Meteorology 110 Name ___________________________
Lab 3

Temperature (Conversions and Lapse Rates)

Temperature is very important in Meteorology. For example, one of the most important parts of the forecast is the temperature of air at the surface of the Earth, just because people want to know. Meteorologists find that the air temperature aloft is also necessary if they are to assess the stability of the atmosphere. If it is too cold aloft or too hot at the surface, the atmosphere is unstable. Hot, light air in bottom layers with cold, dense air above leads to vertical air motions. Thus, we need to know the **lapse rate**.

In this lab we will evaluate the lapse rate, given a series of temperatures at different altitudes. This is called a **sounding** and it is usually done by releasing a radiosonde balloon, although we will not do that. The radiosonde is equipped with a thermometer and a radio, among other weather devices, and it transmits the temperatures at many different levels.

Since the weather is international in scope, countries have treaties and agreements to share weather data such as soundings. One of the conventions of the agreements is that temperatures aloft are measured using the Celsius scale. The United States is virtually alone in our continued use of Fahrenheit degrees, but American meteorologists do follow the Celsius convention for upper air temperatures.

To convert from Fahrenheit to Celsius, use the following formula:

Temperature in °C = (Temperature in °F - 32)÷1.8

To convert from Celsius to Fahrenheit temperatures, use the following formula:

Temperature in °F = 1.8 x (Temperature in °C) + 32

In addition, there is another scale, used for scientific calculation, called the Kelvin scale. To convert between Celsius and Kelvin temperatures, simply add or subtract 273°:

Temperature in °K = Temperature in °C + 273
Temperature in °C = Temperature in °K - 273

<u>Temperature Conversion Assignment</u>

Perform the following conversions. Write your answers here. On a separate page, show (neatly) all work in doing your calculations (Show at least one decimal!):

a. 50°C = _______°F	f. 5°F = ______°C	k. 17°C = ______°K
b. 6000°C = _______°F	g. 1472°F = ______°C	l. -73°C = _______K
c. -150°C = _______°F	h. 85°F = ______°C	m. 300°K = _____°C
d. 26°C = _______°F	i. -120°F = ______°C	n. 283°K = ______°F
e. 37.78°C =_______°F	j. 132°F = ______°C	o. 6000°K =_______°F

Lapse Rate Assignment + Graphing Practice

The lapse rate is the change of temperature as you go aloft in the atmosphere:

$$\text{Lapse Rate} = -\frac{\text{Temperature at level 1 - Temperature at level 2}}{\text{altitude at level 1 - altitude at level 2}}$$

Lapse rates are expressed either in **°F/1000 feet** or **°C/km**. In the troposphere the temperature usually decreases with increasing height. This will make a negative lapse rate. For example, suppose the temperature at 1000 feet is 60°F and the temperature at 5000 feet is 20°F. Using the formula above, the lapse rate would be:

-(60°F - 20°F)/(1000-5000 feet) = -40°F/-4000 feet = 10°/1000 feet

When temperature decreases as you go up, this is the **normal** situation in the troposphere. When the temperature increases with height, the lapse rate will be negative. This is the opposite of the usual case in the troposphere and is called an **inversion.**

To calculate lapse rates one needs a series of temperatures at various atmospheric levels. Assume that a summer morning radiosonde has given us the following sounding:

Station A

Temperature (°F):	70	54	52	58	47	37	28	18	18	15	0
Level (feet):	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000

1. Plot this sounding on the graph paper supplied with this lab. Hold the page like this . Put altitude on the Y (side) axis, increasing toward the top of the page. Put temperature on the X (bottom) axis, increasing toward the right, 0 to 70. Use 1 box for each °F and 10 boxes for each 1000 feet. Label each axis. Plot the points and connect them with straight, ruled lines. The map on the last page shows you what a proper graph looks like.

2. Calculate the lapse rates for the following layers: 0 feet to 1000 feet, 0 feet to 3000 feet, 2000 feet to 3000 feet, 3000 feet to 10,000 feet . Show your work. Show the answers to this and all other questions on a separate sheet of paper. Remember to express each lapse rate in units of °F/1000 feet, not °F/3000 feet or °F/7,000 feet. Show the units.

3. Of the four lapse rates you calculated in question 2, which (from x thousand feet to y thousand feet) are normal? (Remember, a normal lapse rate is positive) Label the normal lapse rates found for question 2 with the word "normal."

4. Of the four lapse rates you calculated in question 2 which are inversions? Label the inversion lapse rates found for question 2 with the word "Inversion."

5. What is the average lapse rate from 0 feet to 10,000 feet? Use the top and bottom levels only Remember to express the lapse rate in °F/1000 feet, not °F/10000 feet. Is this overall lapse rate normal or is it an inversion?

Next, the following sounding is in the more conventional Celsius units: Station B

Temperature (°C):	20	17	13	10	7	3	0	-3	-8	-11	-15
Level (km):	0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0

6. Plot this sounding on the same page of graph paper. Put the temperature axis across the top and the heights along the right hand side axis. Here's the tricky part: The scales must be the same even though station B is °C/km while the station A is °F/1000 feet. So mark 15°C on the same line as 59°F, 10°C is equivalent to 50°F, and so on. Mark the vertical axis of 0.3 km at 1000 feet, 0.6 km is the same as 2000 feet, etc. Label all axes and title the graph. Plot

the points and connect them with straight, ruled lines. Use a different color if possible. If you only have one color, make the Station B sounding a dashed line. Include a key to the lines.
You may find it easier to convert Station B's temperatures to Fahrenheit to find the place to plot them on the graph, rather than using the top temperature axis.

7. What is the lapse rate from 0 km to 3 km? Use the correct unit for your answer, **°C/km** (not °C/3 km). Normal or inversion?

8. The bigger a normal lapse rate is, the more unstable it is because cold air above warm air tends to overturn. Even though the average lapse rates for the complete soundings were about the same, individual layers could be very different. Using your graph, which is the most stable layer on either (not both) sounding? Estimate that by deciding which single layer has the largest slope. Use your graph to make this decision.

Identify the layers as 0-1000 feet, 3000-4000 feet, 0-0.3 km, 1.2-1.5 km, etc. Remember Station A and Station B are in different units.

Example of the proper way to draw a graph. Note: the graph paper lines are not shown for clarity.