|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Name: | **[insert name]** | Period: | **[insert Period]** | Date: | **[insert date]** |

Football in the Lab

# Background

Scientists can learn about concussions by replicating the hits in a game in a lab setting. While not as accurate as real time data, these types of experiments can be used as starting points in understanding the effect of large impact forces on concussions.

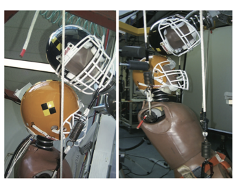
To understand how acceleration of a hit affects force we will use Newton’s 2nd Law. Newton’s 2nd Law states that the force of an impact is proportional to its mass and acceleration.

It can be represented by the formula: F=ma. Using this relationship, we can see the relationship of acceleration and force in causing concussions.

# Real World Data

## Experimental Set-Up

Doctors David Viano and Elliot Pellman were part of the Mild Traumatic Brain Injury Committee with the National Football League (NFL) and were working to understand how and why concussions are occurring in football. They were given documented concussion diagnoses and the video footage from the game when the concussion occurred. They took this information to reconstruct the hits with dummies as seen in the photo below.



## Data Analysis

The force of each impact was measured, and data was compared between collisions that caused concussions, referred to as mild traumatic brain injury (MTBI), and those that did not. The results of the test are provided below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Case no.** | **MBTI?** | **Impact Velocity (m/s)** | **Acceleration (g)** | **Impact Force (N)** |
| 7 | YES | 6.9 | 50 | 6030 |
| 9 | YES | 10.3 | 79 | 11680 |
| 38 | YES | 9.5 | 60 | 9776 |
| 39 | YES | 10.9 | 44 | 7889 |
| 48 | NO | 9.7 | 32 | 4108 |
| 57 | YES | 8.8 | 32 | 5333 |
| 59 | NO | 5.3 | 32 | 4913 |
| 69 | YES | 10.3 | 38 | 4796 |
| 71 | YES | 10.3 | 102 | 8258 |
| 77 | YES | 9.9 | 35 | 5612 |
| 154 | NO | 6.6 | 29 | 3774 |
| 155 | YES | 9.1 | 45 | 6247 |
| 157 | YES | 10.8 | 79 | 9568 |
| 175 | NO | 9.6 | 47 | 5011 |
| 182 | NO | 8.1 | 87 | 8239 |

1. Use the data above to create a scatter plot that shows the relationship between the acceleration and the impact force. Use the graph included in the table below and add your points using Google Drawing. Estimate a line of best fit on your graph and mark it with a red line.

|  |  |
| --- | --- |
| **Your Graph** | |
|  | |
| **Question/ Prompt** | **Your Response** |
| As acceleration increases, force\_\_\_\_\_\_\_\_. |  |
| How is this relationship between force and acceleration demonstrated in Newton’s second law? |  |

1. In the table below, create a bar graph that compares the average force of impact between collisions that led to a concussion and ones that did not.

|  |  |
| --- | --- |
| **Your Graph** | |
|  | |
| **Question/ Prompt** | **Your Response** |
| How does the average force of the collision affect whether or not a concussion occurred? |  |
| Based on this evidence, what will be the criteria you will need to meet to develop a helmet that will be able to withstand an impact without leading to a concussion? |  |

Reference:

Viano, David and Pellman, Elliot. C*ONCUSSION IN PROFESSIONAL FOOTBALL: BIOMECHANICS OF THE STRIKING PLAYER—PART 8*. Neurosurgery, Vol 56. No2, February 2005 pp 266-280