January 25 MIE237 Tutorial Questions

All the textbook questions between 9.35 and 9.50, and 10.19 and 10.54 are suitable practice, with the usual caveats:

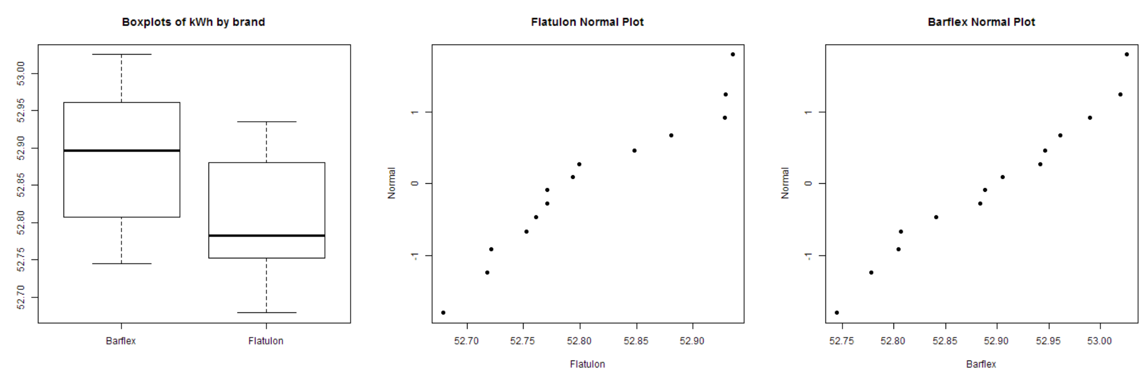
1. that the "no equal variance assumption" questions shouldn't be done manually; 2. don't bother trying to guess null and alternative hypothesis based on mind-reading of hopes and dreams...just use the two-sided alternative no matter what the book is cajoling you to do. Be strong!

Textbook questions 9.51, 9.52, 9.53(a), 9.55(a), 9.56(a), 9.57(a) are also suitable practice.

In addition, here are some questions from past tests and exams.

1. Your dog biscuit factory is going to purchase a dehumidifier for its dog biscuit warehouse. Two suppliers, Flatulon (1) and Barflex (2), offer to provide units for you to test for three months. First you decide to measure how much electricity is consumed by each unit. You run the units on alternating days for 28 days, resulting in fourteen daily kWh measurements for each unit.

Here are some plots and some numerical summaries (consisting of observed sample averages and observed sample standard deviations) you can use, if necessary:



Brand	$\overline{y}$	s
Flatulon	52.806	0.08424
Barflex	52.895	0.09016

Notes: this is a regular two-sample t-test question.

(a) Test $H_0 : \mu_1 = \mu_2$ versus $H_1 : \mu_1 \neq \mu_2$ by producing a p-value as part of your conclusion.

(b) Comment on the validity of the model assumptions and if they would affect your conclusion in (a).

2. The next test of the dehumidifiers will be to measure their effectiveness in removing moisture from the air. The units are run at opposite ends of the same warehouse on 10 consecutive days, as follows. At noon on each day, the starting humidity in the warehouse is measured. Both units are run for one hour, and the humidity is measured again near each unit. The reduction in humidity is recorded as that unit's *score* for the day.

You are interested in whether the amount of moisture reduction is the same on average for each unit or if it is different.

Here is the data along with a row of observed sample averages and a row of observed sample standard deviations, for each column:

Day	Starting	Barflex	Barflex Score	Flatulon	Flatulon Score	Score Difference
1	70.00	65.54	4.46	67.68	2.32	2.14
2	74.00	68.17	5.83	70.75	3.25	2.57
3	77.33	71.76	5.57	72.70	4.64	0.93
4	80.00	75.01	4.99	76.07	3.93	1.06
5	82.00	75.79	6.21	78.13	3.87	2.34
6	83.33	77.77	5.57	79.37	3.97	1.60
7	84.00	78.60	5.40	80.42	3.58	1.82
8	84.00	80.68	3.32	80.89	3.11	0.21
9	83.33	80.30	3.03	81.61	1.72	1.31
10	82.00	78.15	3.85	79.15	2.85	1.00
Average	80.00	75.18	4.82	76.68	3.32	1.50
SD	4.78	5.14	1.10	4.76	0.86	0.73

Perform the appropriate hypothesis test to determine if there is a difference on average between the units. Use a p-value in your conclusion, and state how you would check any relevant model assumptions to verify the validity of the p-value you obtained.

Notes: In this question you need to correctly interpret the design of the experiment. Are there really two independent samples? Or is the experiment a matched pairs design? I believe it is the latter since the same warehouse is being measured by both units at the same time each day.

So answer this question as a "paired t-test". It's possibly you disagree with me that it really "paired" and that's fine. I am not an expert on humidity or dog biscuits.

3. **REPEATED FROM LAST WEEK - THE ACTUAL QUESTION. The main purpose is to think more carefully this week about the design of the experiment.** A mining company is considering switching to a new brand of oil additive for the diesel engines on its fleet of

haul trucks. They are concerned about the amount of calcium contained in the oil additive, since too little can lead to poor oil performance and too much can lead to calcium deposits.

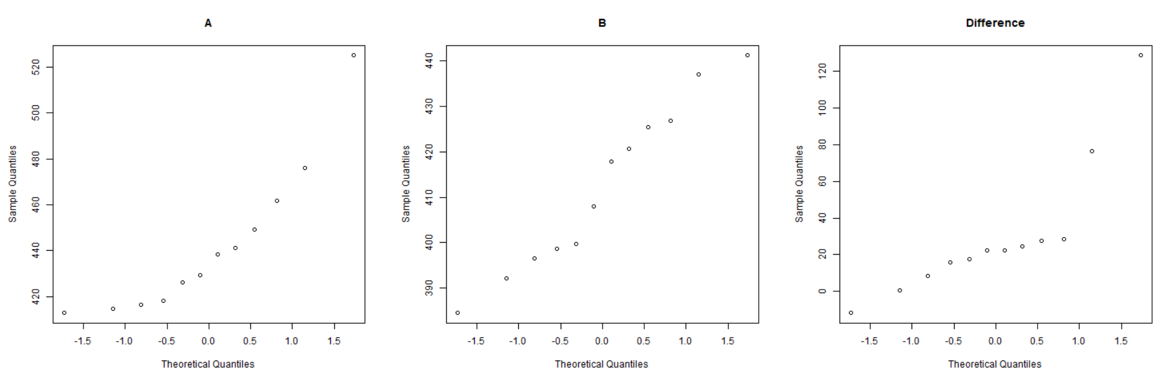
They decide to run an experiment on their 24 haul trucks to see if there is a difference in the average amount of calcium between the old brand and the new brand. The trucks are all of the same model. The trucks are divided at random into two groups of 12 trucks each - group A and group B.

Group A trucks (with identification numbers A01, A02, up to A12) use the old brand of oil additive. Group B trucks (with identification numbers B01, B02, up to B12) use the new brand of oil additive. The trucks then all operate in the same mine for the next 500 operating hours (about 30 days) as usual. An oil sample is then taken from each truck and the amount of calcium in parts per million is determined by a laboratory.

A summer student took the data and made the following spreadsheet with it. The first row of actual data is from group A. The second row is from group B. The third row is the difference between the number in the first row and the number in the second row. At the end of each row are the observed sample averages and the observed sample standard deviations for the numbers in that row.

Sample ID	01	02	03	04	05	06	07	08	09	10	11	12	Average	SD
A	441	416	476	462	426	413	415	429	449	525	438	418	442	33
B	425	408	400	437	399	385	392	441	427	396	421	418	412	20
Difference	16	8	76	25	27	28	23	-12	22	129	17	0	30	38

Here are the normal quantile plots for all three rows of data:



Provide an analysis of the data that answers the question *is there a difference in the average amounts of calcium between the old brand and the new brand.* Include the following:

- specify an appropriate model;
- perform the hypothesis test using a p-value in your conclusion;
- comment on whether or not the model assumptions have been satisfied, and if they haven't been satisfied, whether the violation casts doubt on the validity of your conclusion.

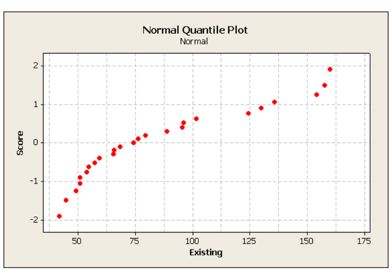
Notes: Again you are to see what the design of the experiment was. In this case you have two independent samples. The labeling of the trucks is arbitrary. The fact the summer student produced the sample standard deviation of the twelve arbitrary trucks is of no relevance and was a red herring.

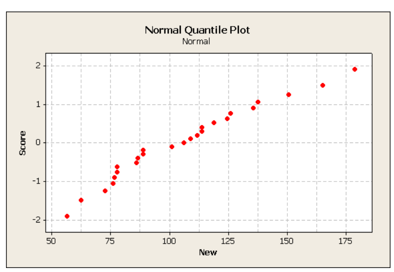
4. Hospital emergency departments can be evaluated based on the average time it takes each patient to be seen by the emergency room physician. A group of 50 hospitals will be used by some health care researchers to test a "new way" to organize the emergency departments. They want to see if the "new way" results in a different mean waiting time than the "existing way".

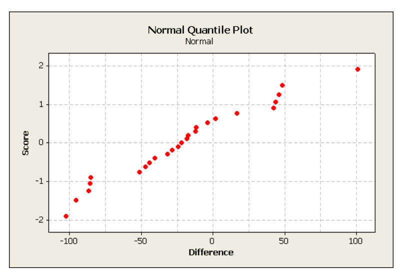
The researchers decide that they don't want to know the names of the hospitals when they do the analysis, so they assign each of the 50 hospitals a random identification (ID) number between 01 and 50. Then they instruct the hospitals IDs 01, 03, 05, 07, . . . , 49 to continue using the "existing way" while the other hospitals with IDs 02, 04, 06, . . . , 50 to use the "new way".

The average waiting times for each hospital are then recorded (over some period of time) by a data entry clerk hired by the researchers. The clerk prepares a dataset in a spreadsheet that looks like the following table. The "Difference" column contains the differences between the second and fourth columns of the table. The clerk also included the sample averages and sample standard deviations of each column, at the bottom of the table.

"Existing Way"		"New Way"		
Hospital	Average Wait	Hospital	Average Wait	Difference
01	42.1	02	137.6	-95.5
03	88.9	04	86.8	2.09
05	76.4	06	178.7	-102.2
⋮	⋮	⋮	⋮	⋮
49	59.4	50	76.8	-17.3
Average	85.52	Average	105.77	-20.25
SD	37.54	SD	31.57	50.90







Denote by μ_1 the mean waiting time for the "Existing way". Denote by μ_2 the mean waiting time for the "New way".

Produce a 95% confidence interval for $\mu_1 - \mu_2$. Include a discussion of any relevant model assumptions.