Paired Differences:

$\boxed{\text{Subtract}}$ Then

μ_d = mean difference

S_d = std dev of the differences

$H_0: \mu_d = 0$ no difference on average

$H_0: \mu_d < 0$ Left Tail

$\mu_d > 0$ Rt Tail

$\mu_d \neq 0$ Two Tail

Stat Test 2: T-Test

C.I Stat Test 8 T-interval

Show your work:

1. Check the conditions
2. State the claim
3. Write the null and alternative hypotheses
4. State the test statistic
5. State the p-value
6. Make a decision and write it in the context of the claim.

18. Waiting in Line A quality-control manager at an amusement park feels that the amount of time that people spend waiting in line for the American Eagle roller coaster is too long. To determine if a new loading/unloading procedure is effective in reducing wait time in line, he measures the amount of time (in minutes) people are waiting in line on 7 days. After implementing the new procedure, he again measures the amount of time (in minutes) people are waiting in line on 7 days and obtains the following data. To make a reasonable comparison, he chooses days when the weather conditions are similar.

Day:	**Mon (2 P.M.)**	**Tues (2 P.M.)**	**Wed (2 P.M.)**	**Thurs (2 P.M.)**	**Fri (2 P.M.)**
Wait time before, X_i	11.6	25.9	20.0	38.2	57.3
Wait time after, Y_i	10.7	28.3	19.2	35.9	59.2

Day:	**Sat (11 A.M.)**	**Sat (4 P.M.)**	**Sun (12 noon)**	**Sun (4 P.M.)**
Wait time before, X_i	32.1	81.8	57.1	62.8
Wait time after, Y_i	31.8	75.3	54.9	62.0

Is the new loading/unloading procedure effective in reducing wait time at the $\alpha = 0.05$ level of significance?

Note: A normal probability plot and boxplot of the data indicate that the differences are approximately normally distributed with no outliers.

17. Getting Taller? To test the belief that sons are taller than their fathers, a student randomly selects 13 fathers who have adult male children. She records the height of both the father and son in inches and obtains the following data.

	1	2	3	4	5	6	7
Height of father, X_i	70.3	67.1	70.9	66.8	72.8	70.4	71.8
Height of son, Y_i	74.1	69.2	66.9	69.2	68.9	70.2	70.4
	8	**9**	**10**	**11**	**12**	**13**	
Height of father, X_i	70.1	69.9	70.8	70.2	70.4	72.4	
Height of son, Y_i	69.3	75.8	72.3	69.2	68.6	73.9	

Source: Anna Behounek, student at Joliet Junior College

Are sons taller than their fathers? Use the $\alpha = 0.1$ level of significance.

Note: A normal probability plot and boxplot of the data indicate that the differences are approximately normally distributed with no outliers.

20. Car Rentals The following data represent the daily rental for a compact automobile charged by two car rental companies, Thrifty and Hertz, in 10 locations.

City	Thrifty	Hertz
Chicago	21.81	18.99
Los Angeles	29.89	48.99
Houston	17.90	19.99
Orlando	27.98	35.99
Boston	24.61	25.60
Seattle	21.96	22.99
Pittsburgh	20.90	19.99
Phoenix	47.75	36.99
New Orleans	33.81	26.99
Minneapolis	33.49	20.99

Source: Yahoo!Travel

Test whether Thrifty is less expensive than Hertz at the $\alpha = 0.1$ level of significance.

Note: A normal probability plot and boxplot of the data indicate that the differences are approximately normally distributed with no outliers.

23. Does Octane Matter? Octane is a measure of how much the fuel can be compressed before it ignites. Some people believe that higher-octane fuels result in better gas mileage for their cars. To test this claim, a researcher randomly selected 11 individuals (and their cars) to participate in the study. Each participant received 10 gallons of gas and drove his or her car on a closed course that simulated both city and highway driving. The number of miles driven until the car ran out of gas was recorded. A coin flip was used to determine whether the car was filled up with 87-octane or 92-octane fuel first, and the driver did not know which type of fuel was in the tank. The results are in the following table:

Driver:	1	2	3	4	5	6
Miles on 87 octane	234	257	243	215	114	287
Miles on 92 octane	237	238	229	224	119	297
Driver:	**7**	**8**	**9**	**10**	**11**	
Miles on 87 octane	315	229	192	204	547	
Miles on 92 octane	351	241	186	209	562	

Conduct a significance to decide if buying the higher octane fuel makes a difference.

Two Independent Samples

Claim

Hypotheses:

$H_0: \mu_1 - \mu_2 = 0$ or $\mu_1 = \mu_2$

$H_a: \mu_1 - \mu_2 < 0$ or $\mu_1 < \mu_2$ Left Tailed

$\mu_1 - \mu_2 > 0$ or $\mu_1 > \mu_2$ Right Tailed

$\mu_1 - \mu_2 \neq 0$ or $\mu_1 \neq \mu_2$ 2-Tailed

T STATISTIC

STAT TEST 4

CI STAT TEST 0

Show your work:

1. Check the conditions
2. State the claim
3. Write the null and alternative hypotheses
4. State the test statistic
5. State the p-value
6. Make a decision and write it in the context of the claim.

13. Concrete Strength An engineer wanted to know whether the strength of two different concrete mix designs differed significantly. He randomly selected 9 cylinders, measuring 6 inches in diameter and 12 inches in height, into which mixture 67-0-301 was poured. After 28 days, he measured the strength (in pounds per square inch) of the cylinder. He also randomly selected 10 cylinders of mixture 67-0-400 and performed the same test. The results are as follows:

Mixture 67-0-301			Mixture 67-0-400			
3,960	4,090	3,100	4,070	4,890	5,020	4,330
3,830	3,200	3,780	4,640	5,220	4,190	3,730
4,080	4,040	2,940	4,120	4,620		

Note: Normal probability plots indicate that the data are approximately normal and boxplots indicate that there are no outliers.

(b) Determine whether mixture 67-0-400 is stronger than mixture 67-0-301 at the $\alpha = 0.05$ level of significance.

11. Walking in the Airport, Part I Do people walk faster in the airport when they are departing (getting on a plane) or when they are arriving (getting off a plane)? Researcher Seth B. Young measured the walking speed of travelers in San Francisco International Airport and Cleveland Hopkins International Airport. His findings are summarized in the table.

Direction of Travels	Departure	Arrival
Mean speed (feet per minute)	260	269
Standard deviation (feet per minute)	53	34
Sample size	35	35

Source: Seth B. Young. "Evaluation of Pedestrian Walking Speeds in Airport Terminals," *Transportation Research Record*. Paper 99-0824.

(c) Do individuals walk at different speeds depending on whether they are departing or arriving at the $\alpha = 0.05$ level of significance?

15. Bacteria in Hospital Carpeting Researchers wanted to determine if carpeted rooms contained more bacteria than uncarpeted rooms. To determine the amount of bacteria in a room, researchers pumped the air from the room over a Petri dish at the rate of 1 cubic foot per minute for eight carpeted rooms and eight uncarpeted rooms. Colonies of bacteria were allowed to form in the 16 Petri dishes. The results are presented in the table. A normal probability plot and boxplot indicate that the data are approximately normally distributed with no outliers. Do carpeted rooms have more bacteria than uncarpeted rooms at the $\alpha = 0.05$ level of significance?

Carpeted Rooms (bacteria/cubic foot)		Uncarpeted Rooms (bacteria/cubic foot)	
11.8	10.8	12.1	12.0
8.2	10.1	8.3	11.1
7.1	14.6	3.8	10.1
13.0	14.0	7.2	13.7

Source: William G. Walter and Angie Stober. "Microbial Air Sampling in a Carpeted Hospital." *Journal of Environmental Health*, 30 (1968), p. 405.

18. Rhythm & Blues versus Alternatives A music industry producer wondered whether there is a difference in lengths (in seconds) of rhythm & blues songs versus alternative songs. He obtained a random sample of each music category and documented song lengths. The results are in the following table. Test whether the length of rhythm & blues songs is different from the length of alternative songs at the $\alpha = 0.1$ level of significance.

Note: $\overline{x}_{\text{RB}} = 242.7, s_{\text{RB}} = 26.9, \overline{x}_{\text{ALT}} = 238.3, s_{\text{ALT}} = 28.9$.

Rhythm & Blues (in seconds)				
267	244	233	293	231
224	271	246	258	255
281	256	236	231	224
203	258	237	228	217
205	217	227	211	235
241	211	257	321	264

Alternative (in seconds)				
246	279	226	255	249
225	216	197	216	232
256	307	237	216	187
258	253	223	264	255
227	274	192	213	272
226	251	202	278	216

Source: www.yahoo.com/music

17. Does the Designated Hitter Help? In baseball, the American League allows a designated hitter (DH) to bat for the pitcher, who is typically a weak hitter. In the National League, the pitcher must bat. The common belief is that this results in American League teams scoring more runs. In interleague play, when American League teams visit National League teams, the American League pitcher must bat. So, if the DH does result in more runs, we would expect that American League teams will score fewer runs when visiting National League parks. To test this claim, a random sample of runs scored by American League teams with and without their DH is given in the following table. Does the designated hitter result in more runs scored at the $\alpha = 0.05$ level of significance?

Note: $\overline{x}_{NL} = 4.3$, $s_{NL} = 2.6$, $\overline{x}_{AL} = 6.0$, $s_{AL} = 3.5$.

National League Park (without DH)				
1	5	5	4	7
2	6	2	9	2
8	8	2	10	4
4	3	4	1	9
3	5	1	3	3
3	5	2	7	2

American League Park (with DH)				
6	2	3	6	8
1	3	7	6	4
4	12	5	6	13
6	9	5	6	7
4	3	2	5	5
6	14	14	7	0

Source: espn.com

Two Proportions

Claim:

Then

$H_0: P_1 - P_2 = 0$ or $P_1 = P_2$

$H_a: P_1 - P_2 < 0$ or $P_1 < P_2$ Left Tailed

$P_1 - P_2 > 0$ or $P_1 > P_2$ Rt. Tailed

$P_1 - P_2 \neq 0$ or $P_1 \neq P_2$ 2-Tailed

Z Statistic

Stat Test 6

C.I. Stat Test B

~~[illegible]~~

Cookbook problems for Inference of a single sample mean

Show your work:

1. Check the conditions
2. State the claim
3. Write the null and alternative hypotheses
4. State the test statistic
5. State the p-value
6. Make a decision and write it in the context of the claim.

1. A reporter at a large metropolitan area newspaper wondered whether there was a difference related to educational attainment in attitudes toward mandatory testing for detection of serious diseases. He subsequently conducted a survey in which 105 of 150 individuals with, at most, a high school diploma (Population 1) felt that such mandatory testing is necessary. The survey also yielded 28 of 80 individuals with a college degree (Population 2) who felt such mandatory testing is necessary. Use the techniques we have been studying to test the difference in proportions of non-graduates and college graduates who favor mandatory testing for detection of serious diseases.

2. A study by Dr. John A. Benvenuto, Jr., of the National Institute of Drug Abuse in Rockville, Maryland, suggests that one third of all U.S. adults use some form of a tranquilizer at least once a year. A sociologist conducts a study expecting to show that a greater proportion of residents of large cities (more than 100,000 residents) use tranquilizers than residents of small cities (fewer than 100,000 residents). She samples 250 large city residents (Population 1) and finds 105 that take tranquilizers. A sample of 180 small city residents (Population 2) yields 52 who take tranquilizers. Do the results support the sociologist's claim at the 5 percent level of significance?

3. A recent issue of Field & Stream magazine stated that 17 percent of the registered voters in the United States support a ban on handguns. The article was based on findings in a poll taken by the Decision Making Information (DMI) firm A member of a Women for Political Action group in a midwestern city feels the proportion of women in the city (Population 1) who favor a ban on handguns is greater than the proportion of men (Population 2) who favor a ban on handguns. With the help of other members, 140 women voters and 93 men voters were contacted. The results yielded sample proportions pl = 0.33 and p2 = 0.25, respectively, of the women and men voters who support a ban on handguns. Do the data support the expectation of the member of the Action group regarding the residents of this ate? Use a = 0.05.

4. An organization of clergy involved in premarital counseling wants to evaluate its effectiveness in reducing divorce in teenage marriages. A survey of 60 couples who were married in their teens without counseling (Population 1) yielded 35 divorces within the first 7 years of marriage. A survey of 48 couples who were married in their teens after counseling (Population 2) yielded 21 divorces within the first 7 years. Can these numbers support the claim that premarital counseling is effective in reducing the divorce rate in teenage marriages?