MG212-01 - DATA ANALYSIS - Fall 2020

HOMEWORK # 4 – 1- and 2-sample t-tests, ANOVA – Due Friday Nov 6th (10 am)

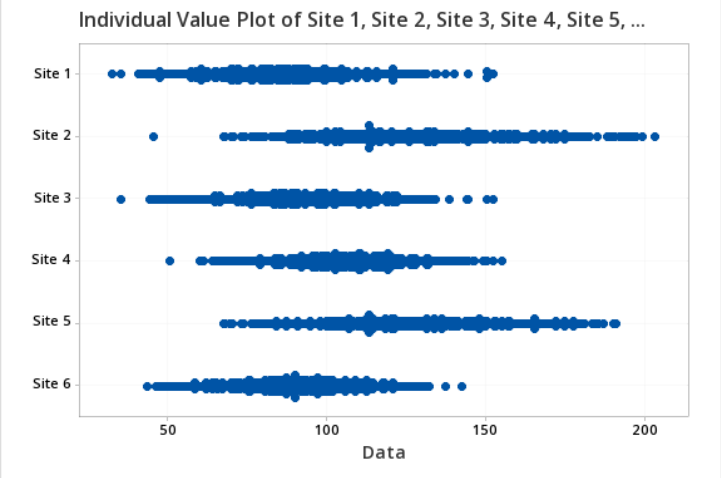
YOUR NAME: Daniel Gillinger

PLEASE ANSWER THE FOLLOWING (You can enter your answers below each question):

1. Which statistical test do we use to compare sample data to a hypothesized mean value?
   1-sample t test

2. You've just been promoted to regional manager for the Lehigh Valley Dunkin' Donuts franchises. The corporate policy for providing excellent customer service includes a **90-second average service time** for all drive-thru customers. You're analyzing the data for the last 3 months, which is found in the file called **"Dunkin Donuts Drive Thru Times (Minitab)"** that is in the "Data Files for Class" tab on BB.

   a. Start by creating an Individual Value Plot for all six locations. Use the transpose option under the Scale button to make the data appear horizontally for each site. Copy the graph and paste it below (hint: if you paste as a picture, you can resize to fit page…):



   b. Run the Display Descriptive Statistics (under Stat) for all six locations. Copy the descriptive statistics as a picture and paste it below:

Statistics

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Site 1	1985	131	86.900	0.372	16.593	32.544	75.840	85.800	97.505	152.550
Site 2	2116	0	128.18	0.513	23.60	45.56	110.56	127.77	145.11	203.36
Site 3	2014	102	90.351	0.344	15.459	35.595	80.093	90.453	100.172	152.550
Site 4	1831	285	105.74	0.342	14.65	51.01	96.02	105.81	115.52	155.29
Site 5	1797	319	126.66	0.499	21.17	67.66	111.55	126.65	141.00	190.78
Site 6	1849	267	89.936	0.348	14.978	43.930	80.125	89.850	99.960	142.620

   c. Which site had the most drive-thru traffic?
      i. **Site 2 has the most drive-thru times recorded**

   d. Which site had the least drive-thru traffic?

i. **Site 5 has the least drive-thru times recorded**

e. How many sites have exactly a 90-second average service time? Is this surprising?
   i. **None of the sites have an exactly 90 second average time, which makes sense when consider that these are people taking the orders. No matter how good they get, human workers will not always have the same time, and when dealing with human customers, that will further mess with the desired time.**

f. From the descriptive statistics, which sites initially appear to have a problem with meeting the 90-second average service time requirement?
   i. **Sites 2 and 5 on average both take significantly more time in the drive thru. Both are more than half a minute (30 seconds) higher than the desired time.**
   ii. **Site 4 is also noticeably above the 90 second average, but not by as severe an amount as sites 2 and 5.**
   iii. **Site 3 is very close to the average, but still not perfectly hitting that 90 second mark.**
   iv. **Sites 1 and 6 are both below the 90 second mark, which if the data is consistent, would be very good for those stores.**

g. What statistical test should we use to compare our sample data (the 3-month performance from each site) to the target value of 90 seconds? Run this test with graphs, and copy and paste the "Test" results (not the graphs) below:
   i. **1-Sample t test**

Descriptive Statistics

Sample	N	Mean	StDev	SE Mean	95% CI for μ
Site 1	1985	86.900	16.593	0.372	(86.170, 87.631)
Site 2	2116	128.177	23.599	0.513	(127.171, 129.183)
Site 3	2014	90.351	15.459	0.344	(89.676, 91.027)
Site 4	1831	105.739	14.650	0.342	(105.067, 106.410)
Site 5	1797	126.657	21.168	0.499	(125.677, 127.636)
Site 6	1849	89.936	14.978	0.348	(89.252, 90.619)

μ: population mean of Site 1, Site 2, Site 3, Site 4, Site 5, Site 6

Test

Null hypothesis $H_0: \mu = 90$
Alternative hypothesis $H_1: \mu \neq 90$

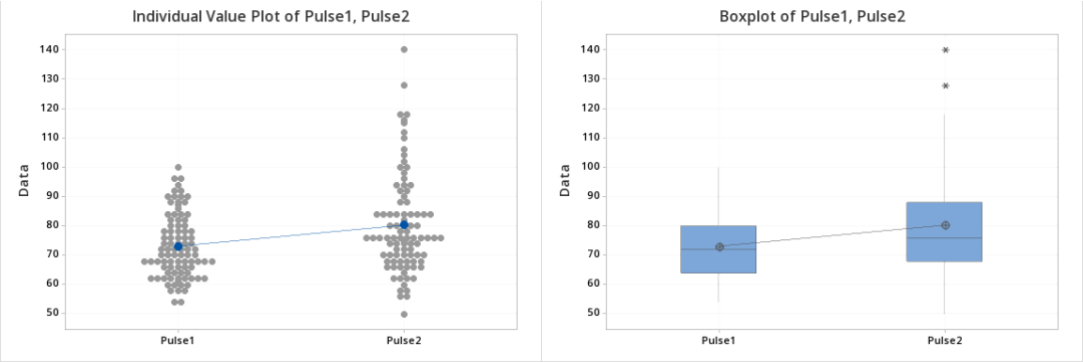
Sample	T-Value	P-Value
Site 1	-8.32	0.000
Site 2	74.42	0.000
Site 3	1.02	0.308
Site 4	45.97	0.000
Site 5	73.41	0.000
Site 6	-0.18	0.853

h. Which of the sites have results from this test that should worry you enough to contact the managers and tell them they need to improve their drive-thru times? Explain.
   i. **Sites 2 and 5 are definitely too high. They both average more than half a minute (30 seconds) above the 90-second time requirement.**
   ii. **Since site 4's stats also show that the null hypothesis of 90 seconds can be rejected, it could be a possible concern too.**

3. Which statistical test do we use to compare the means of two different groups of data?
    a. **2-Sample t test**

4. Open the Minitab file called **"3 – Pulse Rate Study (Minitab)"** that is in the "Data Files for Class".

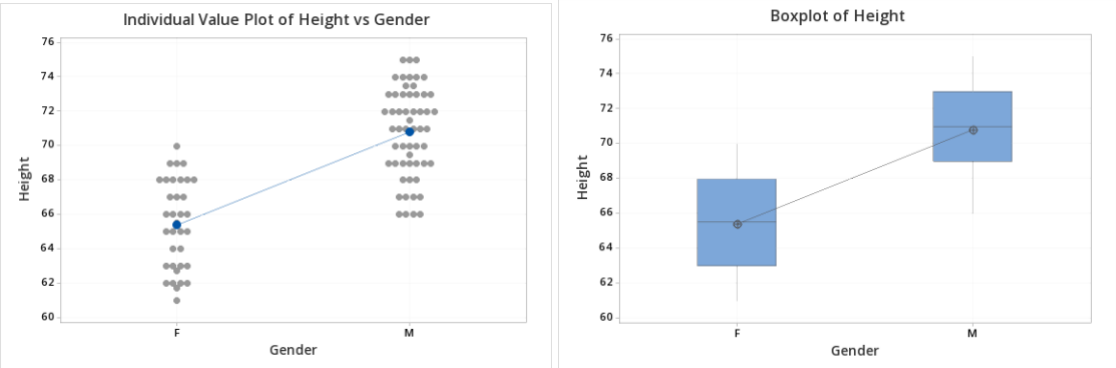
    a. Run the Stat/Basic Statistics/2-sample t-test to compare the **Pulse1 (before exercise) and Pulse2 (after exercise)** values, and include the individual value plot and boxplot using the Graphs option.



    b. Do the graphs reveal a difference in average pulse rates before and after exercise?
        i. **The graphs alone clearly show a noticeably higher pulse rate after exercise.**

    c. Can we conclude with confidence from the test of this sample that average pulse rates before and after exercise are different, or are the different means due to random chance? Please explain.
        i. **We can conclude that they are in fact different.**
        ii. **The 95% confidence interval shows no possibility of the data sets being equal**
        iii. **The P-value shows a .1% possibility of the null being true, which is below our 5% requirement to be able to say that the null cannot be rejected. So, the null can be rejected.**

    d. Run the Stat/Basic Statistics/2-sample t-test to compare the **height** of females and males in the study, and include the individual value plot and boxplot using the Graphs option.



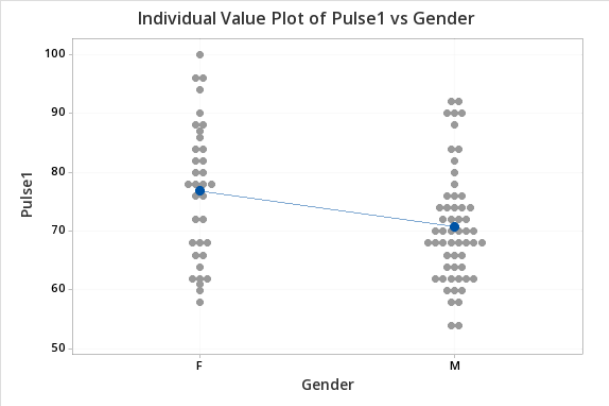
    e. Do the graphs reveal a difference in height between females and males in the sample?
        i. **Yes, the graphs show a clear difference in height between males and females.**

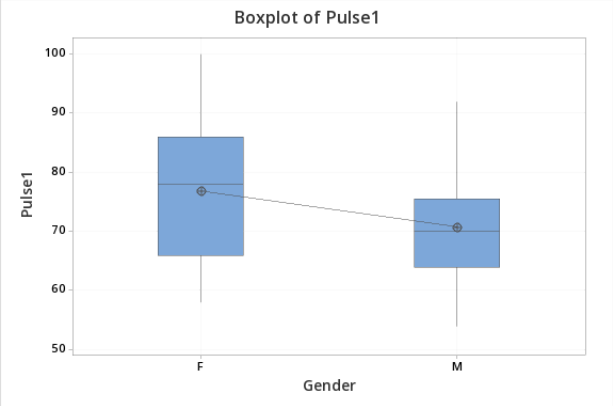
f. Can we conclude with confidence from the test of this sample that the populations of females and males have the same average height? Please explain.

   i. **No, the P-value shows that there is no chance that the two groups have the same data set.**

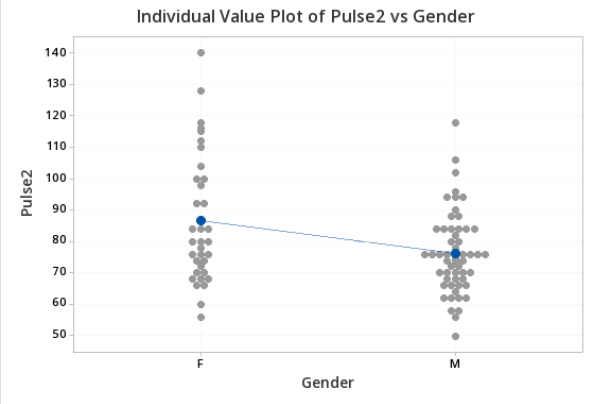
g. Run the Stat/Basic Statistics/2-sample t-test to compare the **pulse rates** of females and males in the study, and include the individual value plot and boxplot using the Graphs option. (Pulse1 was taken before exercise, and Pulse2 was taken after exercise.)

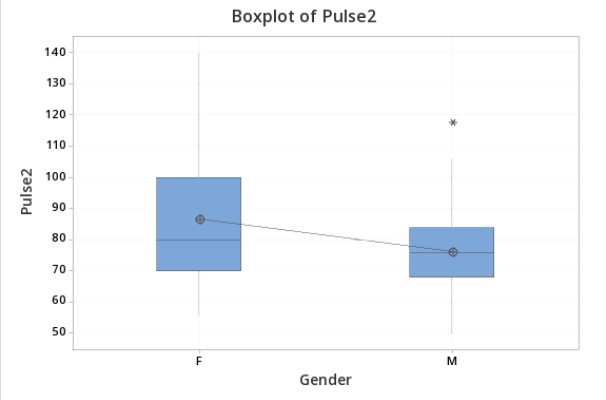
Pulse1:





Pulse2:



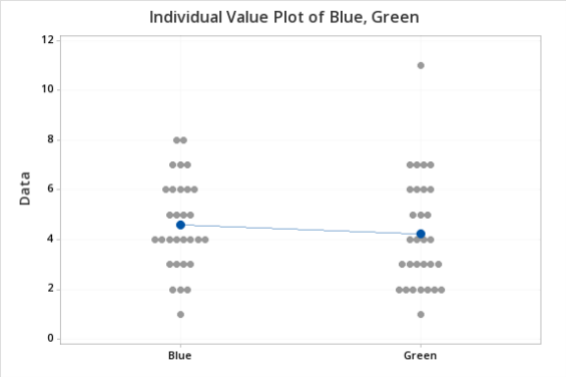


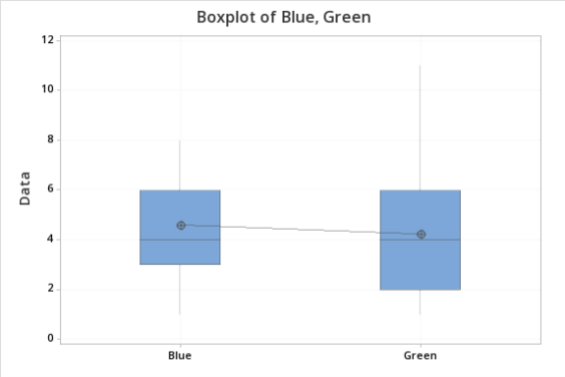
h. Can we conclude with confidence from the test of this sample that the populations of females and males have the same pulse rates? Please explain.

   i. **No, for both rates the P-value was at or just above 1%, which is below the 5% requirement to be able to not reject the null hypothesis.**

5. Open the Minitab file called **"2 – M&Ms Package Weight Info (Minitab)"** that is in the "Data Files for Class".

   a. Run the Stat/Basic Statistics/2-sample t-test to compare the number of **Blue** and **Green M&Ms** in each package, and include the individual value plot and boxplot using the Graphs option.





   b. Do the graphs reveal a difference in average number of blue vs. green M&Ms?

      i. **Not a difference that can be statistically proven. The p-value is 49%, which means that the null hypothesis cannot be rejected.**

   c. Can we conclude with confidence from the test of this sample that we should expect more blues or greens in a package of M&Ms, or are the different means due to random chance? Please explain.

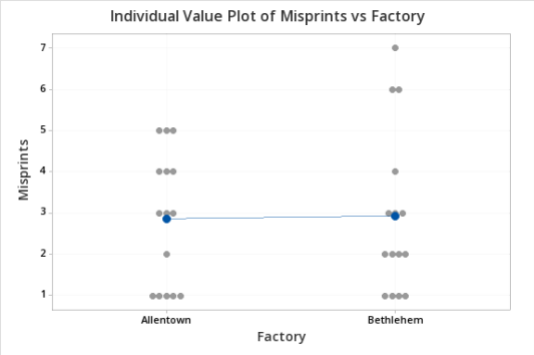
      i. **Even though the blue sample averages a little higher, we cannot deny that this may just be random chance and the two populations are identical because the p-value shows that we cannot reject null hypothesis, that the difference between the averages of the two populations are zero.**

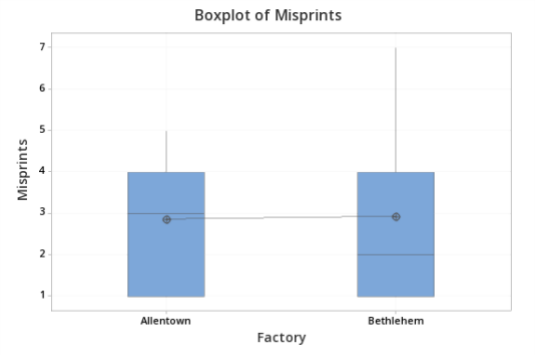
   d. Can we expect to find the same number of **Blues and Reds** in a package?

      i. **Without looking at the data on blue M&Ms compared to Red M&Ms we cannot make any assumptions from the data we have already looked at, Blue compared to Green.**

      ii. **The Red M&Ms could be made in a machine that is older, newer, poorly calibrated, or it could still be possible that none of the M&Ms have the same number and the sample that was pulled for Blue and Green was just random chance. We cannot reject the null hypothesis for Blue and Green, but it does not have to be true.**

   e. Run the Stat/Basic Statistics/2-sample t-test to compare the **misprints** at the Allentown and Bethlehem factories, and include the individual value plot and boxplot using the Graphs option.

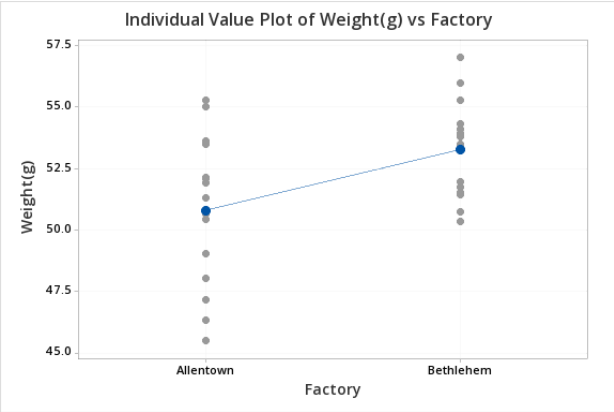


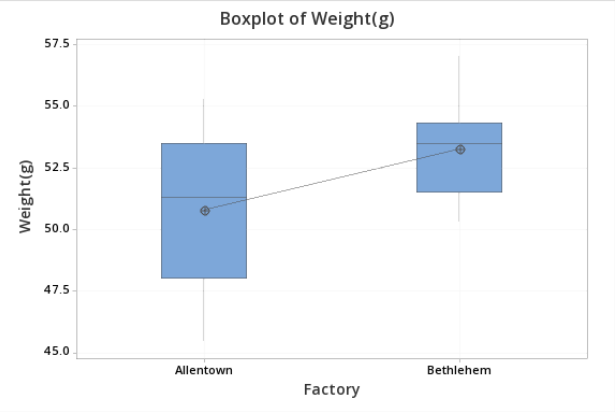


f. Do the graphs reveal a difference in the number of misprints between the factories?
   i. **The graphs are not identical, but they do suggest that the number of misprints between the two factories are very close, if not identical.**

g. Can we conclude with confidence from the test of this sample that one factory is better than the other in terms of misprinted M&Ms? Please explain.
   i. **Allentown's sample looks slightly better than Bethlehem's, but I do not think it can be said with statistical significance that the population of one factory is better than the other. In fact, the p-value shows a 92% chance that the two sets of data are identical.**

h. Run the Stat/Basic Statistics/2-sample t-test to compare the **weights** of M&M packages from each factory, and include the individual value plot and boxplot using the Graphs option.

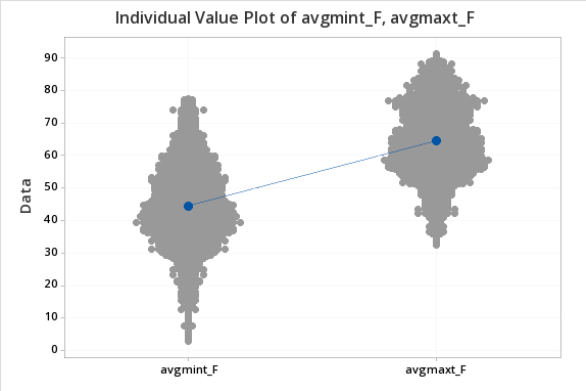


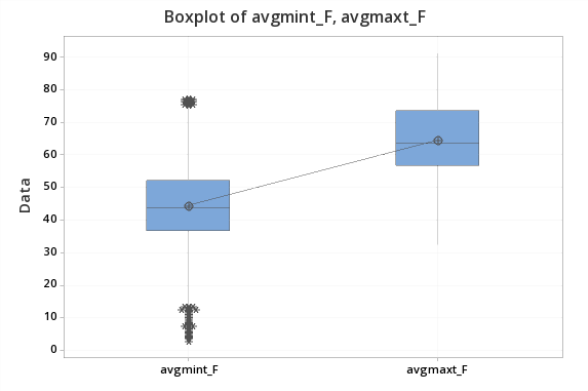


i. Can we conclude with confidence from the test of this sample that the factories are producing packages of M&Ms that are about the same weight? Please explain.
   i. **No, these samples fail the 2-Sample t test. The p-value is less than 5%, which means that the null hypothesis, that the two populations are identical, can be rejected.**

6. Open the Minitab file called **"Solar Radiation Data – Annual Averages (Minitab)"** that is in the "Data Files for Class" under Solar Radiation Data from NBER (1991 – 2010).

   a. Run the Stat/Basic Statistics/2-sample t-test to compare the **average minimum temperature (avgmint_F)** and the **average maximum temperature (avgmaxt_F)** at each location, and include the individual value plot and boxplot using the Graphs option.

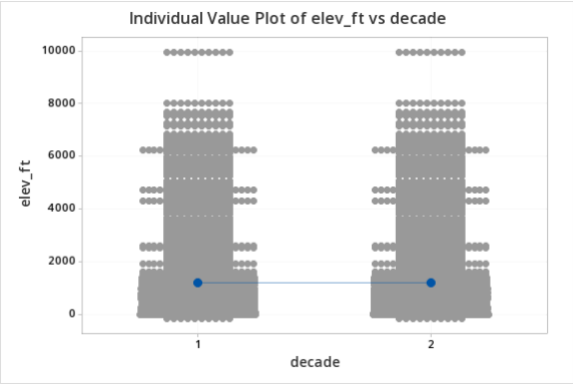


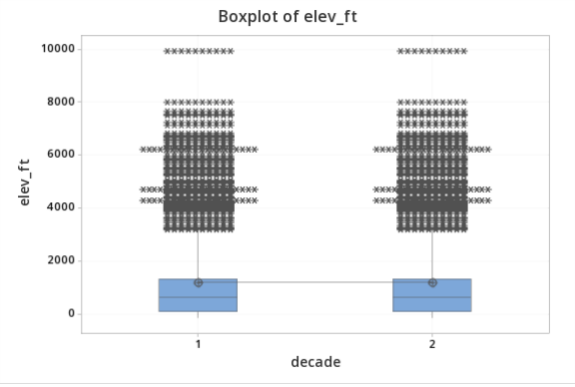


   b. Do the graphs reveal a difference in average minimum and maximum temperatures?
      i. **Yes, there is a clear difference between the average minimum temperatures and the average maximum temperatures.**

   c. Can we conclude with confidence from the test of this sample that we should expect the minimum and maximum temperatures of all locations to be different, or are the different means due to random chance? Please explain.
      i. **The test shows that there is no statistical evidence to show that the difference in means is due to random chance. The populations are very likely to be very different.**

   d. Run the Stat/Basic Statistics/2-sample t-test to compare the **elevation of each location (elev_ft) in decade 1 (1991-2000) and decade 2 (2001-2010)**, and include the individual value plot and boxplot using the Graphs option.

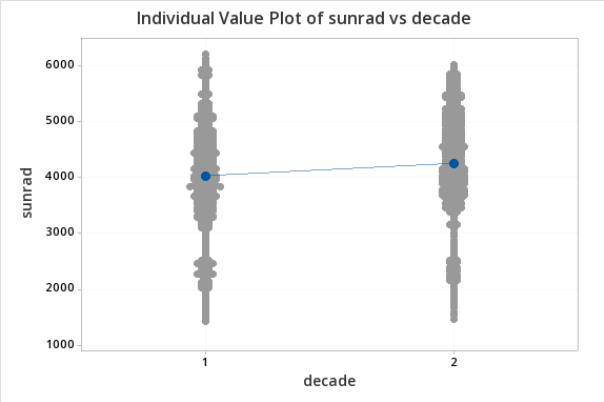


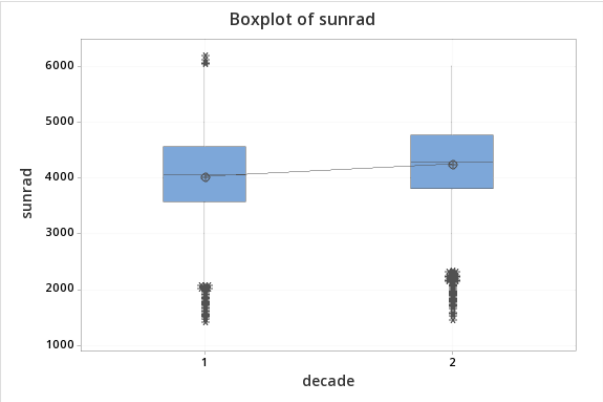


e. Would you expect, and does the test reveal, any difference between the **elevation** of a location in one decade or the other? **(this is a trick question)**

   i. **No, it would not be expected that the elevations would change over the course of two decades, and the data shows that they, in fact, do not change at all, over the two decades.**

f. Run the Stat/Basic Statistics/2-sample t-test to compare the **amount of solar radiation received at each location (sunrad) in decade 1 (1991-2000) and decade 2 (2001-2010)**, and include the individual value plot and boxplot using the Graphs option.





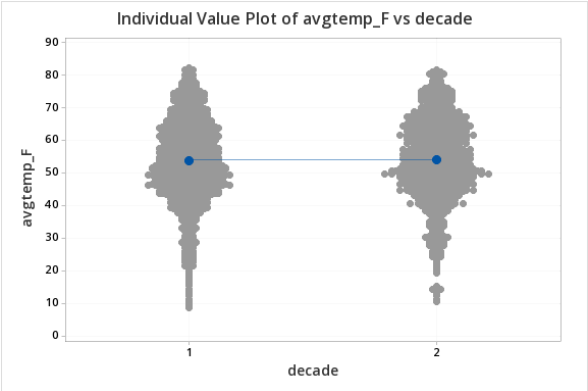
g. Do the graphs reveal a difference in the amount of solar radiation received at these locations between the two decades?

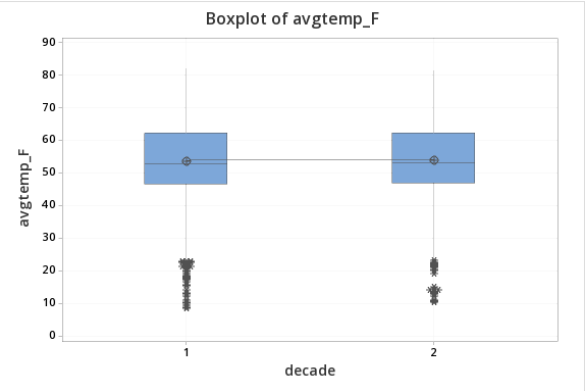
   i. **Yes, while the graphs do appear fairly similar, they do still show a clear difference in the data.**

h. Can we conclude with confidence from the test of this sample that the amount of solar radiation received has changed from the 1990's to the 2000's? Please explain.

   i. **Yes, the p-value is 0, which shows that the null hypothesis, that the two data sets are identical, can be rejected. So, we can confidently say that the two data sets are different.**

i. Run the Stat/Basic Statistics/2-sample t-test to compare the **average temperature of the locations (avgtemp_F) in each decade** and include the individual value plot and boxplot using the Graphs option.





j. Do the graphs reveal a difference in the average temperature at these locations between the two decades?
    i. **The graphs, by themselves, are too similar to be able to state that there is any difference in the average temperatures at these locations between the two decades.**

k. Can we conclude with confidence from the test of this sample that the average temperature has changed from the 1990's to the 2000's? Please explain.
    i. **No, the p-value is 10%, which means that the null cannot be rejected. The two data sets could be identical.**

l. Repeat this to compare precipitation (avgh2o_in), relative humidity (avgrh), and wind speed (avgws_mph) between the two decades. What do these tests tell us?
    i. **All of the graphs look very similar between the two decades, but both relative humidity and wind speed have a p-value of 0%, which means that the data sets are different between decades. Precipitation between the two decades is the only set of data sets where the null hypothesis cannot be rejected. So, precipitation could be identical in all of the locations, between decades.**

7. Which statistical test do we use to multiple groups to determine if at least one of them is different from the rest, and to identify clusters of observations that are statistically similar?
    a. **ANOVA**

8. Open the Minitab file called **"Solar Radiation Data – 6 States Annual (Minitab)"** that is in the "Data Files for Class" under Solar Radiation Data from NBER (1991 – 2010).

    a. Run the Stat/ANOVA/One-way test to compare the mean **latitude** for all six states (what's the state code?). Make sure you select "Tukey" under the Comparisons button, and selecting the "Graphs" option is also nice.

    b. What is the null hypothesis?

        i. **The null hypothesis is that all means are equal.**

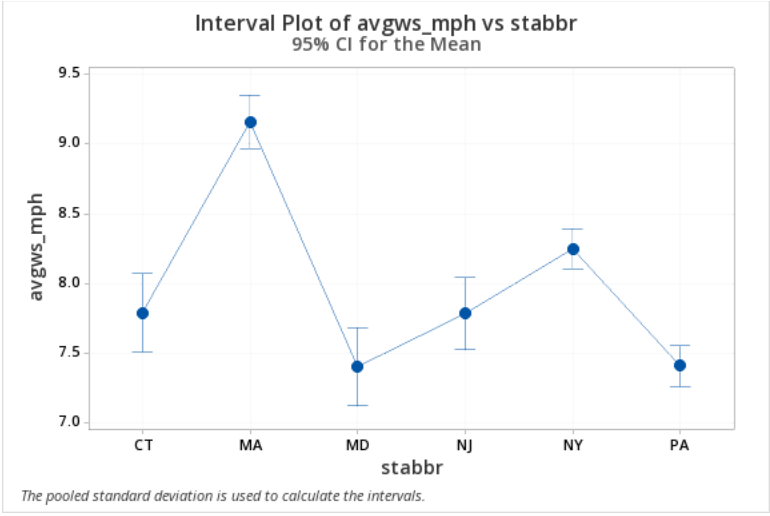
    c. Does the Analysis of Variance P-Value support the null hypothesis or not?
        i. **No, the p-value is 0% so the null hypothesis can confidently be rejected.**

    d. From the Tukey Pairwise Comparisons, does it appear that any of the states can be grouped into of statistically significant clusters with similar **latitudes**?
        i. **No, none of the states are grouped together.**

    e. Which states can be grouped together into statistically significant clusters that receive similar amounts of solar radiation (**sunrad**)?
        i. **CT, PA, and MA**

f. Which states can be grouped together into statistically significant clusters that have the same average altitude above sea level? (**elev_ft**)?
    i. **MD, MA, CT, NJ**

g. Your friends are arguing about leaves blowing around in the Autumn sky. Chris from Connecticut says his state is the windiest. Mary from Massachusetts says her state is windier. Paul from Pennsylvania says his state is just as windy as the others. You step in - and what do you say to settle the argument?

i. 

ii. **We can say with 95% statistical confidence that out of the three states, PA is the windiest, then CT, and finally MA is the least windy of the group.**

[END OF HOMEWORK – HOPE YOU ENJOYED IT]