Stat 250 Final Review
Hypothesis Testing

Identifying Question Types

- The most important skill to work on as you prepare for the exam is the ability to determine which type of test, interval, or distribution you should be using.
- Make sure you know the purpose of each before jumping into example questions.

Hypothesis Tests

We have seven different hypothesis tests we learned this semester:

- Single proportion (z), testing how a single proportion compares to a hypothesized value.
- Two proportions (z), testing how two population proportions compare to one another.
- Single mean (t), testing how a single mean compares to a hypothesized value

- Two Means (t), testing how two population means compare to one another.
  - Two means with unpooled variances, for **independent samples**
  - Two means for **paired data.**
- Chi-Sq Goodness of Fit (χ^2), testing if a single categorical variable is distributed as hypothesized
- Chi-Sq Test for Independence (χ^2), testing if two categorical variables have a relationship or association with one another.

Practicing Identifying

The next questions, I have removed the actual question and we will just determine which hypothesis test we should be using for each situation.

Treat these as flashcards to test yourself!

1. A group of 50 students each measured the length of their right arm and the length of their left arm. The average right arm lengths were compared to the average left arm lengths.

Which type of test?

1. A group of 50 students each measured the length of their right arm and the length of their left arm. The average right arm lengths were compared to the average left arm lengths.

Which type of test? **TWO MEANS, PAIRED DATA**

Reasoning: We're comparing two averages (means) and there is a meaningful way to pair this data (since each student measured both arms).

2. A researcher thinks that when 98.6 Fahrenheit was set as "normal" body temperature, an error occurred in rounding and converting from Celsius, and that the true mean temperature is lower.

Which type of test?

2. A researcher thinks that when 98.6 Fahrenheit was set as "normal" body temperature, an error occurred in rounding and converting from Celsius, and that the true mean temperature is lower.

Which type of test? **SINGLE MEAN**

Reasoning: We’re comparing the “true mean” to a hypothesized value of 98.6.

3. The maximum distance at which a highway sign can be read is determined for a sample of young people and a sample of older people. The mean distance is computed for each age group.

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3. The maximum distance at which a highway sign can be read is determined for a sample of young people and a sample of older people. The mean distance is computed for each age group.

Which type of test? **TWO MEANS, INDEPENDENT SAMPLES, UNPOOLED**

Reasoning: We can see the keyword of mean. We have two samples (a sample of young people and a sample of older people) **and they did not tell us that the variance between the two groups was equal.**

4. The paper "Contemporary College Students and Body Piercing" (Journal of Adolescent Health, 2004) described a survey of 450 undergraduate students at a state university. Each student in the sample was classified according to one of four class levels (Freshman, Sophomore, Junior, Senior) and one of 4 body art categories (body piercings only, tattoos only, both body piercing and tattoos, no body art).

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4. The paper "Contemporary College Students and Body Piercing" (Journal of Adolescent Health, 2004) described a survey of 450 undergraduate students at a state university. Each student in the sample was classified according to one of four class levels (Freshman, Sophomore, Junior, Senior) and one of 4 body art categories (body piercings only, tattoos only, both body piercing and tattoos, no body art).

Which type of test? **Chi-Sq Test for Independence**

Reasoning: There are two categorical variables mentioned.

5. Use the data below to test at the 5% level whether the likelihood of developing breast cancer is different for the hormone group than the placebo group.

	Yes	No	Total
Hormone	166	8340	8506
Placebo	124	7978	8102
Total	290	16318	16608

Which type of test?

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Which type of test? **Chi-Sq Test for Independence**

Reasoning: Again, two categorical variables…

6. The population of eligible voters in a region is 45.1% non-Hispanic white, 6.7% Black or African American, 28.8% Hispanic, 15.9% Asian, and 3.5% other. A sample of actual voters had the following racial/ethnic breakdown. Does the distribution of race/ethnicity for actual voters match that of eligible voters? Conduct a test at the .05 level.

White	93
Black or African American	13
Hispanic	43
Asian	24
Other	5
Total	178

Which type of test?

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Which type of test? **Chi-Sq Goodness of Fit**

7. A test of manual dexterity was given to students to determine if they perform better with their dominant hand than with their non-dominant hand. The data are presented below. Conduct a test at the 5% level.

Participant	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Mean	sd
Dominant	22	19	18	17	15	16	16	20	17	15	17	17	14	20	26	17.93	3.10
Nondominant	18	15	13	16	17	16	14	16	20	15	17	17	16	18	25	16.87	2.83
Difference	4	4	5	1	-2	0	2	4	-3	0	0	0	-2	2	1	1.07	2.43

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Which type of test? **Two Means, Paired Data**

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Which type of test? **SINGLE PROPORTION**

9. For samples of female (group 1) and male (group 2) students taken in 2003, a test was carried out to determine if the proportion carrying cell phones is higher for females.

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Which type of test? **TWO PROPORTIONS**

10. In a study comparing diet versus exercise, the 42 men on a diet lost an average of 7.2 kg with a standard deviation of 3.7 kg. The 47 men on an exercise regimen lost an average of 4.0kg with a standard deviation of 3.9kg. Assuming similar variances for the two groups, conduct a hypothesis test at the .05 level to determine if there is a difference in mean weight loss for the two groups.

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Which type of test? **Two means, independent samples**

Hypotheses Questions

- Hypotheses will always be about parameters (population values): μ or p
  - Never about statistics (sample values): $\bar{x}$ or $\hat{p}$
- The null hypotheses is always about **no difference** or the values being the **same**, so it will contain an = sign
- The alternative hypotheses will always be about a difference or association, and you will need to read the question to determine the direction (if any) of the alternative ($>, <, \neq$)

11. For samples of female (group 1) and male (group 2) students taken in 2003, a test was carried out to determine if the proportion carrying cell phones is higher for females. What are the null and alternative hypotheses?

A. $H_0: p_1 > p_2 \quad H_A: p_1 = p_2$
B. $H_0: \widehat{p_1} = \widehat{p_2} \quad H_A: \widehat{p_1} > \widehat{p_2}$
C. $H_0: p_1 = p_2 \quad H_A: p_1 > p_2$
D. $H_0: \widehat{p_1} > \widehat{p_2} \quad H_A: \widehat{p_1} = \widehat{p_2}$

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B. $H_0: \widehat{p_1} = \widehat{p_2} \quad H_A: \widehat{p_1} > \widehat{p_2}$

C. $\boldsymbol{H_0: p_1 = p_2 \quad H_A: p_1 > p_2}$

D. $H_0: \widehat{p_1} > \widehat{p_2} \quad H_A: \widehat{p_1} = \widehat{p_2}$

Reasoning: B and D are about statistics! They are WRONG. And the null needs = sign to be correct, so A is wrong!

12. The maximum distance at which a highway sign can be read is determined for a sample of young people and a sample of older people. The mean distance is computed for each age group. What's the most appropriate null hypothesis about the means of the two groups?

A. The population means are different.
B. The population means are the same.
C. The sample means are different.
D. The population means are the same.

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A. The population means are different.

B. The population means are the same.

C. The sample means are different.

D. The population means are the same.

Reasoning: Hypotheses are about POPULATION VALUES, null is about SAME.

13. Suppose that a difference between two groups is examined. In the language of statistics, the alternative hypothesis is a statement that there is

A. A difference between the sample means.
B. No difference between the sample means.
C. A difference between the population means.
D. No difference between the population means.

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A. A difference between the sample means.
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Reasoning: This one asks for the ALTERNATIVE HYPOTHESIS. So still about population means, but now want DIFFERENCE.

14. A researcher thinks that when 98.6 Fahrenheit was set as "normal" body temperature, an error occurred in rounding and converting from Celsius, and that the true mean temperature is lower. What are the hypotheses for this research question?

A. $H_0: \mu = 98.6 \quad H_A: \mu < 98.6$
B. $H_0: p = 98.6 \quad H_A: p < 98.6$
C. $H_0: \bar{x} = 98.6 \quad H_A: \bar{x} < 98.6$

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A. $\boldsymbol{H_0: \mu = 98.6 \quad H_A: \mu < 98.6}$

B. $H_0: p = 98.6 \quad H_A: p < 98.6$

C. $H_0: \bar{x} = 98.6 \quad H_A: \bar{x} < 98.6$

Reasoning: C is out because it has x-bar which is a statistic. Then you just need to figure out if the test is on means or proportions.

15. You are interested in determining whether there is strong evidence in support of the claim that less than 40% of retired adults have a part-time job. To answer this question, what null and alternative hypothesis should you test?

A. $H_0: p < 0.4 \quad H_A: p = 0.4$

B. $H_0: p = 0.4 \quad H_A: p > 0.4$

C. $H_0: p = 0.4 \quad H_A: p \neq 0.4$

D. $H_0: p = 0.4 \quad H_A: p < 0.4$

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B. $H_0: p = 0.4 \quad H_A: p > 0.4$

C. $H_0: p = 0.4 \quad H_A: p \neq 0.4$

D. $\boldsymbol{H_0: p = 0.4 \quad H_A: p < 0.4}$

Reasoning: This time, they are testing on our ability to read for the direction of the alternative. "less than" gives us D!

Test Statistics

- Be able to calculate test statistics. This is a simple plug and chug question, if they give it.
- The most important part of this will be to use the correct formula and translate the given information correctly.

16. The Better Business Bureau of Springfield states that the standard hotel room average price for a Saturday night stay is \$87, but you think it is higher. You go out and take a random sample of 33 hotels and get an average price of \$89.80 with a sample standard deviation of \$10. The test statistic is

A. -2.80
B. -1.61
C. 0.28
D. 1.61
E. 2.80

16. The Better Business Bureau of Springfield states that the standard hotel room average price for a Saturday night stay is \$87, but you think it is higher. You go out and take a random sample of 33 hotels and get an average price of \$89.80 with a sample standard deviation of \$10.

Test: SINGLE MEAN

Given information:

$$\mu = 87, n = 33, \bar{x} = 89.8, s = 10$$

Note: We know that 89.8 and 10 are sample values because they are in the same sentence as the word sample.

Calculation: $t = \frac{\bar{x}-\mu}{s/\sqrt{n}} = \frac{89.8-87}{10/\sqrt{33}} = 1.61$

17. When appropriate conditions are met for a hypothesis test of a single mean, which is true of the test statistic

$$\frac{\bar{x}-\mu_0}{s/\sqrt{n}}\ ?$$

A. It has a t distribution with n-1 degrees of freedom when the alternative hypothesis is true.
B. It has a t distribution with n-1 degrees of freedom when the null hypothesis is true.
C. It has a standard normal distribution (z) when the alternative hypothesis is true.
D. It has a standard normal distribution (z) when the null hypothesis is true.

17. When appropriate conditions are met for a hypothesis test of a single mean, which is true of the test statistic

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B. It has a t distribution with n-1 degrees of freedom when the null hypothesis is true.

C. It has a standard normal distribution (z) when the alternative hypothesis is true.

D. It has a standard normal distribution (z) when the null hypothesis is true.

Reasoning: Not a calculation question, just asking which this is, t or z. Single mean is a t-test with df=n-1 and all hypothesis tests are done under the assumption that the null is true.

P-Values

- P-values are areas under a curve. It could be z (standard normal), t, or chi-square.

  Know which distribution you are looking for an area under the curve of:

  standard normal: single p, two p

  t distribution: single mean, two mean, mean difference

  χ^2 distribution: chi-sq GOF, chi-sq ind

P-Values continued

2. Get the direction correct!

For one prop, two prop, one mean, two mean, you will have to read the question for the direction of the alternative. That will tell you whether area to the left (<), area to the right (>) or two times the area in the appropriate tail ($\neq$)

For χ^2 distribution, always to the right.

P-Values still…

3. Get your df correct! For t and χ^2, you will need to know which df you're looking up for:

One mean: $df = n - 1$

Two mean:

Independent unpooled: too complicated – use software or smaller of $n_1 or\ n_2$ - 1

Independent pooled: $df = n_1 + n_2 - 2$

Paired differences: $df = n - 1$ (n is number of pairs)

Chi-Square:

Goodness of Fit: $df = k - 1$ (k is number of categories)

Independence: $df = (r - 1)(c - 1)$ (r is number of row/categories in first variable, c is number of columns/categories in second variable)

18. An analyst conducts a test of the hypotheses H_0: $\mu=10$ versus the alternative H_a: $\mu>10$. The sample mean and sample standard deviation from a sample of size 15 are used to arrive at a test statistic of 1.7. What is the p-value for this test?

18. An analyst conducts a test of the hypotheses H_0: $\mu=10$ versus the alternative H_a: $\mu>10$. The sample mean and sample standard deviation from a sample of size 15 are used to arrive at a test statistic of 1.7. What is the p-value for this test?

A. Area to right of 1.7 on a standard normal distribution
B. Area to right of ${}^{1.7}/_{\sqrt{15}}$ on a standard normal distribution
C. Area to right of 1.7 on a t distribution with 14 degrees of freedom = 0.0556
D. Area to right of ${}^{1.7}/_{\sqrt{15}}$ on a t distribution with 14 degrees of freedom

Reasoning: This is a one mean test, which means a t distribution, ruling out

19. Birds use color to select and avoid certain types of food. A researcher studies pecking behavior of 1-day-old bobwhites. In an area painted white, four pins with different colored heads were inserted. The color of the pin chosen on the bird's first peck was noted for 36 bobwhites as in the table below. Under the null hypothesis of no color preference, the test statistic of 8.44 was calculated.

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The area to the right 8.44 on a χ^2 distribution with 3 df = 0.0377

df = k – 1 = 4 – 1 = 3

More on P-values

We've also been asked a number of conceptual questions about p-values. Know:

- The p-value is the probability that the sample values or test statistic is as or more extreme than observed, GIVEN the null hypothesis is true.
- The smaller the p-value is the more evidence we have against the null hypothesis.

True or False:

It is customary to say that the result of a hypothesis test is statistically significant (reject the null hypothesis) when the *p*-value is smaller than alpha (type I error probability).

Large *p*-values (close to a value of 1) indicate that the observed sample is inconsistent with the null hypothesis (reject the null hypothesis).

True or False:

It is customary to say that the result of a hypothesis test is statistically significant (reject the null hypothesis) when the *p*-value is smaller than alpha (type I error probability). **TRUE**

Large *p*-values (close to a value of 1) indicate that the observed sample is inconsistent with the null hypothesis (reject the null hypothesis). **FALSE**

Decisions / Conclusions

Here’s a list of things that are all mean the same thing for us (REJECT THE NULL):

- Test statistic > critical value
- P-value < significance level (α)
- Reject the null
- There is enough evidence to conclude the alternative hypothesis.
- There is sufficient evidence to reject the null hypothesis.
- The results are statistically significant.

Here’s a list of things that are all mean the same thing for us (FAIL TO REJECT THE NULL):

- Test statistic < critical value
- P-value > significance level (α)
- Fail to reject the null
- There is not enough evidence to conclude the alternative hypothesis.
- There is insufficient evidence to reject the null hypothesis.
- The results are not statistically significant.

20. A null hypothesis is that the mean nose lengths of men and women are the same. The alternative hypothesis is that the men have a longer mean nose length than women.
A statistical test is performed for assessing if men have a longer mean nose length than women. The *p*-value is 0.225. Which of the following is the most appropriate way to state the conclusion?

A. The mean nose lengths of the populations of men and women are identical.
B. There is not enough evidence to say that the populations of men and women have different mean nose lengths.
C. Men have a greater mean nose length than women.
D. The probability is 0.225 that men and women have the same nose length.

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D. The probability is 0.225 that men and women have the same nose length.

Reasoning: That is a large p-value, so we would FTRN, and there is not enough evidence to conclude the alternative (which is that there is a difference)

21. A chi-square test is performed to study the association between cigarette tar level and lung cancer. The chi-square statistic is found to be 14.44. The p-value is 0.025. we may conclude that

A. A cigarette tar level is associated with lung cancer.
B. There is not enough evidence to conclude cigarette tar level is associated with lung cancer.
C. Since the test statistic is large, the proportion of smokers with lung cancer is greater than the proportion of non-smokers with lung cancer.
D. Since the test statistic is large, the tar level in cigarettes is larger than expected.

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B. There is not enough evidence to conclude cigarette tar level is associated with lung cancer.
C. Since the test statistic is large, the proportion of smokers with lung cancer is greater than the proportion of non-smokers with lung cancer.
D. Since the test statistic is large, the tar level in cigarettes is larger than expected.

Reasoning: It's a little strongly worded, but p-value = 0.025 < alpha = 0.05, so we RTN and can conclude: There is enough evidence to conclude that there is an association (the alternative for a Chi-Sq test for independence).

22. A researcher conducted a test at the .05 level to determine if the mean calories in a chain restaurant's hamburger exceed the calorie count of 525 posted on the menu. 200 burgers were sampled from a variety of the chain's restaurants and their calorie content measured with a bomb calorimeter. The sample average was 530 with a sample standard deviation of 20, yielding a test statistics of 3.536 and a p-value of .00025. Which of the following is NOT a valid conclusion/interpretation?

A. The small p-value is strong evidence against the null hypothesis.
B. There is sufficient evidence to conclude that the mean calorie count in the chains burgers is larger than 525.
C. While the results of the test are practically significant, they may not be statistically significant.

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B. There is sufficient evidence to conclude that the mean calorie count in the chains burgers is larger than 525.
C. While the results of the test are practically significant, they may not be statistically significant.

Reasoning: The first two are correct decisions for such a small p-value since we would RTN. The last one is reversed. The results are statistically significant (since we RTN), but they aren't practically significant because we were comparing 525 as our hypothesized value to 530 as our observed. Those are pretty dang close to one another.

Conditions Necessary

To conduct a hypothesis test OR make a confidence interval, you have to make sure you are allowed to first. This always means RANDOM samples, but there are a few more assumptions depending on the test.

Proportion tests: Need np_0 and $n(1-p_0) \geq 10$

In a two sample test, BOTH samples must have at least 10 successes and 10 failures.

Conditions Necessary continued

Mean tests: Need n $\geq$ 30 OR population to be approximately normal

In a two independent sample test, BOTH samples must meet this criteria.

For the paired differences test, your number of pairs must meet this criteria

Chi-Sq test: Need expected values to all be $\geq$ 5

23. For which of the following sample sizes and $\hat{p}$ values would it be appropriate to use

$$\hat{p}_1 - \hat{p}_2 \pm (z \text{ critical value}) \sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$ to

estimate a difference in population proportions?

I. $n_1 = n_2 = 100, \hat{p}_1 = 0.09, \hat{p}_2 = 0.12$

II. $n_1 = n_2 = 50, \hat{p}_1 = 0.71, \hat{p}_2 = 0.69$

III. $n_1 = n_2 = 300, \hat{p}_1 = 0.98, \hat{p}_2 = 0.96$

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II. $n_1 = n_2 = 50, \hat{p}_1 = 0.71, \hat{p}_2 = 0.69$

III. $n_1 = n_2 = 300, \hat{p}_1 = 0.98, \hat{p}_2 = 0.96$

Answer: II only

Reasoning: Check the np and n(1-p) rule for each situation

Situation I : $\boldsymbol{n_1 p_1 = 100(0.09) = 9}$ **which does not follow the rule!**

Situation III : $\boldsymbol{n_1 p_1 = 300(0.98) = 294 \quad n_1(1 - p_1) = 300(0.02) = 6}$
The np is good, but n(1-p) is not! So this doesn't follow the rule either!

General Stuff about the Distributions used in Hypothesis Testing / Intervals

- Standard normal – symmetric, centered at 0
- t distribution – symmetric, centered at 0
  - Approached the standard normal as the df increases, becoming less spread out.
  - Has larger spread than the standard normal to account for the unknown standard deviation being estimated by the sample standard deviation (s).
  - Results in larger CI and p-values than the standard normal for that reason (the added uncertainty)
- Chi-Sq distribution – skewed to the right, takes strictly positive values
  - Shape changes as the df changes.

24. Which is true of t-distributions and their use in inference for a single mean?

A. the degrees of freedom to use in a t-distribution is the sample size minus one
B. t-distributions have a smaller spread than the standard normal distribution
C. t-distributions are used when the population standard deviation, sigma, is known
D. in confidence intervals, the t* multiplier is smaller than the z* multiplier for the same confidence level.

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C. t-distributions are used when the population standard deviation, sigma, is known
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Errors / Power

Have on your cheat sheet:

- Type I error: RTN when H_0 is true.
- Type II error: FTRN when H_0 is false.
- Power: RTN when H_0 is FALSE.

Know how to identify errors in context.