CAR CRASH LAB – PORTFOLIO ANALYSIS

INSTRUCTIONS: *Complete both the theoretical and quantitative sections completely and individually (no part of this analysis should be done with a partner; failure to comply will result in a 0 for both parties and an academic fraud report):*

- ✓ *For every calculation, clearly show your work. This could include a list of the data used and a diagram. But it MUST include the equation used in variable form, all of your work, and the final answer with correct units.*
- ✓ *Be sure to answer all parts of the questions completely*
- ✓ *You must type all responses. For calculations, type using proper equation formatting. If work is illegible or messy, it will not be scored.*
- ✓ *You must submit your lab portfolio to TurnItIn.com*

TECHNICAL ANALYSIS OF CRUMPLE SYSTEM:

Report all of the following measurements (with appropriate units and significant figures):

a. Initial length of the crumple zone
b. Minimum length of the crumple zone
c. The distance the crumple zone crumpled (change in length)
d. Mass of your wooden car base
e. Mass of your attached components (car body)
f. Mass of both of your eggs
g. Total mass of your car body, base, and eggs
h. Distance the car rolled down track
i. Angle of the incline track (only given value)

THEORETICAL (IDEALIZED) DATA ANALYSIS

Do the following problems based on our unit 5 equations only. You may use measurements from the technical analysis, but not data from the LoggerPro data files.

1. How much ***potential energy*** did your car begin with? Be sure to show how you calculated the vertical distance your car "fell."
2. Calculate how ***fast***, theoretically, your car was traveling the instant before it hit the brick wall (ignoring friction).
   a. ***Explain*** whether or not this is an accurate assumption (i.e. - was the true velocity faster or slower than what you calculated).
3. Using the velocity you calculated in #2, how much ***momentum*** did your car have the instant before it hit the wall?
   a. Without a crumple zone at all, the car would slam into the brick wall and stop practically instantaneously.
      i. Assuming that the time involved in stopping the car was 0.001 seconds, what would the size of the ***stopping force*** acting on the car be?
      ii. ***Explain*** how (conceptually) the crumple zone should help the passenger and driver survive a crash?

4. Calculate the following information regarding the crash specifications of your car:
    a. How much ***work*** was done to bring your car to a stop? How do you know? *(Hint: think about work energy theorem)*
    b. The crumple zone of your car should have reduced the force acting on the car significantly. Calculate the size of the average ***force*** that stopped your car based on the crumple zone data you collected in class.
    c. Suppose the crumple zone compressed the entire 10.0 cm you were allowed in front of the wood base. This would give you a theoretical minimum force to bring the car to a stop because the stopping distance would be maximized.
        i. Calculate this ***theoretical minimum average force***
        ii. Now ***compare*** the minimum force to the experimental force (#4b) your car experienced.
5. According to the impulse-momentum theorem and your calculated experimental force (#4b) and momentum (#3), approximately how much ***time*** did it take to bring your car to a stop?
    a. Does this seem reasonable? ***Explain*** your reasoning.
6. <u>Suppose your car bounced</u> (whether it really did or not). How would that affect the force the car experienced upon impact? ***Explain*** your reasoning.
7. Some of the cars in the class had <u>different masses</u>, depending on how they were designed. This should not have affected the velocity of each car when they hit the wall. How do you think this mass difference DID affect the results of the collisions? ***Explain*** your reasoning.

REAL-TIME SENSOR DATA ANALYSIS:

Do the following problems based on the actual impulse and velocity data that was gathered in class during your official car crash test. (Again be sure to type up all answers)

8. How much ***momentum*** did your car have at the instant before it hit the barrier?
    - <u>REMEMBER: download 2 files of data</u> for your experiment from the public server "Ciustea–Physics" folder: VELOCITY data and IMPULSE data.
    - <u>Open the velocity data file in Logger Pro</u>. To get the velocity of the car at the bottom of the ramp look at your velocity time graph and use the maximum velocity (not position) value.
        - To do this, highlight the first peak on the velocity graph by clicking and dragging over it. Go to the "Analyze" menu at the top of the screen and select "Statistics." This will give you the maximum value in your selected range.
9. How much ***impulse*** would it require to stop your car at the bottom of the ramp?

    (Hint: consider impulse-momentum theorem and assume your car comes to rest at the bottom)
10. Calculate the ***average force*** required to stop your car using your answer from #9 and the impulse-momentum theorem.
    - *Hint: You can find change in time by highlighting the <u>impulse graph</u> during the peak. In the bottom left corner it will list a value for Δt.*
11. Looking at the <u>LoggerPro file for impulse</u>, you should see a graph of the actual impulse measured by the force plate sampling at 1000 samples per second. As you can see, the force

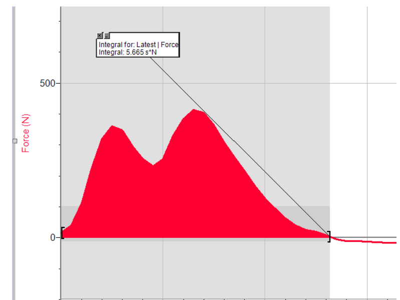
doesn't stay constant during the collision rather it reaches maximum value(s) as part of your crumple zone buckles. You can find the maximum value the same way you found the maximum velocity in #8.

a. What is the ***maximum force*** exerted between the crashing car and the barrier?

b. How does this ***compare*** to the average force required in the last question?

12. Using your LoggerPro impulse data, highlight the entire graph that is above the *x*-axis. You need to find the area under the curve *(remember the area under a curve represents the y-axis value multiplied by the x-axis value).*

The term used to describe the area under a curve is called the integral. To find the integral you need to *(after highlighting the graph)* go to the analyze menu and click "integral". The area being measured should turn red and Logger Pro will report a value for you to use *(see example on the right).* Notice the units reported to you as well. This area represents the total impulse the plate applied to the crashing car.



Example force-time graph from crash

a. What was your ***total impulse*** according to your graph?

b. How does this measured value ***compare*** to the value you calculated in #9.

(*The answer for #9 is your theoretical value and the answer to this question is your experimental value. Do a percentage error calculation to give you real numbers for your discussion.)*

$$\%\ \boldsymbol{Error} = \left|\frac{\boldsymbol{Theoretical\ Value - Experimental\ Value}}{\boldsymbol{Theoretical\ Value}}\right| \times \mathbf{100}\%$$

13. What does the ***shape of your impulse graph*** tell you about your crumple zone?

14. ***Do you consider your car design to be a success?*** Why or why not? Be sure to reflect on the purpose/objective for the project that was stated in the original project handout.

15. ***What kind of recommendations would you make to classmates*** (which could even include yourself) in general to help the cars succeed if we were to do this again at a higher angle? Explain your reasoning.