Stat 998, Fall 2012 (Larget)
Diesel Engine Problem

Attached is a problem that describes a practical "real-world" situation. (The problem comes from a previous M.S. Exam.) This problem will be used for classroom discussion on **Tuesday, September 11 and Thursday, September 13**. Your assignment for **Tuesday, September 11** is to:

(a) understand exactly what is being asked in the problem;

(b) prepare a list of questions (aimed primarily at the engineer who conducted the study) to which you belive that you need answers before doing a thorough analysis of the problem;

(c) prepare a **"key graph"** (or a very small number of "key graphs") that provide a useful graphical summary of the main points;

(d) develop an analytical strategy for solving the problem.

Note that you are **not** expected to perform a complete analysis or prepare a report. Your primary preparation should be for an oral discussion.

You are to hand in (a), (b), and (c) on Tuesday, September 11. One paragraph will be sufficient for (a) (you need to describe what is being asked in your own words). The questions for (b) can just be entered in a list. The target number of pages for what you hand in is two or three. We will start discussing parts (a), (b), and (c) on September 11 and continue with (d) on September 13.

An electronic copy of the data is available on the course home page.

Your plots must be legible, neat, and informative. Include meaningful labels and titles. Use clear and correct language in the written responses.

Problem Description

The data in Table 1 were collected by researcher workers in the Mechanical Engineering Department at the University of Wisconsin to learn how the ignition delay in a diesel engine is affected by four experimental variables: speed of engine, load on engine, percentage of alcohol in the fuel, and injection timing (normal or retard). They want to find an equation that will adequately express ignition delay as a function of the four experimental variables.

Analyze these data and write a report describing the best mathematical model you can devise for the purpose of predicting ignition delay **as a function of these four experimental variables**. Give estimates of the parameters in this model with measures of uncertainty in these estimates. Indicate other models that you considered.

Note that the final two columns in Table 1 are labeled "temperature" and "pressure". The pressure is a measured quantity and the temperature is a calculated value obtained from thermodynamic considerations. One model that has been proposed to relate ignition delay to pressure (P) and temperature (T) is the following:

$$\text{ignition delay} = AP^{-n}e^{E/RT}$$

where A, n, and E are parameters to be estimated and R is the gas constant, which has a known value of 1.98 BTU per (pound mole degree Rankine). Your task, however, is to relate ignition delay to the four experimental variables, not to P and T.

Notes for Table 1: CA^o = crank angle degrees. BTDC = before top dead center. ^{o}R = degrees Rankine.

Table 1. Data on diesel engine

run	speed (rpm)	load (lbs)	alcohol (mass %)	injection timing (CA^o BTDC)	ignition delay (CA^o)	temp. (^{o}R)	pressure (psi)
1	1500	20	0	30	1.1556	1511	504
2	1500	20	31.7	30	1.2111	1514	502
3	1500	20	55.9	30	1.2778	1504	505
4	1500	20	74	30	1.4444	1474	504
5	1500	20	84.5	30	1.5556	1460	512
6	1500	40	0	30	1.0222	1536	529
7	1500	40	42.7	30	1.0889	1527	524
8	1500	40	58.1	30	1.2000	1504	523
9	1500	40	73.2	30	1.3666	1494	522
10	1500	60	0	30	0.8778	1609	566
11	1500	60	30.7	30	0.9333	1596	563
12	1500	60	45.3	30	1.0333	1580	557
13	1500	60	56.3	30	1.0889	1571	555
14	1500	20	0	24	1.0222	1530	569
15	1500	20	31.15	24	1.0889	1495	566
16	1500	20	55.09	24	1.2333	1481	536
17	1500	20	71.47	24	1.3667	1455	552
18	1500	40	0	24	0.9111	1593	624
19	1500	40	39.7	24	1.0111	1571	615
20	1500	40	56	24	1.0337	1536	603
21	1500	60	0	24	0.7778	1650	688
22	1500	60	30.16	24	0.8333	1636	670
23	1500	60	42.78	24	0.8889	1628	662
24	1500	60	56.02	24	0.9333	1601	640
25	1500	70	0	24	0.7000	1725	738
26	1500	70	22.2	24	0.6444	1702	717
27	1500	70	32.6	24	0.6556	1684	705
28	1500	70	43.1	24	0.6556	1666	684
29	2000	20	0	24	0.8000	1658	607
30	2000	20	43.6	24	0.8833	1639	607
31	2000	20	58.7	24	1.0000	1605	598
32	2000	20	69.2	24	1.0667	1608	605
33	2000	20	77.8	24	1.1333	1591	603
34	2000	40	0	24	0.6333	1792	694
35	2000	40	30.7	24	0.6917	1730	671
36	2000	40	44.7	24	0.7167	1682	660
37	2000	40	56.8	24	0.7667	1661	651
38	2000	40	63.8	24	0.8000	1634	638
39	2000	60	0	24	0.5417	1817	746
40	2000	60	44.7	24	0.6167	1742	711
41	2000	60	54	24	0.6333	1731	705
42	2000	70	0	24	0.5167	1879	799
43	2000	70	40	24	0.3500	1816	728
44	2000	70	49.2	24	0.2833	1784	701
45	1500	70	0	30	0.8222	1637	600
46	1500	70	38.9	30	0.9333	1609	577
47	1500	70	49.2	30	0.9777	1576	570