Study Guide for the Final Exam

When studying, remember that the computational portion of the exam will only involve new material (covered after the second midterm), that material from Exam 1 will make up about 15% of the conceptual portion of the exam, material from Exam 2 will make up about 35% of the conceptual portion of the exam, and new material will make up about 50% of the conceptual portion.

Material from Exam 1

- Basic definitions
  - Know the definitions for: variable, sample, population, parameter, statistic, inferential & descriptive statistics, and sampling error.
  - Understand the relationships between samples & populations and statistics & parameters
- Measurement Scales & Data Types
  - Know the 4 different measurement scales
  - Know the difference between continuous and discrete variables
  - Know the difference between qualitative/categorical and quantitative/measurement data
- Basic research designs
  - Know the differences between basic research designs
    - Experimental
    - Correlational
    - Quasi-experimental
  - Know the functional difference between dependent and independent variables
  - Know the definitions for random sampling and random assignment and the consequences of failing to sample or assign randomly
- Central Tendency
  - Understand all three measures of central tendency and know how to compute them
  - Be able to identify the strengths and weaknesses of each measure.
  - Understand how the shape of the distribution affects the different measures of central tendency
  - Understand how measures of central tendency are affected by extreme scores, by adding scores to a sample, or by adding constants to all scores.
- Dispersion or Variability
  - Know how to compute:
    - Range
    - Variance (for populations and samples)
    - Standard deviation (for populations and samples)
  - As with the measures of central tendency, you should understand how the different measures of variability are affected by extreme scores, by adding scores to a sample or by linearly transforming (i.e., adding and/or multiplying by a constant) each of the scores in a sample
- Probability
Know the definitions of independent and dependent events
Understand the difference between mutually exclusive events and independent events
Understand the difference between joint and conditional probabilities
Know how (and when) to use the multiplicative and additive laws to compute compound probabilities from simple (marginal) probabilities

The Normal Distribution
Understand the role of the normal distribution in statistics and the various reasons it is used.
Understand the relationship between the standard normal distribution and any other normal distribution
  - Know the parameters of the standard normal distribution
Be sure to remember that the distribution is symmetrical and the relationship between its three measures of central tendency
Try to remember roughly how much of the distribution falls within the central one (~68%) and two (~95%) standard deviations

z-Scores
Know (and understand!) the formulas for computing z-scores for x-scores drawn for arbitrary distributions and how to compute x-scores from z-scores given the parameters of a normal distribution
Remember to interpret z as “units of standard deviation from the mean”
Understand how to compute z given a percentage or a proportion
  - Remember that the table used on the test always gives tail probabilities (i.e., always values smaller than 0.5) so if you want to determine the area of the body of the curve, you have to look up the tail probability and subtract it from one.
  - Remember that computing z from a probability or percentage is the first step in determining the percentile of a distribution with arbitrary mean and standard deviation
Know how to compute
  - The probability area in the lower or upper tail of the distribution
  - The probability area of the normal distribution within a given interval
  - An x or z probable interval for any percentage given a mean and standard deviation

Material from Exam 2

Sampling Distributions & Hypothesis Testing

Sampling distributions
Make sure you understand the concept of sampling error and how sampling errors give rise to a sampling distribution
  - The sampling error of a statistic is the variability of a statistic from sample to sample due to chance
  - The sampling distribution of a statistic is a description of its sampling error
o Know the relationship between the sampling distribution of a statistic and its standard error. **You should also clearly understand the difference between the sampling distribution of a statistic and the population distribution of its underlying scores**

- **Hypothesis testing**
  - Understand the relationship between sampling distributions and hypothesis testing. You should be able to answer the question “why do we use hypothesis tests?” with an answer that includes discussion of the sampling distribution or sampling error. [Really! Even if you take nothing else from this class, you should understand this.]
  - Understand the basic steps involved in hypothesis testing
    - Know the definitions of a type I error and the type I error rate (\(\alpha\)), as well as type II errors and the type II error rate (\(\beta\)).
    - Understand the relationship between the significance level (\(\alpha\)), the critical statistic value, and the rejection region

- **Central Limit Theorem**
  - Make sure you understand the implications of the central limit theorem regarding the sampling distribution of the mean:
    - The mean of the sampling distribution of the mean is the population mean of the underlying scores
    - As the number of scores \(n\) used to compute the sample mean increases, the standard error of the mean decreases
    - Whatever the distribution of the parent population, the sampling distribution of the mean approaches a normal distribution as the sample size (\(n\)) increases.

**z-Tests and t-Tests:**

- **z-tests and one-sample t-tests**
  - Make sure that you understand the relationship between the \(z\) and \(t\) statistics

- **t-test for Repeated/Related Measures**
  - Know the definition of a repeated-measures or related-measures research design
    - Know the advantages and disadvantages of a repeated-measures design
  - Know how difference scores are computed
  - Remember that a related samples \(t\)-test is equivalent to a one-sample \(t\)-test computed on difference scores

- **t-test for Two Independent Samples**
  - Know how to compute the \(t\)-statistic for the independent samples \(t\)-test
  - Know the definition of pooled variance
  - Know the definition of the variance sum law
  - Know the assumptions underlying the independent samples \(t\)-test
    - Homogeneity of variance
    - Independence of sample scores
    - Normality of sample scores

- **General \(t\)-test knowledge**
  - Know the difference between the independent-measures and repeated-measures research designs and the advantages and disadvantages of each
Know how to compute the *t*-statistic for the independent samples *t*-test

In particular, know how computing the degrees of freedom and the standard error differs from the computation of these same terms in the related-samples test

Know how to compute effect size (Cohen’s d) for each type of *t*-test

Know how to choose among the various *t*-tests and how the computation of the *t*-statistic differs across the different tests

**Estimation & Confidence Intervals:**

- **Confidence Intervals**
  - Understand the difference between a point estimate and an interval estimate
  - Know how to use the *t* table to compute confidence intervals for the population mean
    - This includes knowing the formula for confidence intervals given the critical *t* or *z* values
  - Understand the relationship between confidence intervals and hypothesis tests

**One-way ANOVAs:**

- Know the definition of the analysis of variance (ANOVA) and the differences between ANOVAs and *t*-tests
- Understand the problem of multiple comparisons and its implications for the familywise or experimentwise error rates
- Know the form of the null hypothesis in the ANOVA (i.e., the omnibus null hypothesis) and how the null and alternative hypotheses differ from those used in the
- Know the assumptions underlying the ANOVA
  - Homogeneity of variance
  - Independence of observations across groups/treatments
  - Normality of sample scores
- Understand the logic of the ANOVA
  - *F* is a ratio of two estimates of the population variance.
  - The estimate in the denominator is estimated as an average of the sample variances
  - The estimate in the numerator is estimated from the variance of the sample means
  - If the null hypothesis is true, both of these values should, on average, be equal and the expected ratio should equal 1.0
  - However, if the null hypothesis is false, then the numerator should include some extra variation due to the treatment effect. In this case, the expected ratio should be greater than 1.0 on average.
- Know how to compute the degrees of freedom and *F*-ratio statistic for the one-way independent-measures (between-subjects) ANOVA
  - You won’t need to do this explicitly on the exam, but you should be able to answer conceptual questions regarding terms involved in the computation.
- **Repeated-Measures (within-subjects) ANOVA**
  - Understand the difference between the repeated-measures ANOVA and the one-way ANOVA
    - The primary computational difference is that you will have to compute the between-subjects variation *SS*\text{subjects} and subtract it from *SS*\text{within} to compute
$SS_{error}$, which will appear in the $MS_{error}$ term in the denominator of the $F$ ratio

- Understand why we must remove the effects of between-subjects variability from the denominator of the $F$ ratio
- Know how to compute the degrees of freedom and the $F$ ratio statistic for the repeated-measures ANOVA
- Know when to choose ANOVAs rather than $t$ tests (when you are comparing more than two samples) and when to choose the repeated-measures ANOVA instead of the one-way ANOVA (when you have scores that are related across samples)

- Know how to use the $F$ table to compute critical regions for hypothesis testing
- Know how to construct and read summary tables for one-way ANOVAs
- Understand how variance is partitioned in an ANOVA
- Post hoc Tests
  - Understand the concept of post-hoc tests for multiple comparisons and why these are used with ANOVAs

**New Material**

**Factorial ANOVAs**

- Besides the stuff mentioned above in the general ANOVA section, make sure that you understand the meaning of: main effects, interactions, and simple effects.
- Also, make sure that you understand the difference between different factors, on the one hand, and different factor levels, on the other.

**Statistical Power**

- Understand the relationship between Type II errors, the Type II error rate $\beta$ and the statistical power of a hypothesis test.
- **Understand the effect of the following on the power of a statistical test**
  - The magnitude of the difference between sample means
  - The Type I error rate $\alpha$
  - The population standard deviation $\sigma$
  - The sample size $n$

**Correlation & Regression**

- **Know how to compute (and interpret) the correlation coefficient $r$ given either $SS_X$, $SS_Y$, and $SP_{XY}$, or $s_X$, $s_Y$ and $\text{cov}_{XY}$**.
- Understand the difference between Pearson’s correlation coefficient, Spearman’s rank correlation coefficient, the point-biserial coefficient, and the phi coefficient.
- **Know how to compute and interpret the equation for a regression line**.

**Chi-square Tests**

- **Know how to compute expected frequencies given probabilities, proportions, or percentages under the null hypothesis**.
• Know how to compute expected frequencies in contingency tables.
• Know how to compute the $\chi^2$ statistic and its associated degrees of freedom for both
the goodness-of-fit test and the test of independence.

Nonparametric Tests
• Know the advantages and disadvantages of nonparametric tests relative to parametric
  tests
• Know the definition of a nonparametric test
• For the four rank-randomization-based nonparametric tests that we discussed in class,
  make sure that you can match each test with its parametric equivalent.

Useful Diagrams

Decision Tree for z and t-tests

[Diagram of decision tree with nodes for: one sample, two samples, one-sample t-test, related samples t-test, independent samples t-test, z-test, and independent samples t-test.]
Decision Tree for ANOVAs

Structure of Variance in ANOVA

Suggested Even-Numbered Textbook Problems

Example Research Scenarios

In this document, I’ve collected many of the scenario problems that we discussed in class throughout the semester. For each problem you should:

a) Identify the most appropriate statistical test
b) Identify the independent variable(s) or factor(s)
c) Identify the dependent variable
d) Identify the scale of measurement for the independent and dependent variables.

I’ll post the answers on Monday evening.

Scenario 1
Research suggests that the antioxidants in foods such as blueberries can reduce perhaps reverse age-related declines in cognitive functioning. To test this phenomenon, a researcher selects a sample of 25 adults aged between 70 and 75 years old and administers a cognitive function test to each participant. The participants then drink a blueberry supplement every day for 4 months before they are tested again. The researcher compares the scores before treatment with the scores after treatment to see if there is any change in cognitive function.

Scenario 2
To examine the relationship between alcohol consumption and birth weight, a researcher selects a sample of 20 pregnant rats and mixes alcohol with their food for 2 weeks before the pups are born. One newborn pup is randomly selected from each subject’s litter and the average birth weight for these 20 pups is recorded. It is known that the average birth weight for regular rats (without alcohol exposure) is 5.6 grams, with a standard deviation of 0.5 grams.

Scenario 3
To examine the relationship between texting and driving skill in students, a researcher uses orange traffic cones to set up a driving circuit in a parking lot. A group of students is then tested on the circuit, once while receiving and sending text messages, and once without texting. For each student, the researcher records the number of cones hit while driving each circuit.

Scenario 4
Childhood participation in sports, cultural groups, and youth programs appears to be related to improved self-esteem for adolescents. In a representative study, a researcher compares scores on a self-esteem questionnaire for a sample of 100 adolescents with a history of group participation and a separate sample of 100 who have no history of group participation.

Scenario 5
A researcher investigated different combinations of temperature and humidity to examine how heat affects performance. The researcher compared three temperature conditions (70°, 80°, and 90°) with a high humidity and a low humidity condition for each temperature. A separate group of participants was tested in each of the 6 different conditions, and for each participant, the researcher recorded the number of errors made on a problem-solving task.
Scenario 6
A statistics instructor thinks that doing homework improves scores on statistics exams. To test this hypothesis, she randomly assigns students to two groups. One group is required to work on the homework until all problems are correct, while homework is optional for the second group. At the end of the semester, exam grades are compared between the two groups.

Scenario 7
Encouraged by the first study, a second statistics instructor wonders if it is necessary to students to complete the entire homework assignment until it is correct or whether just working on the homework is sufficient. He randomly assigns students to three groups: a “homework optional” group, a “must answer each question” group, and a “must get all questions correct” group.

Scenario 8
Researchers interested in the effect of moderate intoxication on driving performance recruited 40 drivers. Half of the drivers drove a driving simulator after consuming a low dose of alcohol and half had not consumed any alcohol. Additionally, half of the participants in each of these groups were highly experienced drivers, while half were relatively inexperienced. The researchers measured the drivers’ reaction time to a stimulus presented in their peripheral vision (with longer reaction times indicating worse performance).

Scenario 9
A professor thinks that this year’s freshman class seems to be smarter than previous classes. To test this, she administers an IQ test to a sample of 36 freshman and computes the mean (M=114.5) and standard deviation (s = 18) of their scores. College records indicate that the mean IQ across previous years was 110.3.

Scenario 10
A psychologist examined the effect of exercise on a standardized memory test. Scores on this test for the general population form a normal distribution with a mean of 50 and a standard deviation of 8. A sample of 62 people who exercise at least 3 hours per week has a mean score of 57.

Scenario 11
A researcher studies the effect of a drug on nightmares in veterans with PTSD. A sample of clients with PTSD kept count of their nightmares for 1 month before treatment. They were then given the medication and asked to record counts of their nightmares again for a month.

Scenario 12
A developmental psychologist wants to determine whether infants systematically prefer any of the three primary colors red, green, and blue. He records looking times to each color for 60 infants and determines their preferred colors by picking the one that was looked at the longest. 10 infants preferred red, 25 preferred green, and 25 preferred blue. Are these data consistent with any systematic color preferences?