2024 Spring – SPC&O HW#11

1. Provide an example, other than those given in the class, where the output performance (Y) of a process or a system has two potential factors (X's) with significant two-factor interaction effect on the output performance. Explain why and how there is a significant two-factor interaction effect.

2. A 2^2 factorial design has produced the following model relating machined part surface finish (y) to feed rate (x_1) and nose radius (x_2) of the tool (x_1, x_2 are in coded units of ± 1):

$$\hat{y} = 90 + 10x_1 - 15x_2 + 5x_1x_2$$

   (a) What is the average surface finish across the experiment?
   (b) What are the values for E_1, E_2, and E_{12} as obtained from the experiment?
   (c) Use Excel to sketch the 3D surface and Contour Charts in the x_1, x_2, y coordinate space.
   (d) Explain the meaning of the interaction effect.
   (e) If a surface finish of 85 is desired, what values of feed rate and nose radius (coded units) should be used? Identify the possible values of the feed rate and the nose radius to achieve the desired surface finish on the response surface in (c).

3. The yield (as large as possible with the maximum at 100%) of a semiconductor fabrication process has been studied as a function of three factors, at the following experimental levels:

Variable	Low Level	High Level
1. Temperature ($^\circ$C)	80	120
2. Pressure (psi)	50	70
3. Reaction time (min)	5	15

A 2^3 factorial design was performed. Each test, or unique combination of the three variables, was performed three times. The table provides the results of the tests.

				Trial			Yield
Test	**Temperature**	**Pressure**	**Time**	**1**	**2**	**3**	**Average**
1	80	50	5	61.43	58.58	57.07	59.03
2	120	50	5	75.62	77.57	75.75	76.31
3	80	70	5	27.51	34.03	25.07	28.87
4	120	70	5	51.37	48.49	54.37	51.41
5	80	50	15	24.80	20.69	15.41	20.30
6	120	50	15	43.58	44.31	36.99	41.63
7	80	70	15	45.20	49.53	50.29	48.34
8	120	70	15	70.51	74.00	74.68	73.07

a.) Used the "coded" value to calculate the effects (Ei), including interaction effects, on the average yield.

b.) Build a coded predictive model using the relatively large effects found from (a).
c.) Build a regression model on the average yield using excel and compare the results to the results of (a).
d.) Since the maximum yield is 100(%), 100−yield becomes a smaller-the-better performance measure. Use the three trial results to calculate the smaller-the-better SN ratio for each of the experimental tests.
e.) Calculate the effects, including interaction effects, on the SN ratio.
f.) Build an SN ratio predictive model using the relatively large effects on SN ratio found from (e).
g.) Build a regression model on the SN ratio using excel and compare the results to the results of (e).
h.) Suggest an optimum setting for the process to achieve the highest, stable yield based on results of (c) and (f).