Nonparametric Statistics

14.1 Using the Binomial Table

To complete this section of homework watch Chapter Fourteen, Lecture Example 181.5.

1. Use the binomial table to calculate the following binomial probability: $P(x \geq 6)$ for $n = 7,\ p = 0.50$
2. Use the binomial table to calculate the following binomial probability: $P(x \geq 5)$ for $n = 9,\ p = 0.50$ VS
3. Use the binomial table to calculate the following binomial probability: $P(x \geq 8)$ for $n = 8,\ p = 0.50$
4. Use the binomial table to calculate the following binomial probability: $P(x \geq 10)$ for $n = 15,\ p = 0.50$ VS
5. Use the binomial table to calculate the following binomial probability: $P(x \geq 15)$ for $n = 25,\ p = 0.50$ VS

14.1 Answers

1. 1 - $P(x \leq 5)$ = 0.062 (technology answer: 0.063)
2. 1 - $P(x \leq 4)$ = 0.500
3. 1 - $P(x \leq 7)$ = 0.004
4. 1 - $P(x \leq 9)$ = 0.151
5. 1 - $P(x \leq 14)$ = 0.212

14.2 Normal as Approximation to Binomial

To complete this section of homework watch Chapter Fourteen, Lecture Example 181.7.

6. Use the normal approximation to calculate the probability that $P(x \geq 17)$ for $n = 30,\ p = 0.50$. VS
7. Use the normal approximation to calculate the probability that $P(x \geq 21)$ for $n = 39,\ p = 0.50$. VS

: *indicates the exercise has a video devoted to it in the corresponding section of STATSprofessor.com*

8. Use the normal approximation to calculate the probability that $P(x \geq 19)$ for $n = 32,\ p = 0.50$.
   VS

14.2 Answers

6. $P(z \geq 0.55) = 0.2912$
7. $P(z \geq 0.32) = 0.3745$
8. $P(z \geq 0.88) = 0.1894$

14.3 Ranking Data

To complete this section of homework watch Chapter Fourteen, Lecture Example 181.9.

9. Rank the following set of data values:

65	13	54	28	14	90	34	27	14	67
12	57	13	89	15	78	72	13	92	22

VS

10. True or False: In general, nonparametric tests are less powerful than our parametric tests.

14.3 Answers

9.

Data	65	13	54	28	14	90	34	27	14	67
Rank	14	3	12	10	5.5	19	11	9	5.5	15
Data	12	57	13	89	15	78	72	13	92	22
Rank	1	13	3	18	7	17	16	3	20	8

10. True, nonparametric tests are less powerful than their parametric counterparts.

14.4 The Sign Test

To complete this section of homework watch Chapter Fourteen, Lecture Examples 182, 183, 184, and 185.

11. An oceanographer believes the median wave height off of South Florida's coast is more than 1.9 feet. Wave heights were measured for a random selection of 20 days. At the 5% significance level, use the sign test to determine if there is enough evidence to reject the claim. VS

2.3	1.5	1.4	2.2	1.3	1.0	3.0	1.9	2.2	1.5
1.2	2.2	2.1	1.6	2.0	1.7	1.7	2.9	1.4	1.2

12. I like to eat at P.F. Chang's, but I believe that the median sodium content of their dishes is higher than 2,300 mg (the recommended daily sodium intake for a normal person). Below, I have included the sodium content for a random selection of ten dinner entrees served at P.F. Chang's. Use the sign test to test my claim at the 1% significance level. VS

6,774	6,475	3,202	2,450	5,141	3,306	3,484	1,362	2,262	2,532

13. I'm a little surprised by this result, so I argue that I couldn't reject the null because the sign test is such a weak test. Is there any validity to this argument? VS

14. As I said, I do like to eat at P.F. Chang's, but I also believe that the median calorie content of their dishes is higher than 1,142 calories (half the recommended daily calorie intake for a normal person my size and age). Below, I have included the calorie content for a random selection of ten dinner entrees served at P.F. Chang's. Use the sign test to test my claim at the 2% significance level.

1122	1281	2110	558	681	603	1485	1236	774	858

15. I claim that half the class should be able to finish exam 3 for STA 3123 on-line, which has 29 questions and a 200 minute time limit, in less than 145 minutes. A random selection of completion times is included below. Use a 5% significance level and the sign test to test my claim. VS

132	135	152	199	103	77	199	104	76

: *indicates the exercise has a video devoted to it in the corresponding section of STATSprofessor.com*

16. A critic of soccer complains that half of all the games played have less than 2 goals scored in the regulation 90 minutes of play. Use the sample of match results below from a random selection of professional games around the globe, the sign test, and a 10% significance level to test the critic's claim.

4	3	5	4	1	3	1	2	2	5	3	0

17. A consumer affairs reporter claims that the median price for the pairs of jeans in typical fashion magazines is $153.00. A random selection of fashion magazines produces the following prices. Use a 5% significance level and the sign test to test the reporter's claim.

$192	$160	$202	$550	$172	$125	$19.99	$49.50	$64.00	$202	$178	$216

18. A researcher claims that the "freshman fifteen" is a myth. The "freshman fifteen" is a reference to the amount of body weight gained by the typical student during their freshman year. The researcher claims that the median weight change is zero. Use the data below which is the weight change for a random selection of students and the sign test to test the researcher's claim at a 10% significance level.

2	4	8	-4	11	2	-2	-7	7	-2	6	4	5	4	3

19. Use the following information and the sign test to determine if the median salary for college professors at FIU exceeds $72,000 (72k): Among 50 randomly chosen professors, 42 had salaries higher than 72k, seven had salaries less than 72k, and one had a salary equal to 72k. VS

20. Use the following information, a 10% significance level, and the sign test to determine if the median waiting time in doctors' offices in Vienna, Austria is less than 18 minutes: Among 168 doctors' visits, 92 have less than 18 minutes of wait-time and 76 have more than 18 minutes of wait-time.

21. Use the following information, a 1% significance level, and the sign test to determine if the median exam grade is 75%: Among 192 randomly selected exams, 66 are below a 75%, 22 are equal to a 75%, and 104 are above a 75%.

14.4 Answers

11. $H_0 : \eta \le 1.9$

$H_a : \eta > 1.9$

$TestStat : S = 8$

P-value: $n = 19,\ p = 0.50, P\left(x \ge 8\right)$ = 0.820

Since $\rho > \alpha$, do not reject the null; the sample data does not support the claim.

12. $H_0 : \eta \le 2,300$

$H_a : \eta > 2,300$

$TestStat : S = 8$

P-value: $n = 10,\ p = 0.50, P\left(x \ge 8\right)$ = 0.055

Since $\rho > \alpha$, do not reject the null; the sample data does not support the claim.

13. Yes, whenever you do not reject the null with a weak test, it is possible that you could have rejected the null with a more powerful test. It seems especially likely in this instance since the p-value is only 5.5% and so many of our data values where well above 2,300 mg. We will visit this data again with a more powerful test to see if we can do better.

14. $H_0 : \eta \le 1,142$

$H_a : \eta > 1,142$

$TestStat : S = 4$

P-value: $n = 10,\ p = 0.50, P\left(x \ge 4\right)$ = 0.828

Since $\rho > \alpha$, do not reject the null; the sample data does not support the claim.

15. $H_0 : \eta = 145$

$H_a : \eta \ne 145$

$TestStat : S = 6$

P-value: $n = 9,\ p = 0.50, 2P\left(x \ge 6\right)$ = 0.508

Since $\rho > \alpha$, do not reject the null; the sample data does not allow rejection of the claim.

16. $H_0 : \eta = 2$

$H_a : \eta \neq 2$

$TestStat : S = 7$

P-value: $n = 10,\ p = 0.50,\ \ 2 \cdot P(x \geq 7)$ = 0.344

Since $\rho > \alpha$, do not reject the null; the sample data does not reject the claim.

17. $H_0 : \eta = 153$

$H_a : \eta \neq 153$

$TestStat : S_+ = 8$

P-value: $n = 12,\ p = 0.50, 2 * P(x \geq 8)$ = 0.388

Since $\rho > \alpha$, do not reject the null; the sample data does not allow us to reject the claim.

18. $H_0 : \eta = 0$

$H_a : \eta \neq 0$

$TestStat : S_+ = 11$

P-value: $n = 15,\ p = 0.50, 2 * P(x \geq 11)$ = 0.118

Since $\rho > \alpha$, do not reject the null; the sample data does not allow us to reject the claim.

19. Conclusion: Reject the null, support the alternative.

$H_A : \eta > 72k$

$H_0 : \eta \leq 72k$

$$z = \frac{(S_{\min} + 0.5) - \frac{n}{2}}{\frac{\sqrt{n}}{2}} = \frac{(7 + 0.5) - \frac{49}{2}}{\frac{\sqrt{49}}{2}} = -4.86$$

$Criticalvalue : -1.645$

20. Conclusion: Do not reject the null, do not support the alternative.

$H_A : \eta < 18$

$H_0 : \eta \geq 18$

$$z = \frac{(S_{\min} + 0.5) - \frac{n}{2}}{\frac{\sqrt{n}}{2}} = \frac{(76 + 0.5) - \frac{168}{2}}{\frac{\sqrt{168}}{2}} = -1.16$$

$Critical value : -1.282$

21. Conclusion: Reject the null, support the alternative.

$H_A : \eta \neq 75$

$H_0 : \eta = 75$

$$z = \frac{(S_{\min} + 0.5) - \frac{n}{2}}{\frac{\sqrt{n}}{2}} = \frac{(66 + 0.5) - \frac{170}{2}}{\frac{\sqrt{170}}{2}} = -2.84$$

$Critical value : -2.576$

14.5 Wilcoxon Ranked Sum Test for Independent Samples

To complete this section of homework watch Chapter Fourteen, Lecture Examples 186 and 187.

22. Find the critical value(s) and the rejection region for the following Wilcoxon Rank-Sum Tests: VS
    a. Left-tailed test (D1 is shifted to the left of D2) with 2.5% significance and $n_1 = 7, n_2 = 8$.
    b. Right-tailed test (D1 is shifted to the right of D2) with 5% significance and $n_1 = 10, n_2 = 9$.
    c. Two-tailed test with 10% significance and $n_1 = 9, n_2 = 8$.
    d. Two-tailed test with 5% significance and $n_1 = 5, n_2 = 5$.

23. The results of independent random samples from two populations are shown below. VS

    Sample A: 41.5, 52.0, 44.7, 43.1, 45.5, 51.1
    Sample B: 36.1, 41.3, 44.0, 53.3, 57.3, 49.1, 51.2, 56.1

    Calculate the rank sum for each sample. Which would be used as the test statistic in a Wilcoxon rank sum test?

24. At a local community college, students have the option of using the TI-83 graphing calculators in their STA 2023 course. About half of the population of students uses the calculators. The data below lists the completion times for students taking the third exam in that course. At the 5% significance level, test the claim that the probability distributions associated with the two types of students are equivalent. VS

Calculators	26	35	36	69	54	58	38	73	80	82
No Calculators	25	45	62	102	75	70	82	67	36	90

25. Let's now try to determine if one group of students does better than the other group regardless of how long they take to finish the exam. At the 5% significance level, test the claim that the probability distributions associated with the calculator group is shifted to the right of the other group (again the data is a random selection of the students who took the third exam). VS

Calculators	69	75	94	46	70	86	81	96	73	74
No Calculators	100	100	83	56	93	75	99	82	68	78

26. In a genetic inheritance study discussed by Margolin [1988], samples of individuals from several ethnic groups were taken. Blood samples were collected from each individual and several variables measured. We shall compare the groups labeled "Native American" and "Caucasian" with respect to the variable MSCE (mean sister chromatid exchange). At the 5% significance level, test the claim that the probability distributions associated with the two groups are equivalent. The data is as follows:

Native American: 8.50, 9.48, 8.65, 8.16, 8.83, 7.76, 8.63

Caucasian: 8.27, 8.20, 8.25, 8.14, 9.00, 8.10, 7.20, 8.32, 7.70

27. Suppose a verbal comprehension test is given to independent samples of educationally handicapped (EH) and educable mentally retarded (EMR) children. The scores from the test are given in the table below. At the 2.5% significance level, test the claim that the probability distributions associated with the EH group is shifted to the right of the other group.

Educationally Handicapped (EH)	77	78	70	72	65	74	
Educable Mentally Ret. (EMR)	60	62	70	76	68	72	70

: *indicates the exercise has a video devoted to it in the corresponding section of STATSprofessor.com*

28. To study the effects of prolonged inhalation of cadmium, researchers exposed 10 dogs to cadmium oxide while 10 dogs serving as controls were not exposed to this substance. At the end of the experiment, they determined levels of hemoglobin of the 20 dogs, as shown in the table below.

Hemoglobin Determinations (grams/dl) in 20 Dogs										
Exposed to Cadmium Oxide:	14.6	15.8	16.4	14.6	14.9	14.3	14.7	17.2	16.8	16.1
Controls:	15.5	17.9	15.5	16.7	17.6	16.8	16.7	16.8	17.2	18.0

Use a 2.5% significance level to test whether the levels of hemoglobin for the dogs exposed to cadmium oxide is to the left of that of the population of dogs which were not.

14.5 Answers

22. A. $T_1 \leq 39$ B. $T_2 \leq 69$ C. $T_2 \leq 54$ or $T_2 \geq 90$ D. T $\leq$ 18 or T $\geq$ 37

23. Sample A: 3, 11, 6, 4, 7, 9 $T_1 = 40$

    Sample B: 1, 2, 5, 12, 14, 8, 10, 13 $T_2 = 65$

    Since $n_1 < n_2$, our test stat is $T_1 = 40$.

24. $H_0 : D_1 \; and \; D_2 \; are \; identical$

$H_A : D_1$ is shifted either to the left or right of D_2

Ranks	2	3	4.5	12	8	9	6	14	16	17.5
	1	7	10	20	15	13	17.5	11	4.5	19

Test stat: T = $T_1 = 92$; Critical Value: T $\leq$ 79 or T ≥ 131

Conclusion: Do not reject the null, do not support the alternative.

The data does not allow us to reject the claim…

25. $H_0 : D_1 \text{ and } D_2 \text{ are identical}$

$H_A : D_1$ is shifted to the right of D_2

Ranks	4	8.5	16	1	5	14	11	17	6	7
	19.5	19.5	13	2	15	8.5	18	12	3	10

Test stat: T = $T_1 = 89.5$

Critical Value: T $\geq$ 127

Conclusion: Do not reject the null, do not support the alternative.

The data does not support the claim…

26. $H_0 : D_1 \text{ and } D_2 \text{ are identical}$

$H_A : D_1$ is shifted either to the left or right of D_2

Ranks	11	16	13	6	14	3	12			
	9	7	8	5	15	4	1	10	2	

Test stat: T = $T_1 = 75$

Critical Value: $T \leq 41$ or $T \geq 78$

Conclusion: Do not reject the null, do not support the alternative.

The data does not allow us to reject the claim…

: *indicates the exercise has a video devoted to it in the corresponding section of STATSprofessor.com*

27. $H_0 : D_1 \text{ and } D_2 \text{ are identical}$
$H_A : D_1$ is shifted to the right of D_2

Ranks	12	13	6	8.5	3	10				
	1	2	6	11	4	8.5	6			

Test stat: T = $T_1 = 52.5$

Critical Value: T $\geq$ 56

Conclusion: Do not reject the null, do not support the alternative.

The data does not support the claim…

28. $H_0 : D_1 \text{ and } D_2 \text{ are identical}$
$H_A : D_1$ is shifted to the left of D_2

Ranks	2.5	8	10	2.5	5	1	4	16.5	14	9
	6.5	19	6.5	11.5	18	14	11.5	14	16.5	20

Test stat: T = $T_1 = 72.5$

Critical Value: T $\leq$ 79

Conclusion: Reject the null, support the alternative.

The data supports the claim…

14.6 Wilcoxon Signed-Ranks Test for Paired Difference Experiments

To complete this section of homework watch Chapter Fourteen, Lecture Examples 188 and 189.

29. A strength training program is designed to improve core strength. To test its effectiveness, 12 patients are timed in seconds while holding a position called the plank before and after a 3 week strength program. Use the results below, the Wilcoxon Sign-Rank Test, and a 1% significance level to test the claim that the program increases core strength. VS

Pre-program	38	47	63	50	41	30	35	34	44	43	46	52
Post-program	67	92	120	75	69	60	68	65	131	122	120	135

30. Remember the P.F. Chang's sodium problem? I believed that the median sodium content of their dishes is higher than 2,300 mg (the recommended daily sodium intake for a normal person). We analyzed the data using the sign test, but we were unable to reject the null. I have included the sodium content for a random selection of ten dinner entrees served at P.F. Chang's. This time, use the Wilcoxon Sign-Rank test to test my claim at the 5% significance level. VS

6,774	6,475	3,202	2,450	5,141	3,306	3,484	1,362	2,262	2,532

31. An English teacher wants to test if her grammar instruction is effective. Ten students are pre and post tested by counting the number of errors missed by the students reading an essay. Use the results below, the Wilcoxon Sign-Rank Test, and a 1% significance level to test the claim that the program produces some change in the students' ability to spot errors in written work.

Pre-test	12	14	5	21	17	18	4	7	13	10	
Post-test	8	11	0	12	7	10	1	2	4	7	

32. A fitness researcher has decided to test the weight loss effects of a sprinting program versus a traditional jogging plan. Each participant engaged in the running programs for 3 months, but some did the jogging first and others did the sprinting first. Use the results below, the Wilcoxon Sign-Rank Test, and a 5% significance level to test the claim that the sprinting program produces more weight loss than the jogging.

Sprinting weight loss	10	6	5	12	15	12	4	8	9	
Jogging weight loss	8	4	0	12	8	10	1	2	11	

: indicates the exercise has a video devoted to it in the corresponding section of STATSprofessor.com

33. A lot of test prep programs claim that they will improve student scores, but a retake may improve test scores without the expensive test prep. Eight students took the LSAT twice to see if there was an improvement on the second attempt. Use the results below, the Wilcoxon Sign-Rank Test, and a 5% significance level to test the claim that there is a difference between the two attempts. What do these results say about the test prep industry? VS

1st score	161	143	142	152	145	147	143	155
2nd score	165	148	150	154	145	152	150	159

14.6 Answers

29. The calculations:

Pre-program	38	47	63	50	41	30	35	34	44	43	46	52
Post-program	67	92	120	75	69	60	68	65	131	122	120	135
Differences	-29	-45	-57	-25	-28	-30	-33	-31	-87	-79	-74	-83
Absolute Diff	29	45	57	25	28	30	33	31	87	79	74	83
Rank	3	7	8	1	2	4	6	5	12	10	9	11

$\begin{matrix} H_0 : \eta_d \geq 0 \\ H_A : \eta_d < 0 \end{matrix}$, $T_- = 78, T_+ = 0$, Test stat = 0. Critical Value = $T_0 = 10$,

Since the test stat is below the critical value we reject the null and support the claim.

30. The calculations:

Sodium	6,774	6,475	3,202	2,450	5,141	3,306	3,484	1,362	2,262	2,532
Diff	4474	4175	902	150	2841	1006	1184	-938	-38	232
Abs Dif	4474	4175	902	150	2841	1006	1184	938	38	232
Rank	10	9	4	2	8	6	7	5	1	3

$\begin{matrix} H_0 : \eta_d \leq 0 \\ H_A : \eta_d > 0 \end{matrix}$, $T_- = 6, T_+ = 49$, Test stat = 6. Critical Value = $T_0 = 11$,

Since the test stat is below the critical value we reject the null and support the claim. We have a better result this time since the Wilcoxon Signed Ranks test is more powerful than the sign test.

31. The calculations:

Pre-test	12	14	5	21	17	18	4	7	13	10
Post-test	8	11	0	12	7	10	1	2	4	7
Diff	4	3	5	9	10	8	3	5	9	3
Abs Dif	4	3	5	9	10	8	3	5	9	3
Rank	4	2	5.5	8.5	10	7	2	5.5	8.5	2

$\begin{matrix} H_0 : \eta_d = 0 \\ H_A : \eta_d \neq 0 \end{matrix}$, $T_- = 0, T_+ = 55$, Test stat = 0. Critical Value = $T_0 = 3$,

Since the test stat is below the critical value we reject the null and support the claim.

32. The calculations:

Sprinting weight loss	10	6	5	12	15	12	4	8	9
Jogging weight loss	8	4	0	12	8	10	1	2	11
Differences	2	2	5	0	7	2	3	6	-2
Abs Diff	2	2	5	0	7	2	3	6	2
Rank	2.5	2.5	6		8	2.5	5	7	2.5

$\begin{matrix} H_0 : \eta_d \leq 0 \\ H_A : \eta_d > 0 \end{matrix}$, $T_- = 2.5, T_+ = 33.5$, Test stat = 2.5. Critical Value = $T_0 = 6$,

Since the test stat is below the critical value we reject the null and support the claim.

33. The calculations:

1st score	161	143	142	152	145	147	143	155
2nd score	165	148	150	154	145	152	150	159
Diff	-4	-5	-8	-2	0	-5	-7	-4
Abs Dif	4	5	8	2		5	7	4
Rank	2.5	4.5	7	1		4.5	6	2.5

$\begin{matrix} H_0 : \eta_d = 0 \\ H_A : \eta_d \neq 0 \end{matrix}$, $T_- = 28, T_+ = 0$, Test stat = 0. Critical Value = $T_0 = 2$,

Since the test stat is below the critical value we reject the null and support the claim.

14.7 Kruskal-Wallis H-Test: Completely Randomized Design

To complete this section of homework watch Chapter Fourteen, Lecture Example 190.

34. Clothing manufacturers use a wear-testing machine to measure different fabrics' ability to withstand abrasion. The wear of the material is measured by weighing the clothing after it has been through the wear-testing machine. A manufacturer wants to determine if there is a difference between the average weight loss among four different materials. The experiment is done by using four samples of each kind of material. The samples were tested in a completely randomized order. The weights are listed below. Use the data below, the Kruskal-Wallis H-test, and a 1% significance level to determine if at least one fabric is significantly different from the others. VS

Fabric			
A	B	C	D
1.93	2.55	2.40	2.33
2.38	2.72	2.68	2.40
2.20	2.75	2.31	2.28
2.25	2.70	2.28	2.25

35. A study was conducted to determine the factor that reduces blood pressure the most: medication, diet, or exercise. Fifteen patients at a hospital with comparable levels of high blood pressure are randomly assigned to each treatment group. After eight weeks, the drop in systolic blood pressure for each patient was measured. Use the data below, the Kruskal-Wallis H-test, and a 5% significance level to test the claim that all three of the treatments produce the same drop in blood pressure. VS

Treatment		
Medication	Exercise	Diet
11	7	12
10	8	6
8	4	10
14	2	8
13	3	5

36. Glue Strength: Four adhesives that are used to fix porcelain to teeth are tested in a completely randomized design. The experiment bonds porcelain to teeth and then a machine is used to pry the tooth from the porcelain. The amount of force needed to do this for each bond is recorded. Use the data below, the Kruskal-Wallis H-test, and a 2.5% significance level to test the claim that there is a significant difference between the bonding strengths.

Adhesive			
204	197	264	248
181	223	226	138
203	232	249	220
262	207	255	304
230	223	237	268
288	197	240	276

14.7 Answers

34. The calculations:

Fabric							
A		B		C		D	
1.93	1	2.55	12	2.40	10.5	2.33	8
2.38	9	2.72	15	2.68	13	2.40	10.5
2.20	2	2.75	16	2.31	7	2.28	5.5
2.25	3.5	2.70	14	2.28	5.5	2.25	3.5
	15.5		57		36		27.5

$$H_0: \eta_1 = \eta_2 = \ldots = \eta_k$$
$$H_A: \text{At least 2 medians differ significantly}$$
, Test Stat: $H = 10.119$, C.Value = 11.345

Since the test stat is less than the critical value we do not reject the null and cannot support the claim.

35. The calculations:

Treatment					
Medication		Exercise		Diet	
11	12	7	6	12	13
10	10.5	8	8	6	5
8	8	4	3	10	10.5
14	15	2	1	8	8
13	14	3	2	5	4
	59.5		20		40.5

$H_0 : \eta_1 = \eta_2 = ... = \eta_k$
H_A : At least 2 medians differ significantly, Test Stat: $H = 7.805$, C.Value = 5.991

Since the test stat is more than the critical value we reject the null and the claim.

36. The calculations:

Adhesive							
204	6	197	3.5	264	20	248	16
181	2	223	9.5	226	11	138	1
203	5	232	13	249	17	220	8
262	19	207	7	255	18	304	24
230	12	223	9.5	237	14	268	21
288	23	197	3.5	240	15	276	22
	67		46		95		92

$H_0 : \eta_1 = \eta_2 = ... = \eta_k$
H_A : At least 2 medians differ significantly

Test Stat: $H = 5.313$, C.Value = 9.348

Since the test stat is less than the critical value we cannot reject the null and cannot support the claim.

14.8 Friedman Fr-Test: Randomized Block Design

To complete this section of homework watch Chapter Fourteen, Lecture Example 191.

37. The effects of four types of graphite coater on light-box readings are to be studied. Since readings will differ from day to day, observations are taken on each of the four types every day. The results are as follows:

	Graphite Coater Type			
Day	M	A	K	L
1	4	4.8	5	4.6
2	4.8	5	5.2	4.6
3	4	4.8	5.6	5

Use the Friedman $F_r - Test$ at the 5% level test the claim that all of the graphite coaters produce the same average light-box readings. VS

38. Test anxiety can hinder academic performance, so a researcher wants to compare the effectiveness of three treatments to reduce test anxiety. The procedure is used on 5 different students. Use the resulting data below, the Friedman $F_r - Test$, and a 1% significance level to test the claim that the three different methods reduce anxiety equally. VS

	Anxiety Level on a Visual-Analogue Scale		
Subject	Beta Blocker	Valerian Root	Meditation
1	2.7	1.3	1
2	3.9	3.6	3.1
3	4.1	4.2	3.9
4	4.3	4.1	4
5	2.9	2.8	2.2

: indicates the exercise has a video devoted to it in the corresponding section of STATSprofessor.com

39. Grocery costs vary for different families, but a researcher wants to study the weekly cost of groceries for typical Florida families at four different grocery chains in South Florida. To do this, the researcher looks at weekly costs for groceries at the four stores for four different families. Each family will visit a different one of the four stores to shop each week for a month. The families will randomly be assigned to the stores each week. Use the resulting data below, the Friedman $F_r - Test$, and a 2.5% significance level to test the claim that the four stores have different average grocery prices. VS

	Store			
Family	Publix	Target	Costco	Whole Foods
1	210	195	200	315
2	300	250	275	400
3	176	171	189	223
4	148	127	130	162

14.8 Answers

37. The calculations:

	Graphite Coater Type							
Day	M		A		K		L	
1	4	1	4.8	3	5	4	4.6	2
2	4.8	2	5	3	5.2	4	4.6	1
3	4	1	4.8	2	5.6	4	5	3
		4		8		12		6

$H_0 : \eta_1 = \eta_2 = \ldots = \eta_k$

H_A : At least 2 medians differ significantly

Test Stat: $F_r = 7.00$, C.Value = 7.815

Since the test stat is less than the critical value we cannot reject the null and cannot reject the claim.

38. The calculations:

	Anxiety Level on a Visual-Analogue Scale					
Subject	Beta Blocker		Valerian Root		Meditation	
1	2.7	3	1.3	2	1	1
2	3.9	3	3.6	2	3.1	1
3	4.1	2	4.2	3	3.9	1
4	4.3	3	4.1	2	4	1
5	2.9	3	2.8	2	2.2	1
		14		11		5

$H_0 : \eta_1 = \eta_2 = \ldots = \eta_k$
H_A : At least 2 medians differ significantly

Test Stat: $F_r = 8.4$, C.Value = 9.210

Since, the test stat is less than the critical value we cannot reject the null and cannot reject the claim.

39. The calculations:

	Store							
Family	Publix		Target		Costco		Whole Foods	
1	210	3	195	1	200	2	315	4
2	300	3	250	1	275	2	400	4
3	176	2	171	1	189	3	223	4
4	148	3	127	1	130	2	162	4
		11		4		9		16

$H_0 : \eta_1 = \eta_2 = \ldots = \eta_k$
H_A : At least 2 medians differ significantly

Test Stat: $F_r = 11.1$, C.Value = 9.348

Since, the test stat is more than the critical value we reject the null and support the claim.

[Take a sample exam for chapter 13 & 14]

Chapter 14 Mixed Review

40. The following data are from an experiment to determine the effectiveness of creatine as a supplement for endurance athletes. Assuming no effect from the interaction between subject and brand, use the Friedman Fr test to determine the **test stat** used to test the claim that the brands of creatine all have the same effect on the time to failure (use a 0.01 significance level).

	Brand A	Brand B	Brand C	Brand D
Subject 1	120.3	120.5	119.8	116.7
Subject 2	133.9	132.5	129.6	125.1
Subject 3	115.2	118.1	113.5	112.4
Totals				

41. Three types of loans produce the following data (the ranks are included in blue):

Loan A	Loan B	Loan C
102 1	115 15.5	125 21
105 2.5	119 18	115 15.5
110 11	107 4.5	110 11
112 13.5	110 11	105 2.5
107 4.5	109 8.5	117 17
108 6.5	108 6.5	120 19
109 8.5	112 13.5	121 20

Use the treatment totals and the given values to find the **test stat** to test (at the 5% significance level) the claim that the three different loan types produce the same median profit.

42. The following data is being used to compare the endurance of athletes while taking placebo and while taking creatine ($\eta_{placebo} - \eta_{creatine}$). Participants sprinted on a road bike until they could no longer maintain a speed of 20 miles per hour. Each of the nine athletes were tested twice, once while taking creatine and once while taking a placebo. The amount of time (in minutes) that each athlete maintained the pace is listed below. Use the result below to find the **test statistic** needed to test if there is a difference between the endurance of subjects using placebo or creatine.

Subject	1	2	3	4	5	6	7	8	9
Placebo	3.5	4.1	2.0	4.1	5.6	2.2	3.6	8.1	2.5
Creatine	4.6	4.2	3.2	3.9	6.6	2.1	4.7	10.4	3.1
Differences	-1.1	-.1	-1.2	.2	-1.0	0.1	-1.1	-2.3	-.6
Abs. Differences	1.1	.1	1.2	.2	1.0	.1	1.1	2.3	.6
Ranks									

43. A strength training program is designed to improve barbell squat weights for women. To test its effectiveness, 12 women are tested for their two-rep maximum squat before and after a four-week strength program. Use the result below to find the **critical value** needed (at the 5% significance level) to test the claim that the program increases squat maximums in women. **What is the conclusion?**

Pre-Program	125	144	175	130	95	226	200	100	110	130	145	165
Post-program	140	160	185	128	125	235	215	140	135	135	130	165
Differences	-15	-16	-10	2	-30	-9	-15	-40	-25	-5	15	0
Absolute Diff.	15	16	10	2	30	9	15	40	25	5	15	0
Rank	6	8	4	1	10	3	6	11	9	2	6	

44. Three types of loans produce the following data (the ranks are included in blue):

Loan A	Loan B	Loan C
102 1	115 15.5	125 21
105 2.5	119 18	115 15.5
110 11	107 4.5	110 11
112 13.5	110 11	105 2.5
107 4.5	109 8.5	117 17
108 6.5	108 6.5	120 19
109 8.5	112 13.5	121 20

Use the treatment totals and the given values to find the **critical value** to test (at the 5% significance level) the claim that the three different loan types produce the same median profit.

45. Exercise researchers claim that the median amount of strength gained in the squat achieved using a six-month training program is 30 pounds. If the researchers want to use the Sign Test, what would the p-value for the test be assuming: 4 strength-gain values are higher than 30 pounds, 8 are below 30 pounds, and 2 are equal to 30 pounds?

46. If a completely randomized design was conducted to compare the drying times for three types of paint, what procedure would be used to test a hypothesis that three types of paint all take the same time to dry? Assume that the normality assumption cannot be met for the data.

47. What nonparametric procedure can be used in place of the independent t-test?

48. A professor claims the median grade for his midterm exam is above an 80. Use the data below to determine the test statistic that would be used if we decided to test the professor's claim using the sign test.

Student	1	2	3	4	5	6	7	8	9
Grade	75	80	95	90	85	85	75	100	85

49. A bank manager is deciding between using two different types of waiting lines. He times the waits for people in the first type of line 9 times and times the waits for 8 people in the second type of line. The results (in minutes) are not shown below, but the rank totals are given. Assume we are using a significance level of 0.05 to test the claim that the first type of line has shorter median wait times, find the **test statistic** and **rejection region**. **What do you conclude**?

Rank total for line type 1 = 59
Rank total for line type 2 = 94

Chapter 14 Mixed Review Answers:

40. $F_r = 8.2$

41. $H = \frac{12}{21*22}\left(\frac{47.5^2}{7} + \frac{77.5^2}{7} + \frac{106^2}{7}\right) - 3*22 = 6.3506$

42. The ranks are given below. The test stat is: T = 3 + 1.5 = 4.5

Subject	1	2	3	4	5	6	7	8	9
Placebo	3.5	4.1	2.0	4.1	5.6	2.2	3.6	8.1	2.5
Creatine	4.6	4.2	3.2	3.9	6.6	2.1	4.7	10.4	3.1
Differences	-1.1	-.1	-1.2	.2	-1.0	0.1	-1.1	-2.3	-.6
Abs. Differences	1.1	.1	1.2	.2	1.0	.1	1.1	2.3	.6
Ranks	6.5	1.5	8	3	5	1.5	6.5	9	4

43. The critical value is $T_0 = 14$ and the test stat, T = 7. This means we reject the null hypothesis since the test statistic is less than 14 (our critical value). The program does increase strength.

44. $\chi^2_{3-1} = 5.991$

45. 0.388

46. The Kruskal-Wallis H-test is the replacement for the ANOVA CRD experiment, which cannot be used here since normality cannot be assumed.

47. The Wilcoxon rank-sum test is the correct procedure.

48. S = 6 (the number of values greater than 80%)

49. The test stat is T = 94, since the second set of data has a smaller sample size. The appropriate critical value is $T_U = 90$, and if $T \geq T_U$, we should reject the null. T is greater than 90, so this means, we reject the null hypothesis and support the claim.