MiSP Weather — Wind Speed and Direction Worksheet #2 L3

Name ________________________________ Date _____________

TORNADOES — PRESSURE AND WIND SPEED

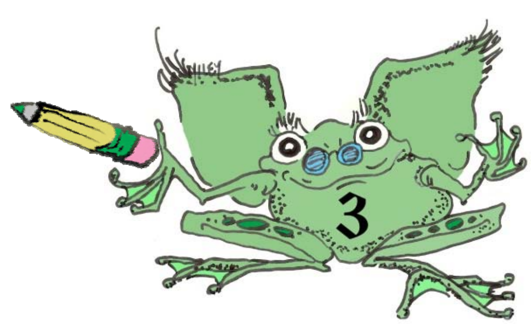
Introduction (excerpts from http://www.srh.noaa.gov/jetstream/tstorms/tornado.htm):

A tornado is a violently rotating (usually counterclockwise in the northern hemisphere) column of air descending from a thunderstorm and in contact with the ground.

The United States experiences more tornadoes by far than any other country. In a typical year about 1,000 tornadoes will strike the United States. The peak of the tornado season is April through June, and more tornadoes strike the central United States than any other place in the world. This area has been nicknamed "tornado alley."

Most tornadoes are spawned by thunderstorms. Tornadoes can last from several seconds to more than an hour, but most last less than 10 minutes. The size and/or shape of a tornado are no measure of its strength.

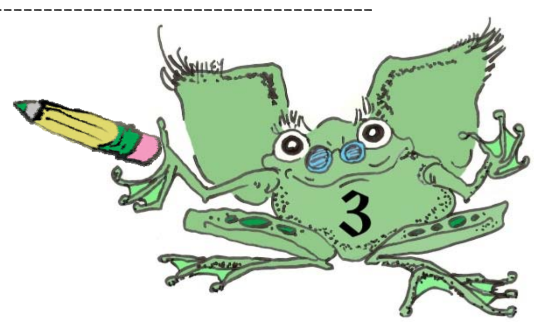
Occasionally small tornadoes do major damage. On the other hand, some very large tornadoes, over a quarter-mile wide, have produced only light damage.



The Fujita Scale

F-Scale Number	Intensity Phrase	Wind Speed	Type of Damage Done
F0	Gale tornado	40–72 mph	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.
F1	Moderate tornado	73–112 mph	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	Significant tornado	113–157 mph	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
F3	Severe tornado	158–206 mph	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.
F4	Devastating tornado	207–260 mph	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
F5	Incredible tornado	261–318 mph	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile-sized missiles fly through the air in excess of 100 meters; trees debarked; steel-reinforced concrete structures badly damaged.

The Fujita Scale (also called the "F-Scale") was originally developed by Dr. Tetsuya Theodore Fujita to estimate tornado wind speeds on the basis of damage left behind by a tornado.



Problem:

- Two variables that can be measured in tornados are the core pressure difference (the difference between the air pressure inside the funnel and the air pressure outside the funnel) and wind speed. You will use a computer simulation to examine the correlation between these two variables. **As the <u>difference</u> between the air pressure inside a tornado funnel and the air pressure outside a tornado funnel increases, what happens to the wind speed?**

Hypothesis:

If the difference between the air pressure inside a tornado funnel and the air pressure outside a tornado funnel increases, then

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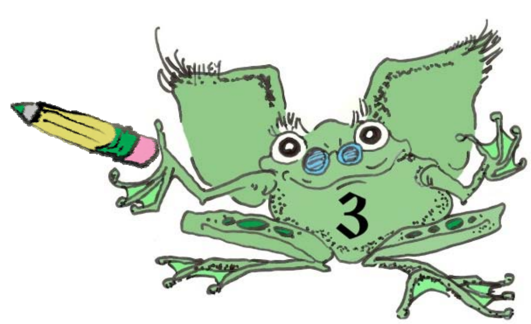
Procedures:

- Collect data about the core pressure difference and tornado wind speed using the simulation at http://whyfiles.org/013tornado/3.html .
    - Keep the funnel diameter constant at the narrowest setting by moving the left slider to the far left..
    - Use the right slider to increase the core pressure difference in intervals of 1.0 in. Hg (inches of mercury). Click "GO" to observe a tornado.
    - Observe the damage each tornado produces.
    - Estimate the F-Scale difference and record the F-Scale number and the wind speed on the data chart below.
    - Press reset between each trial.



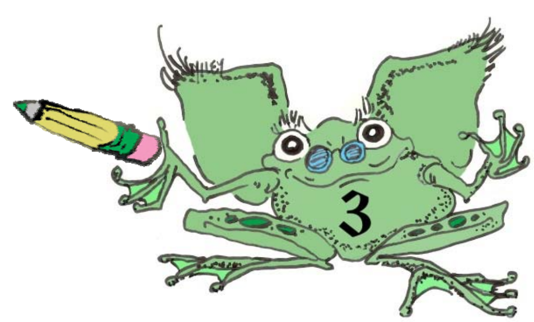
Record your data:

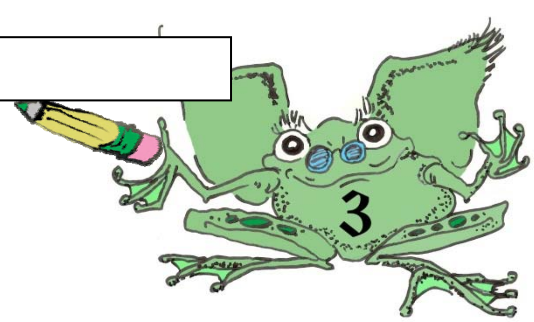
Core Pressure Difference (in. Hg)	Wind Speed (mph)	Intensity (F-Scale)
0	0 (no tornado)	Not applicable (no tornado)
1.0		
2.0		
3.0		
4.0		
5.0		
6.0		

Graph your data:

Graph the data on the next page to show the relationship between the core pressure difference (in. Hg) and the wind speed (mph).

- Label the *x*-axis.
- Label the *y*-axis.
- Connect the data points by drawing a straight line between them.

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Discussion Questions L1-3

1a. Explain the relationship between tornado core pressure difference and wind speed by completing this statement: As the DIFFERENCE between the air pressure inside a tornado and the air pressure outside a tornado INCREASES,

the wind speed of the tornado ______________________________.

1b. How is the relationship in 1a shown by the graph?

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2. The relationship between core pressure difference and wind speed is not a straight line. On the graph, where did a 1.0 in. Hg increase in core pressure produce the greatest change in wind speed? How do you know that? Refer to the graph in your answer.

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3. Using the graph, predict what a tornado's wind speed would be if the core pressure difference is 7.0 in. Hg.

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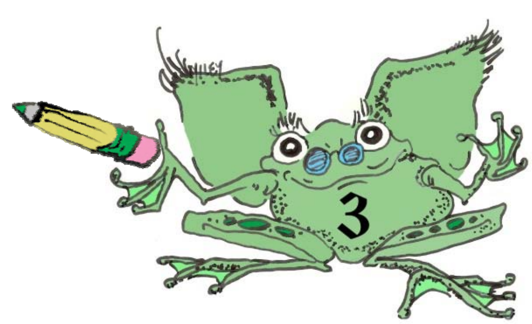


4. Compare the changes in wind speed in two regions of the graph (0 to 1.0 in. Hg and 5.0 to 6.0 in. Hg) by calculating the unit rate of change (slope).

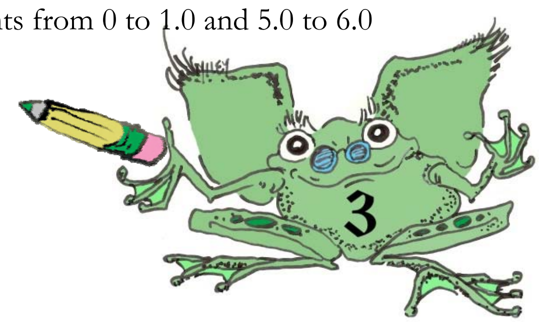
$$\text{Unit Rate of Change} = \frac{\Delta \text{ Wind Speed (mph)}}{\Delta \text{ Pressure (in. Hg)}} = \frac{\Delta y}{\Delta x} = \frac{(y_2 - y_1)}{(x_2 - x_1)}$$

Section of Graph	Ordered Pair used for calculation (x_1, y_1) (x_2, y_2)	Δ Wind Speed (mph) Δy	Δ Pressure (in. Hg) Δx	**Unit Rate of Change (slope)** $\Delta y/\Delta x$
0 – 1.0 in. Hg				
5.0 – 6.0 in. Hg				

5a. How do the unit rates of change (slopes) of the two sections of the graph compare? Discuss numerical value and sign (positive/+ or negative/-).

5b. According to the unit rates of change, in which section of the graph did an increase in pressure difference result in the greatest change in wind speed?

5c. Look at the graph. How would the unit rate of change (slope) for the line segment from 3.0 to 4.0 in. Hg compare to the unit rates of change for the line segments from 0 to 1.0 and 5.0 to 6.0 in. Hg?



6. If the line segment from 5.0 to 6.0 in. Hg were extended, it would intersect the y-axis. Determine the y-intercept for this section of the graph. The equation for a line is

$y = mx + b$
where m is the unit rate of change (slope) and
b is the y-intercept

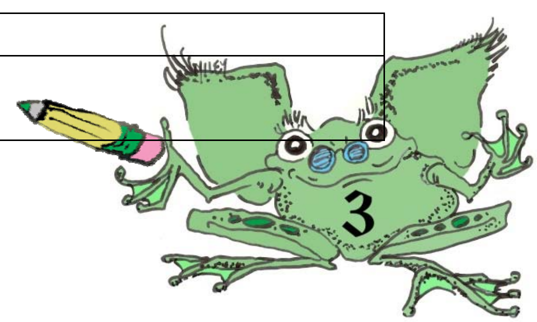
Y-Intercept
$m =$ Ordered pair (x, y) = (___ , ___) $y = mx + b$ Solve for b:

7. Based on the unit rate of change that you calculated above and the intercepts, write an equation for the 5.0 to 6.0 in. Hg section of the graph. Remember that the equation for a line is $\boldsymbol{y = mx + b}$ where m is the unit rate of change (slope) and b is the y-intercept.

Equation

8a. Use the formula you determined above to calculate the wind speed for pressure differences of 3.5 and 7.5 in. Hg. Show your work.

Pressure Difference	Calculated Wind Speed
x = 3.5 in. Hg	y = ____________ mph



$x = 7.5$ in. Hg	$y =$ ____________ mph

8b. Even though your calculation of wind speed in 8a may be correct mathematically, the formula you made in #7 should not be used to calculate wind speeds when the pressure is less than 5.0 in. Hg or more than 6.0 in. Hg. Why?

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