Lab Group_____Names_____DATE_____

Visual Physics Lab Project 2

Prompt:

You are working for the Aggie athletic department. Coach Fran has decided to take a more scientific approach to improving the Aggie's kicking game. You have been asked to evaluate the possibility of using game footage to study their kickoff, field goal, and punting game. You will need to set up a couple of experiments in a controlled environment to determine whether you can reconstruct the power and angle of the kick by evaluating the videos. You will need to evaluate how systematic and random errors affect the results, and then you will need to evaluate some game footage and report your findings to your boss. You will be working as a team of 3, so each of you will need to submit a technical memo to your boss, James Duncan (Audio & Video Manager for the Aggies), on the results of your experiments.

Objectives:

The purpose of this experiment is to evaluate two-dimensional motion using a camera. You should be able to break down the motion into an *x*, and *y* coordinate system and evaluate each component separately. You will need to quantify the errors in each case and present equations of motion that approximately (to within your error calculations) fit the projectile motion you observed.

Expectations:

You are expected to have read Chapter 3 from Young & Freedman's University Physics before coming to this lab. You must understand two-dimensional motion and know how to identify displacement, constant velocity, and acceleration on a graph. You will also need to have completed your 1st lab assignment and understand how to incorporate error into your analysis.

Experiment 1

EXPLORATION

When talking about a football kick, two expressions are often used to describe the kick. "Hang time" describes how long the ball stays in the air, and "Range" describes how far the ball goes before it hits the ground. Consider how the "Power" of the kick should affect each of these. What do all these expressions (hang time, range, and power) mean in terms of initial velocity and acceleration?

"*Preflight" Questions:*

- How should you measure random errors in two dimensions?
- How can you locate and minimize systematic errors in two dimensions?
- What type of trendline should you use on the graph of horizontal motion?

- What type of trendline should you use on a graph of vertical motion?
- What effect will a more powerful kick have on both horizontal and vertical motion?

Set Up

In this experiment you will be evaluating what effect the "power" of a kick has on the ball's trajectory. You will be using the marble launcher you used in the first experiment to do this.

1. Place the marble launcher on the end of your table such that it is aimed toward the table behind (in front of) you
2. Aim your camera toward the marble launcher such that the center of the picture is about the center of the marble's trajectory.
3. Make sure that the marble is essentially the same distance from the camera throughout its trajectory. (A lesson we learned from Project 1; ask your TA for assistance if you do not understand how or why we do this.)
4. Arrange 2 types of calibration intervals that can be seen easily in the video. (This is also a lesson we learned in Project1; ask your TA for assistance if you do not understand how to do this.)
5. Set the marble launcher to its 3 lowest settings and record a video of its flight in each case.
6. Open LabApp and capture the marble's trajectory to a chart. (remember to calibrate more than once; this means making multiple Excel files for each trajectory)
7. Analyze the motion and answer the following questions.

Questions from your boss

- How dependable are the results you acquired?
- What was the cumulative effect of parallax in your graph of motion?
- What type of trendline should you use for the horizontal motion? Vertical?
- What was the initial velocity of the marble in each of the 3 cases?
- How far would the marble have traveled before it hit the ground? What was its "range"?
- How long did the marble stay in the air? What was its "hang time"?
- What effect will a more powerful kick have on both horizontal and vertical motion?

Prepare a technical memo that addresses the above questions and submit it to your boss.

Experiment 2

EXPLORATION

Think about the difference between a punt and a kick-off. Think about how a punt seems to stay in the air so long but doesn't travel as far as the kickoff. How does the angle of the kick affect this?

"Preflight" Questions

- What effect should the angle of a kick have on the vertical motion?
- What effect should the angle of a kick have on the horizontal motion?
- How can you calculate the angle given the initial velocity in x and y?

Set up

In this experiment you will evaluate what effect angle has on the trajectory of a ball. You will again use the marble launcher, but you will use only 1 "power" setting and instead use several different angles.

1. Do steps 1-4 from experiment 1.
2. Set the marble launcher to at least 3 different angles and record a video of its flight in each case.
3. Open LabApp and capture the marble's trajectory to a chart. (remember to calibrate more than once; this means making multiple excel files for each trajectory)
4. Analyze the motion and answer the following questions.

Questions from your boss

- How dependable are the results you acquired?
- What was the cumulative effect of parallax in your graph of motion?
- What type of trendline should you use for the horizontal motion? Vertical?
- What was the initial velocity of the marble for each angle?
- How far would the marble have traveled before it hit the ground? What was its "range"?
- How long did the marble stay in the air? What was its "hang time"?
- What effect will a larger angle have on "hang time" and range?

Prepare a technical memo that addresses the above questions and submit it to your boss.

Experiment 3

EXPLORATION

When you look at the actual football you will notice that the distance scale is much larger. There are many differences between your marble experiment and the actual kickoff. Consider these differences and how they might affect your results.

"Preflight" Questions

- Will the information you gathered in your smaller experiments scale-up here?
- Will the shape and density of the football change its motion?
- If so, in what way?

- What effect could air resistance have on the motion?
- How could you calibrate a video of a football field?

Set up

In this experiment you will take a look at an actual video recording of an Aggie Kickoff. You will need to evaluate this video using LabApp Software. Since you will be using a prerecorded video, there will not be any experimental setup for this part of the project. The video is located on your computer at c:\218labs\game.avi

Questions from your boss

- How dependable are the results you acquired?
- What was the cumulative effect of parallax in your graph of motion?
- What type of trendline should you use for the horizontal motion? Vertical?
- What was the initial velocity of the football?
- How far would the football have traveled before it hit the ground? What was its "range"?
- How long did the football stay in the air?
- What was the initial angle of the kick?

Prepare a technical memo that addresses the above questions and submit it to your boss.

"Post-Flight" Extensions:

- *To what other games could you apply what you learned about the flight of the football?*
- *How could you explain projectile motion to your little brother?*
- *What effect do you think the mass and shape of the football have on its trajectory? How could you design an experiment that would test your theories?*
- *What factors could improve the predictability of the flight of the football?*