Problem 1 111 students took Exams 1 and Exam 2 this quarter. The class average for Exam 1 was 85.09 with a standard deviation of 19.08, and the average for Exam 2 was 85.46 with a standard deviation of 18.28. Is this a significant change? Since each student took two tests, we can test the significance of this difference with a t-test for two dependent groups.

This is done by calculating the difference between Exams 1 and Exams 2 for each student. This gives a list of 111 differences. We then run a t-test that the mean of differences is different from zero.

The mean of these differences is $\bar{D} = 0.37$ points (which is the same as the differences of the means) and from the data I've calculated that the standard deviation of these difference is $s_D = 19.51$ points. In the following steps, test the hypothesis that the scores from Exam 1 are drawn from a population with a different mean than the scores from Exam 2 using an alpha value of 0.05.

a) State the null and alternative hypotheses.

$H_0 : \bar{D} = 0$, Exam 1 and Exam 2 are drawn from populations with the same mean.

$H_A : \bar{D} \neq 0$, Exam 1 and Exam 2 are drawn from populations with the different means.

b) Calculate your t-statistic

$s_D = \frac{19.51}{\sqrt{111}} = 1.85$

$t = \frac{0.37}{1.85} = 0.2$

c) Find the critical value(s) of t

$df = 111-1 = 110$

$t_{crit} = \pm 1.98$

d) What is your decision? State it as a complete sentence using APA format. Find the p-value using the t-calculator in the spreadsheet.

We fail to reject $H_0$.

The grades of Exam 1 ($M = 85.09$, $SD = 19.08$) is not significantly different than the grades of Exam 2 ($M=85.46$, $SD = 18.28$), $t(110) = 0.2$, $p = 0.8418$. 
e) What is the effect size? Is it small, medium or large?

Effect size: $g = \frac{|\bar{D}|}{s_D} = \frac{0.37}{19.51} = 0.02$

This is a small effect size.

f) What is the probability of making a type I error for this hypothesis test?

$P(\text{Type I error}) = \alpha = 0.05$

g) Use the appropriate power curve to determine the power of this hypothesis test. Explain what this number means about this year's tests scores in complete sentences.

Using the power curve for $\alpha = 0.05$, 2-tails, 1 mean, a sample size of 111, and an effect size of 0.02, the power is about 0.06.

This means that if we assume that the true mean difference in scores is 0.37 points, then the probability of correctly rejecting the null hypothesis is 0.06.

Problem 2 For the 111 students this quarter, the correlation of scores between Exam 1 and Exam 2 is $r = 0.46$. Let's test the hypothesis that this correlation is significantly different from zero. We'll use an alpha value of 0.05.

a) Find the critical value of $r$ using table G.

For a two-tailed with $df = 111 - 2 = 109$ and $\alpha = 0.05$, the critical value of $r$ is $\pm 0.187$

b) State your decision in a complete sentence.

We reject $H_0$. The correlation between Exam 1 and Exam 2 for scores is significantly different than zero, $r(109) = 0.46$, $p < 0.0001$. 
Problem 3 For the 105 students in 2016, the correlation between Exam 1 and Exam 2 scores was 0.51. Is this significantly different from the correlation between Exam 1 and Exam 2 scores this year? Use an alpha value of $\alpha = 0.05$.

a) Use table H to calculate the Fisher $z’$ values for the two correlations:
For $r_1 = 0.51$, $z’ = 0.563$
For $r_2 = 0.46$, $z’ = 0.497$

b) Calculate the statistic:

$$ z = \frac{z’_1 - z’_2}{\sigma_{z’_1 - z’_2}} $$

where

$$ \sigma_{z’_1 - z’_2} = \sqrt{\frac{1}{n_1 - 3} + \frac{1}{n_2 - 3}} $$

$$ \sigma_{z’_1 - z’_2} = \sqrt{\frac{1}{105 - 3} + \frac{1}{111 - 3}} = 0.1381 $$

$$ z = \frac{0.563 - 0.497}{0.1381} = 0.478 $$

c) Find the critical value of $z$

For a two-tailed test with alpha = 0.05, the critical value of $z$ is $\pm 1.96$

d) State your decision in a complete sentence. For an extra challenge, use Table A to calculate the p-value. Don’t forget to double the value for two-tailed test!

To calculate the p-value, we find using the z-table that $Pr(z > 0.478) = 0.3164$
Since this is a two-tailed test, we double it to get $p = (0.31635)(2) = 0.6327$

We fail to reject $H_0$.
The correlation between the Exam 1 and Exam 2 for scores in 2016 (0.51) is not significantly different than the correlation for scores this year (0.46), $z = 0.478$, $p = 0.6327$. 