**Research questions**

* + - 1. What is a crumple zone? Describe how auto-makers design their cars so that there is a crumple zone.
      2. What standards does the insurance institute for highway safety use when they determine “safety ratings” for passenger vehicles?
      3. Describe the details of how seatbelts work and are useful in a car crash.
      4. How do airbags work, and how do they add to the safety of passengers in a car crash?
      5. What kinds of things must you consider when designing your car? You should use the words **force** | **time** | **change in...** | **momentum** and any other words from physics you need to answer this question.

**Construction Time Log**

|  |  |  |
| --- | --- | --- |
| Date | Work hours | Description of the task/work completed |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

* Does my time log include the dates of the work days?
* Does my time log include the number of hours for each session the car was worked on?
* Does my time log include a total time I spent constructing the car?
* Is each entry detailed and specific as to what I completed during each work session?

**Scaled Test #1**

|  |  |
| --- | --- |
| **Date:** | **Notes on Test Conditions:** |
| **Time:** |
| **Location:** | **Results of Test:** |
| **System Being Tested:** |
| **Members Present for Test:** |

**Refinement Cycle #1**

|  |  |
| --- | --- |
| **Date:** | **Summary of Refinement Performed:** |
| **Location:** |
| **System Being Refined:** | **Sketch or description of System Post-Refinement:** |
| **Person(s) Performing Refinement:** |
| **Evidence Used for Refinement:** |

**Technical Analysis** *(½ point each)*

* Do my measurements include the proper level of precision?
* Did I include a measurement with units for each of the following?
  + Initial length of crumple zone
  + Final length of crumple zone
  + Change in length of crumple zone
  + Mass of your car base
  + Mass of attached car body
  + Mass of both of your eggs
  + Total mass of car body, base, and eggs
  + Distance the car rolled down track
  + Angle of the incline track

**Theoretical (Idealized) Analysis** *(1 point each)*

* #1 Potential Energy
* #2 Final Velocity
* #2a + explanation for whether or not this is an accurate assumption
* #3 Final Momentum
* #3ai Impact Force
* #3aii + explanation of the importance of a crumple zone
* #4a Work done to stop the car
* #4b Average stopping force
* #4ci Minimum stopping force
* #4cii + comparison of the forces in 4b and 4c
* #5 Time to stop
* #5a + explanation for whether or not this is a reasonable result
* #6 Correct answer for how the impact force would be impacted by bouncing + explanation
* #7 Correct answer for how mass affected the passengers in the collision + explanation

**Quantitative (Real-Time) Data Analysis** *(1 point each)*

* #8 Final momentum
* #9 Impulse at the bottom of the ramp
* #10 Stopping force
* #11a Value for maximum impact force – from LoggerPro
* #11b Comparison of the forces in #10 and #11
* #12a Value for total impulse – from LoggerPro
* #12b Percent error
* #13 Discussion about the shape of graph and my crumple zone
* #14 Discussion/reflection about car design
* #15 Recommendations for future physics students with a higher angle