Feedback — Lecture 04B: univariate data analysis

To help you work on the quiz earlier, the quizzes will be based on the textbook material.

This quiz is based on material from pages 62 to 64, as well as earlier parts of the course will also be tested.

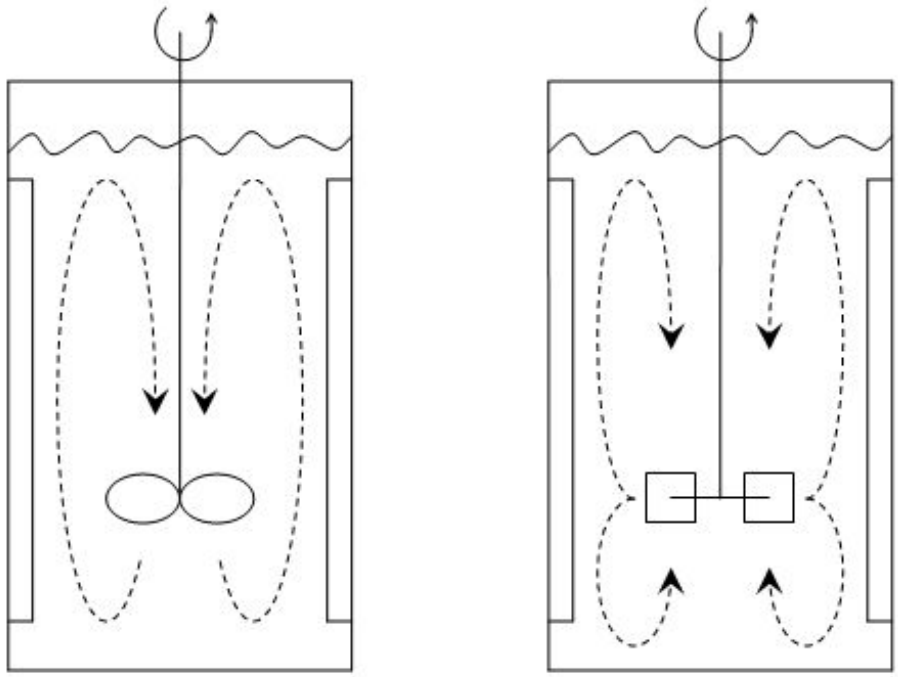
Videos on the new content will be posted on Thursday, during the day. All will be available on early Thursday evening, before 7:00pm.

You have 1 attempt for the quiz. Please read the instructions carefully. Please double check your answers before submitting.

Solutions will be released when the quiz closes, at 09:25am, Friday, 30 January 2015.

Question 1

You are convinced that a different impeller (mixing blade) shape for your tank will lead to faster, i.e. shorter, mixing times. The choices are either an axial blade (left) or a radial blade (right).



Credit: Wikipedia

You obtain the following confidence interval from various tests:

$-21 \text{ seconds} \leq \mu_{\text{Axial}} - \mu_{\text{Radial}} \leq 187 \text{ seconds}$

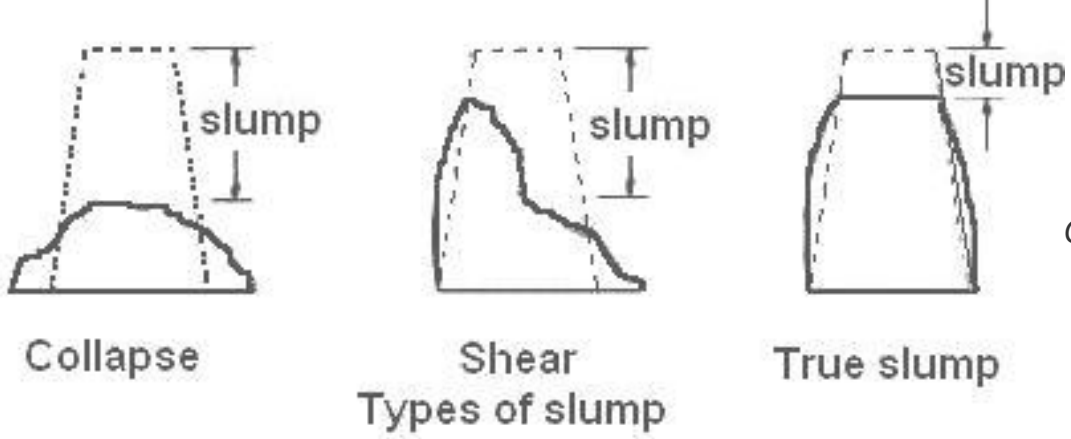
Check all the options that correctly apply on how you might be able to make the confidence interval narrower.

Your Answer		Score	Explanation
☑ Take more samples from either the axial impeller, or radial impeller, or both.	✔	0.25	Correct, this will likely make the interval narrower (though with diminishing returns)
☑ If it is possible, we should make the standard deviation smaller (though this might not be feasible in practice).	✔	0.25	
☑ Using a higher level of confidence will get a narrow interval, because we will get closer bounds for the true population value.	✖	0.00	Increasing the level of confidence will increase the bounds
☑ Use a smaller magnitude value for c_t (if z is t-distributed) or use a smaller value for c_n (if z is normally distributed).	✔	0.25	Yes, this will work; this is equivalent to increasing your level of confidence.
Total		0.75 / 1.00	

Question 2

A concrete slump test is used to test for the fluidity, or workability, of concrete. It's a crude, but quick test often used to measure the effect of polymer additives that are mixed with the concrete to improve workability.

The concrete mixture is prepared with a polymer additive. The mixture is placed in a mold and filled to the top. The mold is inverted and removed. The height of the mold minus the height of the remaining concrete pile is called the "slump".



Credit: Wikipedia

You run several tests to acquire data. The goal is see which one of your additives, either A or B, provides a **smaller slump**.

Which of the following are good experimental practices, to ensure that you get independent data?

(*please check all that correctly apply*)

Your Answer		Score	Explanation
☑ In an ideal situation where you can do many trials, use a variety of suppliers for the cement, binder, and other ingredients, to ensure you test the additive performance across a variety of conditions.	✔	0.25	Yes, this should ideally be done. The variation induced by various ingredients, binders and cements should be much smaller than the variation in slump due to the additive. If the additive variation is swamped by the above, then it indicates the additive isn't particularly effective.
☑ Ideally, all the additive A experiments should be done by 1 person, then all the additive B experiments done by another person so they have no relationship with each other.	✖	0.00	This is very bad experimental practice. The worst part about this option is that you will end up having the effect of the person (the operator) mixed up with the effect of the additive. We call this confounding. As engineers, we will very likely make this mistake in the future, because it is so easy to fall into this trap.
☑ Clean the slump test equipment thoroughly between runs.	✔	0.25	

☑ Perform all the additive A samples first, then all the additive B samples next.	✖	0.00	This is poor experimental practice, and it means that successive samples of A, A, A, A, then B, B, B, B, B, etc have a relationship between them.
Total		0.50 / 1.00	

Question Explanation

We know we should keep all factors as constant as possible, such as temperature, humidity, etc. This applies to operators too. It should be the same person for all experiments (or if you have to use multiple people, then randomly assign them to different A and B runs).

Question 3

Continue on with the concrete slump example in the prior question. Which are valid assumptions in order to calculate a confidence interval of the form shown below?

$$\_\_\_\_\_ \leq \mu_B - \mu_A \leq \_\_\_\_\_$$

(*check all that correctly apply*)

Your Answer		Score	Explanation
☑ Assume the data for sample A and sample B are from the central limit theorem.	✖	0.00	No, there is no such thing. The central limit theorem applies when certain conditions are met, but data cannot come from a theorem.
☑ To calculate the variance of the difference in sample averages, $\mathcal{V}\{\bar{x}_B - \bar{x}_A\}$, we must assume the averages from each sample are independent.	✔	0.20	Yes, this is true.
☑ Assume the data points are independent.	✔	0.20	Yes, this is required.
☑ Assume the variances for sample A and B are the same.	✔	0.20	Yes, this is required to simplify the statistical check.
☑ Assume the data are uniformly distributed.	✖	0.00	This is not a required assumption.

Total	0.60 / 1.00

Question 4

Here are the data that were collected for the slump tests, with the two additives: A and B.

Samples for A	Samples for B
12	13
15	7
12	9
6	12
17	12
	5

Based on these data, we would like to calculate a confidence interval:

$\_\_\_\_\_ \leq \mu_B - \mu_A \leq \_\_\_\_\_$

To do so, we calculate some intermediate values.

Please *check all that correctly apply*:

Your Answer		Score	Explanation
☑ The critical values for a 90% confidence interval would have 5% in each tail.	✔	0.29	Yes, this is correct.
☑ If we were to calculate the z-value, the denominator would be 2.22, which is the overall standard deviation.	✔	0.29	
☑ There are $5 + 6 = 11$ degrees of freedom	✖	0.00	Not true, there will be 9 degrees of freedom.
☑ The standard deviations for each sample can be pooled, so we have $s_A = 4.16$, $s_B = 3.2$, and the pooled variance is 3.66.	✖	0.00	Not quite: the variance is 13.4 and not 3.66.

☑ The sample means are $\bar{x}_A = 12.4$ and $\bar{x}_B = 10.5$	✖	0.00	
☑ The z-value should be assumed to be normally distributed.	✖	0.00	Not true: the z-value is from the calculated (estimated) standard deviation, so it will be t-distributed, not normally distributed.
☑ The z-value should be assumed to be t-distributed.	✔	0.29	Yes, we are estimating the denominator standard deviation, so this z value follows a t-distribution.
Total		0.86 / 2.00	

Question 5

Once again, here are the data that were collected for the slump tests, with the two additives: A and B.

Samples for A	Samples for B
12	13
15	7
12	9
6	12
17	12
	5

Based on these data, this time we would like to calculate a **95% confidence interval**:

_____ $\leq \mu_B - \mu_A \leq$ _____

Please *check all that correctly apply*:

Your Answer		Score	Explanation
☑ The confidence interval shows that there is no statistical difference between additive A and additive B.	✔	0.14	
☑ The critical t value is 1.83 for this level of confidence.	✖	0.00	Not correct; use `qt(0.975, df=11-2)` to calculate it.

☑ The upper bound in the confidence interval is 2.28	✔	0.14
☑ The lower bound in the confidence interval is 7.75	✖	0.00
☑ The critical t value is 2.26 for this level of confidence.	✔	0.14
☑ The lower bound in the confidence interval is -7.75	✔	0.14
☑ The upper bound in the confidence interval is -2.28	✖	0.00
Total		0.57 / 1.00

Question 6

Based on the statistical analysis in the foregoing questions, which additive do you recommend to get the smaller slump value? You have to pick A or B.

Please ensure your calculations in the prior questions are accurate, since there is no partial credit here: as in real-life, you have to pick A or B -- one is appropriate, the other isn't.

Your Answer		Score	Explanation
○ A			
◉ B	✔	1.00	
Total		1.00 / 1.00	

Question 7

Check all options that *correctly apply* with regards to paired testing.

Please note:

- that if I take 2 samples, one from system A and another from system B, these two values are called my *within-pair* values,
- and if I collect another 2 samples, then the first pair of values can be compared to the second pair of values: this is called a *between-pair* comparison
- So I can collect many such paired values, and in the end I will have n pairs, but $2n$ raw samples.

Your Answer		Score	Explanation
☑ The raw data (the individual sample values) **do not** need to be normally distributed.	✔	0.33	This is correct.
☑ Any systematic difference *within* pairs is eliminated (for example, if both sample A and sample B from a pair had a laboratory mis-calibration, causing the recorded value to be too low by 10 units).	✔	0.33	This is the advantages of paired testing.
☑ My friend and I are both randomly selected for a clinical trial to test a drug's efficiency. My friend receives the placebo and I get the actual drug. Later it switches around, my friend gets the drug and I get the placebo. For the purpose of analyzing data from the clinical trial, my friend and I are considered pairs.	✖	0.00	Not true: pairing would require the value from your placebo result and your drug result to be subtracted: you are the item that is in common. Similarly for the friend: the friend's placebo and drug values should be subtracted, to eliminate the person's effect.
Total		0.67 / 1.00	