

STAT 496, Spring 2009
Homework Assignment #2, Due by Friday, February 6

1. The three fundamental principles of a designed experiment are: control of outside variables, randomization, and replication. Consider each of the following scenarios. Does each adhere to all three principles? If so, describe how. If not, indicate how you would change the design to incorporate the missing principle(s). Be specific and be sure to comment on all three principles.
 - a) An aluminum smelting operation makes its own carbon anodes for use in their aluminum smelting pots. The density of the anode is an important quality characteristic because it affects the usable life of the anode. An experiment is conducted to see the effect of bake temperature on anode density. Twenty anodes are made using the same raw materials, methods and people. Five anodes are assigned at random to each of four temperatures, 500, 525, 550 and 575 °C. A temperature is picked at random and the five anodes are baked in the oven at that temperature. One of the remaining temperatures is picked at random and the five anodes are baked in the oven at that temperature. This random selection of a temperature and baking 5 anodes continues until all temperatures have been used once. The density of each anode is then measured. The order of measurement is completely random.
 - b) A chemist wants to compare a new and simpler assay method with the standard method. She prepares a batch of solution, divides it into 40 specimens, and then selects 20 at random. She asks her technician to analyze these 20 specimens using the new method and the remaining 20 using the standard method. The technician finishes analyzing the 20 specimens using the new method in the morning. He takes a break for lunch and does the remaining 20 specimens using the standard method in the afternoon.
 - c) A fuel economy study of four diesel-powered vehicles was conducted. All four vehicles were tested under controlled conditions in a laboratory using a dynamometer to control the speed and load conditions and to avoid the effects of weather. A single test fuel was used. Eight tests were run on each vehicle. Fuel economy in miles per gallon (mpg) was measured. The total of 32 tests were run in a completely random order.

2. Before the experiment in 1 (c) is run, there is discussion on how much, and what sort of, replication should be involved.
 - a) If the chances of making errors are set at $\text{Alpha}=0.05$ and $\text{Beta}=0.10$ and a difference in mean fuel economy of 1 standard deviation is to be detected, how many runs are required for each vehicle?
 - b) If resources limit the number of runs to 8 per vehicle, give two combinations of Alpha and Beta and the size of difference that can be detected. Explain briefly the trade-offs between the two combinations.
 - c) An argument develops over what is replication. One person argues that 8 Mercedes, 8 Peugeots, 8 Oldsmobiles and 8 Volkswagons must be used. The

other person argues that one vehicle of each type is sufficient provided each vehicle is tested 8 times. Discuss the advantages and disadvantages of each person's view of replication. Be sure to comment on the scope of the experiment, that is what sort of generalizations can be made, for each person's view.

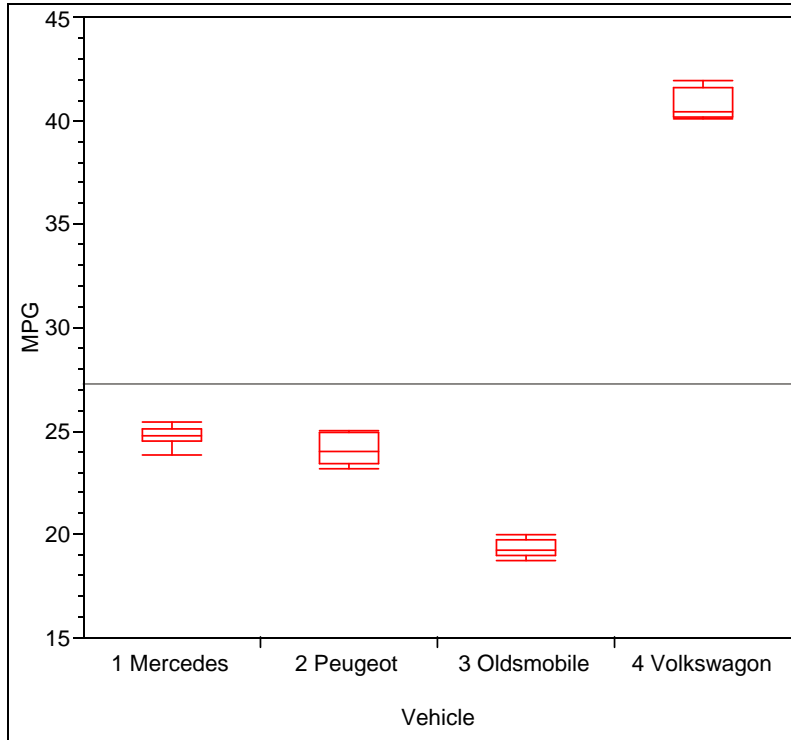
3. Below are the data for the experiment described in 1 c). The numbers have been ordered from smallest to largest for each vehicle. Refer to the JMP output that accompanies this homework.

	Mercedes	Peugeot	Oldsmobile	Volkswagon
	23.8	23.2	18.7	40.1
	24.5	23.3	18.9	40.1
	24.7	23.9	19.2	40.3
	24.7	24.0	19.2	40.4
	24.8	24.1	19.3	40.5
	25.0	24.7	19.7	40.9
	25.1	25.0	19.8	41.8
	25.4	25.0	20.0	41.9
\bar{Y}_i	24.75	24.15	19.35	40.75
s_i	0.475	0.703	0.450	0.725

- Comment on the side-by-side box plots for the four vehicles. Be sure to discuss both center and spread.
- Calculate, by hand, the value for the Least Significant Difference (LSD) using $t=2$. Indicate which pairs of vehicles have differences in mean fuel economies that are statistically significant.
- How does your analysis in b) compare to JMP using Comparisons - Each pair, Student's t and an individual error rate of $\alpha = 0:05$?
- Calculate, by hand, the value for the Least Significant Difference (LSD) using $t=3$. Indicate which pairs of vehicles have differences in mean fuel economies that are statistically significant.
- How does your analysis in d) compare to JMP using Comparisons - Each pair, Student's t and an individual error rate of $\alpha = 0:01$?
- If you want the best fuel economy, which vehicle would you recommend? Explain your choice briefly.
- If you want to avoid the vehicle with the worst fuel economy, which vehicle should you avoid? Explain your choice briefly.

JMP Output for Homework 2

Oneway Analysis of MPG By Vehicle



Summary of Fit

Rsquare	0.995158
Adj Rsquare	0.99464
Root Mean Square Error	0.601783
Mean of Response	27.25
Observations (or Sum Wgts)	32

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Vehicle	3	2084.1600	694.720	1918.359	<.0001
Error	28	10.1400	0.362		
C. Total	31	2094.3000			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1 Mercedes	8	24.7500	0.21276	24.314	25.186
2 Peugeot	8	24.1500	0.21276	23.714	24.586
3 Oldsmobile	8	19.3500	0.21276	18.914	19.786
4 Volkswagon	8	40.7500	0.21276	40.314	41.186

Std Error uses a pooled estimate of error variance

Means Comparisons

Comparisons for each pair using Student's t

t	Alpha				
2.04841	0.05				
Abs(Dif)-LSD		4 Volkswagon	1 Mercedes	2 Peugeot	3 Oldsmobile
4 Volkswagon		-0.616	15.384	15.984	20.784
1 Mercedes		15.384	-0.616	-0.016	4.784
2 Peugeot		15.984	-0.016	-0.616	4.184
3 Oldsmobile		20.784	4.784	4.184	-0.616
Level			Mean		
4 Volkswagon	A		40.750000		
1 Mercedes	B		24.750000		
2 Peugeot	B		24.150000		
3 Oldsmobile	C		19.350000		

Levels not connected by same letter are significantly different

Means Comparisons

Comparisons for each pair using Student's t

t	Alpha				
2.76326	0.01				
Abs(Dif)-LSD		4 Volkswagon	1 Mercedes	2 Peugeot	3 Oldsmobile
4 Volkswagon		-0.831	15.169	15.769	20.569
1 Mercedes		15.169	-0.831	-0.231	4.569
2 Peugeot		15.769	-0.231	-0.831	3.969
3 Oldsmobile		20.569	4.569	3.969	-0.831
Level			Mean		
4 Volkswagon	A		40.750000		
1 Mercedes	B		24.750000		
2 Peugeot	B		24.150000		
3 Oldsmobile	C		19.350000		

Levels not connected by same letter are significantly different