Introduction

Each week, you will have to write a conclusion on **ONE** section from the previous week's lab assigned by your TA. In your conclusion, you should summarize the physics concepts you studied in that section, describe how your results relate to the concepts, and do some error analysis. You should divide your conclusion into these three parts. Your conclusion does not need to be long (one page maximum).

Hypothesis/Physics Concepts

Each lab will explore one or more physics concepts. During lab, you will test whether the world works the way your professor said it does in lecture. This often takes the form of an assumption and an equation based on this assumption. In this section, you should explain the principle you are verifying, demonstrate that you understand what equation you are testing, and detail where that equation came from. Do not include a repetition of the lab procedures since your TA already knows the procedure.

Results

In this section, you will describe whether the equation you tested is consistent with your measurements. You will do this by comparing your predictions with your actual measurements. In essence you are explaining how what you performed in lab explains/verifies the hypothesis/physics concepts. If you have numerical results, be sure to show your TA what your results were by including both the predicted and measured numbers. Do not merely say that your measurements did or did not agree with your predictions without supporting your statements. For some labs a graph will represent your data better than a table will. You only need to include your results, not your raw data. Do not hand in your in-lab notes. Always include the correct units. Not all labs will have numerical results.

Error Analysis/Improvement

Here you will evaluate the precision of your results as well as detail sources of error. In order to compare your results with your predictions, you need to know how much error is in your numbers. For example, if you predicted 52 but you measured 50, your percent error (difference between prediction and measurement) is 4%. You should also explain whether or not this error is consistent. Your prediction would be consistent if you had measured everything to the nearest 10% but it would not be consistent if you measured everything to the nearest 1%. Not all labs will have an error that can be easily calculated. Include calculations when appropriate for a given lab.

You should also describe the biggest sources of error for your measurements and give an estimate of how large it is. If your measurements and predictions are close to each other, do not say that there was no error. All data has error. Do not mention mistakes you made or that you could have made. Instead give examples of non-human error, that is, error intrinsic to the experiment. For example, if you assume a surface is perfectly smooth, energy loss due to friction would be one source of error. Do not mention rounding or calculation error since you should perform the calculation again more carefully if this is causing problems.

In this section you can also discuss what could have been done to improve your results. This may include how you measured the data or any other idea that you feel is appropriate.

Notes
- Your conclusion should be a **maximum** length of one page.
- When calculating the slope, you can use Excel, use a graphing calculator's linear regression function, or manually draw a line of best fit and measure the slope. **Do not calculate the slope by calculating the rise over the run between two points.** This method does not include all of the measurements you have made.
- The questions in the lab can help you get an idea of what concepts and results are important in a particular section.
- Your conclusion should be handwritten, except for any graphs from excel.
- As with the rest of the homework, you can discuss your conclusion with your classmates, but what you hand in must be your own work.
- The Example Conclusion on the next page demonstrates how a conclusion can be written with the three parts (note that numerical data or graphs are not necessarily appropriate for every experiment).

Example Procedure
(NOTE: You do not need to include the procedure in your conclusion. It is only here to provide context for the example conclusion.)
    In a lab studying centripetal forces, students moved a tennis ball on a string in a horizontal circle. In the section of interest, they wanted to study the relationship between the angle of the string from vertical and the frequency of the ball's motion.
    They measured a length of string so that it was 0.25 m from the center of the ball to their fingers. They then used trigonometry to determine the radius of the circle that would cause the string to be at 30º, 45º, and 60º (0.125 m, 0.177 m, and 0.217 m). They placed a ruler under the center of the circle so that they could see what the radius of the circle was and know when they were moving the ball at the right frequency. They measured the time it took the ball to complete ten rotations using a stopwatch. Their data appears in the following table.

Example Conclusion

In this lab, we studied the motion of a tennis ball on a string moving in horizontal circles. Because the ball is not accelerating vertically, the vertical component of the tension cancels the weight ($T \cos(\theta) = mg$). Because the ball is moving in a horizontal circle, the horizontal component of the tension is a centripetal force ($T \sin(\theta) = m (2\pi f)^2 R$). Combining these two equations gives us $g \tan(\theta) = (2\pi f)^2 R = a_c$. In this section, we studied whether this equation held as the angle changed.

We took measurements of radius and frequency at three different angles, and we were able to calculate a_c and $g \tan(\theta)$. We used Excel to plot a_c v. $g \tan(\theta)$ and plotted a line of best fit through the points. Since a_c and $g \tan(\theta)$ should be the same, we expected the slope to be 1.00. The slope of our line was 1.04. Our plot is at the end of this conclusion. As expected, the centripetal acceleration increased as the angle increased, going from 6.2 m/s^2 at 30º to 18.8 m/s^2 at 60º. Our results are below:

_	Measured Radius (m)	Actual _	g Tan(_) (m/s/s)	10 T (s)	f (Hz)	Acceleration (m/s/s)
30°	0.13	31°	6.0	9.1	1.10	6.2
45°	0.18	46°	10.2	8.5	1.18	9.8
60°	0.22	62°	18.2	6.8	1.47	18.8

a_c v. g Tan(_)

$y = 1.0428x - 0.3265$
$R^2 = 0.9962$
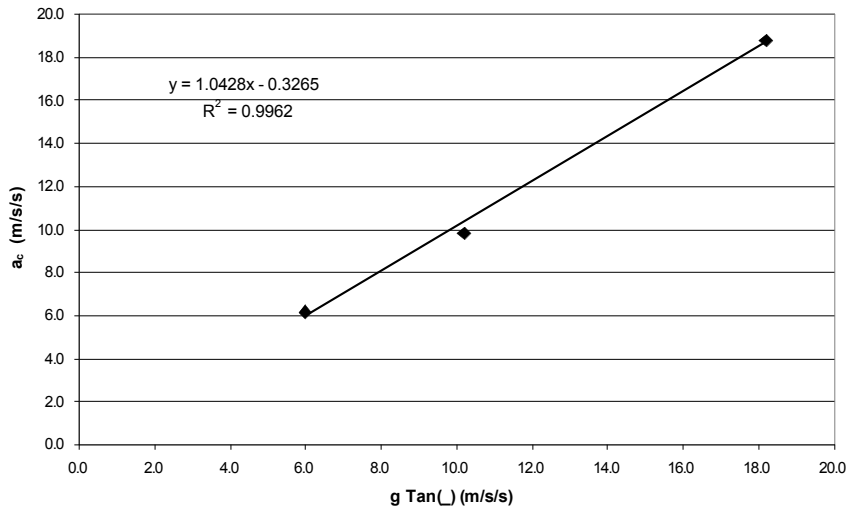
Errors in this lab came from our measurement of the radius and the period. The radius shifted by about 1 cm because the person moving the ball could not maintain a constant motion. This caused an error of about 5-10%. Error in our measurement of the period came from the limit of our reaction time. This caused an error of about 0.3 s, which is about 3-5%. Because the difference between our measurements and predictions was smaller than our error, our experiment confirms our predictions the angular dependence of circular motion. Our results would have been improved if we had included more data points by taking more measurements at different angles. If done properly this would have decreased our error with calculating the slope of the line.