Stat 441/541 Homework #4 Due: Monday, 02/02/15.

A temperature-accelerated lifetest experiment was performed on a type of heating unit. Twenty-four heaters were randomly selected and six were randomly assigned to five temperature treatments: 1520°F, 1600°F, 1680°F, 1760°F, 1840°F. The number of hours to failure was recorded for each of the heaters in the study.

Temperature	Failure Time in Hours					
1520°F	1253	1435	1771	4027	5434	5614
1600°F	1190	1286	1550	2125	2557	2845
1680°F	751	837	848	1038	1361	1443
1760°F	611	691	751	772	808	859
1840°F	513	546	517	420	471	556

You have been given *SAS* code which has two parts. The first part is used to find the proposed transformation using the empirical method and the Box-Cox method. The second part of the analysis is to perform an ANOVA using the original data and an ANOVA using reciprocal (i.e., 1/response) transformed data. For any test, you can use $\alpha = .05$.

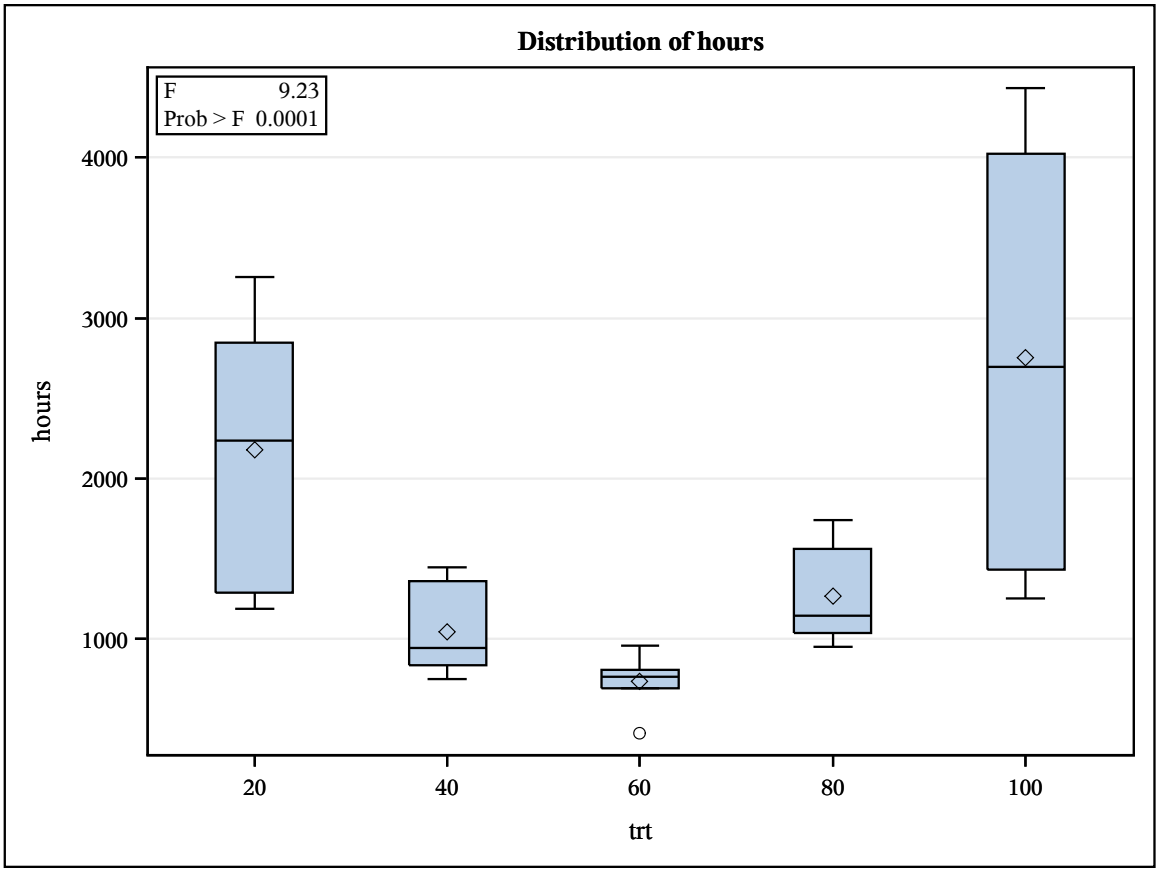
1. (1pt) What transformation is suggested by the empirical method and is it consistent with a reciprocal transformation?
2. (1pt) What transformation is suggested by the Box-Cox method and is it consistent with a reciprocal transformation?
3. For the ANOVA of the original data:
   (a) (1pt) State the means model and what each parameter represents in the context of this problem.
   (b) (1pt) Run Levene's Test. Include the hypotheses to be tested and your conclusion.
   (c) (1pt) Based on the residual diagnostic plots, comment on any serious violations of the ANOVA assumptions.
   (d) (1pt) Based on the side-by-side boxplots, describe the relationship (if any) between the means and variances.
   (e) (1pt) Based on Tukey's multiple comparison procedure, which pairs of means are considered significantly different?
4. (5pt) Repeat (3) but using the ANOVA of the reciprocal data.
5. (1.5pt) Which analysis would you recommend? Briefly justify your choice.
6. (3pt) **Stat 541 students**: Include linear, quadratic, cubic, and quartic orthogonal contrasts to the analysis of the reciprocal data. Interpret the results.
7. Attached is SAS output for a weighted least squares (WLS) ANOVA.
   (a) (1pt) Based on the boxplots, do you think it was reasonable to perform a WLS ANOVA? Justify your answer in at most three sentences.
   (b) (1pt) Suppose the researcher asks you to use a Box-Cox transformation on the data. Do you think this is a reasonable suggestion? Justify your answer in at most three sentences.
8. (1pt) Problem 3.44, page 136. However, change $\mu_4 = 60$ to be $\mu_4 = 55$.
9. (2.5pt) Problem 3.45, page 137. However, change $\mu_4 = 60$ to be $\mu_4 = 55$.

Weighted Least Squares ANOVA Output

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	36.91905500	9.22976375	9.23	0.0001
Error	25	25.00000000	1.00000000		
Corrected Total	29	61.91905500			

R-Square	Coeff Var	Root MSE	hours Mean
0.596247	0.105108	1.00000	951.3988

Source	DF	Type III SS	Mean Square	F Value	Pr > F
trt	4	36.91905500	9.22976375	9.23	0.0001



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DM 'LOG; CLEAR; OUT; CLEAR;';

ODS GRAPHICS ON;
OPTIONS NODATE NONUMBER;

*****************************************;
*** Variance Stabilizing Transformations ***;
*****************************************;
DATA in;
DO temp =  1520 , 1600 , 1680 , 1760 , 1840;
DO rep = 1 to 6;
   INPUT hours @@; OUTPUT;
END; END;
LINES;
1253 1435 1771 4027 5434 5614
1190 1286 1550 2125 2557 2845
 751  837  848 1038 1361 1443
 611  691  751  772  808  859
 513  546  517  420  471  556
;

*********************************************************;
*** Find the transformation using the empirical method ***;
*********************************************************;

PROC SORT DATA=in; BY temp;
PROC MEANS DATA=in NOPRINT; BY temp;
     VAR hours; OUTPUT OUT=yset MEAN=mean STD=std;
DATA yset; SET yset;
     logstd =LOG(std);   logmean=LOG(mean);
PROC PRINT DATA=yset;
     VAR mean std logstd logmean;
TITLE 'EMPIRICAL SELECTION OF ALPHA';

PROC GLM DATA=yset;
     MODEL logstd=logmean / SS3 solution;
TITLE 'ANOVA TO FIND EMPIRICAL SELECTION OF ALPHA';

*******************************************************;
*** Find the transformation using the Box-Cox method ***;
*******************************************************;

PROC TRANSREG DATA=in;
     MODEL BOXCOX(hours / LAMBDA=-2 to 2 by .1) = CLASS(temp);
TITLE 'Find the Box-Cox Transformation using PROC TRANSREG';

*** Apply the transformationto the response and      ***;
*** rerun the analysis with the transformed response ***;

DATA in; SET in;
     trans = 1/hours;

************************************;
*** ANOVA BEFORE A TRANSFORMATION ***;
************************************;
PROC GLM DATA=in PLOTS=(DIAGNOSTICS);
     CLASS temp;
     MODEL hours = temp / SS3;
     MEANS temp / TUKEY HOVTEST=LEVENE(TYPE=ABS);
TITLE 'ANOVA -- WITH ORIGINAL DATA';

************************************;
*** ANOVA AFTER A TRANSFORMATION ***;
************************************;

PROC GLM DATA=in PLOTS=(DIAGNOSTICS);
     CLASS temp;
     MODEL trans = temp / SS3;
     MEANS temp / TUKEY HOVTEST=LEVENE(TYPE=ABS);
TITLE 'ANOVA -- WITH TRANSFORMED DATA';
RUN;
```