Physics 110 **Fall 2026**

Lab 4: Flying Pigs

Name: ____________________________

Lab Partner(s): ____________________________

Honor Code Statement: I affirm that I have carried out my academic endeavors with full academic honesty. ____

Please neatly answer all of the questions in the lab packet. Make sure you attach any graphs generated, Excel files you produced, and any calculations/derivations you did. This lab packet is due one week from the completion of the lab.

Introduction

In the mid 1600s Newton realized that the moon is always "falling" towards the center of the earth. If the moon was not "falling" towards the earth, then, by his first law of motion, the moon would continue in some straight-line path rather than follow a circular orbit. Therefore, there must be a force, which he called the centripetal force, perpendicular to the motion of the moon that changes the motion of the moon and makes it follow a circular trajectory. This centripetal force he showed, pointed along the radius of the circular orbit towards the center of the circle about with the object is orbiting. The resulting centripetal force pointing inward, caused in the moons case by the force of gravity, produces the centripetal acceleration. In this laboratory experiment we will be using a flying pig to investigate circular motion and from the motion of the pig, make some predictions about the motion and then make measurements of those predictions. In particular we will measure the period of the pig's motion and the tension force in the string connecting the pig to the ceiling.

Procedure

1. Gather your equipment: one plastic pig with wings, a length of string, a spring scale, and a magnetic hook.

2. Measure out a known length of string and record its length, L and its uncertainty ΔL.

   $L \pm \Delta L =$

3. Weight the pig and record its mass m and its uncertainty Δm.

   $m \pm \Delta m =$

4. Use the magnetic hook to stick the flying pig to the ceiling by tying one end of the string through the loop on the pig's back and place the loop at the other end over the hook. Open the pig's wings (so that they click into place) and turn on the switch on the pig's side, and watch it fly!

5. Note the pig's motion. What kind of motion is this and how do you know the motion is this type? Explain

6. What parameters of this motion are measurable? List the parameters you think you will may need in the experiment and explain why they are measurable. For each of these parameters what are the measurements and their uncertainties?

7. What parameters do you think must be calculated from the measurable parameters? List the parameters and explain why they need to be calculated. For each of these parameters what are the calculations needed along with their uncertainties?

8. Using the available equipment, obtain values for the following quantities along with their uncertainties. Be sure to explain how you measured or calculated each of these.
   - period of the motion,
   - frequency and angular frequency of the motion,
   - speed of the pig,
   - acceleration of the pig,
   - tension in the string.

Theoretical Analysis:

1. Draw a free-body diagram of the pig at a moment during its motion and derive an expression for the net force in terms of the measurable parameters.

2. Considering the type of motion of the pig, what other expression must the net force equal? Setting these two expressions for net force equal to each other derive an expression for the period of the motion T_{theo} based on the necessary measurable parameters and then evaluate your period. Hint: The angle the string makes with the vertical is reasonably small for the pig. In this case, $\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} + \cdots \sim x$ and $\cos x = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} + \cdots \sim 1$

3. Considering the result from question 2, what parameters should the period depend on? What do they depend on?

4. Now, test your theory. Explain your method for measuring the pig's period of motion and then measure the period of the pig's motion, T_{expt}, along with its uncertainty, ΔT_{expt}. Does your experimental value of the period agree with the theoretical value within experimental uncertainties? Discuss the results. If there is a significant disagreement, re-examine your theory. See if you can reconcile the results and your theoretical model. You may also confer with other lab groups and see if their data lead to a calculated period that agrees with their measured value.

   Method:

   $T_{theo} =$

   $T_{expt} \pm \Delta T_{expt} =$

5. Derive an expression for the expected tension, $F_{T,theo}$ in the string and then evaluate your expression with the numbers you have measured. Again, assume the angles involved are small.

   $F_{T,theo} =$

6. Hang the spring scale between the string and the magnetic hook. Start the pig flying and record a video of the force seen on the spring scale $F_{T,expt}$, and estimate the uncertainty as seen on the spring scale from your movie, $\Delta F_{T,expt}$. Is the value seen the tension force? Explain why or why not.

   $F_{T,expt} \pm \Delta F_{T,expt} =$

7. Compare your “theoretical value” of the tension force ($F_{T,theo}$) to your measured value ($F_{T,expt}$). Do the two values agree with in experimental uncertainties? Discuss the results. If there is a significant disagreement, re-examine your theory. See if you can reconcile the results and your theoretical model. You may also confer with other lab groups and see if their data lead to a calculated tension force that agrees with their measured value.