

Question 1: ANOVA

★ Given

Four different, though supposedly equivalent, methods of applying torque to a bolt on to the chassis of a machine were performed on each of 5 bolts (in a random order), and the following are the measured torque applied in $ft \cdot lbf$:

Bolt	Method A	Method B	Method C	Method D
1	75	83	86	73
2	73	72	61	67
3	59	56	53	62
4	69	70	72	79
5	84	92	88	95
\bar{x}_{method}	72.0	74.6	72.0	75.2
s_{method}	9.11	13.67	15.28	12.77

★ Find

Perform an ANOVA [you may use R] to test whether it is reasonable to treat the 4 methods as equivalent at a significance level of $\alpha = 0.05$.

★ Solution

Question 2: Completing an ANOVA Table

★ Given

An experiment is designed to determine which of six different oils provides the best lubrication for a complex mechanism. Each oil is run in the mechanism eight times. The run order is completely random.

Source	df	SS	MS	F	p
Oil	?	4525	?	?	?
Error	?	14742	?		
Total	?	?			

★ Find

Use this information to complete the following ANOVA table. Is there evidence that one or more of the oils is different from the others?

★ Assumptions

$$\alpha = 0.05$$

★ Solution

Source	df	SS	MS	F	p
Oil		4525			
Error		14742			
Total					

Question 3: More Complex ANOVA

★ Given

A platinum thermal deflection sensor was mounted on a stationary probe craft that landed on the surface of Mars. For a specific period of 5 Martian days each Earth year, the thermally induced deflection of a strain gage is measured as a relative deflection from the previous day and transmitted back to mission control in Huston. The data for the last 6 years [2001-2007] is included in the CSV file (downloadable from the course website). It was discovered, after a preliminary data analysis, that the highest average deflection tends to occur on Day 3.

★ Find

- Use ANOVA to confirm that the third day difference in relative deflection is statistically meaningful.
- Next, normalize the deflection per day by the total deflection during the 5 day period for each year. For example, if the deflections were [10,20,50,80,40] (total = 200) then the normalized (divide each one by the overall total) ones would be [0.05, 0.1, 0.25, 0.4, 0.2] (total = 1). Use ANOVA to determine if the normalized relative deflection rate difference by day is real or due purely to chance occurrence.

★ Assumptions

$$\alpha = 0.05$$

★ Solution

Bonus Question: Systemic Experimental Thinking

★ **Given**

You have ten shipments of diesel engines, each shipment contains 500 or more engines. The manufacturer just sent you a bulletin that one of the shipments is made of engines that are missing a hard to locate internal component, and would like you to ship it back, at their expense. Your large scale is a little finicky and can only be trusted for the first measurement of the day [so you only get one shot at it]

The missing component has a mass of 5kg, and the normal diesel engine has a mass of 1000kg. The scale has a capacity of 75,000kg and an ability to detect a difference of 2.5kg.

★ **Find**

Describe a plan to discover the shipment with incomplete engines, with **only one** scale measurement allowed.

★ **Solution**

END OF ASSIGNMENT