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Analytical Task Assignment

This assignment talks about the linear acceleration calculation of the smart helmet project. Safety is one of the most important customer needs in the smart helmet project. Thus, calculating the linear acceleration will help in increasing the safety of this design. Knowing the input and output acceleration of the linear acceleration will help the team to recognize the g force required of this design. In more detail, If the team identifies the g forces data from the accelerometer then the forces of the player can be calculated as well.

```
x: 1 4191 y: 302 z:  286
x: 1 3941 y: 209 z:  242
x: 1 3661 y: 226 z:  254
x: 1 3821 y: 274 z:  290
x: 1 3821 y: 248 z:  219
x: 1 2991 y: 299 z:  286
x: 1 3941 y: 389 z:  374
x: 1 4541 y: 301 z:  329
x: 1 3391 y: 218 z:  206
x: 1 3191 y: 295 z:  348
x: 1 4151 y: 352 z:  360
x: 1 3651 y: 265 z:  220
x: 1 3131 y: 297 z:  327
x: 1 4481 y: 309 z:  363
x: 1 3581 y: 231 z:  186
x: 1 3131 y: 277 z:  312
x: 1 3421 y: 269 z:  296
x: 1 3591 y: 317 z:  250
x: 1 3611 y: 338 z:  269
x: 1 3641 y: 332 z:  267
x: 1 3651 y: 327 z:  267
x: 1 3641 y: 327 z:  267
x: 1 3651 y: 327 z:  267
x: 1 3651 y: 327 z:  268
x: 1 3651 y: 327 z:  267
x: 1 3651 y: 327 z:  267
x: 1 3651 y: 327 z:  267
```

**Figure 1:** Linear acceleration in the x, y, and z direction

Figure 1 explains the linear acceleration in the x, y, and z direction. The team calculated this linear acceleration data output from the Accelerometer in the Arduino. With using this linear acceleration data, the team will be able to increase the safety of the smart helmet. In more explanation, the team will increase the safety of this design by knowing the acceleration of the helmet. In another word, the tam will figure out the force of the player from using this linear acceleration data. This engineering characteristic will help the team to identify the required g force of this design.

Arduino_output_

```
//www.elegoo.com
//2016.06.13

int x, y, z;
int a1 = 1;
int a2 = 3;
int a3 = 5;
void setup()
{
  pinMode(1,INPUT);
  pinMode(3,INPUT);
  pinMode(5,INPUT);
  Serial.begin(9600);
}
void loop()
{
  x = analogRead(1);
  y = analogRead(3);
  z = analogRead(5);
  Serial.print("x: 1 ");
  Serial.print(x, DEC);
  Serial.print("1 ");
 Serial.print("y: ");
  Serial.print(y);
 Serial.print(" z:  ");
  Serial.println(z, DEC);
  delay(500);
}
```

**Figure 2:** The Arduino output codes that creates the linear acceleration data

Figure 2 explains the Arduino output codes. Valid setup is where the team write the codes that goes only one time. On the other hand, the valid loop is a place where the team writes the codes that run again and again. The input of this codes was made in the pinMode code. This code helps identify what goes in or out the Arduino codes. However, analogRead is a code in Arduino helps to read the voltage input from the basic board in Arduino kit. Serial print codes is where the x, y, and z axes are printed in the linear acceleration data. The Approximated voltage range used in this code was between 0 to 5 volts.

$$mag(a) = \sqrt{(ax)^2 + (ay)^2 + (az)^\wedge 2} \quad (1)$$

ax= The linear acceleration in the x-direction
ay= The linear acceleration in the y-direction
az= the linear acceleration in the z-direction

Equation number one was used to find the magnitude of the linear acceleration in the x, y, and z direction. Since the linear acceleration data was made in x, y, and z direction, then magnitude of the linear acceleration will be used to approximated linear acceleration in all direction. This value will help the team to identify and figure out the force of the player. Since we don't know the exact velocity and the exact linear acceleration used in this project. Then, the team made approximated values of the linear acceleration in the x, y, and z direction from the linear acceleration data. Figure number 1 used to figure out the linear acceleration in the x, y, and z directions. The approximated values of the linear acceleration in the x, y, and z directions are $a_x$= 3651 m/s$^2$ , $a_y$= 327 m/s$^2$, and $a_z$= 267 m/s$^2$ from Figure 1.The linear acceleration is very high value. The team approximated this value by dividing the value of the linear acceleration in the x axis over 5. Because of the linear acceleration of the smart helmet should be less than 1228 m/s$^2$, then this assumption was made in the project. As a result, the linear acceleration in the x axis will equal to 730.2 m/s$^2$ . The magnitude of the linear acceleration can be solved by using equation (1).

$$mag(a) = \sqrt{(730.2)^2 + (327)^2 + (267)^\wedge 2} = 843.45\, m/s^\wedge 2$$

After the magnitude of the linear acceleration was determined, then Newton 's second low was applied to determine the smart helmet force caused by the players. Since the team did not create the helmet yet, the approximated mass of the helmet is about 1.36 kg. Next, equation two was applied to determine the force of helmet caused by the players.

$$F = ma \quad (2)$$

F= smart helmet force caused by the players
m= mass of the helmet
g= linear acceleration

$$F = (1.36)\times(843.45) = 1147.092\, N$$

This force will help in increasing the safety of the smart helmet. By knowing this force, the team can avoid the maximum performance of the force for the smart helmet design. Thus, with knowing the linear acceleration of the helmet, the team will increase the safety of this project by decreasing the force. In order to decrease the force of impact in the smart helmet design, the team should use another equation to determine the impulse of the smart helmet. Hence, impulse equation was applied to increase the safety of this design. The assumption made in this equation is the time of collision $\Delta t = 6\, second$. The reason of making this assumption is because the team don't know the exact time of impact because the team did not create the helmet yet. This equation can be used to find the momentum caused by the smart helmet

$$F\Delta t = m\Delta v \tag{3}$$

FΔt= The impulse of the helmet
mΔv= The change in momentum

$$m\Delta \mathrm{v} = (1147.092) \times (6) = 6682.552\ kgm/s$$

From equation (3), the team recognizes the relationship between the time and the force applied to the helmet. For example, when the force of the impact is reduced, the time of collision is increased. The team should increase the time of collision and decrease the force of impact to increase the safety of this project. However, knowing the momentum of this design help the team to know the performance of the smart helmet before and after the collision.

Without designing the smart helmet, the team will not be able to create the physical model. The physical model helps the team to pictures the design in more details. Those calculations and analysis will help the team to create the physical model in the future.

At the conclusion, the linear acceleration is important engineering characteristic for this design. The linear acceleration helps in figuring out the momentum, and the impulse of this design. The linear acceleration helps in finding the force of the smart helmet caused by the player. Many assumptions were made to find the momentum of this project. Those analysis will help visualize the physical model in the future.

**Referance:**


https://www.revzilla.com/motorcycle/speed-and-strength-ss1310-fast-forward-helmet
http://www.batesville.k12.in.us/physics/PhyNet/Mechanics/Momentum/ObjCh7Moment.html