University of Waterloo
Stat 372 – W16
Term Test II

Date: Thursday, March 3, 2016. Duration: 60 minutes

Family Name:_____ First Name:_____ I.D. #:_____

Signature:_____

Instructor: P. Balka

Solutions

Instructions:

- This exam has 5 pages including this cover page. The marks for each question are indicated (total of 30). **Show your work. Your grade will be influenced by how clearly you express your ideas, and how well you organize your solutions.**
- When using the probability tables, choose the closest degrees of freedom listed if the actual degrees of freedom are not provided.
- No questions will be permitted.

1) In a packaging trial investigating the effects of colour (green, blue) and image (1,2) on sales, 20 stores were split into 5 geographical regions (4 in each region), and within each region, the 4 treatment combinations were randomly assigned to the stores. The treatment means and (partial) output are provided below (the data are adapted from Example 2 on p. 47 of the Course Notes)

5 Blocks (regions)
4 Treatments (2x2 Factorial)

Colour	Image	Mean Sales
Blue	1	806.8
Blue	2	837.6
Green	1	742.8
Green	2	857.4

$\bar{y}_{++} = 811.15$

Analysis of Variance Table

Response: sales

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
colour	*	2442	****	****	****
image	*	26426	****	****	****
colour:image	*	****	****	****	****
block	*	****	****	30.0941	****
Residuals	*	****	3218		

a) **[8]** Complete the full ANOVA table. Show your work.

$SS(Treat) = 5[(806.8-811.15)^2 + \cdots + (857.4-811.15)^2]$

$= 37647$

$SS(col*image) = SS(Treat) - SS(image) - SS(colour)$

$= 37647 - 2442 - 26426$

$= 8779$

$F = \frac{MS(Block)}{MS(Res)} = 30.0941 \Rightarrow MS(Block) = MS(Res)(30.0941)$

$= 3218(30.0941)$

$= 96842.8$

ANOVA table

Source	Df	SS	MS	F	p-value
Colour	1	2442	2442	0.76	>0.05
image	1	26426	26426	8.21	<0.05
col*image	1	8779	8779	2.73	>0.05
block	4	387371	96843	30.09	<0.05
Residuals	12	38616	3218		

b) [3] From the completed ANOVA table, summarize your conclusions regarding the effects of colour and image on sales.

Must look at interaction first:

- No significant interaction effect of image & colour on sales
- No significant effect of colour on sales
- Effect of image on sales is significant

c) [5] Confirm the presence/absence of interaction between colour and image by creating a 95% confidence interval for the appropriate contrast.

$\theta = (\tau_{11} - \tau_{12}) - (\tau_{21} - \tau_{22})$ (or, $\theta = (\tau_{11} - \tau_{21}) - (\tau_{12} - \tau_{22})$)

$\hat{\theta} = (806.8 - 837.6) - (742.8 - 857.4)$

$= 83.8$

$SE(\hat{\theta}) = \hat{\sigma}\sqrt{\frac{1}{5}+\frac{1}{5}+\frac{1}{5}+\frac{1}{5}}$

$= \sqrt{3218}\sqrt{0.8}$

$= 50.74$

95% C.I. for θ:

$\hat{\theta} \pm t_{12,.975}\, SE(\hat{\theta})$

$= 83.8 \pm 2.179(50.74)$

$= 83.8 \pm 110.6 \quad = (-26.8, 194.4)$

Since the interval contains 0, we can conclude there is no significant interaction effect

2) The following is an excerpt from the cnn.com article, *Spam costing companies $22 billion a year* (Thursday, Feb. 3, 2005):

NEW YORK (AP) -- Time wasted deleting junk e-mail costs American businesses nearly $22 billion a year, according to a new study from the University of Maryland.
A telephone-based survey of adults who use the Internet found that more than three-quarters receive spam daily. The average spam messages per day is 18.5 and the average time spent per day deleting them is 2.8 minutes.
... The random survey of 1,000 U.S. adults was conducted in November and has a margin of sampling error of plus or minus 3 percentage points.

a) **[2]** Suggest a reasonable sampling frame for this study.

The sampling frame (or study population) is the collection of units on which the sampling protocol is applied.
In this context (telephone-based survey), a reasonable sampling frame is all adults with registered phone numbers

b) **[2]** Explain why study error may be a potential problem for this study.

study error is the difference in attribute of interest between the target & study populations.
In this context, it may be that those adults not part of the study population (i.e. those without phones) have a different mean # of spam messages, mean time spent deleting spam, etc. than those adults with phones

c) **[2]** Consider that some adults contacted would either be unavailable or would chose not to participate in the survey. With which type of error is this associated? Briefly explain.

This would be a type of sampling error (specifically, non-response error), as the attributes of interest of respondents & non-respondents in the frame may be different.

d) **[2]** It may be that people tend to overestimate the time they spend deleting spam per day. With which type of error is this associated? Briefly explain.

This would be a type of measurement error, as there would be a systematic difference between the true & measured value of the response variate

3) **[6]** Suppose you wish to conduct a study on University of Waterloo's 3500 employees (1000 faculty and 3000 staff) to investigate the effect on productivity of the time spent deleting spam. You select a random sample of 200 employees (50 Faculty, 150 Staff) based on the following sampling protocol:

   i) Select 50 faculty by randomly selecting 5 Departments, and randomly selecting 10 faculty from each department.

   ii) Select 150 staff by randomly selecting 10 Departments, and randomly selecting 15 staff from each department.

   Identify the different sampling protocols associated with this study. Be sure to explain your reasoning.

This is an example of multi-stage sampling:

- Stratified sampling: The study population (Waterloo employees) is stratified into faculty & staff.
- Cluster sampling: Departments (clusters) are randomly selected from each strata.
- Simple random sampling (SRS): Clusters, and units within each selected cluster, are selected using SRS.