1. The following data (sorted for your convenience) on gross efficiency (ratio of work accomplished per minute to calorie expenditure per minute) for trained endurance cyclists was given in a paper in the journal *Medicine and Science in Sports and Exercise* (1992). Of interest to the researchers was to find a 95% confidence interval for $\mu$: mean gross efficiency for trained endurance cyclists.

GrossEff

18.3 18.9 19.0 19.9 20.1 20.1 20.5 20.5 20.5 20.5 20.6
20.8 20.9 21.2 21.4 21.9 22.1 22.6 22.6

a) What assumptions are needed to safely construct a 95% confidence interval in this case?

b) Begin your assessment of these assumptions by finding the five number summary for this data.

<table>
<thead>
<tr>
<th>Lo</th>
<th>$Q_1$</th>
<th>Med</th>
<th>$Q_3$</th>
<th>Hi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

c) Use the five number summary found above to construct a boxplot for this sample.
d) Use the following Minitab output to continue in your assessment of the assumptions. Is it safe to conclude that our assumptions are reasonable?

MTB > hist c1
Histogram of GrossEff  N = 19
Midpoint Count
18.5  1 *
19.0  2 **
19.5  0
20.0  3 ***
20.5  5 *****
21.0  3 ***
21.5  1 *
22.0  2 **
22.5  2 **

MTB > stem c1
Stem-and-leaf of GrossEff  N = 19
Leaf Unit = 0.10
1  18 3
2  18 9
3  19 0
4  19 9
6  20 11
(7) 20 5555689
6  21 24
4  21 9
3  22 1
2  22 66

e) Verify that the interval that Minitab calculates is correct by building a 95% interval in this case.

MTB > tint 95 c1
Variable  N  Mean  StDev  SE Mean  95.0 % C.I.
GrossEff  19  20.653  1.173  0.269  ( 20.087,  21.218)

f) Would it be safe to conclude, based on this interval, that the mean gross efficiency for all endurance cyclists is at least 20? Explain why or why not.
2. Many Americans think it doesn't matter which political party controls Congress. In an Associated Press article (1995) it was reported that 442 individuals in a sample of 1005 US adults said it wouldn't make much difference which party is in power. Find a 90% confidence interval for the proportion of US adults who believe that it wouldn't make much difference which party is in power by answering the following series of questions.

MTB > tally c1

Congress Count
0 563
1 442
N= 1005

MTB > mean c1 k1

Mean of Congress= 0.43980

MTB > let k2=sqrt(k1*(1-k1))

MTB > print k1 k2

K1 0.439801
K2 0.496363

MTB > zint 90 k2 c1

The assumed sigma = 0.496

Variable N Mean StDev SE Mean 90.0 % C.I.
Congress 1005 0.4398 0.4966 0.0157 ( 0.4140, 0.4656)

b) What conclusion could you give about the proportion of US adults who believe that it wouldn't make much difference which party is in power, based on the 90% interval?

c) Based on your interval above, is it plausible that a majority of US adults feel that it makes no difference which party is in control? Explain your reasoning.
A new instructor at a university read an article from *The American Freshman* that discussed a study of the amount of time (in hours) college freshmen study each week. The study reported that the mean study time is 7.06 hours. The instructor feels that freshmen at her university study more than 7.06 hours per week on average and decides to test her hypothesis. She collects a simple random sample of size $n=15$ from her university and found the following data (in hours):

6.0, 1.7, 5.9, 13.3, 9.8, 7.8, 7.6, 10.3, 11.8, 11.0, 3.1, 12.3, 8.3, 10.4, 6.2

a) One of the assumptions to safely perform a test in this situation is for the data to come from a normal population. Since the sample size is so small, normality is often hard to determine conclusively. One of the most important departures from normality is the existence of many outliers. (The normal distribution is notorious for having few outliers, if any.) Based on the boxplot of the data below, do you believe it is safe to perform a test? Support your conclusion.

b) What are the appropriate null and alternative hypotheses for this problem?
MTB > ttest 7.06 c1;
SUBC> alte -1.

Test of mu = 7.060 vs mu < 7.060

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
<th>T</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours</td>
<td>15</td>
<td>8.367</td>
<td>3.359</td>
<td>0.867</td>
<td>1.51</td>
<td>0.92</td>
</tr>
</tbody>
</table>

MTB > ttest 7.06 c1;
SUBC> alte 0.

Test of mu = 7.060 vs mu not = 7.060

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
<th>T</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
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<td>Hours</td>
<td>15</td>
<td>8.367</td>
<td>3.359</td>
<td>0.867</td>
<td>1.51</td>
<td>0.15</td>
</tr>
</tbody>
</table>

MTB > ttest 7.06 c1;
SUBC> alte 1.

Test of mu = 7.060 vs mu > 7.060

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
<th>T</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours</td>
<td>15</td>
<td>8.367</td>
<td>3.359</td>
<td>0.867</td>
<td>1.51</td>
<td>0.077</td>
</tr>
</tbody>
</table>

c) Conduct the test mentioned in part (b), by using the Minitab output (circle the correct output) and by answering the following questions:

i) What is the test statistic?

ii) What is the p-value?

iii) What is my decision (reject $H_0$ or do not reject $H_0$)?

iv) What should the new instructor believe based on this research?

v) If the instructor had used as a level of significance $\alpha = 0.10$, would her conclusion be different? Explain.

vi) Verify that the test statistic calculated by Minitab is correct.
4. In the past, it has been stated that 60 percent of all students at our college work part time (or more) during the school year. A counselor, after speaking with many students over the past few weeks regarding schedules, feels that this percentage is actually too low. We are interested in assessing if the proportion of students working part time is indeed larger than 0.60. A simple random sample of $n = 120$ students was obtained and of those 83 worked at least part time. Based on this sample can we safely conclude that the proportion is indeed larger than 0.60? Answer this general question by answering the following sequence of questions and by using the accompanying Minitab output.

```
MTB > tally c1

    Work?  Count
       0    37
       1    83
      N=  120

MTB > mean c1 k1

   Mean of Work? = 0.69167

MTB > let k2=sqrt(k1*(1-k1))
MTB > let k3=sqrt(.6*(1-.6))
MTB > print k1 k2 k3

  K1       0.691667
  K2       0.461805
  K3       0.489898
```

a) What role could $k_1$, $k_2$ and $k_3$ play in our problem or a similar problem?

b) State the null and alternative hypotheses that the counselor is interested in assessing.

c) What assumptions are needed for us to safely test these hypotheses and are they met in this case?
d) What is the test statistic associated with the hypotheses mentioned in part (b)?

e) What is the corresponding p-value? Circle the correct output for the hypotheses in part (b).

f) What is our decision (reject $H_0$ or do not reject $H_0$)?

g) What conclusion can you make about the proportion of students who work at least part time?

```
MTB > ztest .6 k3 c1;
SUBC> alte -1.

Test of mu = 0.6000 vs mu < 0.6000
The assumed sigma = 0.490

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
<th>Z</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work?</td>
<td>120</td>
<td>0.6917</td>
<td>0.4637</td>
<td>0.0447</td>
<td>2.05</td>
<td>0.98</td>
</tr>
</tbody>
</table>

MTB > ztest .6 k3 c1;
SUBC> alte 0.

Test of mu = 0.6000 vs mu not = 0.6000
The assumed sigma = 0.490

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
<th>Z</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work?</td>
<td>120</td>
<td>0.6917</td>
<td>0.4637</td>
<td>0.0447</td>
<td>2.05</td>
<td>0.041</td>
</tr>
</tbody>
</table>

MTB > ztest .6 k3 c1;
SUBC> alte 1.

Test of mu = 0.6000 vs mu > 0.6000
The assumed sigma = 0.490

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
<th>Z</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work?</td>
<td>120</td>
<td>0.6917</td>
<td>0.4637</td>
<td>0.0447</td>
<td>2.05</td>
<td>0.020</td>
</tr>
</tbody>
</table>
```
5. Medical researchers are comparing two treatments for migraine headaches. They wish to perform a double-blind experiment to assess if Treatment 2 (the new treatment) is significantly better than Treatment 1 (the standard treatment) using a 5% significance level. Twenty subjects were available for the study and were randomized to one of the two treatment groups. Treatment 1 was administered to 10 subjects, while treatment 2 was administered to the remaining 10 subjects. Each subject was instructed to take the medication at the onset of a migraine headache and to record the time that elapsed until relief, defined as a reduction in throbbing. The data are as follows:

<table>
<thead>
<tr>
<th>Treatment 1</th>
<th>Treatment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 16 21</td>
<td>12 20 22</td>
</tr>
<tr>
<td>20 34 29</td>
<td>20 8 21</td>
</tr>
<tr>
<td>19 25 23</td>
<td>19 24 9</td>
</tr>
<tr>
<td>23</td>
<td>21</td>
</tr>
</tbody>
</table>

Answer the following concerning this problem.

a) What does double-blind refer to?

b) Briefly mention how the subjects could be randomized to one of the treatment groups and explain why this is important.

c) If the new treatment, Treatment 2, is an improvement over Treatment 1, we would expect that the mean relief time would be shorter for Treatment 2 than for Treatment 1. How does this translate to the null and alternative hypotheses in this case? (Let \( \mu_1 \) = mean relief time for Treatment 1 and let \( \mu_2 \) = mean relief time for Treatment 2.)
MTB > TwoSample 95.0 'Trt 1' 'Trt 2';
SUBC>   Alternative -1.

Twosample T for Trt 1 vs Trt 2
   N   Mean   StDev   SE Mean
Trt 1 10  22.40   5.93    1.9
Trt 2 10  17.60   5.72    1.8

95% C.I. for mu Trt 1 - mu Trt 2: (-0.7, 10.3)
T-Test mu Trt 1 = mu Trt 2 (vs <): T= 1.84  P=0.96  DF=  17

MTB > TwoSample 95.0 'Trt 1' 'Trt 2';
SUBC>   Alternative 0.

Twosample T for Trt 1 vs Trt 2
   N   Mean   StDev   SE Mean
Trt 1 10  22.40   5.93    1.9
Trt 2 10  17.60   5.72    1.8

95% C.I. for mu Trt 1 - mu Trt 2: (-0.7, 10.3)
T-Test mu Trt 1 = mu Trt 2 (vs not =): T= 1.84  P=0.083  DF=  17

MTB > TwoSample 95.0 'Trt 1' 'Trt 2';
SUBC>   Alternative 1.

Twosample T for Trt 1 vs Trt 2
   N   Mean   StDev   SE Mean
Trt 1 10  22.40   5.93    1.9
Trt 2 10  17.60   5.72    1.8

95% C.I. for mu Trt 1 - mu Trt 2: (-0.7, 10.3)
T-Test mu Trt 1 = mu Trt 2 (vs >): T= 1.84  P=0.041  DF=  17

d) Is there strong evidence that the new treatment (Trt 1) is better than the old treatment (Trt 2) based on time to relief?
i) What is the test statistic?
ii) What is the p-value?
iii) What is our decision?
iv) What is our conclusion?
6. A study was performed to compare two cholesterol-reducing drugs. Data on the number of units of cholesterol reduction were recorded for 12 subjects randomly assigned to Drug1 and the remaining 14 subjects who received Drug2:

<table>
<thead>
<tr>
<th></th>
<th>Drug1</th>
<th>Drug2</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Drug1 is a new experimental drug that researchers hope is very effective while Drug2 is a very effective, but is expensive to produce and has potential harmful side-effects (for some people). If Drug1 can be declared equally effective, it could potential become approve by the USDA with further testing.

a) Assess whether Drug1 is equally effective by verifying that the 95% confidence interval that Minitab produced for this problem is correct.

```
MTB > TwoSample 95.0 'Drug1' 'Drug2';
SUBC> Alternative 0.
```

Twosample T for Drug1 vs Drug2

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drug1</td>
<td>12</td>
<td>5.83</td>
<td>1.47</td>
<td>0.42</td>
</tr>
<tr>
<td>Drug2</td>
<td>14</td>
<td>5.36</td>
<td>1.08</td>
<td>0.29</td>
</tr>
</tbody>
</table>

95% C.I. for mu Drug1 - mu Drug2: (-0.60, 1.55)
T-Test mu Drug1 = mu Drug2 (vs not =): T= 0.93  P=0.36  DF= 19

b) This interval contains both positive and negative values? How do you interpret such an interval?