Table of $z$ values and probabilities for the standard normal distribution. $z$ is the first column plus the top row. Each cell shows $P(X \leq z)$. For example $P(X \leq 1.04) = .8508$. For $z < 0$ subtract the value from 1, e.g., $P(X \leq -1.04) = 1 - .8508 = .1492$.

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Table of *t* values and right tail probabilities. Degrees of freedom are in the first column (df). **Right tail probabilities** are in the first row. For example for df = 7 and α = .05 the critical *t* value for a two-tail test is 2.365 and for df = 10 and α = .1 the critical *t* value for a one-tail test is 1.372.

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<td>3</td>
<td>2.61</td>
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</table>
Chapter 1: no key formulas.
Chapter 2: Relative Frequency = freq. of the class/n.
Approx. Class Width:
= (largest value - smallest value) / number of classes.
Chapter 3: sample and population means
\( \bar{x} = \frac{\sum x_i}{n} \) and \( \mu = \frac{\sum x_i}{N} \)
Weighted mean and geometric mean
\( \bar{x}_w = \frac{\sum w_i x_i}{w_1} \) and \( \bar{x}_g = \left[ (x_1) (x_2) \ldots (x_n) \right]^{1/n} \).
Interquartile Range: IQR = Q_3 - Q_1.
Population and sample variance
\( \sigma^2 = \frac{\sum (x_i - \mu)^2}{N} \) and \( s^2 = \frac{\sum (x_i - \bar{x})^2}{n-1} \).
Population and sample standard deviation
\( \sigma = \sqrt{\sigma^2} \) and \( s = \sqrt{s^2} \).
Coefficient of Variation
\( \left( \frac{\text{Standard deviation}}{\text{Mean}} \times 100 \right) \% \)
z-Score: \( z_i = \frac{x_i - \bar{x}}{\sigma} \).
Chapter 4 continued:
Probability Rules: \( P(A) = 1 - P(A^c) \)
Counting Rule for Permutations
\( \frac{N!}{n!} \)
Probability Rules: \( P(A) = 1 - P(A^c) \)
Chapter 4 continued: \( P(A \cup B) = P(A) + P(B) - P(A \cap B) \)
\( P(A \mid B) = \frac{P(A \cap B)}{P(B)} \)
Multiplication Law for Independent Events
\( P(A \cap B) = P(B)P(A \mid B) = P(A)P(B \mid A) \).
Bayes’ Theorem
\( P(A_i \mid B) = \frac{P(A_i)P(B \mid A_i)}{\sum P(A_j)P(B \mid A_j)} \)
Chapter 5 continued: Variance for the Hypergeometric Distribution:
\( \text{Var}(x) = \sigma^2 = n \left( \frac{r}{N} \right) \left( 1 - \frac{r}{N} \right) \left( \frac{N - n}{N - 1} \right) \).
Chapter 6: Uniform PDF
\( f(x) = \frac{1}{b-a} \) if \( a \leq x \leq b \), otherwise
Normal PDF The density function is
\( f(x) = \frac{1}{\sqrt{2\pi} \sigma} \exp \left( -\frac{(x - \mu)^2}{2\sigma^2} \right) \).
Converting to the Standard Normal rv:
\( z = \frac{x - \mu}{\sigma} \).
Exponential PDF and CDF for \( x \geq 0 \)
\( f(x) = \mu e^{-x/\mu} \) and \( P(x \leq x_0) = 1 - e^{-x_0/\mu} \).
Chapter 7: expected value of \( \bar{x} \)
\( E(\bar{x}) = \mu \).
Standard Deviation of \( \bar{x} \) (Standard Error)
\( \sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}} \).
Expected Value and Std Dev (Standard Error) of \( \beta \)
\( E(\hat{\beta}) = \beta \) and \( \sigma_{\hat{\beta}} = \sqrt{\frac{p(1-p)}{n}} \).
Chapter 8: Interval Estimate of Population Mean, \( \sigma \) known and unknown
\( \bar{x} \pm z_{\alpha/2} \frac{\sigma}{\sqrt{n}} \) and \( \bar{x} \pm t_{\alpha/2} \frac{s}{\sqrt{n}} \).
Necessary Sample Size for Interval Estimate of \( \mu \)
\( n = \frac{(z_{\alpha/2})^2 \sigma^2}{E^2} \).
Chapter 8 continued: Interval Estimate of \( p \)

\[
\hat{p} \pm z_{\alpha/2} \frac{p(1-p)}{\sqrt{n}}
\]

Necessary Sample Size for Interval Estimate of \( p \)

\[
n = \left( \frac{z_{\alpha/2}}{\hat{p}(1-\hat{p})} \right)^2 \]

Chapter 9: Test Statistic for Hypothesis Tests About \( \mu, \sigma \)

known and unknown

\[
z = \frac{\bar{x} - \mu_0}{\sigma / \sqrt{n}} \quad \text{and} \quad t = \frac{\bar{x} - \mu_0}{s / \sqrt{n}}
\]

Test Stat for Hypothesis About \( p \)

\[
z = \frac{\hat{p} - p_0}{\sqrt{p_0(1-p_0) / n}}
\]

Chapter 10: Point Estimate and Standard Error for Difference in Two Population Means

\[
\bar{x}_1 - \bar{x}_2 \quad \text{and} \quad \sigma_{\bar{x}_1-\bar{x}_2} = \sqrt{\frac{\sigma^2}{n_1} + \frac{\sigma^2}{n_2}}
\]

Interval Estimate and Test Statistic for Difference in Two Means with Known Variances

\[
\bar{x}_1 - \bar{x}_2 \pm z_{\alpha/2} \sqrt{\frac{\sigma^2}{n_1} + \frac{\sigma^2}{n_2}} \quad \text{and} \quad z = \frac{\bar{x}_1 - \bar{x}_2 - D_0}{\sqrt{\frac{\sigma^2}{n_1} + \frac{\sigma^2}{n_2}}}
\]

Interval Estimate and Test Statistic for Difference in Two Means with Unknown Variances

\[
\bar{x}_1 - \bar{x}_2 \pm t_{\alpha/2} \sqrt{\frac{s^2}{n_1} + \frac{s^2}{n_2}} \quad \text{and} \quad t = \frac{\bar{x}_1 - \bar{x}_2 - D_0}{\sqrt{\frac{s^2}{n_1} + \frac{s^2}{n_2}}}
\]

Degrees of Freedom for \( t \), Two Independent Random Samples

\[
df = \frac{\left( \frac{s^2}{n_1} + \frac{s^2}{n_2} \right)^2}{\frac{1}{n_1-1} \left( \frac{s^2}{n_1} \right)^2 + \frac{1}{n_2-1} \left( \frac{s^2}{n_2} \right)^2}
\]

Chapter 10 continued: Test Statistic (Matched Samples)

\[
t = \frac{\bar{d} - \mu_d}{s_d / \sqrt{n}}
\]

ANOVA Related:

\[
\bar{x}_j = \frac{\sum_{i=1}^{n_j} x_{ij}}{n_j} \quad s_j^2 = \frac{\sum_{i=1}^{n_j} (x_{ij} - \bar{x}_j)^2}{n_j - 1} \quad \bar{\bar{x}} = \frac{\sum_{j=1}^{k} \sum_{i=1}^{n_j} x_{ij}}{n}
\]

\[
MSTR = \frac{SSR}{k-1} \quad SSTR = \sum_{j=1}^{k} n_j (\bar{x}_j - \bar{\bar{x}})^2 \quad MSE = \frac{SSE}{n_T - k}
\]

\[
SSE = \sum_{j=1}^{k} (n_j - 1)s_j^2 \quad F = \frac{MSTR}{MSE}
\]

\[
SST = \sum_{j=1}^{k} \sum_{i=1}^{n_j} (x_{ij} - \bar{x}_j)^2 \quad SST=SSTR+SSE
\]

Chapter 11: not covered in this course

Chapter 12: \( y = \beta_0 + \beta_1 x + \epsilon \)

\[
E(y) = \beta_0 + \beta_1 x \quad \hat{y} = b_0 + b_1 x \quad b_0 = \bar{y} - b_1 \bar{x}
\]

\[
b_1 = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sum(x_i - \bar{x})^2} \quad SSE = \sum(y_i - \hat{y}_i)^2
\]

\[
SST = \sum(y_i - \bar{y})^2 \quad SSR = \sum(\hat{y}_i - \bar{y})^2 \quad SST=SSTR+SSE
\]

\[
r^2 = \frac{SSR}{SST} \quad r_{xy} = (\text{sign of } b_1) \sqrt{r^2} \quad s^2 = MSE = \frac{SSE}{n-2}
\]

Standard Error of the Estimate, \( s = \sqrt{MSE} \).

\[
s_{b_1} = \frac{s}{\sqrt{\sum(x_i - \bar{x})^2}} \quad b_1 = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sum(x_i - \bar{x})^2}
\]

For simple regression, \( MSR = SSR \) because there is only one independent variable.

\[
F = \frac{MSR}{MSE} \quad s_{g^*} = s \sqrt{\frac{1}{n} + \frac{(x^* - \bar{x})^2}{\sum(x_i - \bar{x})^2}}
\]

Confidence Interval for \( E(y^*) \):

\[
\hat{y}^* \pm t_{\alpha/2}s_{g^*}
\]

\[
s_{\text{pred}} = s \sqrt{1 + \frac{1}{n} + \frac{(x^* - \bar{x})^2}{\sum(x_i - \bar{x})^2}}
\]

Chapter 12 continued: Prediction Interval for \( y^* \):

\[
\hat{y}^* \pm t_{\alpha/2}s_{\text{pred}}
\]

Residual for Observation \( i \): \( y_i - \hat{y}_i \)

Other Math Rule Reminders:

\[
e^x = \exp(x)
\]

\[
\ln 1 = 0 \quad \ln e = 1
\]

\[
x! = (x)(x-1)(x-2) \cdots (2)(1) \quad 0! = 1 \quad x^0 = 1
\]
Use the output below to answer the appropriate questions in the exam. Be sure to check which table the question references.

### ANOVA Table 1

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<th>SS</th>
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<th>MS</th>
<th>F</th>
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Here is regression output from a model where per capita income is the independent variable and % of overweight adults is the dependent variable. The data are for the countries where both variables were available for 2014. I retrieved the data from the World Bank.

### Regression Table 2

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<td>Adjusted R Square</td>
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<td>Observations</td>
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### ANOVA

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<td>251.819</td>
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<table>
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<th>coefficients</th>
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<th>t stat</th>
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<td>per.cap.income</td>
<td>0.000359</td>
<td>0.0000635</td>
<td>5.65861</td>
</tr>
</tbody>
</table>
VERSION B

Choose the best answer. Do not write letters in the margin or communicate with other students in any way. If you have a question note it on your exam and ask for clarification when your exam is returned. In the meantime choose the best answer. Neither the proctors nor Dr. Cox will answer questions during the exam.

Please check each question and possible answers thoroughly as questions at the bottom of a page sometimes run onto the next page. Please verify that your test version and scantron version are the same.

This exam has 25 questions.
1. I have checked that my ID is bubbled in correctly. If it is bubbled in incorrectly I will get this question wrong. I also understand that questions and their possible answers may run onto the next page and so I should always check the top of the next page for possible answers. I understand that if I have a question I should simply make a note on my exam and ask Dr. Cox afterwards. I should always choose the best answer.

   (a) False.
   (b) I didn’t read the directions.
   (c) True.

2. The following graph shows the height of the tallest mountains in the world in hundreds of meters. The tallest mountain in the world is 8,848 meters; note that the ones place is missing in the graph below. What kind of graph is this?

   (a) scatter plot
   (b) hair chart
   (c) dot plot
   (d) stem and leaf display

3. Looking at the graph above concerning mountain heights, how tall is the 5th tallest mountain in the world? Hint: as a reminder from the previous question the tallest mountain is 8848 meters.

   (a) about 8120m
   (b) about 8020m
   (c) about 8480m
4. The probability that a $z$ value is less than 0.5 is
   
   (a) 0.5
   (b) 0.6914625
   (c) 0.8413447
   (d) 0.6616608

5. Consult Table 1. From the table you can conclude that the total sum of squares is?
   
   (a) 104.345
   (b) 63.2583333
   (c) 83.8016667
   (d) 52.1725

6. Consult Table 1. From the table you can conclude that the total number of observations used in this analysis/experiment was?
   
   (a) 16
   (b) 4
   (c) 13
   (d) 18

7. Consult Table 1. From the table what can you conclude concerning the null hypothesis?
   
   (a) fail to reject
   (b) reject the null
   (c) cannot be determined
   (d) depends on the number of observations.

8. Consult Table 1. What is the test statistic?
   
   (a) 0.5482224.
   (b) 0.7967125.
   (c) 5.1358333.
   (d) 0.3983562.
9. Consult Table 1. What is the critical value for a test at the .05 level?

(a) 2.03  
(b) 4.53  
(c) 9.12  
(d) 3.18

10. Suppose that the number of homework assignments a professor gives follows a Poisson distribution with a mean of 10. What is the probability of drawing a professor that gives exactly 12 assignments?

(a) 0.012764  
(b) 0.0947803  
(c) 0.1143679  
(d) 0.072765

11. Suppose that you collect data on apartment prices in Tempe. You look at 44 different apartments and find a mean of 738 and a standard deviation of 183. Construct a 95% confidence interval for the mean apartment price. The interval is

(a) [ 682.3629147, 793.6370853 ]  
(b) [ 686.3629147, 789.6370853 ]  
(c) [ 676.3629147, 799.6370853 ]  
(d) [ 614.1266233, 714.2733767 ]

12. Suppose that you collect data on apartment prices in Tempe. You look at 44 different apartments and find a mean of 738 and a standard deviation of 183. Test the hypothesis, $H_0 : \mu = 616$ at the .05 level of significance.

(a) the test statistic is 4.4221664 so we fail to reject  
(b) the test statistic is 3.7999497 so we reject the null  
(c) the test statistic is 4.4221664 so we reject the null  
(d) the test statistic is 4.974383 so we fail to reject

13. Suppose you have a random variable that is exponentially distributed with a mean of 50. What is the probability of observing a random variable drawn from this distribution with a value of less than 50?

(a) 0.6321206
14. The p-value tells us whether or not the null hypothesis is true.

(a) True.
(b) False.
(c) True, only if we know $\alpha$.

15. The F distribution

(a) is symmetric
(b) has mean 0
(c) is right skewed
(d) all of the above
(e) none of the above

16. Consider the regression output in Table 2. What is the estimated variance of the error term?

(a) 251.8192812
(b) 7.9344074
(c) 15.8688147
(d) 32.02

17. Consider the regression output in Table 2. What is the percentage of variation in the percentage of overweight adults that can be explained by the variation in the per capita income?

(a) $-15.1700262\%$
(b) 16.1700262\%
(c) 19.4040314\%
(d) 15.6650263\%

18. Consider the regression output in Table 2. What is the predicted or estimated percentage of overweight adults for a country where the per capita income is $40,000?

(a) 54.9111927\%
19. Consider the regression output in Table 2. Suppose you want to test the hypothesis that per capita income has no impact on the percentage of overweight adults, i.e. $H_0 : \beta_1 = 0$. What is the test statistic for this hypothesis?

(a) 5.6586097
(b) 0.0000635
(c) 0.0000001
(d) 28.8050896

20. Consider the regression output in Table 2. Suppose you want to test the hypothesis that per capita income has no impact on the percentage of overweight adults, i.e. $H_0 : \beta_1 = 0$. What is your conclusion for this hypothesis test?

(a) This is inconclusive unless we know whether it is a right tail or a left tail test.
(b) This cannot be determined without the appropriate df.
(c) reject the null
(d) fail to reject

21. Because of the assumptions of the linear regression model we know that

(a) The parameter estimate is unbiased.
(b) The error terms are not correlated.
(c) The slope is positive.
(d) the slope is not zero.
(e) none of the above.

22. You are in a business meeting and a colleague presents regression results in the following form

$$\hat{y} = 10 + 3.2X.$$ 

You know that the regression was performed with over 100,000 observations and your colleague reports that the p-value was .005 so that it is statistically significant. However, the executive to whom you are presenting asks what the standard error was. The value is not in your power point slides but you tell her you will give it to her in just a moment. While your colleague moves to the next slide you find that it is:
23. It is useful (a good idea) to perform residual diagnostics

(a) True.
(b) False.
(c) This is only true when the assumptions of the linear regression model are violated.

24. $H_0$ and $H_a$ are mutually exclusive; the null hypothesis and the alternative hypothesis are mutually exclusive.

(a) true
(b) false

25. The graphs shown here are
(a) histograms
(b) scatter plots
(c) stem and leaf displays
(d) box and whiskers plots
Key

Most questions required your knowledge of definitions and vocabulary discussed in class and in the notes or they required you to be able to make calculations or read excel output similar to examples done in class and required in the homework. A few questions required either a deeper understanding of what a p-value is or how to work backwards from a p-value to find the standard error.

1. c
2. d
3. c
4. b
5. a
6. d
7. a
8. b
9. d
10. b
11. a
12. c
13. a
14. b, no even if the p-value is extremely small it only tells us that the probability of committing a type I error is extremely small.
15. c
16. a, for all of the questions requiring reading the regression output you obviously need to know how to read the output in excel as shown in class.
17. b
18. b
19. a
20. c

21. e, we only know that if the assumptions are met then the OLS estimators will have certain properties.

22. c, with over 100,000 observations the t distribution is essentially the same as the z distribution. If \( p = .005 \) the you can look on the z table and find that the test statistic was 2.81 and then you back this out to find a standard error of \( 3.2/2.81 \) is 1.13879.

23. a

24. a

25. d