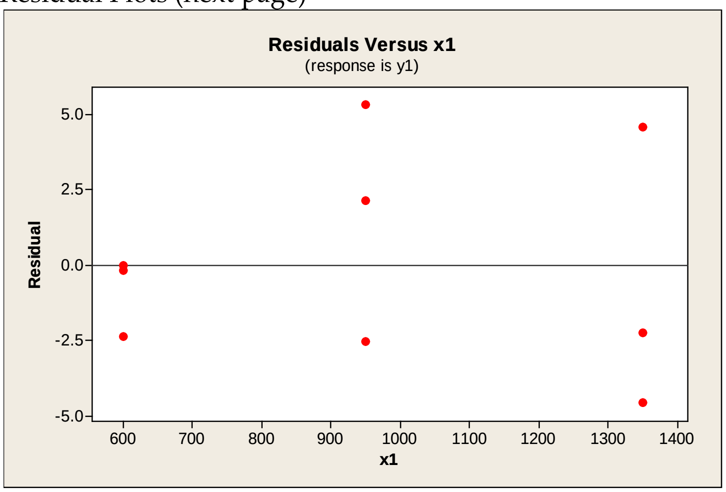
Math 226 **Assignment #4 Solutions**

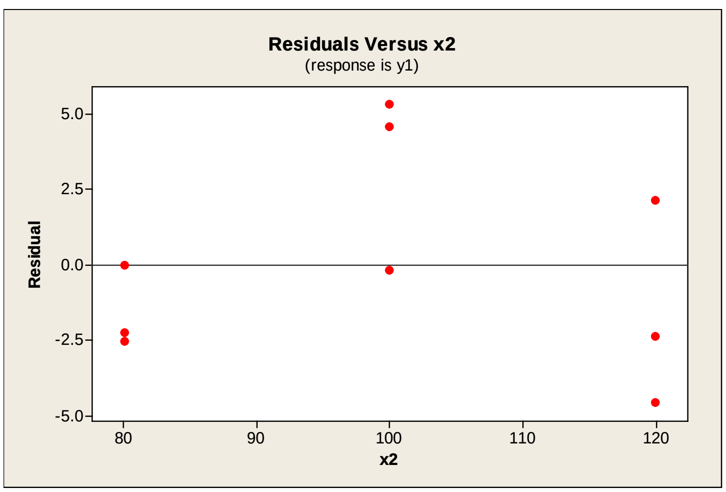
P1. Chemical engineering graduate, S. Osaka, studied the effects of agitator speed (X1) and polymer concentration (X2) on the percent recoveries of pyrite form a particular step of an ore refining process. Data from one set of n=9 experimental runs are provided.

a.
```
The regression equation is

y1 = 116 - 0.0157 x1 - 0.192 x2
S = 3.91080   R-Sq = 76.4%
```

b. Residual Plots (next page)





The R^2 value of 0.764 is low, indicating that the model does not adequately fir the data. The residual plots also portray curvature in the data, indicating that higher order terms should be considered.

c.
```
The regression equation is

y1 = - 16.9 + 0.0185 x1 + 2.23 x2 - 0.000017 x1sq - 0.0121 x2sqr
S = 2.87711   R-Sq = 91.5%
```

This model is does a much better job describing the data as the R^2 term has increased to 0.915.

d. `The regression equation is`
```
y1 = - 17.9 + 0.0195x1 + 2.24x2 - 0.000017x1sq - 0.0121x2sq - 0.000010x1x2
S = 3.32099   R-Sq = 91.5%
```
This model has the same R^2 of 0.915 as the previous model, but the standard error S has increased. It does not appear, therefore, to model the data as closely as the previous model.

e. `The model from part (d) best described the relationship, i.e.`
`y1 = - 16.9 + 0.0185 x1 + 2.23 x2 - 0.000017 x1sq - 0.0121 x2sqr.  It has equal to the highest` R^2 value and the lowest S value of the models tested.

Vars	R-Sq	R-Sq (adj)	R-Sq (pred)	Mallows Cp	S	x1	x2	x1x2	x1^2	x2^2
1	74.2	70.5	52.2	4.1	3.7812			X		
1	55.8	49.5	18.3	10.5	4.9490				X	
2	80.4	73.9	55.5	3.9	3.5598				X	X
2	78.5	71.4	51.4	4.6	3.7256		X		X	
3	90.6	84.9	68.7	2.3	2.7041		X		X	X
3	88.4	81.4	62.3	3.1	3.0015	X	X			X
4	91.5	82.9	56.8	4.0	2.8771	X	X		X	X
4	90.8	81.6	58.7	4.2	2.9893		X	X	X	X
5	91.5	77.3	0.0	6.0	3.3210	X	X	X	X	X

3.19 a Reaction yield.

b Reaction temperatures: 100, 150 and 200°F

c Randomly assign the three temperatures: 100, 150 and 200° to the twelve time slots. Run experiments at the assigned temperatures, measure the yield and compare.

d Four

3.20 a There will be six treatments: 100°F and 1200rpm, 150°F and 1200rpm, 200°F and 1200rpm, 100°F and 1800rpm, 150°F and 1800rpm, and 200°F and 1800rpm.

b Randomly assign all six treatments to the twelve time slots. In each time slot, conduct the experiment with the assigned temperature and mixture speed, measure the reaction yields and compare.

P4. What is a *blocking variable?* Explain what it is intended to accomplish in an engineering experiment.

A blocking variable is an extraneous variable which is believed to affect the response variable, but is not something that the experimenter wants to measure. It is supervised in order to separate out its effect on the response variable from that of the experimental variable(s) of interest. This technique is called "blocking".

P5. Experimental factor A has two levels (A1 & A2), and experimental factor B has three levels (B1, B2, & B3).

a. List all of the treatment combinations for this experiment.

There are 2x3=6 treatments:

A1	B1
A1	B2
A1	B3
A2	B1
A2	B2
A2	B3

b. Two runs or replicates are to be made for each of the different treatment combinations. Assign a random order of experimentation to each experimental run as follows: label each run, code each label, and use Table 3.4 in your text to randomize. Show all work and provide your solution (i.e. the random order or all runs).

2x3x2 = 12 total runs

From the table, we'll designate:

[01,08] = #1
[09,16] = #2
[17,24] = #3
[25,32] = #4
[33,40] = #5
[41,48] = #6
[49,56] = #7
[57,64] = #8
[65,72] = #9
[73,80] = #10
[81,88] = #11
[89,96] = #12

Scanning Table 3.4 from left to right, 2 digits at a time, the values obtained (with repeats removed) are:

96, 41, 09, 63, 35, 55, 24, 82, 79, 71, 08 COINCIDING WITH the following random order of runs: **12, 6, 2, 8, 5, 7, 3, 11, 10, 9, 1, 4**

Resulting random order:

12	A1	B1	R1
6	A1	B1	R2
2	A1	B2	R1
8	A1	B2	R2
5	A1	B3	R1
7	A1	B3	R2
3	A2	B1	R1
11	A2	B1	R2
10	A2	B2	R1
9	A2	B2	R2
1	A2	B3	R1
4	A2	B3	R2