Lab Group_________Names________________________________DATE__________

Visual Physics Lab Project 3

Prompt:

You are a product research engineer at the Gig'em Toy Company (GETCo) and assigned to a team performing tests for 3 new product lines. Your tasks are: (i) calibrations of a force testing equipment for the new "Reveille and Friends" stuffed memorabilia collection, so that they meet the strict safety regulation for toddlers' toys required by National Agency for Safety at Texas (NAST); (ii) evaluation of a design of the "Giga-Launcher" for possible flaws and overall feasibility issues; (iii) testing the braking system for the "Street Slider" downhill racer in which you will need to calculate the coefficient of friction for the proposed materials and determine what influence surface area of contact has on this coefficient. When you are finished you will need to write a technical memo (TM) only for one of three experimental procedures. Your TA will assign it to you at the end of the laboratory work.

Objectives:

The purpose of these experiments is to evaluate the vector nature of forces and Newton's 2nd law of motion using Free-Body diagram. We will also see how frictional forces affect the acceleration in one-dimensional motion of an object.

Expectations:

You are expected to have read Chapter 4 & 5 from Young & Freedman's University Physics before coming to this lab. You must understand Newton's laws of motion, know how to draw free body diagrams, and understand how to evaluate surface-to-surface frictional forces. You will also need to have completed your 1st and 2nd lab assignments and understand how to incorporate error into your analysis. You should also know what affect camera positioning has on your data and be able to select the proper camera angle on your own.

Experiment 1

EXPLORATION

This series of activities is intended to produce a clear trail of documentation for the force-testing procedures at GETCo. Your team protested loudly that a cheesy little setup consisting of a pegboard, spring gauges, and a set of brass weights was not adequate equipment for employees of your outstanding caliber. What you really needed was a state-of-the-art, computer controlled, multi-axis universal tester. Your boss forcefully informed you that (a) this was the equipment you will use, (b) back in her day they launched plenty of products with this exact equipment – so she knows it works just fine, and (c) if this project is delayed because your team spent too much time griping about old equipment, there will be a new team of employees (replacing you) who don't have a problem with pegboards.

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“Preflight” Questions:

- Sketch and explain how the little spring gauges work.
- How does gravity impact the gauges?
- What do we mean by *balanced* force?
- Is tension different?
- How is force vector used to measure?

Set Up

1. First verify that the spring gauges work correctly.
    a. Hold the top of the spring gauge so that the gauge hangs vertically.
    b. Read the note on the spring gauge – the scale slides to set the 0-gram reading. Set the sliding scale to read 0g.
    c. Measure the distance between 100g marks with a ruler. Note this in your lab notebook. Also measure (and record) the length of the whole spring gauge (from the top of the top hook to the bottom of the bottom hook), and the inner diameter of the washer.
    d. Add masses of 100g, 200g, and 400g to the spring gauge (note that you can hang one mass under another). Verify that the gauge reads within 10g of the actual mass. If it does not, contact your TA and see if a replacement gauge is available.
    e. Repeat a-c for the other two spring gauges.
2. Now you will calibrate the gauges for the intended use.
    a. Lay the pegboard flat on the table (so that the holes are perpendicular to the plane of the table).
    b. Mount a pulley along one edge of the pegboard so that a string moving on the pulley will travel perpendicular to the edge.
    c. Insert a hook in the pegboard on the side opposite the pulley. It helps if the hook is lined up with the pulley!
    d. Attach the top of a spring gauge to the hook.
    e. Use a piece of string to hang a 100g weight over the pulley to the bottom of the spring gauge. You might have to slightly support the end of the gauge to make a smooth line from the hook to the pulley. Read the scale: Does it still read 100g? What changed?
    f. Keep the scale at the same angle and remove the weight. Repeat 1(b) to set the 0g reading at this angle.
    g. Reattach the 100g mass to the string. Does it read correctly now?
    h. Repeat e-g for the other two spring gauges.
3. You have verified that your spring gauges work correctly and have properly calibrated them for your experiments. Now you need to do a quick verification that your pegboard-and-hooks setup actually yields physically correct results: You have heard many times “for every force there is an equal and opposite reaction”. This is what you will test now.
    a. Insert two hooks in the pegboard.
    b. Attach the top hooks of two spring gauges to the hooks.

c. Attach the bottom hooks of the gauges to the washer. DO NOT OVERSTRETCH THE SPRING GAUGES! If you need to adjust the positions of the hooks, do it.
d. Record the force values of the gauges in your lab notebook. Are they equal?
e. What is the angle between both the gauges?
f. Repeat a-e twice, moving both hooks each time.

QUESTIONS:

- From your data, how could you derive the *actual* angle between the forces?
- How does that compare with the *theoretical* angle between the forces?
- Did the gauges stretch equally? Why or Why not?
- How could you reconcile your data with the fundamental laws of force and motion?

4. Having convinced yourself that all is well with your setup, you can use it with confidence to measure the three-force setup needed for the safety memo.
   a. Arrange three hooks on the pegboard.
   b. Attach the top hooks of the spring gauges to the hooks.
   c. Attach the bottom hooks of the gauges to the washer. DO NOT OVERSTRETCH THE SPRING GAUGES! If you need to adjust the positions of the hooks, do it.
   d. Take a picture (1 sec video) of the gauges, and record the force values in your lab notebook.
   e. Use LabApp to collect the three top positions of gauge-hook and the center of the washer.
   f. Repeat a-e twice, moving all three hooks each time.

In your memo, you will need to compare these data with theory. During the initial calibration, you collected all the data needed to predict the gauge readings for any given configuration of the gauges.

Summarize the analysis of this experiment by graphing your experimental data in a meaningful way against the theoretical results, and providing <u>plausible</u> explanations for any systematic errors.

QUESTIONS:

- From your data, how could you derive the *actual* angle between the forces?
- How does that compare with the *theoretical* angle between the forces?

Prepare technical memo that addresses the above questions and submit it to the legal department.

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Experiment 2

EXPLORATION

Below is an excerpt from the marketing memo introducing this new toy the "*Giga Launcher*". Consider the design (from the diagram in Figure 1) and think about how this device should work.

> *"Gig' em's new mini-football launcher will let kids practice their skills at running short patterns and catching a pass without inconveniencing their parents or requiring them to have any team mates. This new toy throws the perfect pass every time. Just set the angle and the height of the pulling mass, then pull the pin and run your pattern. Kids will be able to change the settings to get the perfect pass for each pattern and practice it over and over until they get it perfect."*

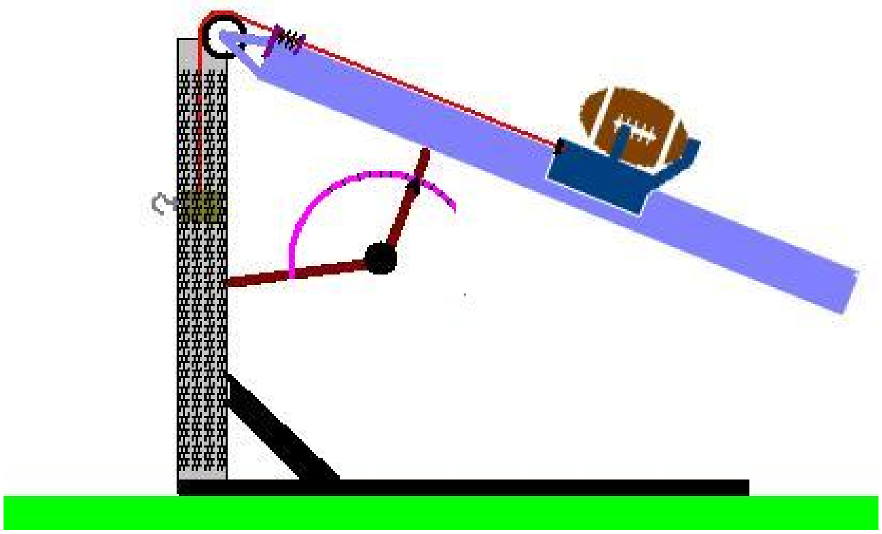

Figure 1: Diagram of Football Launcher as imagined by its inventor Joe Brinkley.

"Preflight" Questions

- What factors will affect the trajectory of the football at the time it is launched?
- What factors are important to consider in calculating the time it takes the football to launch after the mass is dropped?
- Is the length of the track a factor? How?
- In what way is mass a factor in making this work?

Set up

You will be using the air track and with a hanging mass (attached by a string) to emulate the design of the Giga-Launcher's geometry. You will use several different masses and a couple of different angles to test the concepts of the Giga-Launcher

1. First perform the experiment with the track level.
    a. Level the air track.

   b. Cut a piece of string the length of the air track.
   c. Attach the string to the car on one end and make a loop at the other end so that you can hang masses as needed.
   d. Setup your camera so that you can capture the motion of the cart.
   e. Loop the string over the pulley at the end of your track and hang an appropriate mass from the string. (Make sure you put something “soft” on the floor below so that you don’t damage the mass or the floor when it drops.)
   f. Using the camera and video capture software record the motion of the cart as the mass is dropped.
   g. Repeat steps e. and f. for a couple of other masses (use your judgement to determine which masses should be used.)
2. Perform the experiment for an angle close to the one in the diagram.
   a. Put a box under the end of the track that has the pulley so that the angle is appropriate to your needs.
   b. Setup your camera so that you can capture the motion of the cart.
   c. By measuring the height of each of the ends of the track determine the angle of inclination. (Make sure you annotate error.)
   d. Loop the string over the pulley at the end of your track and hang an appropriate mass from the string. (Make sure you put something “soft” on the floor below so that you don’t damage the mass or the floor when it drops.)
   e. Using the camera and video capture software record the motion of the cart as the mass is dropped.
   f. Repeat steps d. and e. for a couple of other masses (use your judgement to determine which masses should be used.)

QUESTIONS

- What is the relationship between the mass and the acceleration of the cart when the track is level?
- What effect does the incline have on the acceleration?
- How long does the track need to be for it to work with a 20-yard pass?
- How much mass (as compared with the mass of football and cart) should be used for this 20-yard pass?
- What angle would be appropriate?
- How many seconds will the child have to run out for this 20-yard pass?
- What are the advantages (disadvantages) to making the track longer (shorter)?

Prepare an techinical memo that addresses the above questions and submit it to the legal department.

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Experiment 3

EXPLORATION

"Preflight" Questions

- What is coefficient of friction?
- Can it be more than one?
- Does this depend on surface area?

Set Up

In this experiment you will be measuring frictional forces by looking at acceleration. You will need a metal track, a clamp on pulley, hanging mass set [in blue box], some string and 2 wooden blocks. (Ask your TA where to find the necessary equipment)

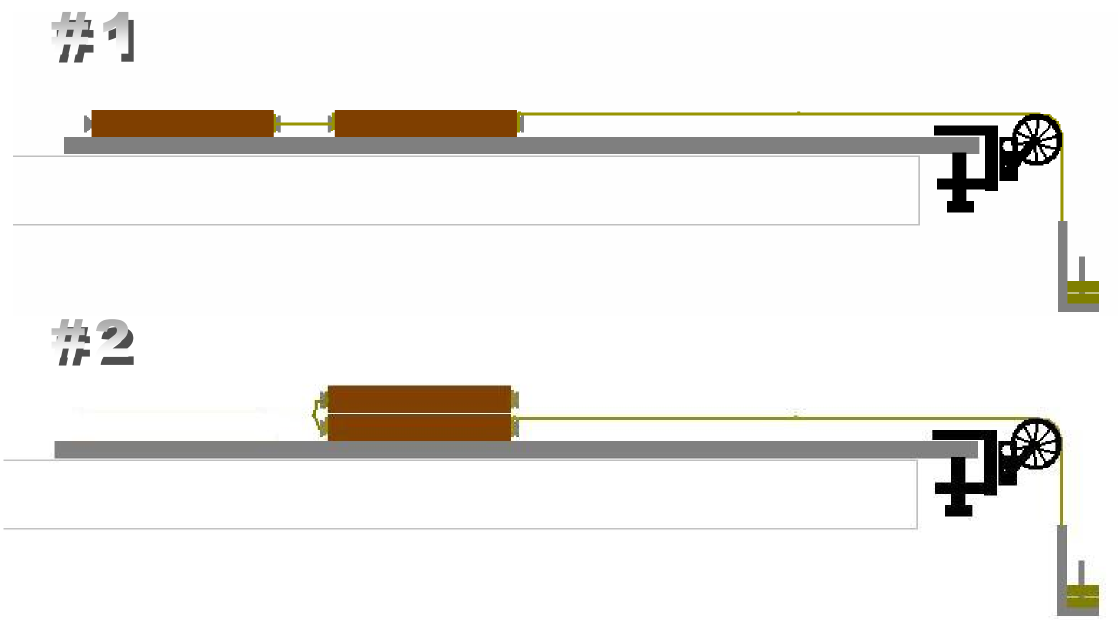

Figure 2: experimental arrangement for measuring coefficient of friction. #1 has both blocks in contact with the metal track and #2 has the blocks stacked on top of each other.

1. Put the metal track at the end of your workstation and attach the pulley as shown in Figure 2.
2. Find the mass of the two blocks of wood, the string and the weight hanger.
3. Use some string to attach the two blocks together and then use another piece of string to connect the blocks to the weight hanger.
4. Measure the maximum force of static friction for arrangement #1 from Figure 2.
    a. To measure static friction, hold the blocks in place and add mass to the hanger.

   b. After you have added mass release the blocks and see if they start to move.
   c. Repeat this process until you find the minimum mass that moves the blocks.
5. Measure the maximum force of static friction for arrangement #2 from Figure 2.
6. Measure the maximum force of static friction for arrangement #2 from Figure 2 with the blocks switched.
7. Orient your camera so that you can capture the motion of the blocks as they move.
8. Put a mass on the hanger close to that associated with the maximum force of static friction.
9. Capture the motion as the blocks accelerate along the track.
10. Repeat 9 for each of the arrangements.

QUESTIONS

- What is the force of static friction for each of the situations above?
- What acceleration would you expect if there were no friction?
- What was the force of friction while the blocks were moving?
- What effect does surface-area have on the frictional force?
- What is the measured coefficient of friction for wood against metal?
- Should wear-in of the brake pad have an effect on the how much pressure is needed to slow down the “Street Slider”?

Prepare an technical memo that addresses the above questions and submit it to the legal department.

“Post-Flight” Extensions:

- For experiment one, how could the arrangement be changed to help you explain this experiment to a new student coming into physics for the first time?
- For experiment two, how could the arrangement improved to give optimum distance?
- For experiment three, why did you get the results you got? In light of this information why do you think dragster cars use wider tires?