

Chapter 17 Solutions

17.1. $s/\sqrt{n} = 21.88/\sqrt{20} \doteq 4.8925$ minutes.

17.2. The mean is $\bar{x} = 251$ ms. Because $s/\sqrt{n} = s/\sqrt{12} = 45$ ms, we have $s \doteq 155.88$ ms.

17.3. (a) $t^* = 2.015$ for $df = 5$ and $\alpha = 0.05$. **(b)** $t^* = 2.518$ for $df = 21$ and $\alpha = 0.01$.

17.4. Use $df = 24$. **(a)** $t^* = 2.064$ for $\alpha = 0.025$. **(b)** $t^* = 0.685$ for $\alpha = 0.25$.

17.5. (a) Use $df = 9$ and $\alpha = 0.025$: $t^* = 2.262$. **(b)** Use $df = 19$ and $\alpha = 0.005$: $t^* = 2.861$. **(c)** Use $df = 6$ and $\alpha = 0.05$: $t^* = 1.943$.

17.6. (a) The stemplot shows a slight skew to the right, but not so strong that it would invalidate the t procedures. **(b)** With $\bar{x} = 18.66$ and $s \doteq 10.2768$, and $t^* = 2.093$ ($df = 19$), the 95% confidence interval for μ is

$$18.66 \pm 2.093 \left(\frac{10.2768}{\sqrt{20}} \right) = 18.66 \pm 4.8096 = 13.8504 \text{ to } 23.4696.$$

0	67888
1	0004
1	67
2	012
2	57
3	00
3	78

17.7. STATE: What is the mean percent μ of nitrogen in ancient air?

PLAN: We will estimate μ with a 90% confidence interval.

SOLVE: We are told to view the observations as an SRS. A stemplot shows some left-skewness; however, for such a small sample, the data are not unreasonably skewed. There are no outliers. With $\bar{x} = 59.5889\%$ and $s = 6.2553\%$ nitrogen, and $t^* = 1.860$ ($df = 8$), the 90% confidence interval for μ is

$$59.5889 \pm 1.860 \left(\frac{6.2553}{\sqrt{9}} \right) = 59.5889 \pm 3.8783 = 55.71\% \text{ to } 63.47\%.$$

4	9
5	1
5	
5	4
5	
6	0
6	33
6	445

CONCLUDE: We are 90% confident that the mean percent of nitrogen in ancient air is between 55.71% and 63.47%.

17.8. (a) $df = 14$. **(b)** $t = 1.82$ is between 1.761 and 2.145, for which the one-sided P -values are 0.05 and 0.025, respectively. (Software reports that $P = 0.0451$.) **(c)** $t = 1.82$ is significant at $\alpha = 0.05$ but not at $\alpha = 0.01$.

17.9. (a) $df = 24$. **(b)** $t = 1.12$ is between 1.059 and 1.318, so $0.20 < P < 0.30$. (Software reports that $P = 0.2738$.) **(c)** $t = 1.12$ is not significant at either $\alpha = 0.10$ or $\alpha = 0.05$.

17.10. STATE: Is there evidence that the percent of nitrogen in ancient air was different from the present 78.1%?

PLAN: We test $H_0: \mu = 78.1\%$ vs. $H_a: \mu \neq 78.1\%$. We use a two-sided alternative because, prior to seeing the data, we had no reason to believe that the percent of nitrogen in ancient air would be higher or lower.

SOLVE: We addressed the conditions for inference in Exercise 17.7. In that solution, we found $\bar{x} = 59.5889\%$ and $s = 6.2553\%$ nitrogen, so $t = \frac{59.5889 - 78.1}{6.2553/\sqrt{9}} \doteq -8.88$. For $df = 8$,

this is beyond anything shown in Table C, so $P < 0.001$ (software gives $P = 0.00002$).
 CONCLUDE: We have very strong evidence ($P < 0.001$) that Cretaceous air contained less nitrogen than modern air.

17.11. PLAN: Take μ to be the mean difference (monkey call minus pure tone) in firing rate. We test $H_0: \mu = 0$ vs. $H_a: \mu > 0$, using a one-sided alternative because the researchers suspect a stronger response to the monkey calls.

-1	10
-0	8
-0	110
0	011123333444
0	56667
1	0001244
1	6677
2	34
2	6

SOLVE: We must assume that the monkeys can be regarded as an SRS. For each monkey, we compute the call minus pure tone differences; a stemplot of these differences shows no outliers or deviations from Normality. The mean and standard deviation are $\bar{x} \doteq 70.378$ and $s \doteq 88.447$ spikes/second, so $t = \frac{\bar{x}-0}{s/\sqrt{37}} \doteq 4.84$ with $df = 36$. This has a very small P -value: $P < 0.0001$.

CONCLUDE: We have very strong evidence that macaque neural response to monkey calls is stronger than the response to pure tones.

17.12. Using the mean and standard deviation found in the previous exercise, and either $t^* = 1.697$ (using $df = 30$ from Table C) or 1.6883 (using $df = 36$ from software), the 90% confidence interval is

$$\begin{aligned} \bar{x} \pm t^* \left(\frac{s}{\sqrt{37}} \right) &= 45.703 \text{ to } 95.054 \text{ spikes/second} \quad (t^* = 1.697), \text{ or} \\ &= 45.830 \text{ to } 94.927 \text{ spikes/second} \quad (t^* = 1.6883). \end{aligned}$$

17.13. The distribution of nitrogen concentration is quite skewed, and has an outlier. With such a small sample size, we should not use t procedures.

0	0000000000111
0	2222233
0	44
0	
0	
1	
1	
1	4

If students find the confidence interval in spite of this, they will find it is quite wide: $225.71 \pm 122.03 = 103.7$ to 347.7 ppm. This is another indication that the t procedures are not useful here.

17.14. The distribution of the carbon-13 ratio is slightly skewed, but t procedures should be fairly reliable. With $\bar{x} = -2.8825$, $s \doteq 1.0360$, and $df = 23$, the 95% confidence interval is

-4	200
-3	9888765
-3	2
-2	8877
-2	4310
-1	85
-1	31
-0	8

$$\bar{x} \pm 2.069 \left(\frac{s}{\sqrt{24}} \right) = -2.8825 \pm 0.4375 = -3.320 \text{ to } -2.445.$$

17.15. (b) In real-life settings, we almost never know the true value of σ .

17.16. (c) $t = \frac{8-10}{4/\sqrt{20}} \doteq -2.24$

17.17. (a) The degrees of freedom are $df = n - 1 = 19$.

17.18. (a) For $df = 19$, 2.25 falls between the critical values 2.205 and 2.539 in Table C. This is a one-sided test, so P equals the upper tail probability, placing it between 0.01 and 0.02.

17.19. (c) Use a t distribution with $df = n - 1 = 14$.

17.20. (a) For a two-sided test with $n = 15$ and $\alpha = 0.005$, we need $df = n - 1 = 14$ and upper tail probability equal to $\alpha/2 = 0.0025$.

17.21. (a) We have $df = 23$ and $t^* = 2.069$, so the 95% confidence interval for μ is

$$85 \pm 2.069 \left(\frac{12}{\sqrt{24}} \right) = 85 \pm 5.0680 = 79.9 \text{ to } 90.1 \text{ mg/dl.}$$

17.22. (a) The sample size should be large enough to overcome mild skewness, but an outlier will make the results unreliable.

17.23. (b) The two samples are independent; there is no matching between a male student and a female student.

17.24. (c) Robustness means that t procedures are approximately correct provided the data are an SRS.

17.25. For the student group: $t = \frac{0.08-0}{0.37/\sqrt{12}} \doteq 0.749$ (rather than 0.49). For the nonstudent group: $t = \frac{0.35-0}{0.37/\sqrt{12}} \doteq 3.277$ (rather than 3.25—this difference might be due to rounding error). From Table C, the first P -value is between 0.4 and 0.5 (software gives 0.47), and the second P -value is between 0.005 and 0.01 (software gives 0.007).

17.26. With $\bar{x} = 26.8$ and $s = 7.42$, and using either $t^* = 1.984$ (using $df = 100$ from Table C) or 1.9636 (using $df = 653$ from software), the 95% confidence interval for BMI is

$$\begin{aligned} \bar{x} \pm t^* \left(\frac{s}{\sqrt{654}} \right) &= 26.8 \pm 0.5756 = 26.2244 \text{ to } 27.3756 \quad (t^* = 1.984), \text{ or} \\ &= 26.8 \pm 0.5697 = 26.2303 \text{ to } 27.3697 \quad (t^* = 1.9636). \end{aligned}$$

17.27. (a) The sample size is very large, so the only potential hazard is extreme skewness. As scores range only from 0 to 500, there is a limit to how skewed the distribution could be.

(b) From Table C, we take $t^* = 2.581$ ($df = 1000$), or with software, we take $t^* \doteq 2.5792$.

For either value of t^* , the 99% confidence interval is $\bar{x} \pm t^*SE \doteq 240 \pm 2.84 = 237.2$

to 242.8. **(c)** Because the 99% confidence interval for μ does not include 243, we can reject $H_0: \mu = 243$ in favor of the two-sided alternative at the 1% significance level.

(The evidence is a bit stronger than that: we would typically test H_0 against the one-sided alternative $\mu < 243$; for this test we find $P = 0.0032$.)

17.28. (a) Use $df = 26$:

$$114.9 \pm 2.056 \left(\frac{9.3}{\sqrt{27}} \right) = 111.2 \text{ to } 118.6 \text{ mm Hg.}$$

(b) The essential assumption is that the 27 men tested can be regarded as an SRS from a population, such as all healthy white males in a stated age-group. The assumption that blood pressure in this population is Normally distributed is *not* essential because \bar{x} from a sample of size 27 will be roughly Normal in any event, provided the population is not too greatly skewed and has no outliers.

17.29. (a) A subject's responses to the two treatments would not be independent. **(b)** We find

$$t = \frac{-0.326 - 0}{0.181/\sqrt{6}} \doteq -4.41; \text{ with } df = 5, \text{ this yields } P = 0.0069 \text{—significant evidence of a difference.}$$

17.30. (a) A stemplot shows that the data are not skewed and have no outliers.

(There is a gap between 1.12 and 1.18, but as 1.18 appears three times, we would not consider it an outlier.) **(b)** Calculate $\bar{x} \doteq 1.1182$ and $s \doteq 0.04378$.

We have $n = 11$, so $df = n - 1 = 10$. The critical value for a 95% confidence interval is $t^* = 2.228$, and the interval for μ is

$$\bar{x} \pm t^* \left(\frac{s}{\sqrt{n}} \right) = 1.1182 \pm 2.228 \left(\frac{0.04378}{\sqrt{11}} \right) = 1.1182 \pm 0.0294 = 1.089 \text{ to } 1.148.$$

(c) Because this interval does not include 1, we can reject $H_0: \mu = 1$ in favor of the two-sided alternative.

17.31. (a) Stems can be split two ways or five ways; both stemplots are shown on the right. The second one suggests that the two highest counts might be outliers, but they are not too extreme; the use of t procedures should be fairly safe. **(b)** With $\bar{x} = 12.8\bar{3}$ and $s \doteq 4.6482$, the 90% confidence interval for μ is

$$12.8333 \pm 1.796 \left(\frac{4.6482}{\sqrt{12}} \right) = 12.8333 \pm 2.4099 = 10.423 \text{ to } 15.243.$$

0	699	0	6
1	01124	0	99
1	55	1	011
2	02	1	2
		1	455
		1	
		1	
		2	0
		2	2

17.32. SOLVE: The mean is $\bar{x} \doteq 25.42^\circ$ and the standard deviation is 7.47° , and t^* is either 2.042 (using $df = 30$ from Table C) or 2.0262 (using $df = 37$ from software). The confidence interval is nearly identical in both cases:

$$\begin{aligned} \bar{x} \pm t^* \left(\frac{s}{\sqrt{38}} \right) &= 22.95^\circ \text{ to } 27.89^\circ \quad (t^* = 2.042), \text{ or} \\ &= 22.96^\circ \text{ to } 27.88^\circ \quad (t^* = 2.0262). \end{aligned}$$

```

TInterval
(22.964, 27.878)
x̄=25.42105263
Sx=7.474755999
n=38

```

CONCLUDE: We are 95% confident that the mean HAV angle among such patients is between 22.95° and 27.89° .

17.33. (a) The stemplot clearly shows the high outlier mentioned in the text.

(b) Let μ be the mean difference (control minus experimental) in healing rates. We test $H_0: \mu = 0$ vs. $H_a: \mu > 0$. The alternative hypothesis says that the control limb heals faster; that is, the healing rate is greater for the control limb than for the experimental limb.

With all 12 differences, $\bar{x} = 6.41\bar{6}$ and $s \doteq 10.7065$, so $t = \frac{\bar{x}-0}{s/\sqrt{12}} \doteq 2.08$ (df = 11, $P = 0.0311$). If we omit the outlier, $\bar{x}^* = 4.1\bar{8}$ and $s^* \doteq 7.7565$, so $t = \frac{\bar{x}^*-0}{s^*/\sqrt{11}} \doteq 1.79$ (df = 10, $P = 0.0520$). With all differences, the evidence

is significant at the 5% level, but dropping the outlier weakens the evidence so that it is not quite significant.

-1 | 3
 -0 | 6
 -0 |
 0 | 12
 0 | 5789
 1 | 012
 1 |
 2 |
 2 |
 3 | 1

Minitab output: All points

Test of mu = 0.00 vs mu > 0.00

Variable	N	Mean	StDev	SE Mean	T	P-Value
Diff	12	6.42	10.71	3.09	2.08	0.031

With outlier removed

Test of mu = 0.00 vs mu > 0.00

Variable	N	Mean	StDev	SE Mean	T	P-Value
Diff	11	4.18	7.76	2.34	1.79	0.052

17.34. (a) Without the outlier, the mean is $\bar{x}^* \doteq 24.76^\circ$ while the standard deviation drops to $s^* \doteq 6.34^\circ$. t^* is either 2.042 (using df = 30 from Table C) or 2.0281 (using df = 36 from software). The confidence interval is

$$\begin{aligned} \bar{x}^* \pm t^* \left(\frac{s^*}{\sqrt{37}} \right) &= 22.63^\circ \text{ to } 26.89^\circ \quad (t^* = 2.042), \text{ or} \\ &= 22.64^\circ \text{ to } 26.87^\circ \quad (t^* = 2.0281). \end{aligned}$$

```
TInterval
(22.643, 26.87)
x=24.75675676
sx=6.339494395
n=37
```

(b) The width of the interval decreases (because the outlier raised both \bar{x} and s).

17.35. (a) The stemplot does not show any severe evidence of non-Normality, so t procedures should be safe. **(b)** With $\bar{x} = 1.17\bar{2}$ days, $s \doteq 0.4606$ days, and $t^* = 1.812$ (df = 10), the 90% confidence interval is

$$\bar{x} \pm t^* \left(\frac{s}{\sqrt{11}} \right) \doteq 1.1727 \pm 0.2517 = 0.9211 \text{ to } 1.4244 \text{ days.}$$

0 | 67
 0 | 89
 1 | 00
 1 | 33
 1 | 4
 1 |
 1 | 9
 2 | 0

17.36. (a) The stemplot of differences shows a sharp right skew, and one or two high outliers. The t procedures should not be used. **(b)** Some students might perform the test ($H_0: \mu = 0$ vs. $H_a: \mu > 0$) despite the right skew noted in (a). If so, they should find that $\bar{x} = 156.3\bar{6}$, $s \doteq 234.2952$, and $t \doteq 2.21$ (df = 10, $P = 0.0256$).

0 | 0012238
 1 | 0
 2 | 1
 3 |
 4 |
 5 | 1
 6 |
 7 | 0

17.37. (a) We test $H_0: \mu = 0$ vs. $H_a: \mu > 0$, where μ is the mean difference (treated minus control). We use a one-sided alternative because the researchers have reason to believe that CO₂ will increase growth rate. **(b)** The mean difference is $\bar{x} = 1.916$, and the standard deviation is 1.050, so the t statistic is $t = \frac{1.916}{1.050/\sqrt{3}} \doteq 3.16$

```
T-Test
mu>0
t=3.159644096
P=.0436279547
x=1.916333333
Sx=1.050493852
n=3
```

with $df = 2$. This is significant at $\alpha = 0.05$, as the TI-83 and Minitab outputs confirm ($P = 0.044$). **(c)** For small samples, the t procedures should be used only for samples from a Normal population; we have no way to assess Normality for these data.

Minitab output

```
Test of mu = 0.000 vs mu > 0.000
```

Variable	N	Mean	StDev	SE Mean	T	P-Value
diff	3	1.916	1.050	0.607	3.16	0.044

17.38. (a) Weather conditions that change from day to day can affect spore counts. So the two measurements made on the same day form a matched pair. **(b)** Take the differences, kill room counts minus processing counts. For these differences, $\bar{x} = 1824.5$ and $s \doteq 834.1$ CFUs/m³. For the population mean difference, the 90% confidence interval for μ is

$$1824.5 \pm 2.353 \left(\frac{834.1}{\sqrt{4}} \right) = 1824.5 \pm 981.3 = 843.2 \text{ to } 2805.8 \text{ CFUs/m}^3.$$

The interval is wide because the sample is small (four days), but we are confident that mean counts in the kill room are quite a bit higher. **(c)** The data are counts, which are at best only approximately Normal, and we have only a small sample ($n = 4$).

17.39. The data contain two extreme high outliers, 5973 and 8015. These may distort the t statistic. (This exercise did not call for a stemplot, but it is shown here because it makes the outliers easily visible.)

0	1123788
1	00115677899
2	01112458
3	
4	
5	9
6	
7	
8	0

17.40. (a) The mean and standard deviation are $\bar{x} \doteq 48.25$ and $s \doteq 40.24$ thousand barrels of oil. From Table C, we take $t^* = 2.000$ ($df = 60$); using software we can obtain $t^* = 1.998$ for $df = 63$. The 95% confidence interval for μ is

$$48.25 \pm 2.000 \left(\frac{40.24}{\sqrt{64}} \right) = 48.25 \pm 10.06 = 38.19 \text{ to } 58.31$$

(software value: $48.25 \pm 10.05 = 38.20$ to 58.30 thousand barrels of oil). **(b)** The stemplot confirms the skewness and outliers described in the exercise. The two intervals have similar widths, but the new interval is higher (by 2000 barrels). While t procedures are fairly robust, we should be cautious about trusting our result from (a) because of the strong skew and outliers; the computer-based method is presumably more reliable for this situation.

0	00001111111111
0	22222233333333333333
0	44444445555555
0	6666667
0	8899
1	01
1	5
1	5
1	9
2	0

17.41. PLAN: We will construct a 90% confidence interval for μ , the mean percent of beetle-infected seeds.

SOLVE: A stemplot (right) shows a single-peaked and roughly symmetric distribution. We assume that the 28 plants can be viewed as an SRS of the population. We find that $\bar{x} \doteq 4.0786$ and $s \doteq 2.0135$. Using $df = 27$, the 90% confidence interval for μ is

```

0 | 07
1 | 9
2 | 24689
3 | 666778
4 | 0000336
5 | 157
6 |
7 | 00
8 | 57
    
```

$$4.0786 \pm 1.703 \left(\frac{2.0135}{\sqrt{28}} \right) = 4.0786 \pm 0.648 = 3.43\% \text{ to } 4.73\%.$$

CONCLUDE: The beetle infects less than 5% of seeds, so it is unlikely to be effective in controlling velvetweed.

17.42. PLAN: Let μ be the mean difference (control minus experimental) in healing rates. We test $H_0: \mu = 0$ vs. $H_a: \mu > 0$. The alternative hypothesis says that the control limb heals faster; that is, the healing rate is greater for the control limb than for the experimental limb.

```

-1 | 0
-0 |
-0 | 43
0 | 113334
0 | 7
1 | 02
1 |
2 | 2
2 |
3 | 1
    
```

SOLVE: We assume that the data can be regarded as an SRS. A stemplot of the differences shows no major deviations from Normality; the highest difference might be an outlier, but it is not too extreme, so we cautiously proceed with the t test. The mean and standard deviation of the set of differences are $\bar{x} \doteq 5.7143 \mu\text{m/hr}$ and $s \doteq 10.5643 \mu\text{m/hr}$, so $t = \frac{5.7143-0}{10.5643/\sqrt{14}} \doteq 2.02$ with $df = 13$, for which $0.025 < P < 0.05$ (software reports 0.032). If subtraction was done in the other order, \bar{x} and t are negative, but P is the same.

CONCLUDE: This is fairly strong evidence (significant at 5% but not at 1%) that altering the electric field reduces the healing rate.

Minitab output

```

Test of mu = 0.00 vs mu > 0.00

Variable   N      Mean    StDev   SE Mean      T      P-Value
HealRate  14      5.71     10.56    2.82        2.02    0.032
    
```

17.43. PLAN: As in the previous solution, let μ be the mean difference (control minus experimental) in healing rates. We construct a 90% confidence interval for μ .

SOLVE: With $\bar{x} \doteq 5.7143 \mu\text{m/hr}$, $s \doteq 10.5643 \mu\text{m/hr}$, and $t^* = 1.771$ ($df = 13$), the 90% confidence interval for μ is

$$5.7143 \pm 1.771 \left(\frac{10.5643}{\sqrt{14}} \right) = 5.7143 \pm 5.0003 = 0.71 \text{ to } 10.71 \mu\text{m/hr}.$$

CONCLUDE: We are 90% confident that the mean healing rate for control limbs exceeds the experimental limb rate by between 0.71 and 10.71 $\mu\text{m/hr}$.

17.44. (a) Fund and index performances are certainly not independent; for example, a good year for one is likely to be a good year for the other.
(b) PLAN: Let μ be the mean difference (fund minus EAFE). We test $H_0: \mu = 0$ vs. $H_a: \mu \neq 0$, taking a two-sided alternative because the VIG Fund could outperform or underperform the benchmark. (The case could be made for a one-sided alternative, but as we shall see, the choice of H_a does not matter.)

-1 | 6
 -1 | 22
 -0 | 877
 -0 | 431100
 0 | 012234
 0 | 568
 1 | 124

SOLVE: A stemplot shows no reason to doubt Normality. We must assume that the data we have can be viewed as an SRS. We find $\bar{x} \doteq -0.0754\%$ and $s \doteq 7.9979\%$, so $t = \frac{-0.0754-0}{7.9979/\sqrt{24}} \doteq -0.05$, for which $P > 0.5$ (software gives 0.96).

CONCLUDE: We have very little reason to doubt that $\mu = 0$; VIG Fund performance is not significantly different from its benchmark.

Minitab output

Test of mu = 0.00 vs mu not = 0.00

Variable	N	Mean	StDev	SE Mean	T	P-Value
diff	24	-0.08	8.00	1.63	-0.05	0.96

17.45. (a) For each subject, randomly select (e.g., by flipping a coin) which knob (right or left) that subject should use first.
(b) PLAN: We test $H_0: \mu = 0$ sec vs. $H_a: \mu < 0$ sec, where μ is the mean of (right-thread time – left-thread time), so that $\mu < 0$ is equivalent to “right-hand time is less than left-hand time.”

-5 | 2
 -4 | 853
 -3 | 511
 -2 | 94
 -1 | 66621
 -0 | 74331
 0 | 02
 1 | 1
 2 | 03
 3 | 8

SOLVE: A stemplot of the differences gives no reason to avoid the t procedures. We assume that our subjects can be viewed as an SRS. We find that $\bar{x} = -13.32$ sec and $s \doteq 22.936$ sec, so $t = \frac{-13.32-0}{22.936/\sqrt{25}} \doteq -2.90$. With $df = 24$, we find that $P = 0.0039$.

CONCLUDE: We have good evidence (significant at $\alpha = 0.01$) that the mean difference really is negative; that is, the mean time for right-hand-thread knobs is less than the mean time for left-hand-thread knobs.

17.46. PLAN: We test $H_0: \mu = 0$ vs. $H_a: \mu \neq 0$, where μ is the mean difference in absorption (generic minus reference). The alternative is two-sided because we have no prior expectation of a direction for the difference.
SOLVE: We assume that the subjects can be considered an SRS. A stemplot of the differences (right) looks reasonably Normal with no outliers, so the t procedures should be safe. We find $\bar{x} = 37$ and $s \doteq 1070.6$, and compute $t = \frac{37}{1070.6/\sqrt{20}} \doteq 0.15$. With $df = 19$, we see that $P > 0.5$ (software gives 0.88).

-2 | 3
 -1 | 5
 -1 | 31
 -0 | 5
 -0 | 321
 0 | 012334
 0 | 577
 1 | 1
 1 | 6
 2 | 0

CONCLUDE: We cannot conclude that the two drugs differ in mean absorption level.

Note: We should be cautious about how we state this conclusion. There is much variation in our sample; a 95% confidence interval for μ is

$$37 \pm 2.093 \left(\frac{1070.6}{\sqrt{20}} \right) = 37 \pm 501.06 = -464 \text{ to } 538.$$

So while we cannot reject H_0 , we are hardly convinced that $\mu = 0$.

17.47. With $df = 24$, the critical value is $t^* = 1.711$, so the interval for μ is

$$-13.32 \pm (1.711) \left(\frac{22.936}{\sqrt{25}} \right) \doteq -13.32 \pm 7.85 \doteq -21.2 \text{ to } -5.5 \text{ sec.}$$

We have $\bar{x}_{RH} = 104.12$ and $\bar{x}_{LH} = 117.44$, so that $\bar{x}_{RH}/\bar{x}_{LH} = 88.7\%$. Right-handers working with right-handed knobs can accomplish the task in about 90% of the time needed by those working with left-handed knobs.

Note: *The exercise asked us to find $\bar{x}_{RH}/\bar{x}_{LH}$, but an alternative approach would be to compute (right-hand time)/(left-hand time) for each subject, for which the mean is 91.7%.*