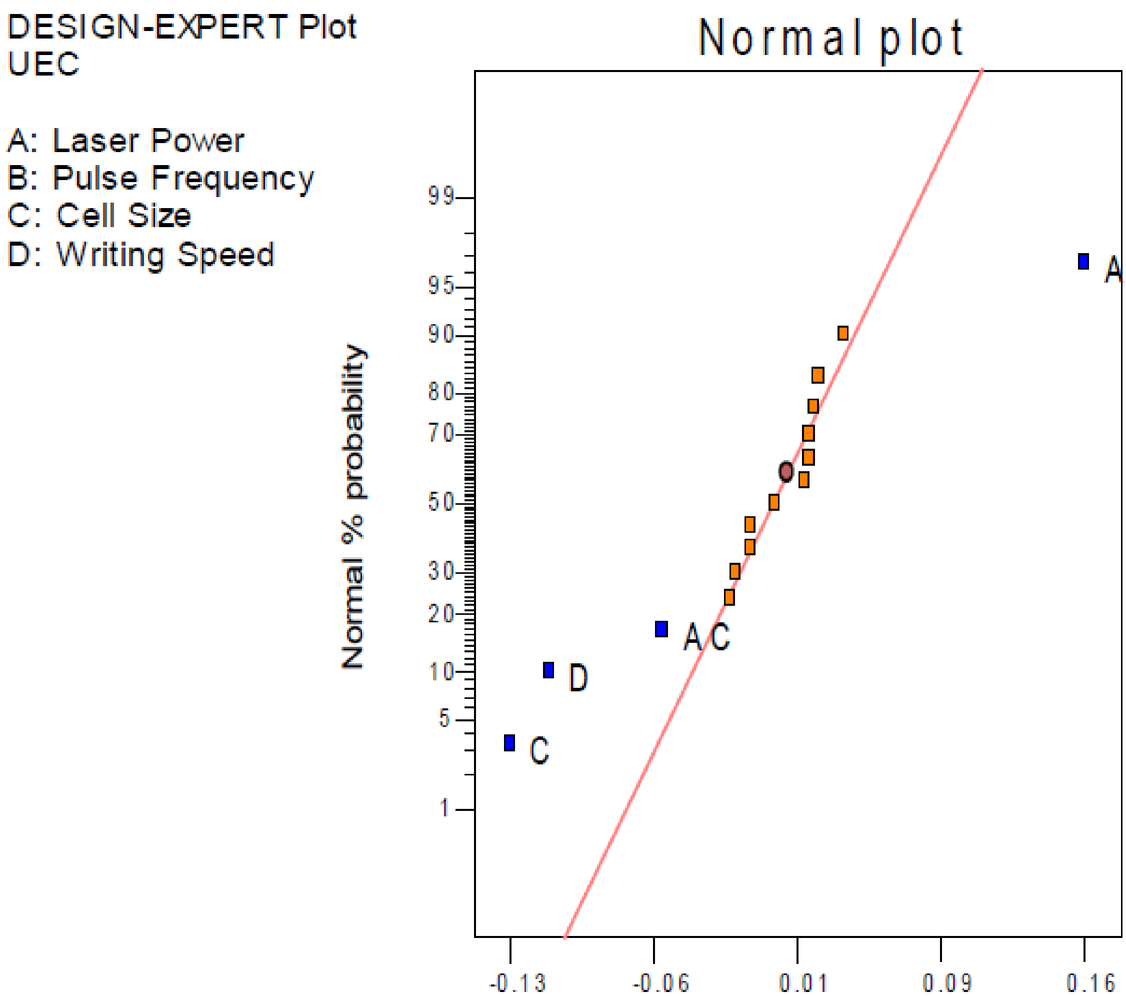
ISE 410 HW#3   Name: Bolun Xu

6.22.sol.

(a) Analyze the data from this experiment. Which factors significantly affect UEC?

A: The normal probability plot of effects identifies A, C, D, and the AC interaction as significant. The Design Expert output including the analysis of variance confirms the significance and identifies the corresponding model. Contour plots identify factors A and C with B held constant at zero and D toggled from -1 to +1.



Response: UEC

ANOVA for Selected Factorial Model

Analysis of variance table [Terms added sequentially (first to last)]

Source	**Sum of Squares**	**DF**	**Mean Square**	**F Value**	**Prob > F**	
Model	0.24	4	0.059	35.51	< 0.0001	significant
A	*0.10*	*1*	*0.10*	*61.81*	*< 0.0001*	
C	*0.070*	*1*	*0.070*	*42.39*	*< 0.0001*	
D	*0.051*	*1*	*0.051*	*30.56*	*0.0002*	
AC	*0.012*	*1*	*0.012*	*7.30*	*0.0206*	
Residual	0.018	11	1.657E-003			
Cor Total	0.25	15				

The Model F-value of 35.51 implies the model is significant. There is only a 0.01% chance that a "Model F-Value" this large could occur due to noise.

Values of "Prob > F" less than 0.0500 indicate model terms are significant. In this case A, C, D, AC are significant model terms.

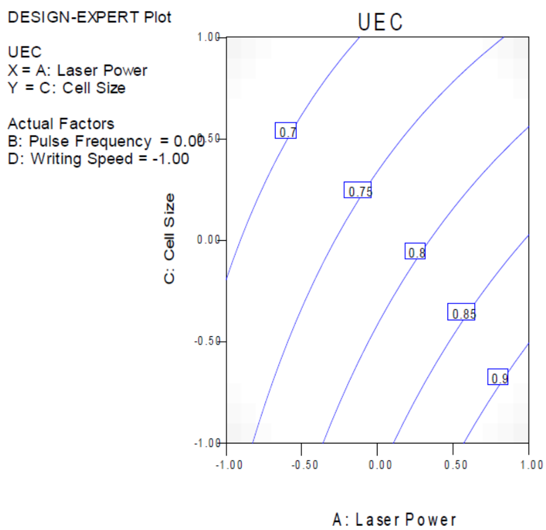
Std. Dev.	0.041	R-Squared	0.9281
Mean	0.72	Adj R-Squared	0.9020
C.V.	5.68	Pred R-Squared	0.8479
PRESS	0.039	Adeq Precision	17.799

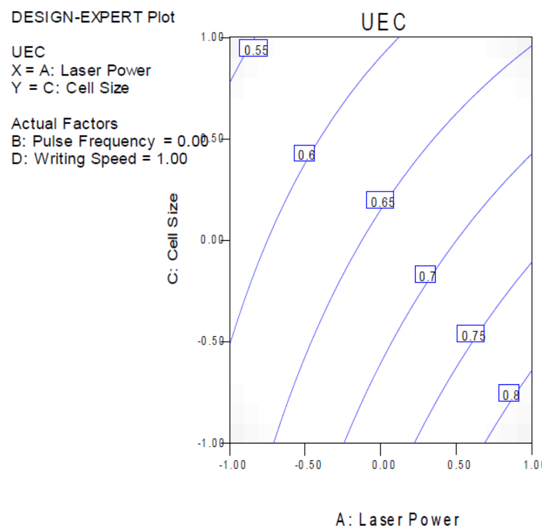
Final Equation in Terms of Coded Factors

UEC	=
+0.72	
+0.080	* A
-0.066	* C
-0.056	* D
-0.027	* A * C

Final Equation in Terms of Actual Factors

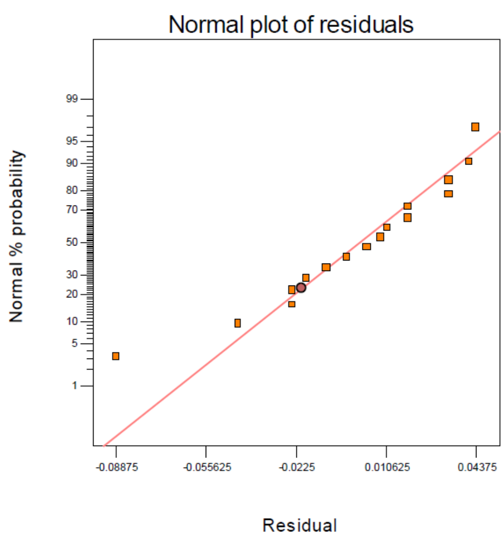
UEC	=
+0.71625	
+0.080000	* Laser Power
-0.066250	* Cell Size
-0.056250	* Writing Speed
-0.027500	* Laser Power * Cell Size

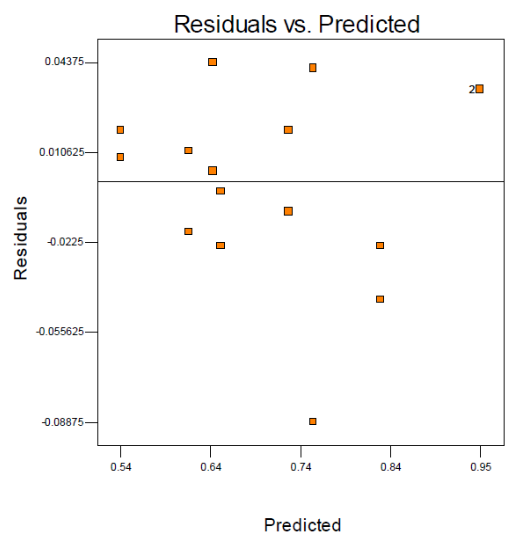


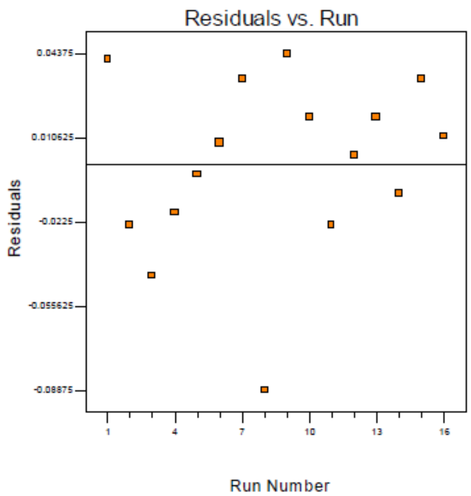


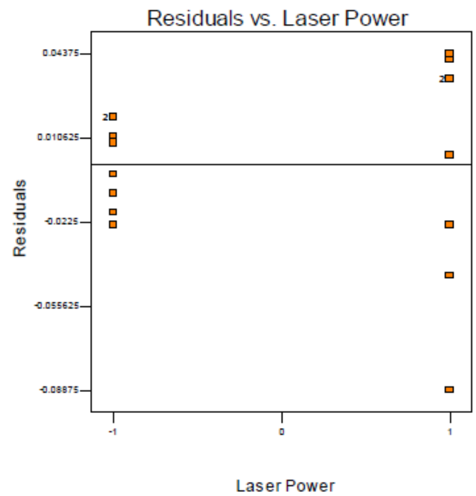
(b) Analyze the residuals from this experiment. Are there any indications of model inadequacy?

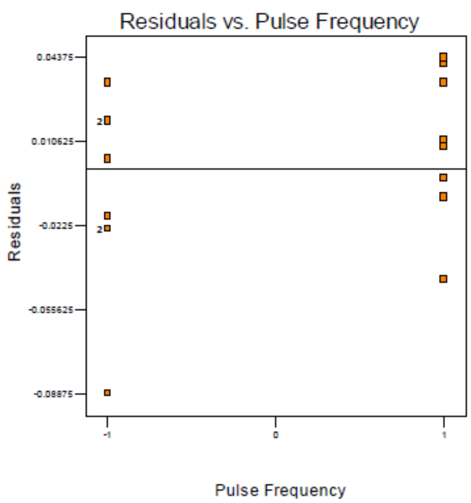
A: The residual plots appear acceptable with the exception of run 8, standard order 6. This value should be verified by the engineer.

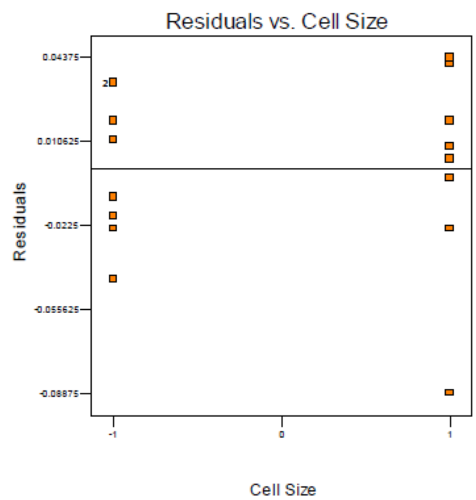








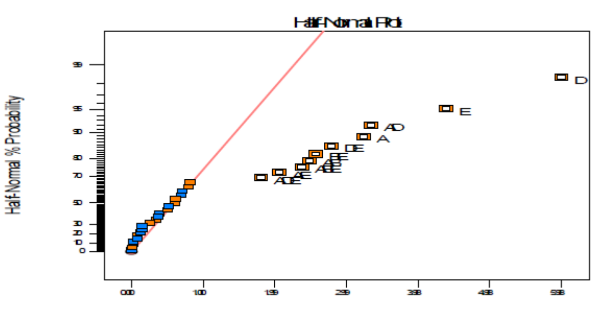




6.39.sol.

(a) Analyze the data from this experiment. Identify the significant factors and interactions.

A:The half normal plot of effects below identifies the significant factors and interactions.



Response 1 y
ANOVA for selected factorial model
Analysis of variance table [Partial sum of squares - Type III]

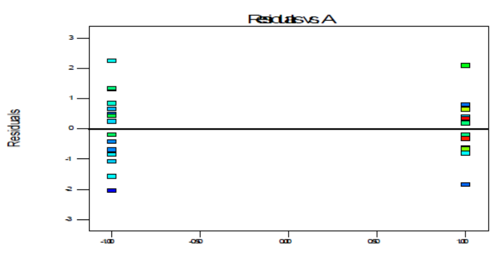
Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	879.62	11	79.97	49.15	< 0.0001	significant
A-A	*83.56*	*1*	*83.56*	*51.36*	*< 0.0001*	
B-B	*0.060*	*1*	*0.060*	*0.037*	*0.8492*	
D-D	*285.78*	*1*	*285.78*	*175.66*	*< 0.0001*	
E-E	*153.17*	*1*	*153.17*	*94.15*	*< 0.0001*	
AB	*48.93*	*1*	*48.93*	*30.08*	*< 0.0001*	
AD	*88.88*	*1*	*88.88*	*54.63*	*< 0.0001*	
AE	*33.76*	*1*	*33.76*	*20.75*	*0.0002*	
BE	*52.71*	*1*	*52.71*	*32.40*	*< 0.0001*	
DE	*61.80*	*1*	*61.80*	*37.99*	*< 0.0001*	
ABE	*44.96*	*1*	*44.96*	*27.64*	*< 0.0001*	
ADE	*26.01*	*1*	*26.01*	*15.99*	*0.0007*	
Residual	32.54	20	1.63			
Cor Total	912.16	31				

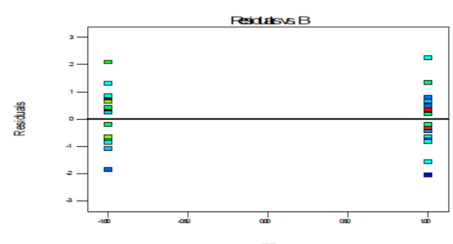
The Model F-value of 49.15 implies the model is significant. There is only a 0.01% chance that a "Model F-Value" this large could occur due to noise.

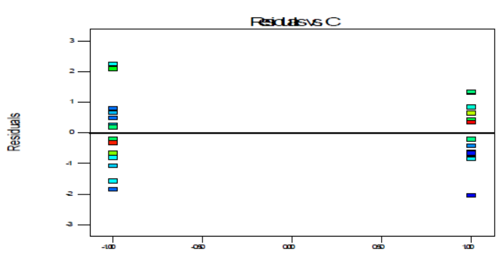
Values of "Prob > F" less than 0.0500 indicate model terms are significant.
In this case A, D, E, AB, AD, AE, BE, DE, ABE, ADE are significant model terms.

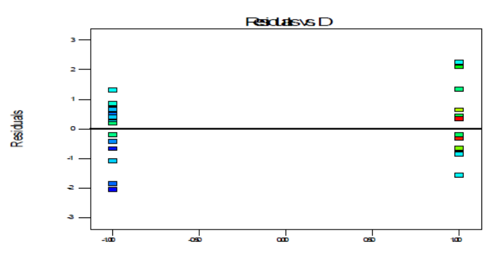
(b) Analyze the residuals from this experiment. Are there any indications of model inadequacy or violations of the assumptions?

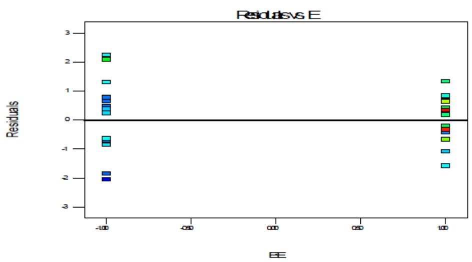
The residual plots below do not identify any concerns with model adequacy or the violations of the assumptions.











(c) One of the factors from this experiment does not seem to be important. If you drop this factor, what type of design remains? Analyze the data using the full factorial model for only the four active factors. Compare your results with those obtained in part (a).

The resulting experimental design is a replicated 24 full factorial design. The ANOVA is shown below. The factor names in the output below were modified to match the factor names in the original problem. The same factors are significant below as were significant in the original analysis.

Response 1 y
ANOVA for selected factorial model
Analysis of variance table [Partial sum of squares - Type III]

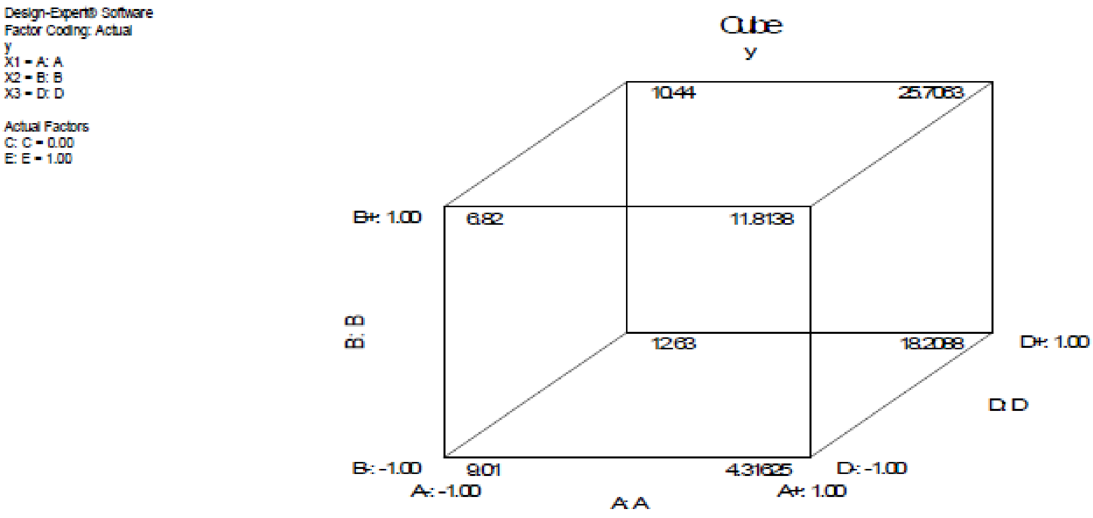
Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	888.80	15	59.25	40.58	< 0.0001	significant
A-A	*83.56*	*1*	*83.56*	*57.23*	*< 0.0001*	
B-B	*0.060*	*1*	*0.060*	*0.041*	*0.8414*	
D-D	*285.78*	*1*	*285.78*	*195.74*	*< 0.0001*	
E-E	*153.17*	*1*	*153.17*	*104.91*	*< 0.0001*	
AB	*48.93*	*1*	*48.93*	*33.51*	*< 0.0001*	
AD	*88.88*	*1*	*88.88*	*60.88*	*< 0.0001*	
AE	*33.76*	*1*	*33.76*	*23.13*	*0.0002*	
BD	*5.778E-003*	*1*	*5.778E-003*	*3.958E-003*	*0.9506*	
BE	*52.71*	*1*	*52.71*	*36.10*	*< 0.0001*	
DE	*61.80*	*1*	*61.80*	*42.33*	*< 0.0001*	
ABD	*3.82*	*1*	*3.82*	*2.61*	*0.1255*	
ABE	*44.96*	*1*	*44.96*	*30.79*	*< 0.0001*	
ADE	*26.01*	*1*	*26.01*	*17.82*	*0.0006*	
BDE	*0.050*	*1*	*0.050*	*0.035*	*0.8549*	
ABDE	*5.31*	*1*	*5.31*	*3.63*	*0.0747*	
Pure Error	23.36	16	1.46			
Cor Total	912.16	31				

The Model F-value of 40.58 implies the model is significant. There is only a 0.01% chance that a "Model F-Value" this large could occur due to noise.

Values of "Prob > F" less than 0.0500 indicate model terms are significant.
In this case A, C, D, AB, AC, AD, BD, CD, ABD, ACD are significant model terms.

(d) Find the settings of the active factors that maximize the predicted response.

The cube plot below, with factors E set at +1 and C set at 0, identifies the maximum predicted response with the remaining factors, A, B, and D all set at +1.



7.13.sol.

A: The analysis is similar to that of Problem 6.22. The significant effects are A, C, D and AC.

Response: UEC

ANOVA for Selected Factorial Model

Analysis of variance table [Partial sum of squares]

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	
Block	2.500E-005	1	2.500E-005			
Model	0.24	4	0.059	32.33	< 0.0001	significant
A	*0.10*	*1*	*0.10*	*56.26*	*< 0.0001*	
C	*0.070*	*1*	*0.070*	*38.59*	*< 0.0001*	
D	*0.051*	*1*	*0.051*	*27.82*	*0.0004*	
AC	*0.012*	*1*	*0.012*	*6.65*	*0.0275*	
Residual	0.018	10	1.820E-003			
Cor Total	0.25	15				

The Model F-value of 32.33 implies the model is significant. There is only a 0.01% chance that a "Model F-Value" this large could occur due to noise.

Values of "Prob > F" less than 0.0500 indicate model terms are significant. In this case A, C, D, AC are significant model terms.

7.16.sol.

(a)Recommend a blocking scheme and set up the design.

Interactions ABC and BDE are confounded with the blocks such that: Block

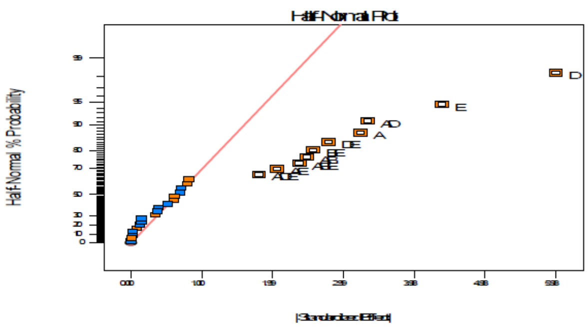
	ABC	*BDE*
1	-	+
2	+	-
3	-	-
4	+	+

Note, the ACDE interaction is also confounded with the blocks. The experimental runs with the blocks are shown below.

Block	A	B	C	D	E	y
Block 1	-1	-1	-1	-1	-1	8.11
Block 2	1	-1	-1	-1	-1	5.56
Block 4	-1	1	-1	-1	-1	5.77
Block 3	1	1	-1	-1	-1	5.82
Block 2	-1	-1	1	-1	-1	9.17
Block 1	1	-1	1	-1	-1	7.8
Block 3	-1	1	1	-1	-1	3.23
Block 4	1	1	1	-1	-1	5.69
Block 3	-1	-1	-1	1	-1	8.82
Block 4	1	-1	-1	1	-1	14.23
Block 2	-1	1	-1	1	-1	9.2
Block 1	1	1	-1	1	-1	8.94
Block 4	-1	-1	1	1	-1	8.68
Block 3	1	-1	1	1	-1	11.49
Block 1	-1	1	1	1	-1	6.25
Block 2	1	1	1	1	-1	9.12
Block 3	-1	-1	-1	-1	1	7.93
Block 4	1	-1	-1	-1	1	5
Block 2	-1	1	-1	-1	1	7.47
Block 1	1	1	-1	-1	1	12
Block 4	-1	-1	1	-1	1	9.86
Block 3	1	-1	1	-1	1	3.65
Block 1	-1	1	1	-1	1	6.4
Block 2	1	1	1	-1	1	11.61
Block 1	-1	-1	-1	1	1	12.43
Block 2	1	-1	-1	1	1	17.55
Block 4	-1	1	-1	1	1	8.87
Block 3	1	1	-1	1	1	25.38
Block 2	-1	-1	1	1	1	13.06
Block 1	1	-1	1	1	1	18.85
Block 3	-1	1	1	1	1	11.78
Block 4	1	1	1	1	1	26.05

(b) Analyze the data from this blocked design. Is blocking important?

Blocking does not appear to be important; however, if the ADE or ABE interaction had been chosen to define the blocks, then blocking would have appeared as important. The ADE and ABE are significant effects in the analysis below.



Response 1 y
ANOVA for selected factorial model
Analysis of variance table [Partial sum of squares - Type III]

Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Block	2.58	3	0.86			
Model	879.62	11	79.97	45.38	< 0.0001	significant
A-A	*83.56*	*1*	*83.56*	*47.41*	*< 0.0001*	
B-B	*0.060*	*1*	*0.060*	*0.034*	*0.8553*	
D-D	*285.78*	*1*	*285.78*	*162.16*	*< 0.0001*	
E-E	*153.17*	*1*	*153.17*	*86.91*	*< 0.0001*	
AB	*48.93*	*1*	*48.93*	*27.76*	*< 0.0001*	
AD	*88.88*	*1*	*88.88*	*50.43*	*< 0.0001*	
AE	*33.76*	*1*	*33.76*	*19.16*	*0.0004*	
BE	*52.71*	*1*	*52.71*	*29.91*	*< 0.0001*	
DE	*61.80*	*1*	*61.80*	*35.07*	*< 0.0001*	
ABE	*44.96*	*1*	*44.96*	*25.51*	*< 0.0001*	
ADE	*26.01*	*1*	*26.01*	*14.76*	*0.0013*	
Residual	29.96	17	1.76			
Cor Total	912.16	31				

The Model F-value of 45.38 implies the model is significant. There is only a 0.01% chance that a "Model F-Value" this large could occur due to noise.

Values of "Prob > F" less than 0.0500 indicate model terms are significant.
In this case A, D, E, AB, AD, AE, BE, DE, ABE, ADE are significant model terms.

8.11.sol.

(a) Verify that the design generators used were I = ACE and I = BDE.

A	*B*	*C*	*D=BE*	*E=AC*	
-	-	-	-	+	*e*
+	-	-	+	-	*ad*
-	+	-	+	+	*bde*
+	+	-	-	-	*ab*
-	-	+	+	-	*cd*
+	-	+	-	+	*ace*
-	+	+	-	-	*bc*
+	+	+	+	+	*abcde*

(b) Write down the complete defining relation and the aliases for this design.

I=BDE=ACE=ABCD.

A	(BDE)	=ABDE	A	(ACE)	=CE	A	(ABCD)	=BCD	A=ABDE=CE=BCD
B	(BDE)	=DE	B	(ACE)	=ABCE	B	(ABCD)	=ACD	B=DE=ABCE=ACD
C	(BDE)	=BCDE	C	(ACE)	=AE	C	(ABCD)	=ABD	C=BCDE=AE=ABD
D	(BDE)	=BE	D	(ACE)	=ACDE	D	(ABCD)	=ABC	D=BE=ACDE=ABC
E	(BDE)	=BD	E	(ACE)	=AC	E	(ABCD)	=ABCDE	E=BD=AC=ABCDE
AB	(BDE)	=ADE	AB	(ACE)	=BCE	AB	(ABCD)	=CD	AB=ADE=BCE=CD
AD	(BDE)	=ABE	AD	(ACE)	=CDE	AD	(ABCD)	=BC	AD=ABE=CDE=BC

(c) Estimate the main effects.

	Term	Effect	SumSqr	% Contribtn
Model	Intercept			
Model	A	-1.525	4.65125	5.1831
Model	B	-5.175	53.5613	59.6858
Model	C	2.275	10.3512	11.5349
Model	D	-0.675	0.91125	1.01545
Model	E	2.275	10.3513	11.5349

(d) Prepare an analysis of variance table. Verify that the AB and AD interactions are available to use as error.

The analysis of variance table is shown below. Part (b) shows that AB and AD are aliased with other factors. If all two-factor and three factor interactions are negligible, then AB and AD could be pooled as an estimate of error.

Response: Yield

ANOVA for Selected Factorial Model

Analysis of variance table [Partial sum of squares]

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	
Model	79.83	5	15.97	3.22	0.2537	not significant
A	*4.65*	*1*	*4.65*	*0.94*	*0.4349*	
B	*53.56*	*1*	*53.56*	*10.81*	*0.0814*	
C	*10.35*	*1*	*10.35*	*2.09*	*0.2853*	
D	*0.91*	*1*	*0.91*	*0.18*	*0.7098*	
E	*10.35*	*1*	*10.35*	*2.09*	*0.2853*	
Residual	9.91	2	4.96			
Cor Total	89.74	7				

The "Model F-value" of 3.22 implies the model is not significant relative to the noise. There is a 25.37 % chance that a "Model F-value" this large could occur due to noise.

Std. Dev.	2.23	R-Squared	0.8895
Mean	19.24	Adj R-Squared	0.6134
C.V.	11.57	Pred R-Squared	-0.7674
PRESS	158.60	Adeq Precision	5.044

Factor	Coefficient Estimate	DF	Standard Error	95% CI Low	95% CI High	VIF
Intercept	19.24	1	0.79	15.85	22.62	
A-Condensation	-0.76	1	0.79	-4.15	2.62	1.00
B-Material 1	-2.59	1	0.79	-5.97	0.80	1.00
C-Solvent	1.14	1	0.79	-2.25	4.52	1.00
D-Time	-0.34	1	0.79	-3.72	3.05	1.00
E-Material 2	1.14	1	0.79	-2.25	4.52	1.00

Final Equation in Terms of Coded Factors:

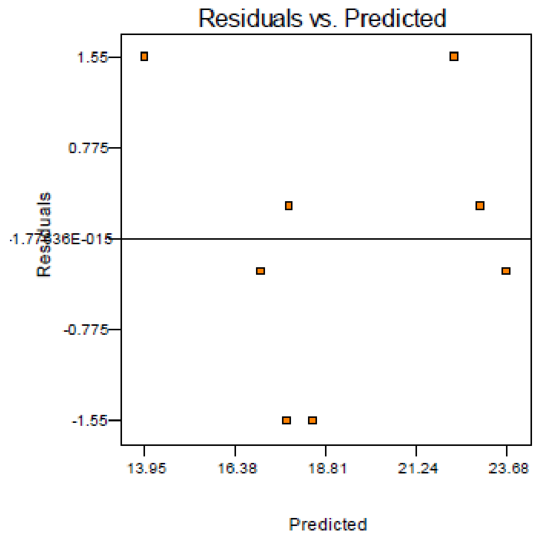
Yield	=
+19.24	
-0.76	* A
-2.59	* B
+1.14	* C
-0.34	* D
+1.14	* E

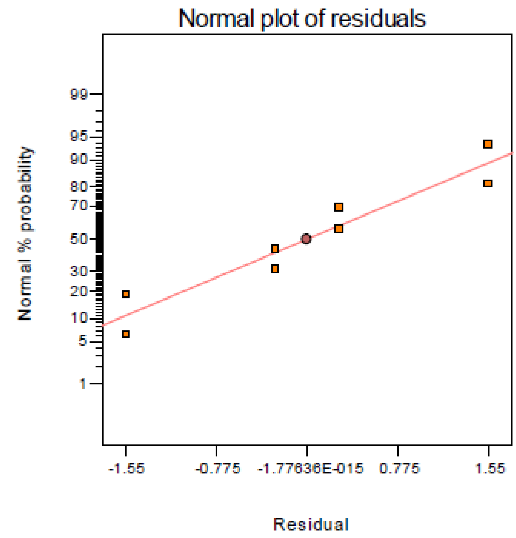
Final Equation in Terms of Actual Factors:

Yield	=
+19.23750	
-0.76250	* Condensation
-2.58750	* Material 1
+1.13750	* Solvent
-0.33750	* Time
+1.13750	* Material 2

(e) Plot the residuals versus the fitted values. Also construct a normal probability plot of the residuals. Comment on the results.

The residual plots are satisfactory.





8.25.sol.

	A	*B*	*C*	*D*	*E*	*F=CDE*	*G=ABC*		Block=ACE	Block=BFG	Block assignment
1	-	-	-	-	-	-	-	(1)	-	-	1
2	+	-	-	-	-	-	+	*ag*	+	+	4
3	-	+	-	-	-	-	+	*bg*	-	-	1
4	+	+	-	-	-	-	-	*ab*	+	+	4
5	-	-	+	-	-	+	+	*cfg*	+	-	3
6	+	-	+	-	-	+	-	*acf*	-	+	2
7	-	+	+	-	-	+	-	*bcf*	+	-	3
8	+	+	+	-	-	+	+	*abcfg*	-	+	2
9	-	-	-	+	-	+	-	*df*	-	+	2
10	+	-	-	+	-	+	+	*adfg*	+	-	3
11	-	+	-	+	-	+	+	*bdfg*	-	+	2
12	+	+	-	+	-	+	-	*abdf*	+	-	3
13	-	-	+	+	-	-	+	*cdg*	+	+	4
14	+	-	+	+	-	-	-	*acd*	-	-	1
15	-	+	+	+	-	-	-	*bcd*	+	+	4
16	+	+	+	+	-	-	+	*abcdg*	-	-	1
17	-	-	-	-	+	+	-	*ef*	+	+	4
18	+	-	-	-	+	+	+	*aefg*	-	-	1
19	-	+	-	-	+	+	+	*befg*	+	+	4
20	+	+	-	-	+	+	-	*abef*	-	-	1
21	-	-	+	-	+	-	+	*ceg*	-	+	2
22	+	-	+	-	+	-	-	*ace*	+	-	3
23	-	+	+	-	+	-	-	*bce*	-	+	2
24	+	+	+	-	+	-	+	*abceg*	+	-	3
25	-	-	-	+	+	-	-	*de*	+	-	3
26	+	-	-	+	+	-	+	*adeg*	-	+	2
27	-	+	-	+	+	-	+	*bdeg*	+	-	3
28	+	+	-	+	+	-	-	*abde*	-	+	2
29	-	-	+	+	+	+	+	*cdefg*	-	-	1
30	+	-	+	+	+	+	-	*acdef*	+	+	4
31	-	+	+	+	+	+	-	*bcdef*	-	-	1
32	+	+	+	+	+	+	+	*abcdefg*	+	+	4

Blocks are confounded with ACE, BFG, and ABCEFG.

8.47.sol.

(a) What is the generator for column D? D = -ABC

(b) What is the generator for column E? E = -BC

(c) If this design were run in two blocks with the AB interaction confounded with blocks, the run d would be in the block where the sign of AB is ____?

A: Either + or -. Run d, is the combination (-1, -1, -1, 1, -1), it is run 1 and is in the + block.

8.48.sol.

(a) What is the generator for column D? D = -ABC

(b) What is the generator for column E? E = BC

(c) If this design were folded over, what is the resolution of the combined design? IV