

Let the words of my mouth and the meditation of my heart
 Be acceptable in Your sight, O LORD, my Rock and my Redeemer.
 -- Psalm 19:14

- Please show all your work! No partial credit will be given for incorrect answers with no work shown.
- Please draw a box around your final answer.
- You are only permitted to use your own calculator and writing implements.
Cell phones should be muted and left in your pocket or bag.
- All relevant tables are attached to the back. You may detach them for your reference.
- Assume $\alpha = 0.05$ everywhere unless indicated otherwise.
- For t-tests on two groups, if the df is not given, you may use the conservative estimate of $df = \min(n_1, n_2) - 1$.

1. A particular FDG-PET (fludeoxyglucose positron-emission tomography) screening test for non-Hodgkin's lymphoma has a 18% false-positive rate (82% specificity) and 91% sensitivity (i.e., 91% of lymphomas are caught by the screening process).

(a) Suppose the screening test is applied to 250 patients, of which 50 have non-Hodgkin's lymphoma. Draw an **event tree** for the outcomes of the test, and **label** the tree with probabilities for each branch of the tree. **[4]**

(b) On average, how many people in this group will **test positive** for non-Hodgkin's lymphoma? **[3]**

(c) If a patient tests positive using this test, what is the probability that the patient **really** has non-Hodgkin's lymphoma? **[2]**

2. The home provinces of 16 students in a class are listed below. Draw a **Pareto** chart showing the distribution of home province in this sample. **[4]**

AB, BC, BC, SK, AB, SK, BC, MB, AB, BC, ON, AB, BC, ON, MB, SK

| | | | |
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3. The average number of hours of exercise per week was measured for a number of urban dwellers and rural dwellers. A 95% **confidence interval** for the difference of means (urban - rural) is (-0.27, 1.23). Based on this information, indicate whether each of the following statements is "True" or "False". (Please write the entire word, "True" or "False".) [6]
- (a) We are 95% certain that urban dwellers exercise between 0.27 hrs less and 1.23 hrs more per week than rural dwellers.
 - (b) 95% of urban dwellers exercise between 0.27 hrs less and 1.23 hrs more per week than rural dwellers.
 - (c) There is no difference in the amount of exercise for urban and rural dwellers.
 - (d) Urban dwellers exercise an average of between 0.27 hrs less and 1.23 hrs more per week than rural dwellers.
 - (e) At a 5% level of significance, this study is unable to find a difference in amount of exercise between urban and rural dwellers.
 - (f) With 95% confidence, the difference in hrs/week of exercise between urban and rural dwellers in this study is between -0.27 and 1.23.
4. Describe two events/conditions that one might reasonably expect are statistically **independent**, and justify why. Be sure also to indicate what the overall sample space is. [3]
5. In clinical trials, a cholesterol pill produced by pharmaceutical company "Murck" exhibits severe side effects in 30 out of 250 patients. The pill produced by competitor "ZastroSeneca" exhibits severe side effects in 14 out of 200 patients.
- (a) Build a 95% **confidence interval** for the risk of side effects with Murck's pill. Do the same for ZastroSeneca. [4]
 - (b) Does the risk of side effects differ significantly for the two companies' cholesterol pills? State the null and alternative hypotheses, both in **words** and in **notation**. [2]
 - (c) What statistical **test** is appropriate to test the hypothesis? Number of tails? [2]
 - (d) **Run** the test: find the test statistic and either bracket a p-value or find the critical value. [4]

(e) Draw a conclusion and **interpret** it in the context of the two drug companies. Please use complete English sentences. [2]

(f) What **assumptions** did you rely upon in conducting the test? Are the assumptions met? Why or why not? [2]

(g) Now let's approach this research question from a different approach: first, identify the two **variables** involved (i.e., for each participant in the study, what two questions need to be asked). What are the **levels of measurement**? [2]

(h) Now, let the research question be: are these two variables **independent**? State the null and alternative hypotheses, both in **words** and in **notation**. [3]

(i) What statistical **test** is appropriate to test the hypothesis? Number of tails? [2]

(j) **Run** the test: find the test statistic and either bracket a p-value or find the critical value. [5]

(k) Draw a conclusion and **interpret** it in the context of the two drug companies. Please use complete English sentences. [2]

(l) What **assumptions** did you rely upon in conducting the test? Are the assumptions met? Why? [2]

6. A biomedical lab recently purchased a new **spirometer** (measures lung functioning) to replace its old one. To assess precision, both spirometers were run 16 times on a standard test apparatus to measure forced vital capacity (FVC). The old spirometer had a standard deviation of 20 mL, and the new spirometer has a standard deviation of 12 mL. Is the new spirometer more precise than the old one?

(a) State the null and alternative hypotheses, both in **words** and in **notation**. [2]

(b) What statistical **test** is appropriate to test the hypothesis? Number of tails? [2]

(c) **Run** the test: find the test statistic and either bracket a p-value or find the critical value. [4]

(d) Draw a conclusion and **interpret** it in the context of the original research question. Please use complete English sentences. [2]

(e) What **assumptions** did you rely upon in conducting the test? [2]

7. The peak expiratory flow (PEF) is the maximum flow rate (in L/min) from the lungs when a person blows out. The PEF for seven females with asthma is measured both before and after the patient inhales a corticosteroid:

| | | | | | | | | Mean | SD |
|---------------|-----|-----|-----|-----|-----|-----|-----|------|-------|
| No inhaler: | 310 | 325 | 350 | 355 | 373 | 395 | 433 | 363 | 41.85 |
| With inhaler: | 332 | 350 | 362 | 370 | 384 | 400 | 420 | 374 | 29.98 |

(a) Do corticosteroids enhance peak expiratory flow in females with asthma? State the null and alternative hypotheses, both in **words** and in **notation**. [2]

(b) What statistical **test** is be appropriate to test the hypothesis? Number of tails? [2]

(c) **Run** the test: find the test statistic and either bracket a p-value or find the critical value. [4]

(d) Draw a conclusion and **interpret** it in the context of the original research question. Please use complete English sentences. [2]

(e) What **assumptions** did you rely upon in conducting the test? Are the assumptions met? Why or why not? [3]

8. Three pharmaceutical companies, "Murck", "ZastroSeneca", and "Faizer", all produce diabetes medication which purports to reduce glycated hemoglobin (A1C, an indicator of plasma glucose concentration). Each company's medication is given to a different group of diabetic patients, and the percent reduction in A1C is recorded (see below). Do all three medications have the same efficacy on A1C?

| | | | | Mean: | SD: |
|---------------|-----|-----|-----|-------|--------|
| Murck: | 0.4 | 0.6 | | 0.5 | 0.1414 |
| ZastroSeneca: | 0.5 | 0.6 | 1.0 | 0.7 | 0.2646 |
| Faizer: | 1.0 | 1.4 | 1.5 | 1.3 | 0.2646 |

(a) State the null and alternative hypotheses, both in **words** and in **notation**. [3]

(b) What statistical **test** is be appropriate to test the hypothesis? Number of tails? [2]

(c) **Run** the test: find the test statistic and either bracket a p-value or find the critical value. [5]

(d) Draw a conclusion and **interpret** it in the context of the original research question. Please use complete English sentences. [2]

(e) What **assumptions** did you rely upon in conducting the test? [2]

9. Anxiety is frequently measured on the Hamilton Anxiety Scale ("HAM-A"), a 14-parameter questionnaire, where a score of 0 indicates minimal anxiety, up a score of 14 representing severe anxiety. Is there a relationship between **coffee intake** (cups/week) and **anxiety** level?
- (a) Name the **variable(s)** which need to be measured and their levels of measurement. [2]
- (b) What statistical **test** is appropriate? Number of tails? [2]
- (c) State the null and alternate **hypotheses**, both in words and in notation. [2]
- (d) A study with 11 participants results in the following data (X represents coffee in cups/week, and Y represents anxiety in HAM-A points):
 $SS_X = 110$, $SS_Y = 41.26$, $SS_{XY} = 55$.
Find the **slope** of the best-fit line, indicate its **units**, and **interpret** the slope in light of the original variables. [3]
- (e) The **average** coffee intake in the study was 9 cups/week, and the average anxiety level in the study was 7.5. Find the **equation** of the best-fit line, and interpret the **intercept** of the line in light of the model. [3]
- (f) Find the **correlation** between coffee intake and anxiety level in this study. Is this a low, medium, or high level of correlation? [2]
- (g) What **fraction** of the variability in anxiety levels in this study is explained by the linear relationship with coffee intake? [2]
- (h) What is the **average** anxiety level predicted by the linear model for people who drink 2 cups of coffee a day (14 per week)? [1]

(i) What is the **standard deviation** in anxiety level predicted by the linear model for people who drink 2 cups of coffee a day (14 per week)? [3]

(j) Conduct a **significance** test to answer the original research question: find the test statistic and either bracket a p-value or find the critical value. [4]

(k) Draw a conclusion and **interpret** it in the context of the research question. Please use complete English sentences. [2]

(l) What **assumptions** did you rely upon in conducting the test? [2]

10. A factory needs to ensure that the widgets it produces have variance no more than 2.5mm^2 . An inspector from corporate headquarters randomly selects 41 widgets from the factory, to check if the factory is within specifications. Those 41 widgets have a variance of 3.52mm^2 in length.

(a) State the null and alternative hypotheses, both in **words** and in **notation**. [2]

(b) What statistical **test** is be appropriate to test the hypothesis? Number of tails? [2]

(c) **Run** the test: find the test statistic and either bracket a p-value or find the critical value. [4]

(d) Draw a conclusion and **interpret** it in the context of the original research question. Please use complete English sentences. [2]

(e) What **assumptions** did you rely upon in conducting the test? [2]

11. The forced expiratory volume in 1 second (FEV1) is the volume of air (in litres) that can forcibly be blown out by a person in 1 second. Does **FEV1** depend on **gender**?

(a) State the null and alternative hypotheses, both in **words** and in **notation**. [2]

(b) What statistical **test** is be appropriate to test the hypothesis? Number of tails? [2]

(c) Data for this experiment are given below. Sketch **boxplots** for the data, on a common axis (number line). [4]

| | | | | | | | | | Mean: | SD: |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-------|--------|
| Males: | 3.0 | 3.1 | 3.3 | 3.4 | 3.4 | 3.7 | 4.0 | 4.1 | 3.5 | 0.4000 |
| Females: | 2.7 | 2.9 | 3.0 | 3.1 | 3.2 | 3.2 | 3.4 | 3.5 | 3.125 | 0.2605 |

(d) **Run** the test: find the test statistic and either bracket a p-value or find the critical value. [4]

(e) Draw a conclusion and **interpret** it in the context of the original research question. Please use complete English sentences. [2]

(f) What **assumptions** did you rely upon in conducting the test? [2]