doctors, we would still receive some of this radiation.

Gamma rays are the most high energy form of radiation and thus the most dangerous. Radioactive materials emit gamma rays. These rays have been known to cause cancer and mutations because of the genetic mutations that they can cause. Their high frequency/high energy allows them to penetrate us deeper and can cause damage to more than the skin.

All of the above are forms of ***electromagnetic radiation***. This means that they are a stream of photons traveling in a wave-like motion at the speed of light. The difference in the above forms is how much energy is found in the photon. Radio wave photons have low energies where as gamma-rays have the highest energies.

In order to keep the numbers understandable, scientist use additional names on the units to keep track of how big or small the numbers really are. If the wavelength were 4000 meters it would be easier to say 4 kilometers. Scientists could also use scientific notation to do the same thing. Rather than saying the wavelength is 0.000000001 m it could be called 1 nanometer or 10-9 m.

<u>Lesson Wrap-up:</u>

Discuss how dangerous you think microwaves are relative to the other waves in the spectrum. Specifically think about the following questions:

Which part of the spectrum has the highest frequency and thus the highest penetration power?

Which type of wave has the lowest frequency?

Which parts of the spectrum are we exposed to the most?

Which part of the spectrum is the most likely to give us cancer with how much a normal person is exposed to each section in their lifetime? Why?

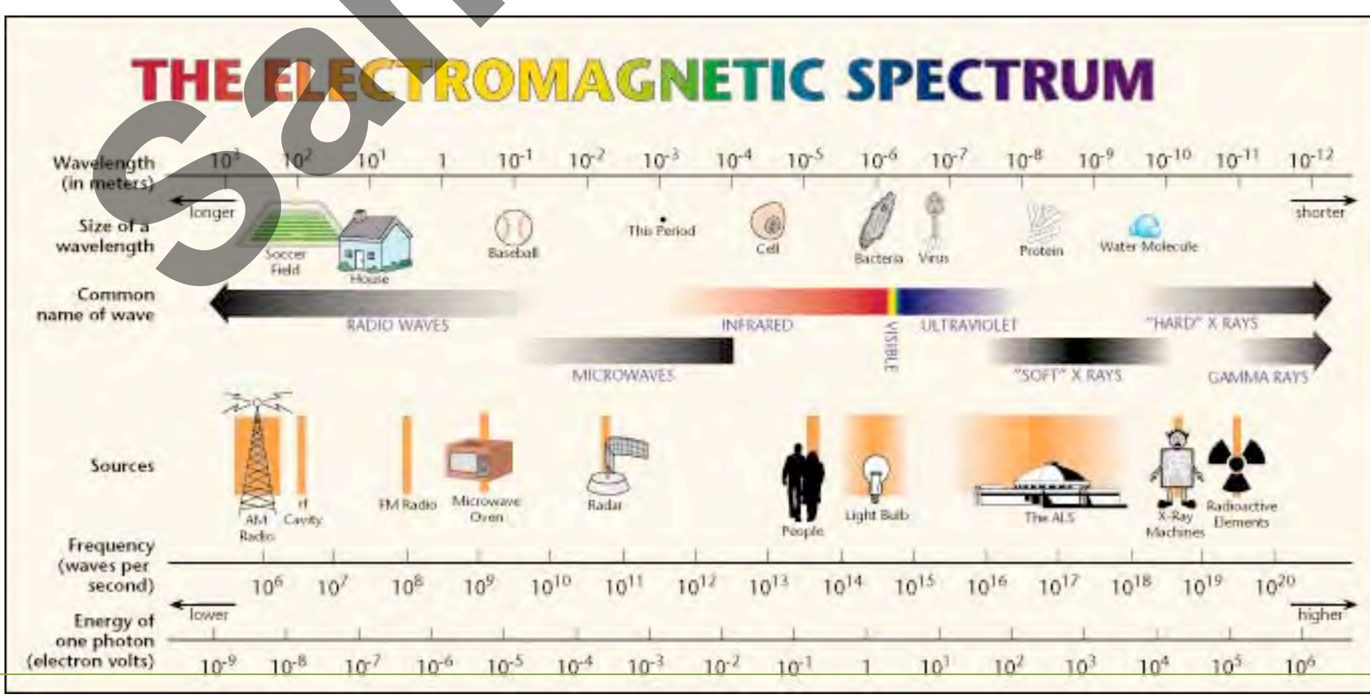
Electromagnetic Spectrum

Name ____________________

Match each kind of wave with one item from column one and one item from column two.

COLUMN 1		WAVE		COLUMN 2
A. used in remote controls for TVs and VCRs	_____	RADIO	_____	**H.** used to find a broken bone
B. goes through most matter except bone & lead	_____	MICROWAVE	_____	**I.** used to kill bacteria on food
C. highest frequency and energy	_____	INFRARED	_____	**J.** ROY G. BV
D. can cause skin cancer promote vitamin D production	_____	VISIBLE	_____	**K.** shortest wavelength
E. longest wavelength	_____	ULTRAVIOLET	_____	**L.** thought to alter food properties & make unhealthy
F. used to transmit cellular phone calls	_____	X-RAY	_____	**M.** TV signals from stations, used in car alarms
G. wavelengths and frequencies that can be seen by the human eye	_____	GAMMA	_____	**N.** radiant heat rays

15. As you go from left to right across the electromagnetic spectrum what happens to the frequency and energy of the waves? ____
____

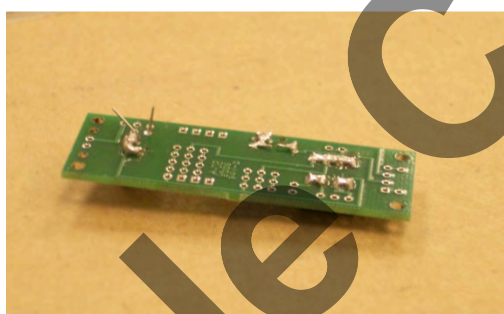


Lesson # 4 Building and Learning to Use the AnaSonde

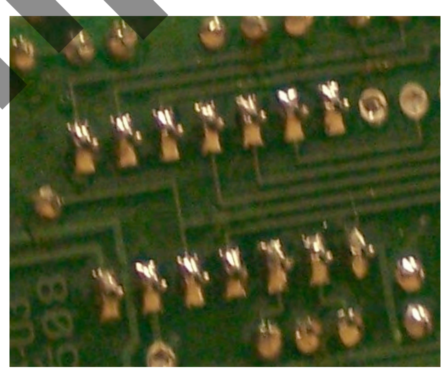
<u>Content Background:</u>

Circuit Board. Circuit boards are made with an insulator (usually fiberglass). The board contains "threads" that run across it that are the wires of the board. These threads allow for an electrical circuit to be built without a mess of wires. In a ***circuit***, charges can flow continuously throughout a closed loop of electrical parts and wires.

Solder. Soldering is a process of making an electrical connection. The ***solder*** is an alloy of metals with a low melting point. A soldering iron is used to heat the solder and make the connection between the part and the board. In order to make the best possible connection, the soldering iron tip must contact both the board and the component to make sure they are the same temperature. To ensure that no ***solder bridges*** (two joints are connected by solder, see below) are made, the solder should be applied in the smallest amount possible. Several solder bridges are pictured below.



However, if there is not enough solder to make the connection all the way around the part, the circuit will not work either. Therefore, it is important to pay attention to how much solder is applied to each joint. Below is the picture of multiple perfect solder joints.



There are a few key terms to know when learning about soldering; the first of which is tinning. ***Tinning*** is the process of coating the soldering iron tip with solder. This allows the solder to melt and stick to the joint better. The ***solder joint*** is where (in this case) the part is soldered to the board. A short occurs when there is an unwanted electrical connection between the positive and negative source. This connection can cause damage to the other parts on the board or the battery. Solder bridges cause shorts and are usually caused by putting too much solder on the joint. This can short the circuit and the AnaSonde will not work. ***Desoldering*** is a process in which solder is removed from the joint so that the part can either be removed or moved to a different space on the board.

Ground. The ***ground*** is a body, such as the earth, that acts as the reference point in the electrical circuit from which all voltages are measured. Ground has a voltage of zero and can be the common return for an electrical circuit. Connections to ground limit the build-up of static electricity which can cause harm to the circuit and to the handler.

Circuit Board Components. A circuit board has several components that are soldered to it to allow it to perform its function.

A ***resistor*** is a component that restricts the electrical current flow through the circuit, in other words, it causes resistance. This is done in order to drop the voltage of current that is flowing through the circuit to a level that is safe for the parts in the circuit. Resistance is measured in ohms.

Capacitors are called capacitors due to their capacity to store an electric charge. They can be used to store both digital and analog data. They can also be used with telecommunications equipment to adjust frequency and tuning.

A ***voltage regulator*** does just what the name implies, regulates the voltage output. The voltage that enters the regulator varies and the voltage regulator is able to take the varied input and turn it into a constant regulated output.

As an integrated chip, a ***microcontroller*** contains most of the same basic parts as a computer. It is essentially a very small computer meant to control a simple system and perform one specific task.

Transmitters, with the help of an antenna, send out signals that allow for telecommunications.

A ***resonator*** naturally oscillates at some frequencies (resonance frequencies). Resonators are used to either generate waves of specific frequencies or to select specific frequencies from a signal.

Morse Code. The ***telegraph*** was invented by a man named Samuel Morse in 1836. Before this invention, Samuel Morse communicated with his deaf wife by tapping his fingers into her hand in a special pattern. This system of dots and dashes is known as Morse Code. He demonstrated the ability of a telegraph system to transmit this dot and dash information over wires using electrical signals. The short signals became referred to as dits and look like dots when on paper; the long signals are called dahs and represented by dashes on paper. This system became very widely used and the most known use for it is dit dit dit//dah dah dah//dit dit dit, or SOS (save our souls). The dits are only one unit in time, the dahs are 3 units in time, the pause between letters are 3 units in time and the pause between words are 7 units in time.

Procedures:

CAUTION: The soldering iron is hot and could burn them or anything it comes into contact with if not used correctly. It is very important to wear safety goggles at all times during the lesson. Bits of wire are cut off and could injure an eye; the iron could burn an eye, etc. In your group, alternate soldering the parts. IT IS VERY important it is that the instructions be followed EXACTLY. If the parts are oriented incorrectly, the AnaSonde will not work!

Assemble the AnaSonde according to the AnaSonde Assembly Instructions (See Appendix) and the AnaSonde Assembly PowerPoint. Once you are finished, check for solder bridges and joints that do not have enough solder and fix them. Also recheck the placement and orientation of each part.

Once you have confirmed that all is good with the circuit board, get your battery from your teacher, attach, and try it out!

Lesson Wrap-up:

Using your knowledge of Morse Code, decode the temperature measurements you take in the room. Discuss how technology and science are complimentary and why it is a necessity for us to use the technology we have in science.

Learning Morse Worksheet

Background Information

Morse code is one of the earliest forms of communication. It uses combinations of dots and dashes (short and long pulses, respectively) of light and/or sound to symbolize the alphabet, numbers, and symbols. Telegraphs were the first instruments to use this system. The telegraph sent electrical signals through metal wires. This was important because at that point in time, there was no other way for immediate long distance communication.

Morse Code Key

Letters		***Numbers***	
A	· -	**1**	· - - - -
B	- · · ·	**2**	· · - - -
C	- · - ·	**3**	· · · - -
D	- · ·	**4**	· · · · -
E	·	**5**	· · · · ·
F	· · - ·	**6**	- · · · ·
G	- - ·	**7**	- - · · ·
H	· · · ·	**8**	- - - · ·
I	· ·	**9**	- - - - ·
J	· - - -	**0**	- - - - -
K	- · -	**+**	· - · - ·
L	- · ·	**-**	- · · · · -
M	- -		
N	- ·		
O	- - -		
P	· - - ·		
Q	- - · -		
R	· - ·		
S	· · ·		
T	-		
U	· · -		
V	· · · -		
W	· - -		
X	- · · -		
Y	- · - -		
Z	- - · ·		

Procedure

1. Use the Morse Code Key to decipher these messages:

Hotter air always holds	____ ____ ____ ____	water vapor than cold air.
	- - - - - . - - . .	
Weather occurs in the atmosphere	____ ____ ____ ____ ____	called the troposphere.
	- . . . - - . - - . . - .	
Lightning strikes because of	____ ____ ____ ____ ____ ____	electricity due to friction from dust, ice, and water droplets
	. . . - . - - . . - . - .	
Circuits that are not	____ ____ ____ ____ ____ ____ ____ ____	will not work.
	- . - . - - - - - . - - . - . . . - .	

2. Write a secret message in the Morse Code.

____

____

3. Exchange papers with someone. Use the Morse Code Key to translate the secret message.

____

____

List the measurements that you found in the classroom and where you took them. What areas of the classroom were coldest? Warmest? Was there any variation in the temperature around the classroom? How might this tool be useful in the real world?

____

____

____

Lesson # 5 The Scientific Method, Graphing and Data Analysis

<u>Content Background:</u>

The scientific method is important in determining what the aim of the study is and what is expected to be learned from performing the study. There is always a question that needs to be answered at the start of a study. The scientist then collects background information so that they can intelligently guess (hypothesize) what is expected to happen and why. Then, a research project must be designed to figure out if the hypothesis holds true or not. The design will have procedures that should be followed and documented carefully every step of the way. Finally, the data will be collected and analyzed into results. The analysis will lead to a discussion/conclusion of the results. This would involve things such as:

What are the possible errors in the experiment?
Can the hypotheses be accepted or rejected?
What is a real world application of this study?

The analysis of data is of great importance in determining what can be concluded from the study. Once it is determined what the data means it should be easy to figure out how it applies real life. Data analysis can be done in a few different ways. The first way is using statistics. There are several different equations that can be used to determine if there is a statistically significant difference in the control group versus the variable group. The next way is graphing. By graphing the data, trends become more obvious and multiple trials can be compared side by side.

Graphing procedures are very important in ensuring that scientific data is presented in a way that makes it easily read and analyzed. Graphs must have the five following features to give all the information necessary for reading them: 1) a title 2) labels for the axes 3) units 4) a scale 5) a key explaining the data. In order to label the axes, the independent and dependent variable must be found. The independent variable is a constant, it is consist throughout the experiment. This variable is on the x-axis. The dependent variable “depends” on the independent variable and is thus recorded on the y-axis. This means that the independent variable causes change in the dependent variable, but it is not possible for the opposite to occur.

Trends in graphs are very important to analyze the data in science. First, a line of best fit should be found. Students in the lesson will do this simply by approximating what the line most looks like. There are three types of trends. Linear graphs, are just as they sound, in the form of a line. With a positive linear relationship, both will increase. With a negative linear relationship, one will increase as the other decreases. Asymptotic graphs can have positive and negative relationships as well. A positive one will also increase as the other variable increases, but in the beginning it will do so more slowly than at the end, creating a curved line. With a negative asymptotic graph, one variable decreases as the other increases, but does so less at the beginning, also creating a curve. Finally, there can be no relationship at all. This is when the line of best fit is just straight across the graph.

Procedures:

Using the data you collected during the greenhouse lab, create a graph on the board. This will be done as a group. Make sure there is a title, labels on the axes, units on the axes, a numerical scale on each axis, and a key (Note: unless there are two things on the same graph, the key is not as important

Lesson Wrap-up:

Practice data analysis from the worksheet graph on your own. Analyze the data and answer the following questions:

What conclusions can you make from this graph?

What is a real world application of this study?

Discuss the importance of having graphs and equations in science.

Graphing Practice Worksheet

Name _________________

Directions: Read the following material, examine and line graph the data, then answer the questions that follow. We sent up an AnaSonde, and this is the data that we got back. We know that the average pressure at ground level for this area is 850 and 4600 ft is ground level. We have already converted it from the Morse code numbers using software, but we need to graph it now so we can see the profile of the atmosphere as the balloon flies through it.

Height in atmosphere (m)	Pressure (mb)	Temperature (C)	Humidity
4600	800	14	49%
6000	772	12	52%
7500	750	9	63%
9200	698	7	74%
10700	658	7	75%
12000	617	6	80%

Graph Title: ____

Lesson # 6 Microclimates

<u>Content Background:</u>

A ***microclimate*** is region where the climate varies from the surrounding climate. The term can refer to anything from a small shaded area under a tree to a large valley. They are very important for many different things such as an area that will support some plant where that plant can normally not grow. A microclimate under a tree can also help block the sun from getting into a house or provide a cooler environment for an animal on a sunny day.

<u>Procedure:</u>

Use your AnaSonde to collect data from several different microclimates around the school. Use the Microclimates worksheet to record your data. Then convert the Morse Code into numbers and graph it. Copy your graph onto the board, overlaying your graphs on the same grid so you can compare results with the rest of the class.

<u>Lesson Wrap-up:</u>

Write a short discussion of the trends you see in the different microclimates and how this data might be useful to know.

Microclimate Worksheet

Name _________________

Directions: Read the following material, examine the data and create a line graph with the data, then answer the questions that follow.

Hypothesis: ____

____

Using your Buzz –E AnaSonde, take your temperature sensor to a microclimate and write the name of that microclimate on the data chart. Make sure to label your graph!!! Record your temperature in that area once every minute for ten minutes. Get another group's results from a different microclimate and then graph them both. Compare your data to theirs, what was different in their microclimate? Why is this important to know? Write your responses to this on the back of this page.

Time (s)	**Group 1 Temperature (C)** ____________________		**Group 2 Temperature (C)** ______________________	
	Morse Code	Decoded	Morse Code	Decoded

Graph Title: ____

Lesson # 7 Flight and Flight Discussion

Procedures:
In this lesson, you will fill the balloon with helium to the point where it has 90 grams of lift and then attach the parachute to the balloon and to the AnaSonde with the parachute being between the balloon and AnaSonde. (Refer to the Appendix for help.) Finally, the computer must be attached to the walkie-talkie receiver.

Make sure the AnaSonde is turned on to start collecting sample data on the ground. This is to ensure that everything is working properly before it is sent into the air. Once the AnaSonde is on, turn the CW get program on. Next, open the software and enter the correct configurations. Finally, before proceeding to the next step, make sure the software is receiving clean lines of data from the AnaSonde. Once it is launched you cannot turn the AnaSonde on or adjust other parts of it.

Next, launch the balloon. Three students will be needed for this part, one to hold the balloon, one to hold the parachute, and one to hold the AnaSonde. The students will let go of the balloon in a way such that the balloon goes up first and it pulls the rest of it out of the other two student's hands. Do this gently to ensure nothing gets broken.

Record the data points every 1 to 2 minutes, you will graph this together in class. Once the AnaSonde reaches a height in which the temperature goes below zero, take the set up back inside and clean up for the day. The data will be discussed in the next class period.

Lesson Wrap-up:
Create a conceptual model of the weather in the form of a concept map. Do your best to include what was just discussed about the AnaSonde data. Also, describe which layer they think is most important and why and relate it to what happens in that layer.

Annotated Bibliography

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“Climate Change – The Greenhouse Effect.” 16 Feb 2008. Science 10. 12 Aug 2008. <http://wblrd.sk.ca/~sci10_dev/2_weather/cc_grnhouse_ef_demo.html>: The greenhouse lab idea was taken from this website and adapted to fit in this curriculum. They just were comparing having a bag over the thermometer. This curriculum adds the Alka Seltzer tablet to produce gas to fill the bag to compound the effect and make it more obvious that we are talking about greenhouse gases.

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“Soldering and Troubleshooting Tips.” www.bae.ncsu.edu. North Carolina State University. 24 July 2008. <http://www.bae.ncsu.edu/programs/extension/4-h/solderingandtroubleshooting_tips.pdf>: This website contains some tips for soldering and tips for troubleshooting if the AnaSonde does not work right away.

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Appendix: AnaSonde-E Parts List and Assembly Instructions

Parts list:

In the foil bag:

q Circuit board
q U1: 78L05 voltage regulator
q U2: PIC12F675 microcontroller
q U3: 433.92 MHz transmitter (direction sensitive)
q X1: 4 MHz resonator (3-pin brown device, not direction sensitive)
q D1: light emitting diode (LED)
q R1: 620 ohm resistor
q C1, C2: 0.1 mF capacitor
q S1: switch
q 9-volt battery snap
q 8-pin socket for U2
q antenna wire, approximately 6.5 inches long

Additional sensors (only checked items are included)

q LM19 temperature sensor
q ASDX015A24R pressure sensor (this is loose inside the box)
q HIH-4000 humidity sensor
q Other:____

In the box:

q 3 x 5 index card to create a sun shield for the sonde
q balloon
q cable tie for sealing the balloon and attaching the payload to the balloon
q parachute
q 18 feet of Dacron line for parachute lines, to attach the sonde to the parachute, and to attach the parachute to the balloon – cut it into six pieces of 3 feet each
q 4 clear round stickers to attach the parachute lines to the parachute

Assembly Instructions

Circuit board assembly:
Note: all components are installed on the component side of the board, which is the side with the white labels. All soldering is done on the solder side (without the labels). You may need to temporarily hold parts in place by gently bending pins or using a small piece of tape prior to soldering them.

1. Install the socket for U2. Orientation is indicated on the socket (notch) and on the board (notch on white outline).

2. Install R1 and D1. D1 is direction sensitive – the longer leg should go to the side marked + on the circuit board.

3. Install U1. This is direction sensitive – be certain the flat side of the case matches with the flat side of the outline on the circuit board. Be certain this is a 78L05, and not the temperature sensor which comes in a case that looks the same.

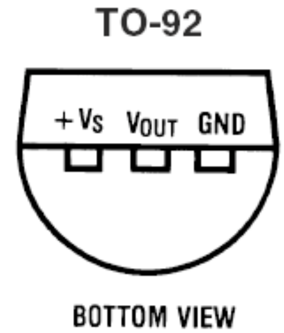
4. Install C1 and C2. These are not direction sensitive.

5. Install S1. Be sure to move it to the off position at this time.

6. Install X1.

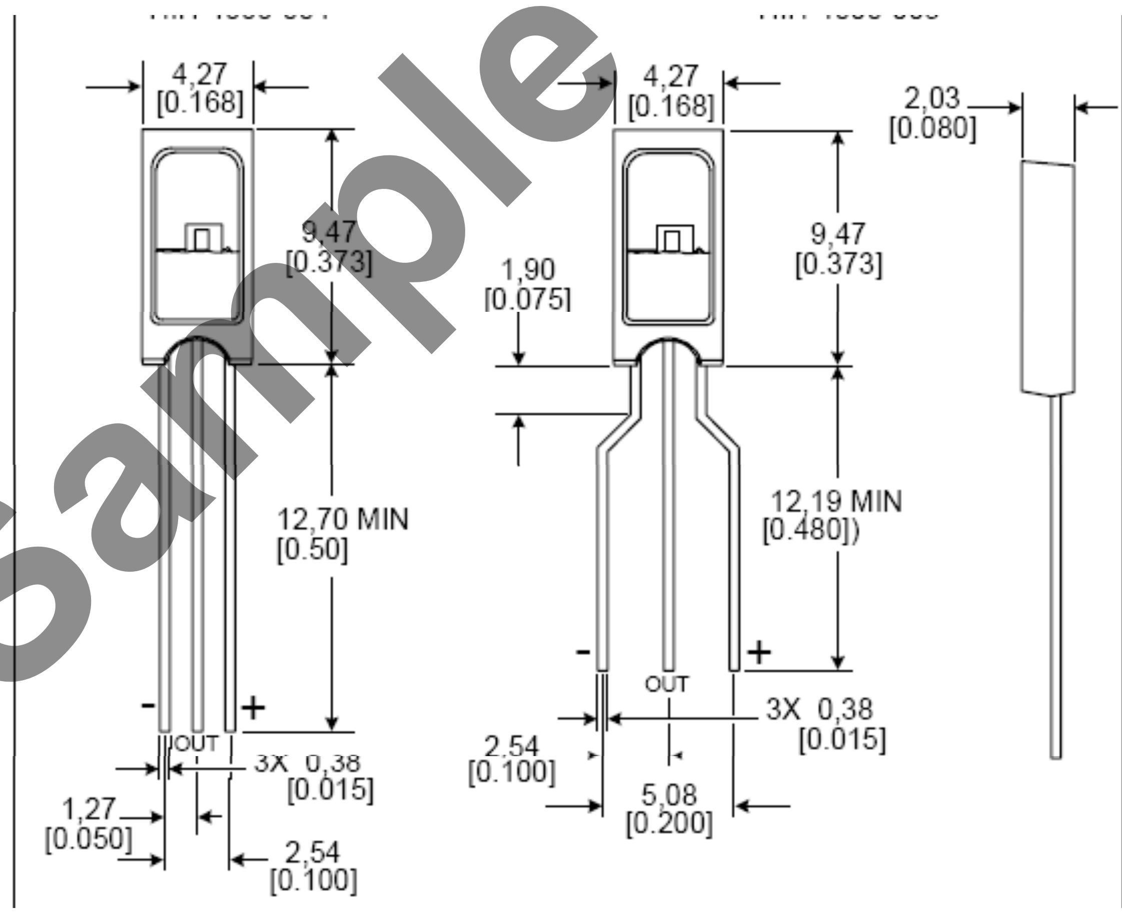
7. Install the sensors – refer as needed to steps 7A through 7D. Only follow those steps for which you have parts. Sensors are installed into the blocks on the board labeled as g1+ and g2+. This notation refers to the connections which are made to the sensors: the "g" section is ground (zero volts), the "1" or "2" refers to where the signal from a device goes, as well as which channel number it will appear under in the telemetry, and the "+" refers to the positive 5-volt power supply. Thus, each sensor section supplies ground, 5 volts, and a signal line for a sensor.

> 7A. Install the pressure sensor. This sensor is in a large 8-pin package, and will only fit the channel 2 position on the AnaSonde-E. Pin 1 has a little notch cut out of it, and this pin goes into the oval pad (in the + row) within the channel 2 block outline. Be certain this is installed correctly – reverse installation will cause immediate destruction of the sensor.
>
> 7B. Install the temperature sensor. This sensor can go into either channel 1 or 2. This sensor has 3 leads, which correspond to +5 volts (pin 1), signal out (pin 2), and ground (pin 3). The following figure illustrates the pinout as viewed from the bottom of the device:

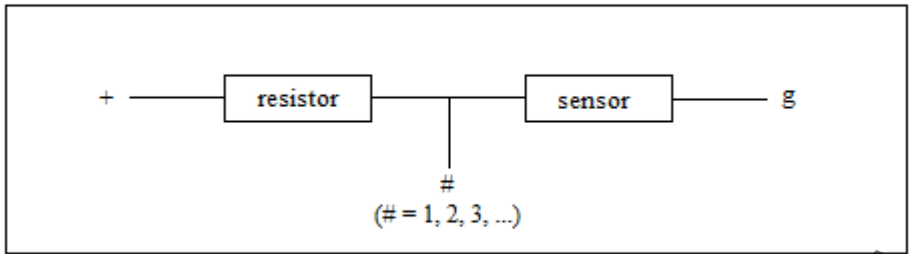


Install the sensor so that pin 1 goes to 5 volts (+), pin 2 to the input (labeled with a channel number), and pin 3 to ground (g). On the AnaSonde-E, this means that the flat side of the case will face the inside of the board if it is board-mounted. However, for fastest response (and best performance on flights), the temperature sensor should be mounted away from the board using either 3 fine wires (two inches of 28 gauge solid wire works well) or a flat ribbon cable.

7C. Install the relative humidity sensor, which can go into either channel 1 or 2. On this sensor, pin 1 is ground, pin 2 is the signal, and pin 3 is +5 volts. This is backwards from the temperature sensor. This figure illustrates the pinout of the device as viewed from the front (when you can see the tiny sensor chip):

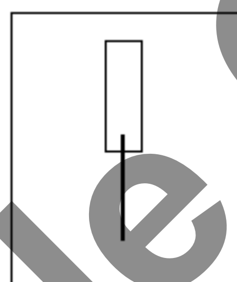


7D. Install any other sensors. A typical connection will use a resistive sensor coupled with a fixed resistor as a voltage divider:



8. Install U3, the transmitter. The transmitter has its pin 4 labeled "ant", which should go next to the hole labeled "ant" on the circuit board. The circular can on the transmitter will face the inside of the board.

9. Install the antenna wire in the hole labeled "ant". Bend this antenna so that it points straight out from the board (and be sure to straighten it before launch!).



10. Install the 9-volt battery snap. Bring the wires from under the board, through the large holes adjacent to the + and – markings at the bottom of the board, and then solder the wires into the smaller holes adjacent to the + and – markings. The black lead goes to -, the red lead goes to +.

11. Install U2 in the socket. Be sure the little indented dot on the top of U2 (which marks pin 1) is placed closest to the notch in the socket.

This concludes the circuit board assembly. You may now connect a 9-volt battery and test the AnaSonde.

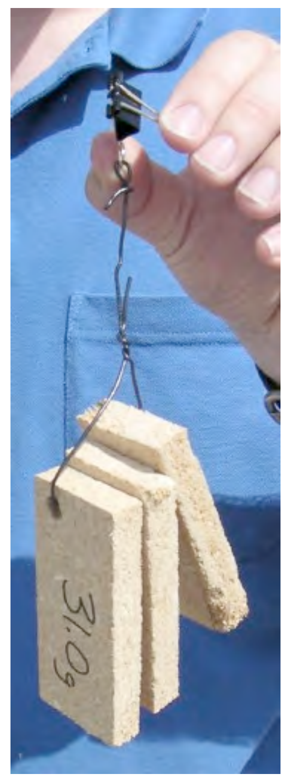
Flight Preparation:

12. Assemble the parachute. There are dots on four corners of the parachute indicating where the shroud lines should be attached. Each shroud line should be 3 feet long (cut from the long piece of Dacron line supplied with the kit), and be attached to the parachute with one of the very sticky clear round stickers. It helps to wrap the end of the line around the sticker once before attaching it to the parachute (so that there are two parts of the line under the sticker). Tie the four lines together at the bottom.

13. Cut another 3 ft long piece of Dacron and tie a small, about 1/2-inch loop in one end of it (this will go to the cable tie that seals the balloon in step 17). Tie the other end of this line to the top center of the parachute by pinching part of the parachute together to provide something for the line to grab onto. Be sure this knot tightly holds the parachute.

14. Use the remaining Dacron line (about 3 feet) to attach the AnaSonde to the knot where the parachute lines come together. When attaching to the AnaSonde, it is best to tie a loop around the 9-volt battery snap such that the loop around the snap passes between the battery terminals. That way, when the battery is snapped on, the loop can’t come off.

15. Make a sun shield for the AnaSonde by folding the 3 x 5 index card into a tube and taping it. The purpose for the shield is to protect the sensors which are sensitive to sunlight, either due to heating by the sun (in the case of the temperature sensor) or whose circuitry is exposed and would be disrupted by exposure to sunlight (in the case of the humidity sensor). Slip the tube around the AnaSonde and tape it to the battery wires to hold it in place. It may help to cut a small slit at one end of the tube into which the wires go, so that the wires can be inserted into the slot and then taped in place there.



16. Fill the balloon with helium. You will want the balloon to lift about half again as much mass as the mass of the AnaSonde plus its battery. Typically, the AnaSonde plus an alkaline 9-volt battery will have a mass of about 60 grams – so, you would w ant a total lift of about 90 grams.

An easy way to do this is to make up a dummy mass using small blocks of wood with holes drilled in them, and then securing the appropriate mass of blocks to a small binder clip with a loop of wire (see adjacent photo). When you are ready to check the balloon lift, twist the neck closed and use the binder clip to hold it closed and to hold the weights on the balloon. If the balloon can just lift the dummy mass, you’re ready to go.

17. Take the end of the line that goes to the parachute (this is the end with the small loop in it you tied in step 13) and put it around the cable tie. Then, with the balloon neck twisted closed, put the cable tie around the neck and tighten it to hold the balloon closed and to attach the payload to the balloon.