Meteorology Course Summary

History of the Atmosphere:

Scientifically, Earth was created 4.6 billion years ago and since then, the atmosphere has changed greatly. Earth's earliest atmosphere was quite toxic, including carbon dioxide levels in the 50-80% range. This has decreased dramatically throughout time and is now only 0.025% of our atmosphere. While carbon dioxide dominated our early atmosphere, nitrogen (78%) and free oxygen (21%) dominate today's atmosphere composition. This is a good thing because without the free oxygen, we would not be here and free oxygen has gone up from 0% in early atmosphere to present day levels.

Layers of the Atmosphere:

The atmosphere can be broken down into four (4) separate layers with three (3) transitional zones in between. The four layers exist because of temperature differences that are happening way up in the atmosphere. The bottommost layer is the troposphere. Here, temperatures decrease as you get higher and higher into the sky (climbing Mt. McKinley is going to get colder and colder). The troposphere is also where all weather events occur. The second layer is the stratosphere, which is where you can find most of the ozone that absorbs the ultraviolet radiation from the sun. In theO stratosphere, temperatures now increase as you get higher and higher in the sky. The next layer is the mesosphere, which is the coldest layer in the atmosphere and again, temperatures decrease with altitude (like the troposphere). Lastly, the thermosphere continues on and on and on, but includes two sub-layers. These two sub-layers are the ionosphere and the exosphere. The ionosphere is best known for the Aurora Borealis, or Northern Lights. These lights can best be seen in the winter time up near the Arctic Circle and are results of solar flares being sent outwards from the Sun and coming in contact with Earth's magnetic field. This magnetic field protects life on Earth from experiencing the impact of the flares, but instead pushes the flares up and down towards our North and South poles. Once gathered at the poles, the flares come in contact with the atoms and the become ionized. In the exosphere, particles simply escape to outer space.

Heating & Temperature:

Our primary source of heat on this planet comes from the Sun. When the energy comes to us from the Sun, it arrives as shortwave radiation and it is absorbed by the Earth. At night, the Earth tries to re-radiate some of that energy back, but this time as longwave radiation that gets trapped in by our atmosphere. This is the basis for the "Greenhouse Effect" and has a bad reputation, but it also keeps us alive and warm at night.

Albedo is a term that is the percentage of sunlight reflected off of a surface. Pure white has an albedo of 100% whereas black is 0%.

Heat is transfered to our Earth through radiation from the Sun's energy. When heat is transfered through a fluid or gas, it is called convection, and this is commonly felt in houses with cold air sinking and warm air rising. When heat is transfered from molecule-to-molecule, it is called conduction.

When it comes to temperature variations, there are many reasons why two cities can have different temperatures. First, places in Alaska get nearly 24 hours of sunlight in the summer, but nearly 24 hours of darkness in the winter. The closer you get to the equator, the more

your length of day is going to be closer to 12 hours daily. Secondly, assuming that locations are on the same latitude and get similar incoming light, temperatures can vary because of their location in regards to the oceans. Locations near the oceans will be more mild year round as compared to a continental location which is cut off from the marine influence. Places in the middle of the continent experience really hot summers, but really cold winters. Places on the West Coast are very similar all year long. Another reason for different temperatures is the direction of nearby ocean currents. If you live on the West Coast, the California Current brings ocean water directly at the coast. On the East Coast, the Gulf Stream brings the warm ocean waters away from the land and towards Europe. Therefore, the West Coast is under a much stronger influence than us here on the East Coast. Another reason for varying temperatures is based off of geographical features like mountains. Locations at higher elevations will be cooler by an average rate of 3.5 degrees Fahrenheit every 1,000 feet you increase.

Moisture & Stability:

When liquid water becomes water vapor, this is called evaporation. When it goes from vapor into liquid, it is called condensation. Transpiration occurs when plants give up water vapor to the atmosphere.

Relative humidity is how near the air is to its maximum capacity for holding water vapor. As temperature decreases, relative humidity increases. In order for condensation to occur, temperatures must reach the dew point so that relative humidity becomes 100%. The easiest way to do this is by cooling the air down so that that size of a parcel of air shrinks. On the other hand, the capacity of air to hold more water vapor increases as temperature increases.

A sling psychrometer is used to measure the dry-bulb (air temperature) and wet-bulb (temperature of a wet wick). The difference between the two temperatures shows the wet-bulb depression and from this, relative humidity can be determined. If the temperatures are ever the same, this means that the air is completely saturated with a relative humidity of 100%.

Air Pressure and Winds:

Wind is simply the movement of air from high to low pressure. Air pressure is simply the weight of the air above. The average air pressure is 14.7 pounds per square inch at sea level. As altitude increases, air pressure decreases (or the barometer falls). A barometer is an instrument used to measure air pressure and is measured in inches of mercury. As water vapor is added to the air, air pressure decreases because the mass of water is less than that of air.

You can find areas of low pressure at the equator (inter-tropical convergence zone) and at 60 degrees north and south of the equator. High pressure zones can be found at 30 degrees north and south and at the poles. The equator is an area where the northeast trade winds and southeast trade winds converge, producing rising air and heavy precipitation (rainforests). We are located in the prevailing southwesterlies.

Air pressure can be a major factor in determining weather. Low pressure areas are usually associated with cloudy skies/rain or snow and move counter-clockwise. High pressure skies

are usually associated with fair weather and rotate clockwise. You can find both of these on a weather map. You will also find isobars, which are lines of equal air pressure.

During the day, the temperature of the land is greater than the water, so the air above the land rises and air from the ocean comes in to fill its place. This is called a sea breeze. Land breezes blow from the land to the sea at night because the water is warmer than the land.

When designing windbreaks, you would want to utilize a variety of trees and shrubs. Larger trees will protect a larger farmstead. To figure out how much area is being protected from the wind, you must consider the zone of protection ((windbreak height - crop heigh) x 6). Also, it is important to set up the windbreak perpendicular to the winds to effectively scatter the wind.

Condensation:
Condensation is simply the act of water going from vapor to liquid. It goes from invisible to visible. Examples of condensation include dew, frost, moisture forming on a cold glass, or a mirror fogging up. For condensation to occur, you absolutely must cool the air to reach its dew point. This can happen in many ways, but dew is the best example. Dew is when water forms on the blades of grass despite the fact that it never rained. The blades of grass acted as condensation nuclei and the water condensed on the ground. This happens at night and not during the day because the temperature at night is colder and cold enough to reach dew point.

Fog:
Radiation fog occurs when the Sun goes down at night and results in the land and air cooling to its dew point. Advection fog occurs in places like San Francisco Bay when the moist air blows over a cold surface. Steam fog occurs in places like Yellowstone National Park, which features geothermal pools of water that evaporate. When the moisture evaporates, it immediately hits the cool air and condenses.

Clouds:
Clouds are given names based on their altitude and their composition. Low-level clouds are found below 6,500 feet and give us most of our precipitation. High clouds are found above 20,000 feet and are made mostly of ice crystals. These include cirrus, cirrocumulus, and cirrostratus. If the cloud names begins with 'alto' it is a mid-level cloud.

There are a few exceptions to the levels and that is because these clouds can either happen anywhere or can exceed way beyond other clouds. Contrails are the streaks in the sky left behind by airplanes when the exhaust serves as the condensation nuclei. Cumulonimbus clouds are known for its towering anvil head and nasty weather. Cumulus clouds are isolate and appear to be dense, billowy, and patchy clouds.

Precipitation:
There are 7 different types of precipitation - rain, freezing rain, drizzle, freezing drizzle, sleet, hail, and snow. Rain is simply liquid water falling from the sky, but when rain freezes on the way down, it is called sleet. Hail, which features onion-like layers, forms inside a cumulonimbus clouds when updrafts of air repeatedly carry raindrops up to freezing levels. Precipitation that evaporates before it reaches the ground is called virga, and is technically

not a true form of precipitation. You can usually find rain and snow on the windward side of a mountain range, which is the side closest to the ocean.

Air Masses:
Air masses are important because they bring weather elements from place to place. Air masses coming in from continental polar areas in Canada (cP) will bring us colder and drier air. However, if it passes over the Great Lakes, it will pick up that moisture and dump snow on the western parts of Pennsylvania and New York. This phenomenon is called lake effect snow. On the other hand, if the air mass comes in from the ocean in the North Atlantic (mP), we get nor'easter storms, which can bring heavy amounts of precipitation to us.

When it comes to fronts, warm and cold fronts are the two major types. Cold fronts typically bring sudden weather changes with colder temperatures and heavy showers. These are shown on a weather map by blue triangles pointed in the direction of the air mass. Warm fronts are more gentle and while bringing in warmer temperatures, they do force cold air aloft, but gradually. Warm fronts are shown by red half-circles on the front line pointed in the direction of travel.

Severe Storms:
Thunderstorms require some type of lifting process forcing the air upwards. There are different types - a single-cell thunderstorm happens on a warm summer day, severe thunderstorms happen when winds get over 58 mph and supercell thunderstorms are just nasty and huge. Once you have a thunderstorm, be careful of the mature stage because this is when you're likely to find heavy precipitation and frequent lightning. When you see the lightning, count how long it takes for the resulting thunderclap. Take the amount of seconds and divide by 5 - that gives you the distance between you and the storm in miles. To see a thunderstorm, your best chance is to go to Florida - the leader in most thunderstorms in the United States.

Hurricanes originate in the warm ocean waters usually during the late summer and early fall.

The eye of the hurricane is a beautiful place to be with clear skies and no rain, but immediately surrounding the eye is the eyewall, the worst part of the storm.

Tornadoes will most frequently occur during the spring and early summer when the Earth is starting to heat up, but the upper air temperatures are still cold. It also is more common for a tornado to form in the late afternoon. This temperature inversion, or difference, creates an unstable atmosphere necessary for tornado formation. They will typically form within "Tornado Alley," which is a belt from North Dakota down to Texas, but they can happen other places in the United States like the Lehigh Valley. Their actual formation is caused by upper level winds moving perpendicular to the lower level winds and a rising air mass starting to rotate. This is called a mesocyclone and a thunderstorm is produced. If a tornado actually forms, it may or may not touch the ground. To measure the severity of a tornado, meteorologists use the Fujita Scale.

Station Models:

These diagrams show several pieces of meteorological data. First, the circle in the middle is shaded in a particular way to express cloud cover. If it is clear, cloud cover is 0%, but if it is completely shaded, there is 100% cloud cover or overcast conditions. The line sticking out from the center circle shows wind direction. It is pointed in the direction that the wind is coming from. At the end of that line are some feathers that show wind speed. To the left of the circle are two numbers, one on top of the other. The number on top shows air temperature and the bottom number is dew point. To the right of the circle is a 3-digit number that shows air pressure. However, if you see the number '958' then the air pressure is actually 995.8 mB. Remember to put a '9' in front of anything greater than '500' and a '10' in front of anything less than '500,' while also adding a decimal in between the last two digits to get the real air pressure.

Psychometric Chart:

The psychometric chart is used to plot different variables and find the resulting dew point, relative humidity, etc... Across the bottom line is absolute humidity. Absolute humidity uses the dashed diagonal lines. On the right side is the relative humidity, which is expressed in solid diagonal lines. However, be aware that the bottom line of the graph is 100% humidity. On the left side is the wet bulb depression, which is shown in solid lines going left-to-right. Like relative humidity, the bottom line is used and is a wet bulb of 0 degrees. Across the top is dew point and air temperature, shown by the vertical lines.

To solve a problem, you will always be given 2 variables. Your first course of action is to figure out where those 2 variables meet and then make a dot. From that point, use the correct lines to find the missing variables.

To find dew point, you need to go directly up from the absolute humidity on the bottom line. The resulting air temperature on the top line is the dew point, which will be equal to or less than the air temperature. On the other hand, if you are given dew point as one of the original variables, go immediately down and find the resulting absolute humidity.