Homework 4

Due February 7, 2017 at 5pm in Snedecor 2404

Please show all work for full credit. Print and staple your assignment together and submit by 5pm of the due date in Snedecor 2404. If you cannot attend class or office hours on the due date, please arrange to submit your homework prior to the due date.

1. [Ch. 4.1 Exercise 3, pg. 140] The article "Polyglycol Modified Poly (Ethylene EtherCarbonate) Polyols by Molecular Weight Advancement" by R. Harris (*Journal of Applied Polymer Science*, 1990) contains some data on the effect of reaction temperature on the molecular weight of resulting poly polyols. The data for eight experimental runs at temperature 165°C and above are as follows (see website for `polyols.csv`):

Pot temperature (°C)	Average molecular weight
165	808
176	940
188	1183
205	1545
220	2012
235	2362
250	2742
260	2935

Use a statistical package (JMP or `R`) to help you complete the following (plots and computation):

a) What fraction of the observed raw variation in molecular weight of resulting poly polyols (y) is accounted for by a linear equation in reaction temperature (x)?
b) Fit a linear relationship $y \approx \beta_0 + \beta_1 x$ to these data via least squares. About what change in average molecular weight seems to accompany a 1°C increase in pot temperature (at least over the experimental range of temperatures)?
c) Compute and plot residuals from the linear relationship fit in b). Discuss what they suggest about the appropriateness of that fitted equation.
d) These data came from an experiment where the investigator managed the value of x. There is a fairly glaring weakness in the experimenter's data collection efforts. What is is?
e) Based on your analysis of these data, what average molecular weight would you predict for an additional reaction run at 188°C? At 200°C? Why would or wouldn't you be willing to make a similar prediction of average molecular weight if the reaction is run at 70°C?

2. Upon changing measurement scales, nonlinear relationships between two variables can sometimes be made linear. The article "The Effect of Experimental Error on Determination of the Optimum Metal-Cutting Conditions" by Ermer and Wu (*The Journal of Engineering for Industry*, 1967) contains a data set gathered in a study of tool life in a turning operation. The data here (and on the website as `tool_life.csv`) are part of that data set.

Cutting speed (sfpm)	Tool life (min)
400	21.5, 24.5, 26, 66
500	6.4, 7.8, 9.8, 16.5
600	2.35, 2.65, 3, 3.6
700	1, 1.2, 1.5, 1.6
800	1, 0.9, 0.74, 0.66

a) Plot tool life (y) by cutting speed (x) and calculate R^2 fir fitting a linear function of x to y. Does the relationship $y \approx \beta_0 + \beta_1 x$ look like a reasonable explanation of tool life in terms of cutting speed?

b) Take natural logs of both x and y and repeat part a) with these log cutting speeds and log tool lives.

c) Using the logged variables as in b), fit a linear relationship between the two variables using least squares. Based on this fitted equation, what tool life would you predict for a cutting speed of 550? What approximate relationship between x and y is implied by a linear approximate relationship between $\ln(x)$ and $\ln(y)$? (Give an equation for the relationship.) As an aside, Taylor's equation for tool life is $yx^\alpha = C$.