 **Burning Rubber** 

**Purpose:** Along with your group members, the purpose of this challenge is to design a car powered by 3 elastic bands that will successfully complete the Physics Pentathlon. The successful group will consider all of Newton’s Laws…may the Force be with you!

**Design Procedure**: You will work in groups of 2 or 3. You will produce a draft of your car by: \_\_\_\_\_\_\_\_\_\_\_that will be peer assessed in class before you begin to build. With your approved draft you will have one class to work in Mr. Henning’s room (luck you!) You will have one class for trials and then one class (maybe 2) for the Physics Pentathlon!

**Materials:** You have full creative freedom! You also have access to the amazing Mr. Henning if you are looking for materials/equipment you can’t find at home or if you have building questions. On the day of the pentathlon, you will also be provided with 3 elastic bands. You will use the same three school issued elastic bands for all events. You may not use any prefabricated materials in your build (i.e. building a cart from a kit).

**Event #1:** Flat Distance. The objective is for you to maximize he distance your car can travel on a flat course

**Event #2:** Up an Incline. The objective is for your car to climb the steepest incline for a distance of 0.5 metres.

**Event #3:** Tractor Pull. The objective is for your car to pull the largest mass for 1.0 metres.

**Event #4**: Bowling. The objective is for your cart to knock over all of the target pins.

**Event #5**: Flat Speed. The objective is for your car to have the fastest time in on a flat 5.0 meter course.

There will be a winning car for each of the 5 categories as well as an overall winner determined on the level of achievement in all five events. How your car does in each category will be assessed with the following scale:

|  |  |  |  |
| --- | --- | --- | --- |
| Beginning | Developing | Accomplished | Exemplary |
| Does not demonstrate a basic understanding of concept. Substantial errors throughout. | Basic understanding of concepts. Errors and inconsistency reveal some missing understanding of the concepts | Solid understanding of concepts. Most answers are correct with only a few errors. | Complete and in depth understanding of concepts. |

**Data:** (page 2)

**Analysis:** Graph the relationship between mass (on the y axis) and acceleration (on the x axis) for Event #1 and Event #3. Use the same graph.

**Discussion Questions:**

1. Find the coefficient of Friction between the tires of your cart and the floor in Event #1*.*

 *Hint: use a force meter to pull your cart at a constant velocity to find Ff.*

1. Draw the FBD of your cart in Event #2
2. Find the force exerted by your cart in Event #3. *Hint: use your graph*
3. If you increased the speed that the car hit the target pins, what would you predict would happen to the pins? Explain your answer using physics.
4. How does the friction between the tires of your car and the floor affect the speed of the car?

**Conclusion:** See the attached rubric

**Mass of cart:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Data:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Distance (m) | Time (s) | Acceleration (m/s2)d=v0t + ½ at2 |
| Event #1 – distance |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
|  | Trial #1 incline (degrees) | Trial #2 incline (degrees) | Trial #3 incline (degrees) |
| Event #2 - incline |  |  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Distance (m) | Time (s) | Acceleration (m/s2)d=v0t + ½ at2 | Maximum mass |
| Event #3 – tractor pull |  |  |  |  |

|  |  |
| --- | --- |
|  | Number of targets knocked down |
| Event #4 – bowling |  |

|  |  |  |  |
| --- | --- | --- | --- |
|  | Distance (meters) | Time (seconds) | Average Speed |
| Event #5 – speed |  |  |  |

**Calculations:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Beginning** | **Developing** | **Accomplished** | **Exemplary** |
| Draft | o diagram is not drawn to scaleo no dimensions are labelledo no materials are identifiedo drawing is confusing and/or incomplete | o diagram is not drawn to scaleo some dimensions are labelledo some materials are identifiedo drawing is confusing and/or incomplete | o most diagram is drawn to scaleo most dimensions are labelledo most materials are identifiedo drawing is clear and complete | o entire diagram is drawn to scaleo all dimensions are labelledo all materials are identifiedo drawing is clear and complete |
| Data | o Original data missingo Tables are missing headings/units  | o Data complete but messy o Tables not organized/neat o All table headings include ***most*** units | o All tables are neatly prepared o All table headings include proper unitso Data is clear and complete | o All tables are neatly prepared ***with a ruler*** o All table headings include proper unitso Data is clear and complete |
| Calculations | o Major calculations are missing o It is difficult/impossible to follow calculation progression  | o Calculations are ***somewhat*** ordered in a step-wise fashion o ***Some*** calculations are easy to follow as they move from solving one variable to the nexto ***Some*** calculations includes a statement of understanding: (Fnet = Fg1-Ff) | o Calculations are ***mostly*** ordered in a step-wise fashion o ***Most*** calculations are easy to follow as they move from solving one variable to the nexto ***Most*** calculations includes a statement of understanding: (Fnet = Fg1-Ff) | o Calculations are ordered in a step-wise fashion o ***All*** calculations are easy to follow as they move from solving one variable to the nexto ***All*** calculations includes a statement of understanding: (Fnet = Fg1-Ff) |
| Graphs | o ***No*** title o ***No*** ruler used for axis/line o ***No*** axis labels o Scale increments intervals unequal /incorrect o Many data plots missing/incorrect o ***No*** line or curve  | o Title does not follow “Y vs. X” or improper placement of independent (X) and dependent (Y) variables o Axis not drawn with ruler, labelled with measurement and unitso A few errors in uniformity of scale o A few data plots are unclear/ incorrect o Line/curve not best fit  | o Title follows “Y vs. X”, without description of process being analyzed o Axis drawn with ruler and labelled with measurement and unitso Uniform scale that includes origin but does not use space effectively o Line of best fit “forced” through origin | o Title follows “Y vs. X”, and includes description of process being analyzed o Proper placement of independent (X) and dependent (Y) variables o Axis drawn with ruler (or on computer) and labelled with measurement and units o Uniform scale that includes origin and uses space effectively o Line/curve of best fit represent data plots  |
| Discussion (completed after the lab) | --Fragments or point form-Does not demonstrate a **basic understanding** of concept. Substantial errors throughout | -Sentence structure lacking or confusing-Demonstrates a basic understanding of concepts. Errors and inconsistency reveal some missing understanding of the concepts. | -Full sentences, well structured-Demonstrates a solid understanding of concepts. Most answers are correct with only a few errors. | -Full sentences, well structured-Demonstrates complete and in depth understanding of concepts. |
| Conclusion (completed after the lab) | - Point form - only 1 or 2 pieces of criteria are covered but not thorough- Personal opinions are included “I like this lab” or, “This lab was FUN!” | - Sentence structure lacking - 3 or 4 pieces of criteria are missing or incomplete | - Full Sentences, well structured- 1 or 2 pieces of criteria are missing or incomplete | - Full Sentences, well-structured and thorough/detailedAll criteria listed below must be included:- Answers purpose - summary of results and what they mean - Interesting Findings- States sources of error- Connects results to big picture (relevance)- Asks new questions-Suggests improvement to this lab |