Problem 1 - Jet turbine aircraft engine components

A nickel-titanium alloy is used to make components for jet turbine aircraft engines. Cracking is a potentially serious problem in the final part. A test is run at the parts producer to determine the effect of four factors on cracks. The four factors are (A), pouring temperature, (B), titanium content, (C), heat treatment method, (D), amount of grain refiner used. Two replicates in a 2^4 design are run, and the length of crack is measured. Data are shown in the following table:

				Treatment	Replicate	
A	B	C	D	Combination	I	II
-	-	-	-	*(1)*	7.037	6.376
+	-	-	-	*a*	14.707	15.219
-	+	-	-	*b*	11.643	12.089
+	+	-	-	*ab*	17.273	17.815
-	-	+	-	*c*	10.403	10.151
+	-	+	-	*ac*	4.368	4.098
-	+	+	-	*bc*	9.360	9.253
+	+	+	-	*abc*	13.440	12.923
-	-	-	+	*d*	8.561	8.951
+	-	-	+	*ad*	16.867	17.052
-	+	-	+	*bd*	13.876	13.658
+	+	-	+	*abd*	19.824	19.639
-	-	+	+	*cd*	11.846	12.337
+	-	+	+	*acd*	6.125	5.904
-	+	+	+	*bcd*	11.190	10.935
+	+	+	+	*abcd*	15.653	15.053

(a) Estimate the factor effects. Which factor effects appear to be large?
(b) Conduct an analysis of variance. Do any of the factors affect cracking? (Use α=0.05)
(c) Write down a regression model that can be used to predict crack length as a function of the significant main effects and interactions you have identified in part (b).
(d) Analyze the residuals from this experiment. Comment on model adequacy.
(e) Is there any indication that any of the factors affect the variability in cracking?
(f) What recommendations would be made regarding process operations. Use interaction and or main effect plots to assist in drawing conclusions.

Problem 2 - Fractional Factorial Design

Suppose that in Problem 1, only one-half fraction of the 2^4 could be run. Construct the design and perform the analysis, using the data from replicate I.

Problem 3

Grains or crystals adversely affect the sensory qualities of foods using dried fruit pulp. A factorial experiment was conducted to determine which factors affect graininess. The factors were drying temperature (three levels), acidity (pH) of pulp (two levels), and sugar content (two levels). The experiment has two replications, with each replication using a different batch of pulp. Response is a measure of graininess.

		Sugar low		Sugar high	
Temp.	Rep.	pH low	pH high	pH low	pH high
1	1	21	12	13	1
	2	21	18	14	8
2	1	23	14	13	1
	2	23	17	16	11
3	1	17	20	16	14
	2	23	17	17	5

Analyze these data to determine which factors effect graininess, and which combination of factors leads to the least graininess.

Problem 4 - Factorial with 3 Levels – Bottle Stocking

An experiment was performed to study the effect of three different types of bottles (A) and three different shelf types (B), smooth, end isle, and grilled, on the time it takes to stock ten 12-bottle cases on the shelves. Three workers (C) were employed in the experiment, and two replicates of a 3^3 factorial design were run. Analyze the data and draw conclusions. The data are found in the file "Problem 4 Bottle Stacking.csv" on Canvas.