AMP IT UP

Advanced Manufacturing & Prototyping Integrated to Unlock Potential

PHYSICAL SCIENCE

Data Visualization

RIDING THE CONCRETE WAVE
PART I

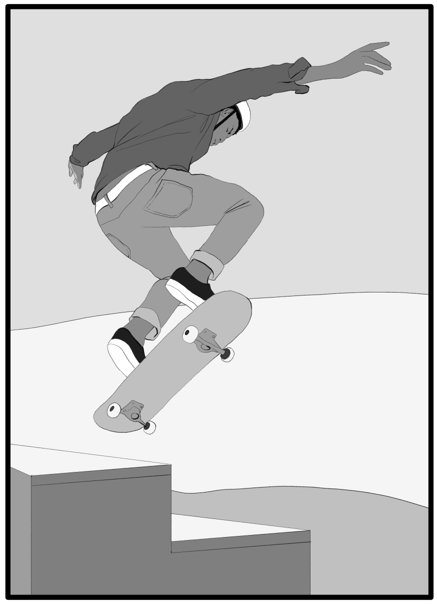
Helmet Challenge

Fall 2018

8DVS

SECTION 1 – THE HELMET CHALLENGE

1.1 INTRODUCTION



Many communities recognize that skateboarding is popular in their neighborhoods. These communities are building skate parks to give skateboarders a safe and exciting place to skate. If the skate park is well designed and challenging, skaters are not forced to use parking lots, streets, stairs, or railings to skate. They are also less likely to run into someone else and cause injury. Even professional skateboarders, like Alana Smith and Shaun White, frequently skate in skate parks.

Watch ***Alana and Shaun*** video #1.

While skateboarding is a very popular sport, it can be a dangerous one. In 2011, there were 42 deaths caused by skateboarding. Half of the people who died skateboarding were teenagers. All but one of those deaths happened on public streets and stairs, not in a skate park. Falling from a skateboard can cause everything from scrapes and cuts to broken bones and head injuries.

Watch ***Skater Mishaps*** video #2.

Many skaters wear helmets to protect their head, but some do not. Some skaters think that they are skilled enough that they do not need a helmet. They think if they fall, they would be able to avoid serious injury **because they believe that they are not going very fast**. These skaters only worry when they are going very fast or dropping-in from the highest heights. This way of thinking has many communities concerned. They want to have skate parks open, but they need to make sure everyone understands the real risks of skating, especially without a helmet.

YOUR CHALLENGE

SkateTech is a company that is dedicated to the sport of skateboarding. They work hard to inform skaters about gear and equipment through product tests and reviews. The people at SkateTech want to help the skate park communities. They want to make sure that kids especially have proper safety equipment to protect them during falls.

As you would imagine, SkateTech tests helmets to see how well they perform and protect. SkateTech believes that a good helmet needs to protect the head during both minor and major falls. Your team will work with SkateTech to use new technology to investigate helmet safety. This investigation will help SkateTech and the communities show skateboarders why they should wear a helmet.

1.2 INVESTIGATING THE PROTECTION HELMETS PROVIDE

SkateTech needs helmet test results to make recommendations about their safety. One way to collect that data on head injuries would be to study skateboarders at a skate park. They could have the skaters fall and then assess any head injury afterwards. While this certainly would be a direct test of helmets, this obviously is a bad idea. Forcing actual skaters to fall would be unethical, not to mention very dangerous.

Another option would be to use computer **simulations**, or “sims.” Sims are used to more safely test and research events that are dangerous. We use computer simulations in science to test earthquake damage, extreme weather events, and even car crashes. Instead of connecting skateboarders to wires and scientific equipment to test head injury, we can use a computer simulation. While sims are a good representation for real-life, there are not an equal substitute for actual phenomena or events. We can use a simulation to test the potential damage to your head during a fall while skating. Additionally, we can use the sim to test how different helmets could protect the head. The computer simulation is much safer and more controlled. A pumpkin will be used in the simulation to represent the skaters.

SkateTech has built a sim that mimics some of the movements that skaters experience at a skate park. It can provide data that shows what happens when a skater falls. The sim will allow us to measure certain aspects, like speed or impact, of a fall during a skater’s run.

KEY TERMS

Simulation: A representation of a real-life phenomenon or event that can test important aspects of that real-life phenomenon or event. Data or results from simulations can be used to generate predictions, explanations, and solutions.

In the next few activities, your class will use the sim to collect data about:

1. How does speed change as a skater rides through the skate park?
2. How will that speed affect the potential damage caused during a fall?

Part A: How does height affect maximum speed?

As a skateboarder rides through the skate park, they are constantly changing their height above the "floor" of the skate park. As a skater rides down a bigger hill in the skate park, it is fairly obvious that the skater's speed will increase. Let's figure out how exactly the height of various skate park hills would affect the speed using this simulated half pipe.

Sim Investigation #1:

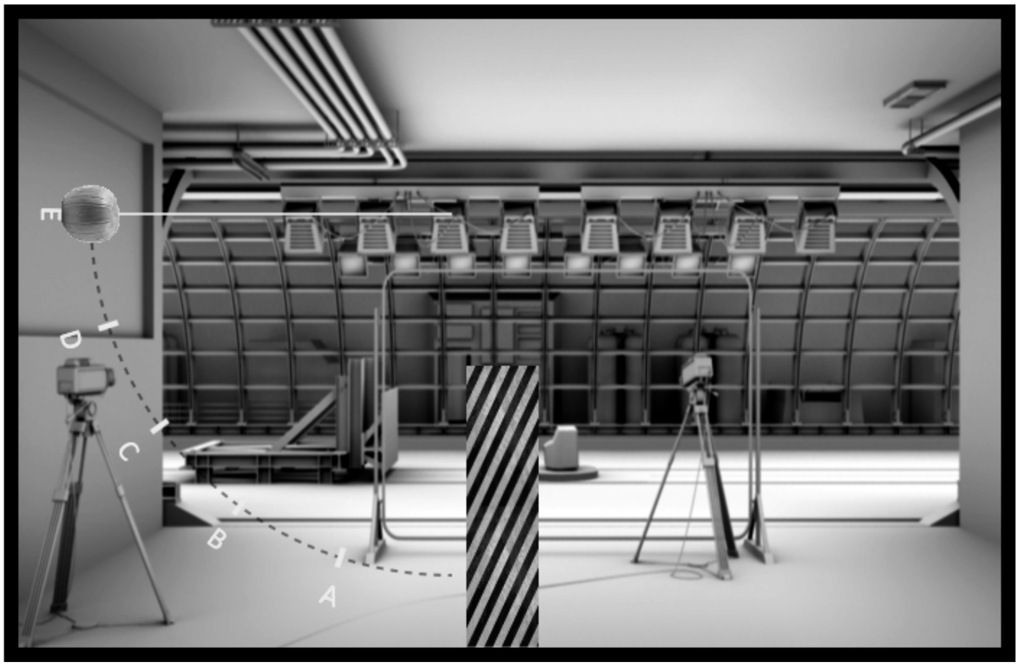
How does the starting position of the ramp affect the maximum speed of the skater coming down the ramp?

Procedure:

1. Record your results for Sim #1 in the table on the *Simulation Data, Section 1* student sheet.
2. Inside the simulation, click on "Skater Speed Check."
3. Start the skater at Position A.
4. Click "Begin the Simulation."
5. Record the skater's maximum speed for Position A.
6. Click "End the Simulation" to stop the simulation and move to the next position.
7. Repeat for Positions B, C, D, E.
8. Answer any questions listed on the sheet.

Part B: How does height affect potential head injury?

You have seen how speed changes with height. Now, let's look at how that height might affect the damage a skater's head might experience during a fall. In this simulation, we will use a pumpkin in place of a head. We will see how the pumpkin reacts when it hits a wall when released from different heights.



Sim Investigation #2:

How does the starting position of the pumpkin affect the amount that is destroyed when it collides with the wall?

Your teacher will provide you with the code to access the simulation.

Procedure:

1. Record your results for Sim #2 in the table on the *Simulation Data, Section 1* student sheet.
2. Inside the simulation, click on "Smashing Pumpkins."
3. Start the pumpkin at Position A.
4. Click "Begin the Simulation."
5. Record the percentage of pumpkin that was destroyed for Position A.
6. Click "End the Simulation" to stop the simulation and move to the next position.
7. Repeat for Positions B, C, D, E.
8. Answer any questions listed on the sheet

Part C: Reflect on the Simulation Investigations

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As a class, discuss your answers to the questions on the *Simulation Data, Section 1* student sheet:

1. What trend do you see when you compared height to maximum speed?

2. What trend do you see when you compared height to pumpkin damage?

3. What, in your opinion, is causing these trends? Why do you think we see these changes in speed and pumpkin damage as height increases?

4. Thinking about helmets, what thoughts have these two investigations provided? What impact do the results suggest about skaters worrying about speed?

SECTION 2 – ADD TO YOUR UNDERSTANDING

2.1 ENERGY BASICS

To better understand this challenge, we need to understand the role energy plays in skateboarding.

“Energy” is a word that gets used a lot in our society, and it has many meanings. You certainly have heard of the word energy, and you likely use it frequently:

“I have lots of energy today.”
“Turn out the lights to save energy.”
“My mom says our energy bill is too high and we need to conserve more.”

While each of these uses has meaning and can be important, we are going to focus on how scientists and engineers use the word energy. For the Helmet Challenge, we are going to look specifically at the energy of moving objects, like the pumpkin from our simulation.

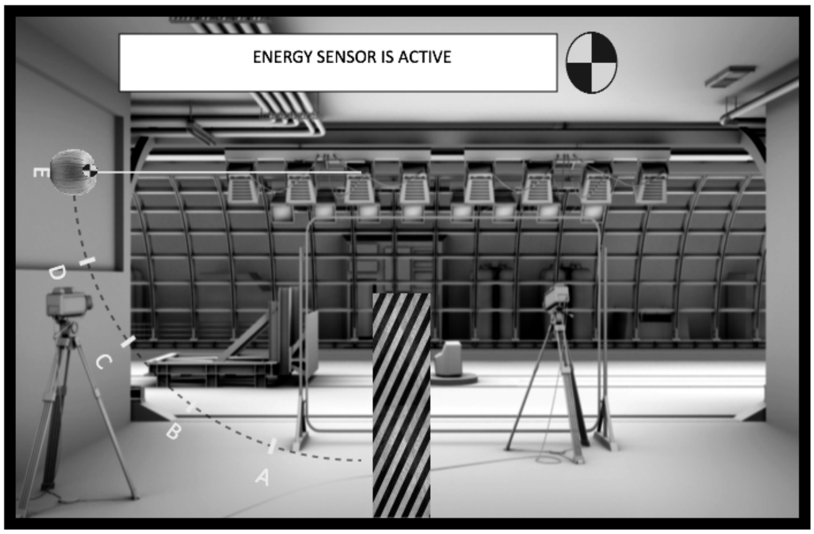
All moving things have energy: a ball thrown through the air, a car driving down the street, or even a piece of paper gently falling from a desktop to the floor. Any object that moves has energy. That “moving” energy is called **kinetic energy**. We measure energy is a unit call **Joules**. Joules measurements are determined by knowing the mass and speed of an object. For this challenge, skateboarders have energy when they move throughout the skate park. In the simulation, the skater had energy as a result of rolling down into the half pipe.

Earlier you investigated the damage to the pumpkin when it was dropped from several different positions (A, B, C, D, E). These differing amounts of damage are only a sign or indicator of how much kinetic energy the pumpkin had at impact. This is, however, not a measure of energy. Let’s return to the simulation and use it to measure the kinetic energy the pumpkin has at the various positions.

SECTION 3 – INVESTIGATE KINETIC ENERGY

3.1 HOW DOES HEIGHT AFFECT KINETIC ENERGY?

We need a way to measure the impact from the wall that is more scientific. In the next simulation we will attached a special sensor to the pumpkin that tells us how much **energy**, in Joules, the pumpkin actually has when it hits the wall.



Sim Investigation #3:

How does the starting position of the pumpkin affect its max kinetic energy as it falls?

Your teacher will provide you with the code to access the simulation.

Procedure:

1. Record your results for Sim #3 in the table on the *Simulation Data, Section 3* student sheet.
2. Inside the simulation, click on “Smashing with Sensor.”
3. Start the pumpkin at Position A.
4. Click “Begin the Simulation.”
5. Record the energy, in Joules, of the pumpkin as it hit the wall.
6. Click “End the Simulation” to stop the simulation and move to the next position.
7. Repeat for Positions B, C, D, E.
8. Answer any questions listed on the sheet.

Discuss this question as a class:

What trend do you see when you compared height to kinetic energy?

3.2 MORE ENERGY BASICS

When a moving object makes contact with another object, the moving object can transfer its kinetic energy to the other object. Sometimes that kinetic energy can cause great damage to the object that is hit. For example, a car traveling very fast into a parked car can cause the parked car a lot of damage. That is because the energy transferred to the parked car causes the car body to bend and crumple. But not all objects that are hit experience damage. If the speeding car hits a 4-foot thick concrete wall, the energy transfer does not damage the wall, but the moving car's body and parts sure do experience damage! Watch this video to get a better sense of energy being transferred from one object to another.

Watch ***Energy Transfer Examples*** video #3.

Discuss these questions as a class:

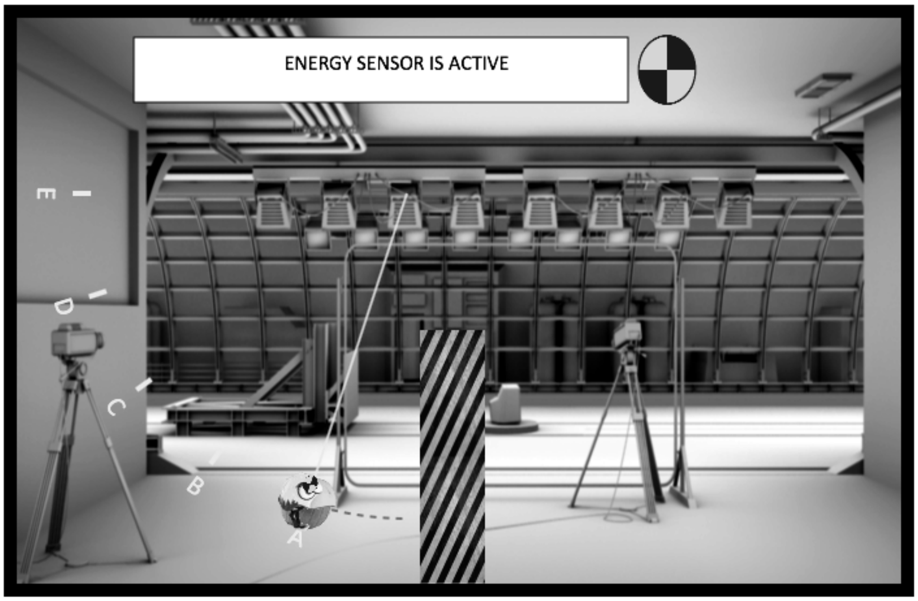
1. What did you observe in the videos about how energy was transferred?
2. Was the same amount of energy transferred in each video?
3. What do you think affected the amount of energy transferred?

Similar to the car example, when a skater falls, one can imagine how the kinetic energy of the skater is transferred to the floor or ground. But, there is no damage to the floor or ground in this case. Instead, the skater's body experiences all the force and trauma of the contact. When a skater does not wear a helmet, the kinetic energy of the skater can lead to a lot of injury to the skull and brain. In the next sim investigation, we will examine what happens to a *pumpkin if it is wearing a helmet.*

3.3 HOW DO HELMETS AFFECT THE TRANSFER OF KINETIC ENERGY?

In this investigation, you will measure the kinetic energy transferred to the pumpkin while it is *wearing a helmet*. In this sim, the energy sensor is still attached to the pumpkin, but there is now a helmet over the sensor and pumpkin.

It is clear that helmets are necessary for protecting your head while skateboarding. Let's investigate how helmets help protect the pumpkin-heads in our simulation.



Sim Investigation Question #4:

How much energy is transferred to the pumpkin, through a helmet, when the pumpkin is released from different positions?

Your teacher will provide you with the code to access the simulation.

Procedure:

1. Record your results for Sim #4 in the table on the *Simulation Data, Section 3* student sheet.
2. Inside the simulation, click on "Helmet Test."
3. Start the pumpkin at Position A.
4. Click "Begin the Simulation."
5. Record the energy, in Joules, of the pumpkin as it hit the wall.
6. Click "End the Simulation" to stop the simulation and move to the next position.
7. Repeat for Positions B, C, D, E.
8. Answer any questions listed on the sheet.

As a class, discuss your answers to the questions on the *Simulation Data, Section 3* student sheet:

1. What trend do you see when you add a helmet to the pumpkin?
2. How do the pumpkin-with-helmet results compare to the pumpkin-with-NO-helmet results?
3. What, in your opinion, is causing the trend you see in Question 2?

3.4 RETURN TO THE CHALLENGE

As you know, many sports, including skateboarding, have rules that require wearing a helmet. Why? How does a helmet actually protect your head? The following videos show the real danger of not wearing a helmet. Watch *How Helmets Work* video first, then watch *Skating Without a Helmet* video.

Watch ***How Helmets Work*** video #4.

Watch ***Skating Without a Helmet*** video #5.

SkateTech has obtained medical information about energy absorbed by the skull and the effect that energy has on the brain. The chart below details the injury risks for low, medium, and high levels of energy transferred.

Amount of Energy	Effects on the Brain
Less than 3 Joules	No effect, possible headache
3 to 7 Joules	Headache, possible confusion or mild concussion
More than 7 Joules	Concussion, possible brain injury

Helmet Challenge

Early in the **Introduction,** we read that...

> *"Some skaters think that they are skilled enough that they do not need a helmet. They think if they fall, they would be able to avoid serious injury* ***because they believe that they are not going very fast****. These skaters only worry when they are going very fast from the highest heights."*

SkateTech wants to know if this perception by skaters is a fair and true point. Your class will work together to analyze the data from your four investigations to determine this.

Procedure:

1. *On Speed & Kinetic Energy Analysis* student sheet, use the data from your *Simulation Data, Section 1* and *Simulation Data, Section 3* student sheets to calculate the change in speed and kinetic energy (no helmet).

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Discuss these questions as a class:

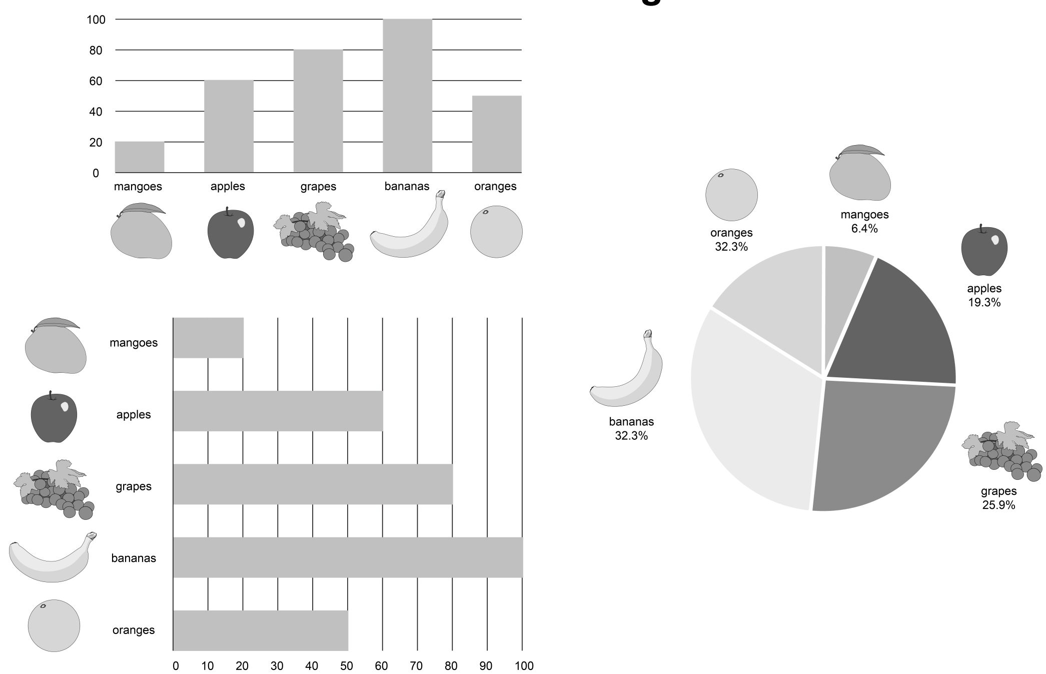
1. How did the maximum speed change as you moved the pumpkin from Position A to Position E?
2. Did the speed change by the same amount each time you moved the pumpkin to the next position?
3. How did the pumpkin energy change as you moved the pumpkin from Position A to Position E?
4. Did the energy change by the same amount each time you moved the pumpkin to the next position?
5. Did energy or speed increase more as the pumpkin moved from Position A to Position E?
6. How do you think this information could help convince skater to wear helmets?

SECTION 4 – MAKING YOUR RESULTS MORE VISUAL

4.1 HELPING OTHERS BETTER UNDERSTAND YOUR DATA

The ability to communicate scientific findings to other scientists and the public is very important. Visuals of the data that you collected will help you tell the story of what is happening. You have most certainly seen a graph or pie chart similar to the charts below.

Favorite Fruits Among Students



In these cases, **visualizing the data** helps the reader understand the data collected easily and quickly. As part of your work for SkateTech, you created four data tables. These tables show relationships between many variables: height, speed, energy, damage, etc. Your class was ultimately able to discuss how increases in height led to uniform increases in speed. BUT, these consistent increases led to BIGGER increases in kinetic energy. As a skater, large jumps in energy increase height, which is what creates a dangerous situation for skaters.

But the question is, “How does someone share that information is a convincing way?” Truthfully, unless you collected that data yourself, combining the information in the tables, it would be difficult for an everyday person to understand this important lesson. It is hard to understand what is going on by just looking at numbers in a table. You will now transform your tables into visuals. These visuals will: 1) help you better understand the lesson learned from this challenge, and 2) help others more easily and see that lesson.

4.2 GRAPHING YOUR MAX SPEED AND KINETIC ENERGY DATA

Part A: Max Speed

Procedure:

1. Find your *Simulation Data, Section* 1 student sheet.
2. On your *Data Visualization* student sheet, create a bar graph displaying the **Max Speed** for each of Positions A – E using the graph on the left. Use color pencils and the color codes below to create the bars in your graph.

Part B: Kinetic Energy

Procedure:

1. Find your *Simulation Data, Section* 3 student sheet.
2. On your *Data Visualization* student sheet, create a bar graph displaying the **Kinetic Energy** for each of Positions A – E. Be careful not to use the helmet data. Use color pencils and the following color codes to create the bars in your graph.

RED	BLUE	GREEN	ORANGE	BROWN
A	B	C	D	E

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Discuss these questions as a class when everyone has finished making the visuals:

1. How do these two graphs help people see the real danger of falling without a helmet?
2. What do the graphs do to help a viewer understand better about the difference between speed and kinetic energy as you move up the half pipe?
3. Compare and contrast the graphs vs. tables in their ability to communicate about the increases in max speed and kinetic energy.

Part C: Max Speed and Kinetic Energy Summary

Procedure:

1. Find the third, narrower graph on your *Data Visualization* student sheet.
2. Draw a line across the Max Speed column for Position A in **RED** at the correct Max Speed level for Position A. That would be 0.9 m/s from the data we collected, right?
3. Color in all the area below this line in **RED**.
4. Using the **BLUE** pencil, draw a line across the Max Speed column for Position B in **BLUE** at the correct Max Speed level for Position B.
5. Color in all the area below this line in **BLUE** but stop at the **red** line you drew for Position A.
6. Continue to do this for each of the remaining Max Speed data you have, using the same color codes as before.
7. Repeat this process using the Kinetic Energy data in the second column. Be sure to continue to use the same color codes as before.

Discuss these questions as a class when everyone has finished making the visual:

1. How does this visual help people see the real danger of falling without a helmet?
2. What does this visual do to help a viewer understand better about the difference between speed and kinetic energy as you move up the half pipe?

Part D: Linear and Non-Linear Relationships

Create a line graph of the results using a transparency copy of the *Data Visualization* student sheet and a transparency marker.

Procedure:

1. Place the transparency over your completed graphs.
2. Line up the images so that the grid lines match.
3. On the Starting Position vs. Max Speed graph, locate the max speed line you drew in **RED** for Position A.
4. Find the midpoint of that line and make a small dot or circle to mark the max speed for Position A on the transparency.
5. Repeat these steps for B, C, D, and E.
6. Then, move over to the Starting Position vs. Kinetic Energy graph. Locate the max speed line you drew in **RED** for Position A.
7. Find the midpoint of that line and make a small dot or circle to mark the max speed for Position A on the transparency.
8. Repeat these steps for B, C, D, and E.
9. Carefully remove the transparency and place over a white sheet of paper.
10. Place your marker point at the origin of the graph.
11. Without smudging the dots you have made, carefully draw a best fit line, starting at the origin, connecting the dots in order from A – E. Do this for both graphs.

Once you have completed your graph building, your class will analyze and discuss what created here. You will receive a separate handout and have a class discussion of how this data visualization can help you answer the Helmet Challenge.

Georgia Tech

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