1. School officials are interested in implementing a policy that would allow students to bring their own technology to school for academic use. There are two large high schools in a town, Lakeville North and Lakeville South, each with 1700 students. At Lakeville North, 60% of students own technological devices that could be used for academic purposes. 75% of students at Lakeville South own those types of devices. The district takes an SRS of 125 students from Lakeville North and a separate SRS of 160 students at Lakeville South. The sample proportions of students who own devices that could be used at the school are recorded and the difference, \( \hat{p}_S - \hat{p}_N \), is determined to be 0.07.

   a) Describe the shape, center and spread of the sampling distribution of \( \hat{p}_S - \hat{p}_N \).

   \[
   125(0.6) = 75; \ 125(0.4) = 50; \ 160(0.75) = 120; \ 160(0.25) = 40; \ all \ expected \ values \ are \ > 10 \ so \ the \ distribution \ will \ be \ Normal. \\
   Center: \ Mean = 0.75 - 0.60 = 0.15 \\
   Spread: \ Standard \ Deviation = \sqrt{\frac{0.4(0.6)}{125} + \frac{0.25(0.75)}{160}} = 0.0556
   \]

   b) Find the probability of getting a difference in sample proportions of 0.07 or less from the two surveys. Show your work.

   \[
   z = \frac{0.07 - 0.15}{0.0556} = -1.44; \ P(z \leq -1.44) = 0.0749
   \]

   c) Does the result in part (b) give you reason to doubt the study’s reported value? Explain.

   NO. Assuming the stated proportions for each high school are true, there is a 7.5% chance we'd observe differences between the sample proportions at least as extreme as those observed. We do not have evidence to doubt the study’s sample proportions.

2. In 1990, 551 of 1500 randomly sampled adults indicated they smoked. In 2010, 652 of 2000 randomly sampled adults indicated they smoked. Use this information to construct and interpret a 95% confidence interval for the difference in the proportion of adults who smoke in 1990 and 2010.

   Parameter: Difference in the proportion of adults who smoke in 1990 (\( p_1 \)) and 2010 (\( p_2 \)) at a 95% confidence level.

   Two-sample z interval for the difference in proportions if conditions are met.

   RANDOM: Both samples are stated as random samples

   NORMAL: 1990: 551 successes and 949 failures; 2010: 652 successes and 1348 failures; all are > 10

   INDEPENDENT: There are more than 10(1500) = 15000 and 10(2000) = 20000 adults in the population in the respective years.

   \[
   \hat{p}_1 = \frac{551}{1500} = 0.367; \hat{p}_2 = \frac{652}{2000} = 0.326 \ \ (\hat{p}_1 - \hat{p}_2) \pm z \sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}} \ = \ (0.0094, 0.0732)
   \]

   We are 95% confident that the interval from 0.0094 to 0.0732 captures the true difference in the proportions of adults who smoked in 1990 and 2010. Since 0 is not contained in the interval, we can conclude that the proportion of adults who smoked in 1990 was higher than in 2010.
3. Lyme disease is spread in the northeastern United States by infected ticks. The ticks are infected mainly by feeding on mice, so more mice result in more infected ticks. The mouse population in turn rises and falls with the abundance of acorns, their favored food. Experimenters studied two similar forest areas in a year when the acorn crop failed. They added hundreds of thousands of acorns to one area to imitate an abundant acorn crop, while leaving the other area untouched. The next spring 54 of the 72 mice trapped in the first area were in breeding condition, versus 20 of the 34 mice trapped in the second area. Give a 90% confidence interval for the difference between the proportion of mice ready to breed in good acorn years and bad acorn years.

Parameter: Difference in the proportion of mice ready to breed in good acorn years ($p_1$) and bad acorn years ($p_2$) at a 90% confidence level.

Two-sample z interval for the difference in proportions if conditions are met.

**Random:** OK to assume random samples were trapped

**Normal:** Good acorn years: 54 successes and 18 failures; Bad acorn years: 20 successes and 14 failures; all are $>10$

**Independent:** There are more than 10(72) = 720 and 10(34) = 340 mice in the population in the respective years.

\[
\hat{p}_1 = \frac{54}{72} = .75; \hat{p}_2 = \frac{20}{34} = .5882
\]

\[
(\hat{p}_1 - \hat{p}_2) \pm z^* \sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}} = (.75 - .5882) \pm 1.645 \sqrt{\frac{.75}{72} + \frac{.5882}{34}}
\]

\[
(-.020785, .324)
\]

We are 90% confident that the interval from -.0005 to .324 captures the true difference in the proportions of mice ready to breed. Since 0 is contained in the interval, we can conclude that there is no difference in the proportion of mice ready to breed.

4. The 1958 Detroit Area Study was an important investigation of the influence of religion on everyday life. The sample "was basically a simple random sample of the population of the metropolitan area" of Detroit, Michigan. Of the 656 respondents, 267 were white Protestants and 230 were white Catholics. The study took place at the height of the cold war. One question asked if the right of free speech included the right to make speeches in favor of communism. Of the 267 white Protestants, 104 said "Yes", while 75 of the 230 white Catholics said "Yes". Give a 95% confidence interval for the difference between the proportion of Protestants who agree that communist speeches are protected and the proportion of Catholics who held this opinion.

Parameter: Difference in the proportion of white Protestants ($p_1$) and white Catholics ($p_2$) who agree that communist speeches are protected at a 95% confidence level.

Two-sample z interval for the difference in proportions if conditions are met.

**Random:** Stated a simple random sample was used

**Normal:** white Protestants: 104 successes and 153 failures; white Catholics: 75 successes and 155 failures; all are $>10$

**Independent:** There are more than 10(656) = 6560 people in the Detroit area

\[
\hat{p}_1 = \frac{104}{267} = .3895; \hat{p}_2 = \frac{75}{230} = .3261
\]

\[
(\hat{p}_1 - \hat{p}_2) \pm z^* \sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}} = (.3895 - .3261) \pm 1.96 \sqrt{\frac{.3895(1-.3895)}{267} + \frac{.3261(1-.3261)}{230}}
\]

\[
(.3895 - .3261) \pm 1.96 \sqrt{\frac{.3895(1-.3895)}{267} + \frac{.3261(1-.3261)}{230}} = (.3895 - .3261) \pm 1.96 \sqrt{\frac{.710}{267} + \frac{.65}{230}}
\]

\[
(-.020785, .147638)
\]

We are 90% confident that the interval from -.021 to .148 captures the true difference in the proportions of white Protestants and white Catholics who agree that communist speeches are protected. Since 0 is contained in the interval, we can conclude that there is no difference in the proportions.
5. A school official suspects the difference in the proportion of students who own technological devices between Lakeville North and Lakeville South high schools may be a result of a difference in socioeconomic status of the students in the two schools. The results of a random sampling of student registration records indicated 28 out of 120 students at Lakeville North came from low-income families while 30 out of 150 students at Lakeville South came from low income families. Do these data provide convincing evidence that the proportion of low income students at Lakeville North is higher than the proportion at Lakeville South? Use a 5% significance level.

Parameter: Difference in the proportion of low income students at Lakeville North \((p_1)\) and Lakeville South \((p_2)\) high schools.

- \(H_0: p_1 = p_2\)
- \(H_A: p_1 > p_2\)

\(\alpha = .05\)

Two-sample z test for the difference in proportions if conditions are met.

**RANDOM:** Stated random sample from each school

**NORMAL:** Lakeville North: 28 successes and 928 failures; Lakeville South: 30 successes and 120 failures; all are > 10

**INDEPENDENT:** There are more than \(10(120) = 1200\) and \(10(150) = 1500\) students in the populations at the respective schools.

\[
\hat{p}_N = \frac{28}{120} = .233; \hat{p}_S = \frac{30}{150} = .2; \hat{p}_C = \frac{28 + 30}{120 + 150} = .214815
\]

\[
z = \frac{(\hat{p}_1 - \hat{p}_2) - (p_1 - p_2)}{\sqrt{\frac{\hat{p}_C(1-\hat{p}_C)}{n_1} + \frac{\hat{p}_C(1-\hat{p}_C)}{n_2}}}
\]

\[
z = \frac{(0.233 - 0.2) - 0}{\sqrt{\frac{0.214815(1-0.214815)}{120} + \frac{0.214815(1-0.214815)}{150}}} = .66269
\]

P-value = .253762

Since the p-value of .253762 > \(\alpha = .05\), we Fail to Reject \(H_0\). There is not sufficient evidence to support the claim that the proportion of low income students is higher at Lakeville North than Lakeville South.

6. The drug AZT was the first drug that seemed effective in delaying the onset of AIDS. Evidence for AZT’s effectiveness came from a large randomized comparative experiment. The subjects were 1300 volunteers who were infected with HIV, the virus that causes AIDS, but did not yet have AIDS. The study assigned 435 of the subjects at random to take 500 milligrams of AZT each day, and another 435 to take a placebo. (The others were assigned to a third treatment, a higher dose of AZT. We will compare only two groups.) At the end of the study, 38 of the placebo subjects and 17 of the AZT subjects had developed AIDS. We want to test the claim that taking AZT lowers the proportion of infected people who will develop AIDS in a given period of time.

a) Carry out the appropriate test.

Parameter: Difference in proportions \(p_1 - p_2\) where \(p_1 = \) the proportion of subjects who took AZT and developed AIDS and \(p_2 = \) the proportion of subjects who did not take AZT and developed AIDS.

- \(H_0: p_1 = p_2\)
- \(H_A: p_1 < p_2\)

\(\alpha = .05\)

Two-sample z test for the difference in proportions if conditions are met.

**RANDOM:** Stated large randomized comparative experiment

**NORMAL:** AZT group: 17 successes and 418 failures; placebo group: 38 successes and 397 failures; all are > 10

**INDEPENDENT:** One subject developing AIDS should have no impact on another subject developing AIDS.

\[
\hat{p}_1 = \frac{17}{435} = .03908; \hat{p}_2 = \frac{38}{435} = .087356; \hat{p}_C = \frac{17 + 38}{435 + 435} = .063218
\]

\[
z = \frac{(\hat{p}_1 - \hat{p}_2) - (p_1 - p_2)}{\sqrt{\frac{\hat{p}_C(1-\hat{p}_C)}{n_1} + \frac{\hat{p}_C(1-\hat{p}_C)}{n_2}}}
\]

\[
z = \frac{(0.03908 - 0.087356) - 0}{\sqrt{\frac{0.063218(1-0.063218)}{435} + \frac{0.063218(1-0.063218)}{435}}} = -2.92563
\]

P-value = .001719

Since the p-value of .001719 < \(\alpha = .05\), we Reject \(H_0\). There is sufficient evidence to support the claim that taking AZT lowers the proportion of infected people who develop AIDS in a given period of time.

b) The experiment was double-blind. Explain what this means.

Double-blind means that neither the subjects nor the researchers who had contact with them knew which subjects were getting AZT and which were getting the placebo.
7. North Carolina State University looked at the factors that affect the success of students in a required chemical engineering course. Students must get a C or better in the course in order to continue as chemical engineering majors. The study looked at possible differences in the proportions of female and male students who succeeded in the course. They found that 23 of the 34 women and 60 of the 89 men succeeded. Is there evidence of a difference between the proportion of women and men who succeeded?

Parameter: Difference in the proportion of female ($p_1$) and male ($p_2$) students who succeeded in the course.

$H_0$: $p_1 = p_2$  
$H_A$: $p_1 \neq p_2$  
$\alpha = .05$

Two-sample z test for the difference in proportions if conditions are met.

*****RANDOM:
NORMAL: Female: 23 successes and 11 failures; Male: 60 successes and 29 failures; all are $> 10$

INDEPENDENT: The success of one student should not impact the success of another student

$\hat{p}_1 = \frac{23}{34} = .676; \hat{p}_2 = \frac{60}{89} = .674; \hat{p}_C = \frac{23+60}{34+89} = .675$

$z = \frac{(\hat{p}_1 - \hat{p}_2) - (p_1 - p_2)}{\sqrt{\frac{\hat{p}_C(1-\hat{p}_C)}{n_1} + \frac{\hat{p}_C(1-\hat{p}_C)}{n_2}}} = \frac{(0.676 - 0.674) - 0}{\sqrt{\frac{0.675(1-0.675)}{34} + \frac{0.675(1-0.675)}{89}}} = 0.024493$

P-value = .980459

Since the p-value of .980459 $> \alpha = .05$, we Fail to Reject $H_0$. There is not sufficient evidence to support the claim that the proportion of females that are successful is different from the proportion of males that are successful, however, violation of assumptions may render this result invalid.

8. Researchers are interested in studying the effect of sleep on exam performance. Suppose the population of individuals who get at least 8 hours of sleep prior to an exam score an average of 96 points on the exam with a standard deviation of 18 points. The population of individuals who get less than 8 hours of sleep score an average of 72 points with a standard deviation of 9.4 points. Suppose 40 individuals are randomly sampled from each population.

a) Describe the shape, center, and spread of the sampling distribution of $\bar{x}_1 - \bar{x}_2$.

Shape: Normal because each sample is $> 30$.  
Center: Mean = 96 - 72 = 24  
Spread: Standard Deviation: $= \sqrt{\frac{18^2}{40} + \frac{9.4^2}{40}} = 3.21076$

b) Find the probability of observing a difference in sample means of 2 points or more from the two samples. Show your work.

$t = \frac{22-24}{3.21} = -0.62; \quad t = \frac{26-24}{3.21} = 0.62$  
$df = 40 - 1 = 39$ use $df = 30$  
$P(t > .62) > .25$  
P-value > .5

Calculator: $tCdf(-9999, -.62) = .269432; \quad 2(.269432) = .538864$  
P-value = .538864
Researchers are interested in determining the effectiveness of a new diet for individuals with heart disease. 200 heart disease patients are selected and randomly assigned to the new diet or the current diet used in the treatment of heart disease. The 100 patients on the new diet lost an average of 9.3 pounds with standard deviation 4.7 pounds. The 100 patients continuing with their current prescribed diet lost at average of 7.4 pounds with standard deviation 4 pounds. Construct and interpret a 95% confidence interval for the difference in mean weight loss for the two diets.

Parameter: \( \mu_1 \) = Mean weight loss on new diet  
\( \mu_2 \) = Mean weight loss on old diet  
We want to estimate \( \mu_1 - \mu_2 \) at a 95% confidence level. 

Two-sample t interval for \( \mu_1 - \mu_2 \) if conditions are met. 

RANDOM: random assignment to new diet or current diet  
NORMAL: Both samples are > 30, sampling distributions should be approximately Normal  
INDEPENDENT: Amount of weight loss of one subject should have no impact on the weight loss of another subject  

\[
\text{df (from calculator)} = 193.065; \quad t^* = 1.97233
\]

\[
\begin{align*}
(\bar{x}_1 - \bar{x}_2) & \pm t^* \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}} \\
(9.3 - 7.4) & \pm 1.97233 \sqrt{\frac{4.7^2}{100} + \frac{4^2}{100}} \\
& (.682737, 3.11726)
\end{align*}
\]

We are 95% confident that the interval from .683 to 3.117 captures the true difference in the mean weight loss for the two diets. This interval suggests that the mean weight loss with the new diet is between .683 and 3.117 pounds more than the current diet.

10. How badly does logging damage tropical rainforests? One study compared forest plots in Borneo that had never been logged with similar plots nearby that had been logged 8 years earlier. The study found that the effects of logging were somewhat less severe than expected. The study report also explains why the plots can be considered to be randomly assigned. Here are the data on the number of tree species in 12 unlogged plots and 9 logged plots.

Unlogged: 22 18 22 20 15 21 13 13 19 13 19 15  
Logged: 17 4 18 14 18 15 15 10 12

Give a 90% confidence interval for the difference in mean number of species between unlogged and logged plots.

Parameter: \( \mu_1 \) = Mean number of species in unlogged plot  
\( \mu_2 \) = Mean number of species in logged plot  
We want to estimate \( \mu_1 - \mu_2 \) at a 90% confidence level. 

Two-sample t interval for \( \mu_1 - \mu_2 \) if conditions are met. 

RANDOM: the study reported that the plots were considered to be randomly assigned  
NORMAL: Although the display shows some skewness, it is not enough extreme enough to overcome the robustness of the t procedures ***Insert sketches of boxplots***  
INDEPENDENT: There are at least 10(12) = 120 unlogged and 10(9) = 90 logged plots of land  

df (from calculator) = 14.7934; \quad t^* = 1.75466

\[
\begin{align*}
(\bar{x}_1 - \bar{x}_2) & \pm t^* \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}} \\
(17.5 - 13.67) & \pm 1.75466 \sqrt{\frac{3.53^2}{12} + \frac{4.5^2}{9}} \\
& (.652, 7.015)
\end{align*}
\]

We are 90% confident that the interval from .652 to 7.015 captures the true difference in the mean number of species between unlogged and logged plots. This interval suggests that there are between .652 and 7.015 more species in unlogged plots.
11. College financial aid offices expect students to use summer earnings to help pay for college. But how large are these earnings? One college studied this question by asking a sample of students how much they earned. Omitting students who were not employed, there were 1296 responses. Here are the data in summary form:

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>$x \bar{}$</th>
<th>s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>675</td>
<td>$1884.52$</td>
<td>$1368.37$</td>
</tr>
<tr>
<td>Females</td>
<td>621</td>
<td>$1360.39$</td>
<td>$1037.46$</td>
</tr>
</tbody>
</table>

a) The distribution of earnings is strongly skewed to the right. Nevertheless, use of t procedures is justified. Why?

Because of the large sample sizes we are OK to use t procedures

b) Give a 90% confidence interval for the difference between the mean summer earnings of male and female students.

Parameter: $\mu_1 = \text{Mean summer earnings of male students}$  
$\mu_2 = \text{Mean summer earnings of female students}$

We want to estimate $\mu_1 - \mu_2$ at a 90% confidence level.

Two-sample t interval for $\mu_1 - \mu_2$ if conditions are met.

RANDOM: random sampling is not stated, it must be assumed
NORMAL: Both samples are > 30, sampling distributions should be approximately Normal
INDEPENDENT: It is reasonable to believe that there are more than 10(1296) = 12960 students enrolled at the college

df (from calculator) = 1249.21; $t^* = 1.64607$

\[
\left( \bar{x}_1 - \bar{x}_2 \right) \pm t^* \frac{s_1^2}{n_1} + \frac{s_2^2}{n_2} = \left( 1884.52 - 1360.39 \right) \pm 1.64607 \sqrt{\frac{1368.37^2}{675} + \frac{1037.46^2}{621}}
\]

(413.62, 634.64)

We are 90% confident that the interval from 413.62 to 634.64 captures the true difference in the mean summer earnings for male and female students at this college. This interval suggests that male students earn between 413.62 and 634.64 dollars more than female students, however, violation of assumptions may render this result invalid.

12. Do boys have better short term memory than girls? A random sample of 200 boys and 150 girls was administered a short term memory test. The average score for boys was 48.9 with standard deviation 12.96. The girls had an average score of 48.4 with standard deviation 11.85. Is there significant evidence at the 5% level to suggest boys have better short term memory than girls? Note: higher test scores indicate better short term memory.

Parameter: Difference in $\mu_1 - \mu_2$, where $\mu_1$ is the short term memory test score for boys and $\mu_2$ is the short term memory test score for girls.

$H_0$: $\mu_1 = \mu_2$  
$H_A$: $\mu_1 > \mu_2$  
$\alpha = .05$

Two-sample t test for $\mu_1 - \mu_2$ if conditions are met.

RANDOM: stated that random samples were used
NORMAL: Both samples are > 30, sampling distributions should be approximately Normal
INDEPENDENT: There are more than 10(200) = 2000 boys and 10(150) = 1500 girls in the population.

\[
t = \frac{\left( \bar{x}_1 - \bar{x}_2 \right) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}
\]

\[
t = \frac{48.9 - 48.4}{\sqrt{\frac{12.96^2}{200} + \frac{11.85^2}{150}}} = .375192
\]

df (from calculator) = 334.615  
P-value = .353878

Since the p-value of .353878 > $\alpha = .05$, we Fail to Reject $H_0$. There is not sufficient evidence to support the claim that boys have better short term memory than girls.
13. An educator believes that new reading activities in the classroom will help elementary school pupils improve their reading ability. She arranges for a third grade class of 21 students to follow these activities for an 8-week period. A control classroom of 23 third graders follows the same curriculum without the activities. At the end of the 8 weeks, all students are given the Degree of Reading Power (DRP) test, which measures the aspects of reading ability that the treatment is designed to improve. Here are the data:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>42</td>
</tr>
<tr>
<td>49</td>
<td>37</td>
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<td>53</td>
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<td>10</td>
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<td>42</td>
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<td>62</td>
<td>42</td>
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<tr>
<td>57</td>
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<td>42</td>
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<tr>
<td>46</td>
<td>37</td>
</tr>
<tr>
<td>43</td>
<td>42</td>
</tr>
</tbody>
</table>

a) Examine the data with a graph. Are there strong outliers or skewness that could prevent use of the t procedures? 

There don't appear to be outliers or strong skewness that would prevent the use of t procedures. 

***Include sketches of boxplots

b) Is there good evidence that the new activities improve the mean DRP score? Carry out a test and report your conclusions.

Parameter: Difference in $\mu_1 - \mu_2$, where $\mu_1$ is the mean score on DRP test with activities and $\mu_2$ is the mean score on DRP test without activities.

$H_0: \mu_1 = \mu_2$  $H_A: \mu_1 > \mu_2$  $\alpha = .05$

Two-sample t test for $\mu_1 - \mu_2$ if conditions are met.

RANDOM: does not describe randomness in the experiment

NORMAL: see part a), displays look fine

INDEPENDENT: One student's performance on the DRP test should not impact another student's performance on the DRP test

$t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} = \frac{51.4762 - 41.5217 - 0}{\sqrt{11.0074^2 + 17.3487^2}} = 2.31089$  $df$ (from calculator) = 37.8554

P-value = .013191

Since the p-value of .013191 < $\alpha = .05$, we Reject $H_0$. There is sufficient evidence to support the claim that the activities improve DRP scores, however, violation of assumptions may render this result invalid.

c) Although this study is an experiment, its design is not ideal because it had to be done in a school without disrupting classes. What aspect of good experimental design is missing?

It is missing the proper randomization aspect so we have to be suspect about the conclusion.

14. Deciding whether to perform a matched pairs $t$ test or a two-sample $t$ test can be tricky. Your decision should be based on the design that produced the data. Which procedure would you choose in each of the following situations?

a) To test the wear characteristics of two tire brands, A and B, Brand A is mounted on 50 cars and Brand B on 50 other cars. **Two-sample $t$ test**

b) To test the wear characteristics of two tire brands, A and B, one Brand A tire is mounted on one side of each car in the rear, while a Brand B tire is mounted on the other side. Which side gets which brand is determined by flipping a coin. The same procedure is used on the front. **Matched pair => one-sample $t$ test**

c) To test the effect of background music on productivity, factory workers are observed. For 1 month they had no background music. For another month they had background music. **Matched pair => one-sample $t$ test**

d) A random sample of 10 workers in Plant A are to be compared to a random sample of 10 workers in Plant B in terms of productivity. **Two-sample $t$ test**

e) A new weight-reducing diet was tried on 10 women. The weight of each woman was measured before the diet and again after 10 weeks on the diet. **Matched pair => one-sample $t$ test**