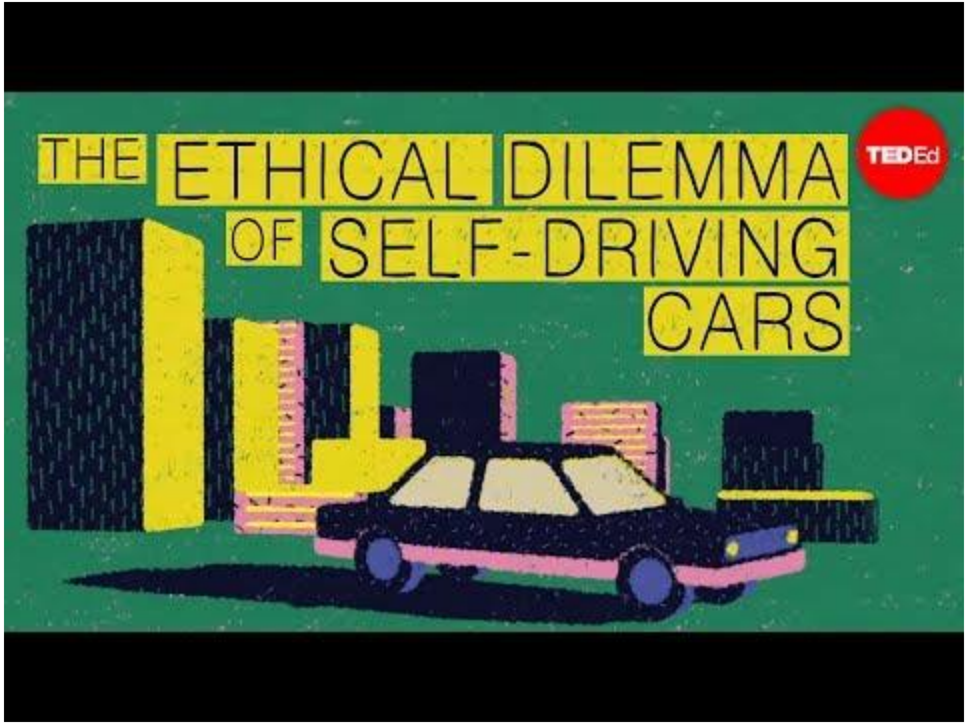
# Ethics of a Self Driving Car

This year we are going to look at the physics of everyday events in order to better understand the world and science.  The first one we are going to study the ethics of a self driving car.  When a person is behind the wheel we know their actions are a reaction, not a deliberate decision .  A self driving car needs to be programmed to make those decisions.

**Learning Objective:** SWBAT begin to look at the ethics of a self-driving car and decide how the car should be programmed to react when an object falls in front of you do you stay straight, hit an SUV or hit a motorcycle?

# Ethics of a Self Driving Car



# Defend Your Assigned Position

At the beginning of class you were given a point of view; stay straight, hit the motorcycle or hit the SUV. Take 3 minutes and defend your assigned point of view. You do not need to agree with this point of view, but you must reason out how to defend it. Record your answer on the paper given to you at the beginning of class.

# Meeting with the Other Points of View

Meeting with your assigned groups and share your points of view. The conversation will be structured. Each person will have a minute to share their assigned point of view. The other members of the group are not to react, but just listen. After each person has shared their position, you will have time to discuss.

1) Stay Straight 1 minute
2) Hit the Motorcycle 1 minute
3) Hit the SUV 1 minute
4) Discussion 5 minutes

# Personal Ideas the Ethics of a Self Driving Car

* consider damage → injury
* speed/distance in each case
* lack of protection for cycle
* physics of collision

# Circle Time

**What choice should the car make?** This is what you think after your group discussion, not the point of view assigned at the beginning of class. There is no need to justify your answer. We will get to that later.

# Tally

| Motorcycle | SUV | Straight |
|---|---|---|
| 1 | 14 | 5 |

# Why?

Now as we go around the circle explain your choice to the class.

**Closing Question:** Are you surprised by the tally?

**Learning Objective**: SWBAT draw out the different scenarios given to the driver of the sedan and explain the science behind their choice.

# Classwork Points

Students that complete one of the following things per cycle (4 contact days) will earn classwork points

- Leader for modeling - When we are doing modeling, the student that has led the discussion in the group can get credit for this. Must be a consensus within the group.
- Presenting modeling - The student within the group that presents the model (if we present them).
- Commenting - Students that give detailed “whys” when they agree or disagree on a model.

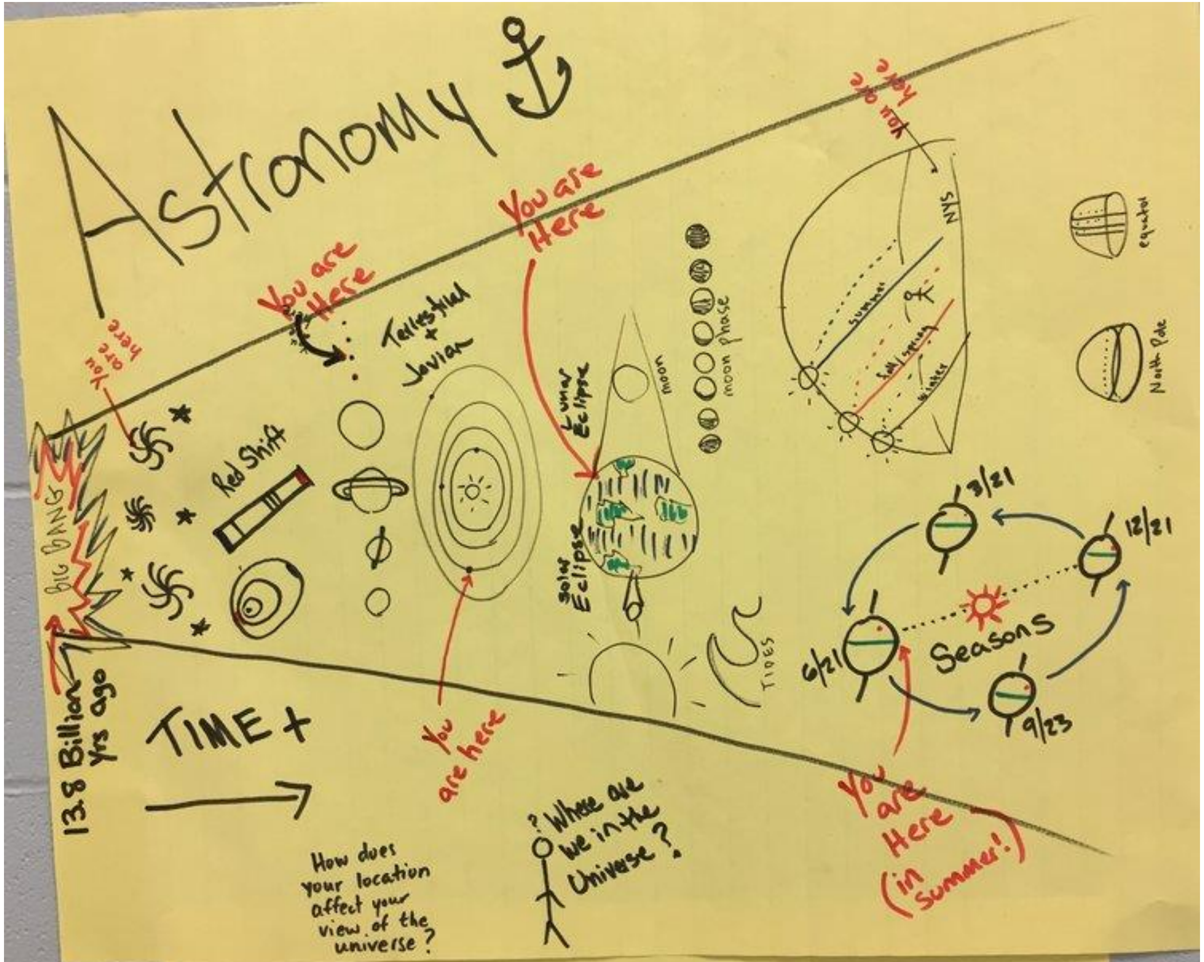
# Classwork Points

- Relevant comments on content - Students that actively relate the content to their own experiences in a way that enhances lecture.
- Physically volunteering - Volunteering for demonstrations or activities
- Leading the computer work during labs - Student that is running PASCO or using Sheets. Must be a consensus within the group.
- Actively collecting data during labs - Student who is most actively participating in physically collecting data. Must be a consensus within the group.

# Modeling

Models are a way to capture what happened (or what will happen) and explain the scientific how or why it happened. The next slide shows a sample model of how we got here going all the way back to the Big Bang.  It has a timeline of events and then gives the evidence for how we know what happened.

# Sample Model: How did we get here



There are three different levels a model can have.

| What Level |
| --- |
| Student describes an observation or summarizes and restates a pattern or trend in data, without making a connection to any unobservable components. |
| Our breathing increased when we started exercising by 30% and the bromothymol blue changed from blue to yellow over the five-minute period. |

There are three different levels a model can have.

| **How Level** |
|---|
| Student describes the observable conditions under which an event or process would happen or states a "partial why" by naming a cause and an effect without saying what the connecting mechanisms are. |
| The bromothymol blue changed from blue to yellow after the exercise because the body exhaled more carbon dioxide than when it was stationary.<br><br>When exercising, the body requires more oxygen. As oxygen intake increases, so does carbon dioxide output. |

# There are three different levels a model can have.

| **Why Level** |
| --- |
| Students can trace a causal story for why a phenomenon occurred. Student uses unobservable processes or structures to explain observable events. |
| When exercising, the body requires more oxygen, which is taken from the lungs to muscle cells (via the circulatory system and diffusion). The cells use the oxygen to break down glucose into energy and carbon dioxide. The carbon dioxide is a waste product,  It diffuses into the blood and then the lungs and is exhaled. Cellular respiration happens at a faster rate when someone is exercising, so more carbon dioxide is produced.  The exhaled carbon dioxide reacts with the water to produce carbonic acid, causing the bromothymol blue indicator to change color. |

# Today’s Models Should Include the **What** and **How** levels.

## Group Roles

Each member of your group will be assigned a role to help the group function more efficiently.

**Big Idea Person**

- A person in this role asks the following:
    - What is the big scientific idea we are trying to understand?
    - How does the work we are doing (something we are studying, reading, investigating, observing, etc.) help us understand the big idea?
    - How does our work so far change the way we are thinking about our big idea?

**Clarifier**

- This is a role for monitoring everyone's comprehension about one or two key scientific terms.The person might ask:
  - Do we know what the words [like carrying capacity or convection] refer to in our activity?
  - Can we put these terms in our own words?

**Questioner/ Skeptic**

- This person asks probing questions during the activity. Students in this role also listen for questions posed by other group members and then revoice the question so others hear it. This is not an easy role. Here are some question stems to help.
    - [paraphrase what others have said]: So, what I think you are saying is _________.  Is that right?
    - [Asks in response to a claim made by another student]: How do we know that?
    - What would happen if we changed ________?
- This person's role is also to strengthen the groups work by probing for weaknesses as the product is being developed. This person might ask:
    - Here's an alternative explanation - is this just as good as what we have now?
    - Why do we think our [ claim, model, explanation, argument, design for an investigation] is consistent with the evidence?

**Progress Monitor/ Floor Monitor**

- This person asks others to periodically take measure of the groups progress towards a goal. This person should also be able to report out the group's ideas and who contributed those ideas.
  - What can we say we have accomplished so far?
  - What do we still need to know/do to accomplish this task?
  - What can we now add to our [explanation, model, argument] that we didn't have before?
- No one should be left in the margins of the conversation. Sometimes one student or two students will dominate the talk and keep others from contributing. The floor manager monitors airtime of the group members. They ask:
  - Can we take a minute and hear from everyone before we move forward?
  - Who has not had a chance to weigh in on this?

# A Place to Record Your Role

Each group needs to assign a role to everyone in the group.  The group needs to fill out the group role document and attach it to the back of their model.

| Activity: | |
|---|---|
| Group Names: | |
| **Role** | **Group Member** |
| **Big Idea Person**- What big idea are we trying to understand? | |
| **Clarifier**- Monitors group comprehension and pushes the group to make up their own definitions for big science words. | |
| **Questioner/ Skeptic**- Asks probing questions during the activity. Looks for the weak areas of the group ideas or model. | |
| **Progress Monitor/ Floor Monitor**- Makes sure the group is progressing towards the goal, makes sure everyone is allowed time to talk and share ideas. | |

**Modeling**

Take twenty minutes and meet with your group of three to four to reason out what the self driving car should choose and why. The "why" should be as scientifically in-depth as you can make it. Everyone's views should be expressed in the model. Make sure your ideas are supported with observable evidence, or ideas about what you already know or have seen in or out of the classroom.  If you are having trouble with wording use the following sentence starters.

Make sure your group assigns a role to each member. This means all voices must be heard and expressed. Linked are different group roles. Each group should also fill out who played what role in the following document, which will go on the back of your model.

**Gallery Walk- (5 minutes)**

Go to another group's model and complete the following.

1. Take two of each color of post-it notes for a total of four.
2. Write your name on the post-it notes.
3. Read the model (1 minute)
4. Critique the poster using the following sentence frames. (1 minute)

| **Post it Color** | **Comment Sentence Frames** |
|---|---|
| | I agree with idea _______________ |
| | I disagree with idea _______________<br>Or<br>I think the poster is missing ______________ |

1. Switch tables and repeat.

# Presentation of Ideas/ Class Discussion

Volunteer to talk about your poster or ideas you agreed with or did not agree with on other posters.  Make sure when dealing with disagreeing with a group you choose your words kindly. The disagreement should be with the merits of the ideas, not the person or group that wrote them. Here are some ideas of how to agree or disagree kindly.

| Adding to an idea: |
| --- |
| • I agree with you, but also think …?<br>• I agree with you, but couldn't we also add …?<br>• I agree with you because …? |

| Respectfully disagreeing with an idea |
| --- |
| • I know where you are coming from, but I have a different idea.<br>• I disagree with the idea because ...<br>• I think you're heading in the right direction, but ... |

| Asking a clarifying idea |
| --- |
| • What do you mean by …?<br>• What makes you think that?<br>• Could you be more specific? |

# Results of the Class Discussion

mass: cycle vs. SUV, boxes

safety features: protection, air bags, zero for cyclist

vocab.:

force, mass, speed, velocity

**Closing Question:** What was the most important science discussed today?

mass

safety features

speed

When driving in a sedan, what is the difference between colliding with an SUV versus a motorcycle?

**Learning Objective:** SWBAT describe what it takes to change the motion of a motorcycle versus an SUV.

# Demonstration - Ceramic Dishes and Tablecloth

# Personal Ideas

How is it possible that the dishes remain in place when the tablecloth is moving?

**Modeling**

Take fifteen minutes and meet with your group of three to four to create a model that explains why the dishes remain in place when the tablecloth is moving. Your model should show what happened and give an explanation of how or why it happened. Make sure your ideas are supported with observable evidence, or ideas about what you already know or have seen in or out of the classroom.  If you are having trouble with wording use the following sentence starters.

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1. Switch tables and repeat.

# Class Discussion

# Class Discussion

# Mythbusters - ~5 min

# Newton’s First Law-

# Inertia-

**Closing Question:** How does this relate to hitting the SUV or the motorcycle?

# Safety Car Race

**Learning Objective:** SWBAT show their knowledge of physics to keep a figure safe during a race.

**Activity**

You will be trying to keep a figure safely on a cart as it races down the track.  You must push your cart and then have your cart stop all while keeping your figure safe on top.  Whoever goes the fastest in a head to head race without losing their passenger will move onto the next round.  There will be as many rounds as needed to get to a winner.

**Personal Idea**: What needed to be done to keep the passengers safe while trying to go as fast as possible? ( 3 minutes)

# Class Discussion

# Class Discussion

**Closing Question:** How does this relate to the ethics of a self driving car?

# Spring Scale and Cart

**Learning Objective**: SWBAT determine the relationship between force, and motion.

# **Activity**: Spring Scale and Cart

Presentation

Document

# **Class Discussion:** Spring Scale and Cart

| | Type of Motion | Why |
|---|---|---|
| Pull the box with a constant force | | |

# **Class Discussion:** Spring Scale and Cart

| | Type of Motion | Why |
|---|---|---|
| Pull the cart at a constant speed | | |

# **Class Discussion:** Spring Scale and Cart

| | Type of Motion | Why |
|---|---|---|
| Pull the cart with a constant force | | |

# Newton’s Second Law

**Closing Question:** How does this relate to hitting the SUV versus motorcycle?

# Force, Mass, and Acceleration

**Learning Objective:** SWBAT understand the relationship between force, mass, and acceleration.

**Force Mass and Acceleration Lab:**

Presentation and Document

**Class Wrap Up:** When mass is added to the frictionless cart, how does acceleration change and why does it change?

**Closing Question:** How does this relate to hitting the SUV versus motorcycle?

**Learning Objective**: SWBAT look at the relationship between forces when two objects interact.

**Activity**

Students will look at how the force and distance traveled by students on a scooter changes. Two students of equal mass will sit on a scooter then both will push, then only one will push. Then two students of different masses will do the same.

## Push-Push

| Prediction | Results |
|---|---|
| | |

## Push-Steady

| Prediction | Results |
|---|---|
| | |

## Different Masses

| Prediction | Results |
|---|---|
| | |

**Modeling**

Take twenty minutes and meet with your group of three to four to create a model that explains what happened in each of the different scenarios. Your model should show what happened and give an explanation of how or why it happened. Make sure your ideas are supported with observable evidence, or ideas about what you already know or have seen in or out of the classroom. If you are having trouble with wording use the following sentence starters.

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1. Switch tables and repeat.

# **Class Ideas**: Scooters

## **Class Ideas**: Scooters

# Newton’s Third Law-

# Examples of Newton’s Third Law-

**Closing Question:** How does this relate to hitting the motorcycle of SUV?

**Learning Objective:** Students will have have a deeper understanding of Newton’s 3rd Law.

**Khan Academy Reading in Google Classroom**: What is Newton's third law? & Questions

## **Class Ideas:** Reading “What is Newton’s third law?”

**Learning Objective:** SWBAT identify which of Newton’s Laws applies to a given situation.

# Newton's Laws Summary Worksheet

# Summary Worksheet

# Group Discussion of Summary Document

Meet with your group of three to four and discuss the summary document.

# CER

# Concept Check

How does a helmet cushion?

**Learning Objective:** SWBAT understand how materials can help cushion.

## **Demonstration:** Happy and Sad Balls

**Personal Ideas:** What makes a ball bounce? ( 2 minutes)

**Class Ideas:** What makes a ball bounce?

**Class Ideas:** What makes a ball bounce?

**Personal Ideas:** Is bouncing good or bad in terms of cushioning? ( 2 minutes)

# Activity: Slow Motion Impacts

**Learning Objective:** SWBAT look at collisions in slow motion to help determine what makes a ball bounce.

**Class Ideas:** What makes a ball bounce?

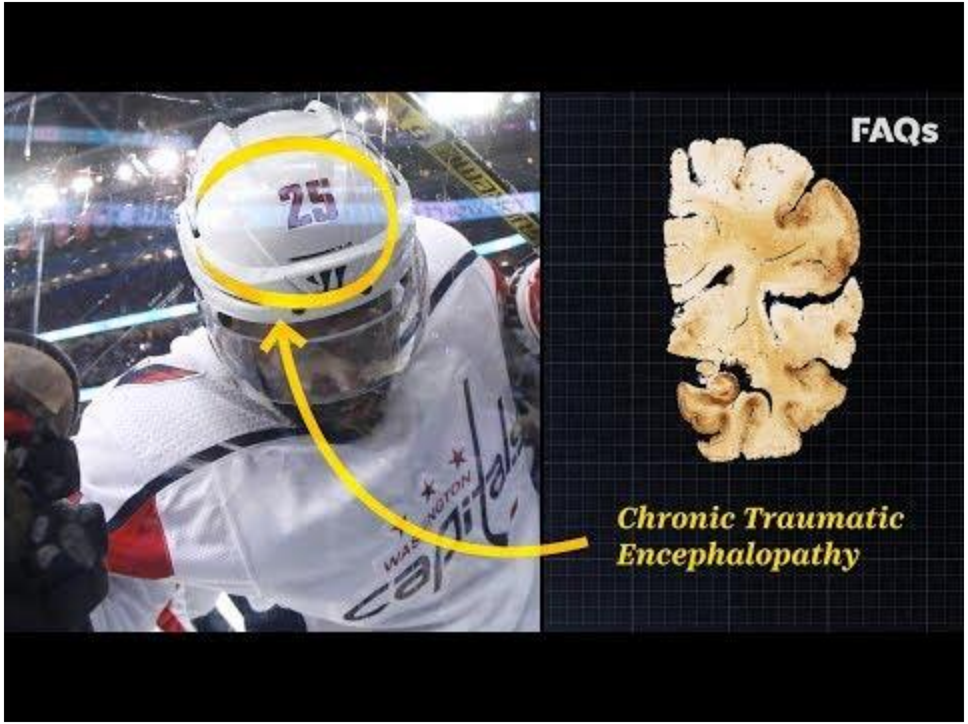
**Class Ideas:** What makes a ball bounce?

**Closing Question:** Would a bouncy object make a good cushion? Think about which would you rather fall on, a golf ball, tennis ball, or stress ball.

**Learning Objective:** SWBAT understand more about what makes a good cushion by looking at NFL helmet design.

**Video:** Concussions in Football  00:03:48

Video: CTE 00:07:00



**Newsela Article**: High Tech Helmets designed to lower the risk of concussion debut in the NFL and Questions

**Class Discussion**: Concussion, CTE and How to Prevent them

## **Class Discussion**: Concussion, CTE and How to Prevent them

**Closing Question:** How could this help a motorcycle helmet?

# Paper Cushioning

**Learning Objective:** Students will design a paper cushion. The cushion will be used to protect a falling egg.

**Personal Ideas:** What can you do to make paper good at cushioning?

**Activity**: Paper Cushioning

Your group will be given a plastic container, six pieces of paper and 10 minutes to design and make your cushion. We will take a group picture of all of the cushions.

# Photos before: Top View

# Photos before: Side View

**The Drop**

An egg will be dropped into the cushioning. Please video your egg in slow motion as it hits the paper cushion.  We will take an after picture and discuss which of the cushions worked best and why.

# Photos after: Top View

# Photos after: Side View

# Observations

# Which paper cushion worked best and why?

**Closing Question:** What helps cushion?

## **Summary Chart**: How does a Helmet Cushion?

# CER

# Concept Check: Google Form

How does an airbag protect during a collision?

Egg Toss

**Learning Objective:** SWBAT examine why sometimes an egg breaks and others it does not.

**Prediction:** Can you break an egg by throwing it into a sheet? Give a brief explanation as to why or why not. ( 2 minutes)

**Demonstration**: Egg into the Sheet vs a Wall

Video: Throwing an egg into a sheet

# Observations

**Modeling**

Take fifteen minutes and meet with your group of three to four to create a model that explains what happened to the egg when it hit the wall versus when it hit the sheet. Your model should show what happened and give an explanation of how or why it happened. Make sure your ideas are supported with observable evidence or ideas about what you already know or have seen in or out of the classroom. If you are having trouble with wording use the following sentence starters.

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**Class Ideas:** Egg in the sheet vs egg on the wall

**Closing Question:** How does this relate to cushioning in a helmet?

# **Activity:** Water Balloon Toss

As a class, we will go outside and throw a water balloon from person to person over an increasing distance. You want to note how the way someone throws and catches changes as the distance increases.  Please start a 1 meter apart and move 1 meter apart in between each throw until your balloon breaks.

# Water Balloon Toss

**Learning Objective**: SWBAT figure out the science behind how to toss a water balloon without letting it pop.

**Personal Prediction:** How does increasing the distance between the thrower and catcher change how the water balloon must be thrown and then caught? (2 minutes)

# Class Ideas: Water Balloon Toss

Throw

over vs. under

wind?

hand speed

# Class Ideas: Water Balloon Toss

Catch

"soft hands" → moving!

palms!

how low/high

# Throwing - We want to throw further!

| What do we want to do? | What stays the same? | What do we change? |
| --- | --- | --- |
| | | |

# Catching - We want to NOT pop the balloon!

| What do we want to do? | What stays the same? | What do we change? |
|---|---|---|
| | | |

**Closing question to model:** How do the "egg thrown into a sheet" and "water balloon toss" activities relate to cushioning in a helmet?

**Modeling**

Take fifteen minutes and meet with your group of three to four to create a model that explains how increasing the distance between the thrower and catcher changes the way you throw and catch. Your model should show what happened and give an explanation of how or why it happened. Make sure your ideas are supported with observable evidence, or ideas about what you already know or have seen in or out of the classroom. If you are having trouble with wording use the following sentence starters.

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# What Killed Gwen Stacy and How Can we Save Spider Man's Next Girlfriend?

**Learning Objective:** SWBAT understand what killed Gwen Stacy and design a new web to save Spider Man's next girlfriend.

# Gwen Stacy's Death: Video

**Modeling**

Take fifteen minutes and meet with your group of three to four to create a model that explains what killed Gwen Stacy and how could you design a new web to save her Spider Man's next girlfriend. Your model should show what happened and give an explanation of how or why it happened. Make sure your ideas are supported with observable evidence, or ideas about what you already know or have seen in or out of the classroom. If you are having trouble with wording use the following sentence starters.

Make sure your group assigns a role to each member. Linked are different group roles. Each group should also fill out who played what role in the following document, which will go on the back of your model.

**Class Discussion:** What Killed Gwen and how can we save his next girlfriend?

# Force of Spiderman Falling his original a web

**Activity:** Building a New Web (20 minutes)

Using rubber bands build a web to save Spider Man’s next girlfriend.

# Class Data

| Group Names | Force (N) |
|---|---|
| **Victoria & Vaughn (+2)** | **4.2** |
| **Sebastian, Skyy & Keisi** | **8.6 to 4.5** |
| **Jamie & Danny** | **5.4 to 4.7** |
| **Camryn** | **4.8** |
| **Kevin** | **5.1** |
| **Jessica, Peter & Anna** | **5.7** |
| **Nicole, Yasmeen & Tara** | **18.7 to 6.5** |
| **Chris & Jenna** | **7.1** |

**Class Discussion:** Which webbing worked best and why?

# Can we Save Spider Man’s next girlfriend? Video

**Closing Question:** How does this relate to protecting us in a car crash?

# **Notes:** Impulse

**Learning Objective:** SWBAT understand how all of our activities about cushioning relate to one equation.

Impulse is important because

Impulse is important because a force in a crash (and other times) is not constant, impulse helps with this

**Video**: Super Slow Show Car Crash

What happens to the force over the course of the crash, from the time the bumpers touch to when the cars come to rest?

# What would a Force versus Time graph look like for the car crash?

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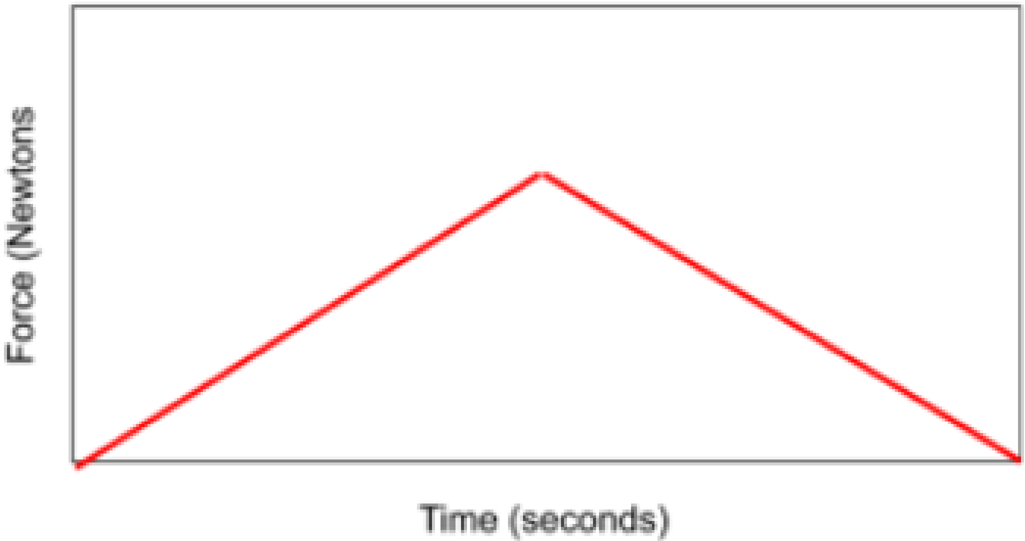
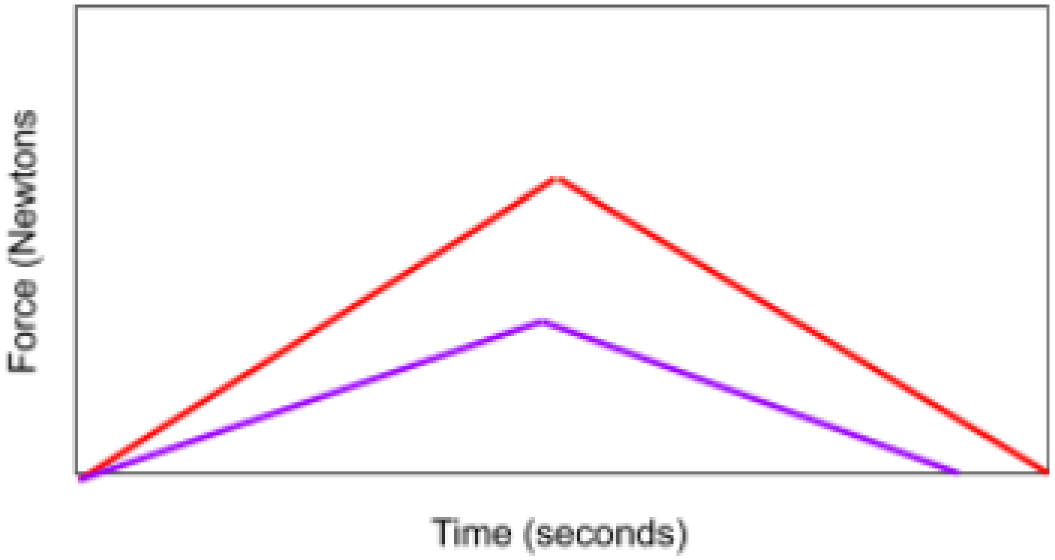


# What would a Force versus Time graph look like for the car crash?



# Impulse -

# Impulse -

What is needed to change the motion of an object (measured in Newton-seconds)

# Impulse -

What is needed to change the motion of an object (measured in Newton- seconds)

- Can make something not moving, start moving

# Impulse -

What is needed to change the motion of an object (measured in Newton- seconds)

- Can make something not moving, start moving
- Can make something stop moving

# Impulse -

What is needed to change the motion of an object (measured in Newton- seconds)

- Can make something not moving, start moving
- Can make something stop moving
- Can make something get faster or slower

# Force

# Force

A push or pull  (measured in Newtons)

# Time

# Time

What a clock reads (seconds)

# Equation

- Impulse = Force $\times$ time
- $I = Ft$

Equation: $\text{Impulse} = \text{Force} \times \text{time}$

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| If Impulse stays constant | | | | | | | |
| Force | ↑ | time | | time | ↑ | Force | |
| If Force stays constant | | | | | | | |
| Impulse | ↑ | time | | time | ↑ | Impulse | |
| If time stays constant | | | | | | | |
| Impulse | ↑ | Force | | Force | ↑ | Impulse | |

Equation: Impulse = Force × time

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| If Impulse stays constant | | | | | | | |
| Force | ↑ | time | ↓ | time | ↑ | Force | |
| If Force stays constant | | | | | | | |
| Impulse | ↑ | time | | time | ↑ | Impulse | |
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| Impulse | ↑ | Force | | Force | ↑ | Impulse | |

Equation: Impulse = Force × time

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| If Impulse stays constant | | | | | | | |
| Force | ↑ | time | ↓ | time | ↑ | Force | ↓ |
| If Force stays constant | | | | | | | |
| Impulse | ↑ | time | | time | ↑ | Impulse | |
| If time stays constant | | | | | | | |
| Impulse | ↑ | Force | | Force | ↑ | Impulse | |

Equation: Impulse = Force × time

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| If Impulse stays constant | | | | | | | |
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Equation: Impulse = Force × time

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| If Impulse stays constant | | | | | | | |
| Force | ↑ | time | ↓ | time | ↑ | Force | ↓ |
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| Impulse | ↑ | time | ↑ | time | ↑ | Impulse | ↑ |
| If time stays constant | | | | | | | |
| Impulse | ↑ | Force | | Force | ↑ | Impulse | |

Equation: Impulse = Force × time

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| If Impulse stays constant | | | | | | | |
| Force | ↑ | time | ↓ | time | ↑ | Force | ↓ |
| If Force stays constant | | | | | | | |
| Impulse | ↑ | time | ↑ | time | ↑ | Impulse | ↑ |
| If time stays constant | | | | | | | |
| Impulse | ↑ | Force | ↑ | Force | ↑ | Impulse | |

Equation: Impulse = Force $\times$ time

| If Impulse stays constant | | | | | | | |
|---|---|---|---|---|---|---|---|
| Force | ↑ | time | ↓ | time | ↑ | Force | ↓ |
| If Force stays constant | | | | | | | |
| Impulse | ↑ | time | ↑ | time | ↑ | Impulse | ↑ |
| If time stays constant | | | | | | | |
| Impulse | ↑ | Force | ↑ | Force | ↑ | Impulse | ↑ |

**Worksheet:** Impulse Practice

# Kahoot: Impulse

**Closing Activity**: Pick one of the cushioning activities we have done and explain how it works using the impulse equation.

Summary Document :How does an airbag protect during a collision?

# CER

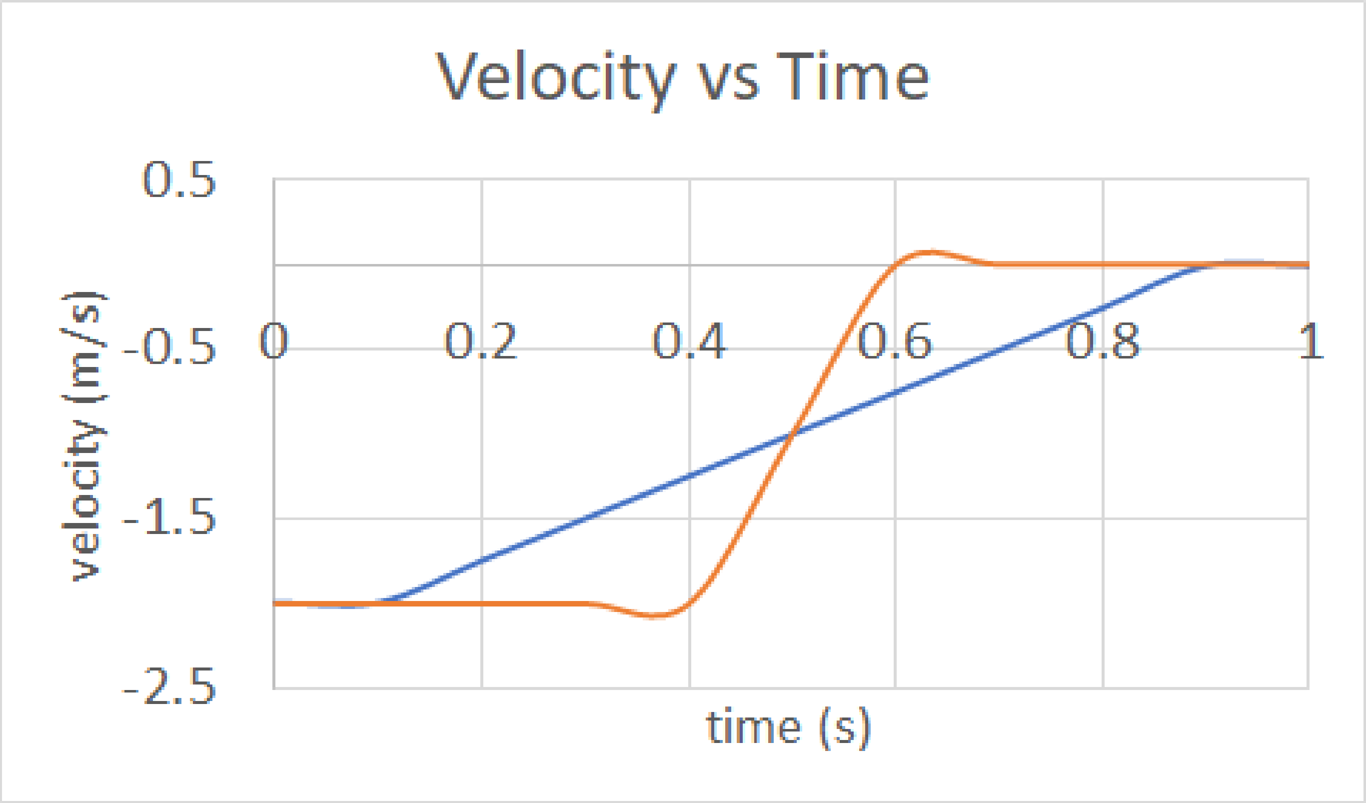
# Concept Check

**Learning Objective:** SWBAT begin to understand what makes a good bumper.

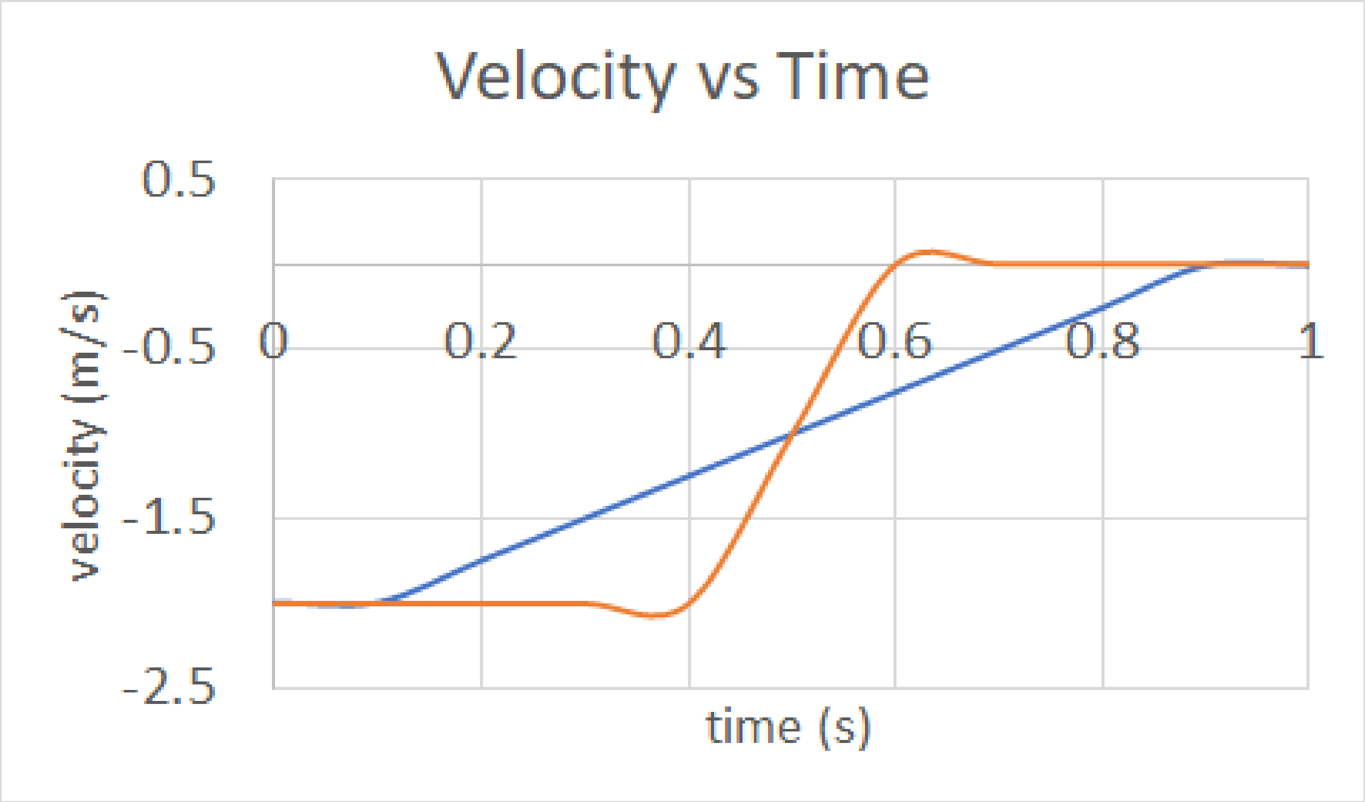
What is a crumple zone in a car?

**Video**: [Crash with and without airbags]

Which graph shows the crash with an airbag and why is it safer?

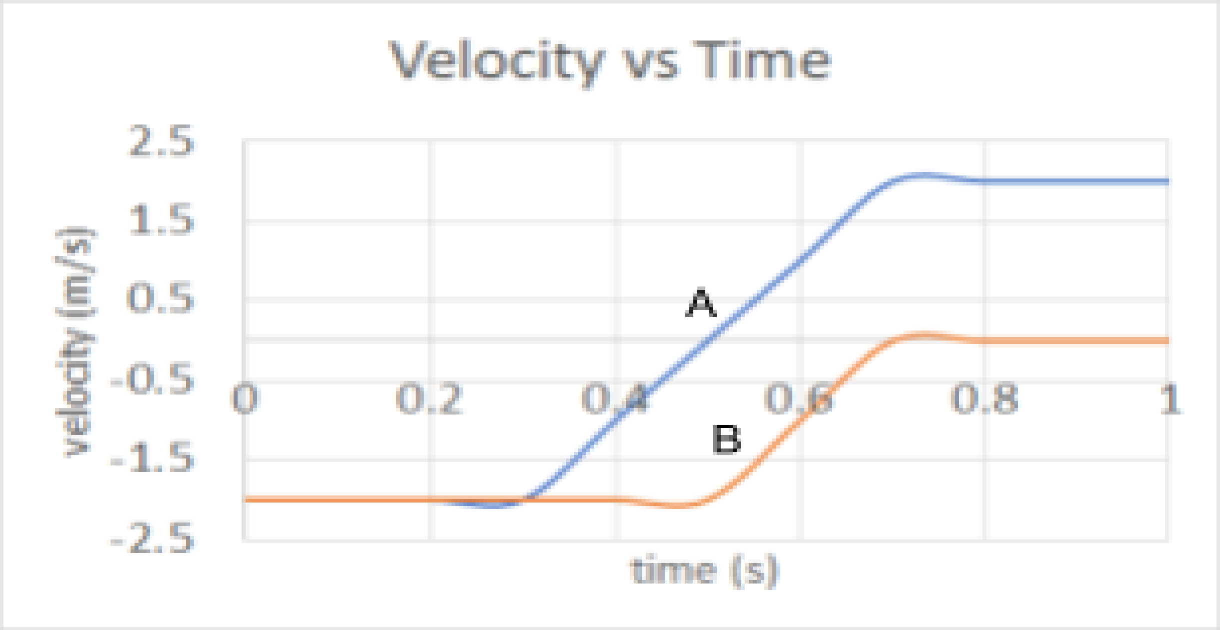


# Which do you think is worse?

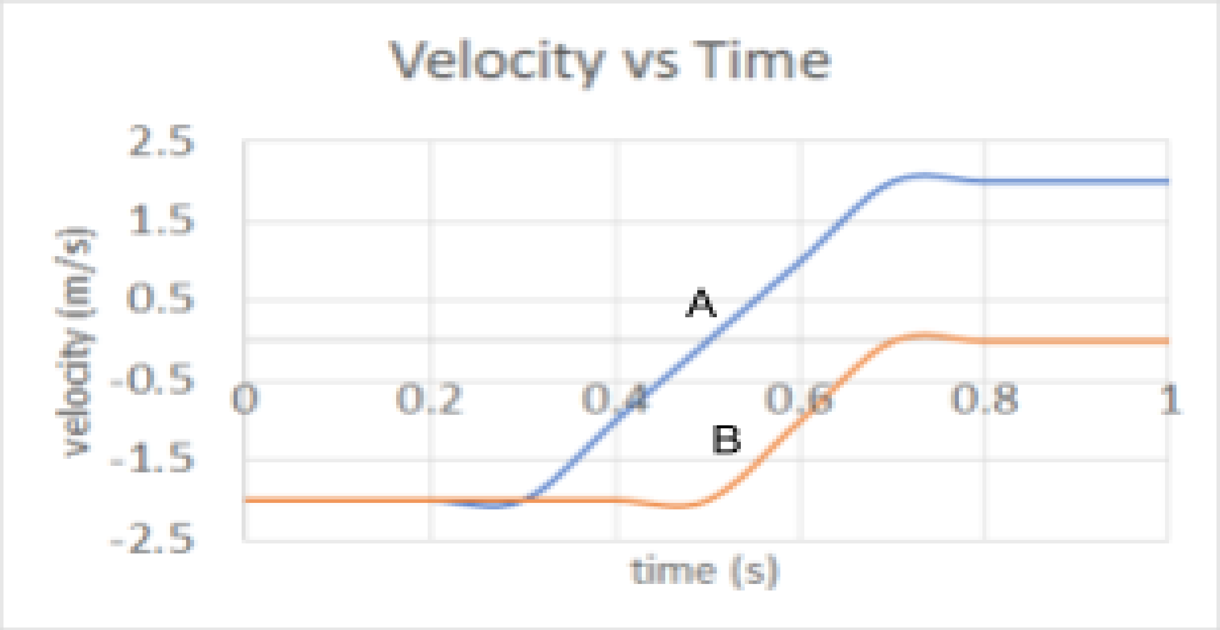


# **Videos**: Crashes in Bumper Cars vs Real Cars

# Which line represents the car?



Why is it fun to be in a bumper car?




Why would you not want the bumper of a car to act the way a bumper car does?

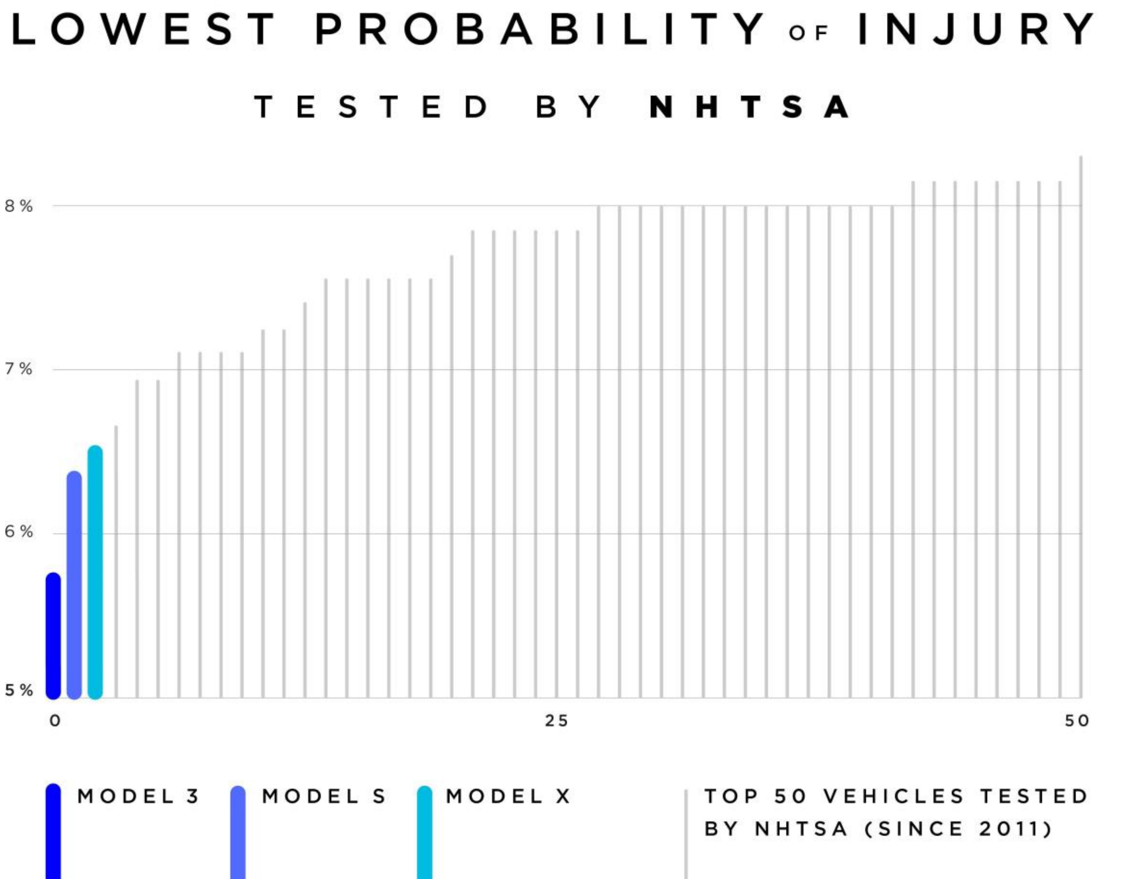
**Mr. Sweeten**
@MrSatCHWest

Thanks, @elonmusk.
Sincerely,
My daughter & I

> **Tesla** @Tesla
> Model 3 has the lowest overall probability of injury for any car ever tested by @nhtsagov. Model S is #2. Model X is #3. There is no safer car in the world than a Tesla
> Show this thread

**Click HERE for more…**

7:13 PM - 8 Oct 2018




**Like Model S and Model X, Model 3 benefits from its all-electric architecture and powertrain design, which consists of a strong, rigid passenger compartment, fortified battery pack, and overall low center of gravity. These safety fundamentals help to prevent intrusion into the cabin and battery modules, reduce rollover risk, and distribute crash forces systematically away from the cabin – all while providing the foundation for our superior front crumple zone that is optimized to absorb energy and crush more efficiently. Here, you can see how the orange internal combustion engine block is thrust towards the cabin during a frontal impact test.**

Observations: What makes a Tesla safer?

Class Idea: What are some ways to make a car safer?

# Engineering a Bumper

**Learning Objective**: Students will use what they have learned throughout the unit to design and build an economical and top of the line bumper.

**Activity**

Students will be designing and building two different car bumpers:

**Day 1**: Economical Bumper

Students will be given 1 sheet of newspaper and 20 minutes to build a bumper.  All bumpers will then be tested on the force sensor.

**Day 2:** Top of the line bumper

Students will be allowed to bring in any materials to build their bumper, given 20 minutes to do the building. **NO MATERIALS THAT HAVE A CUSIONING PURPOSE CAN BE USED!** All bumpers will then be tested on the force sensor and then refined before being tested a second time.

# Class Discussion: What bumper worked the best and why?

longest length → t↑ → F↓

best → impractical!

↳ adding mass & air resist.

Closing Question: Has anything we have learned recently changed your mind about what the car should do: stay straight, hit the SUV or hit the motorcycle?

# **Notes:** Impulse and Momentum

**Learning Objective:** SWBAT bring together impulse and momentum to problem solve.

# Momentum

# Momentum

- Momentum = mass $\times$ velocity

# Momentum

- Momentum = mass × velocity
  - Heavier things have more momentum

# Momentum

- Momentum = mass ✕ velocity
    - Heavier things have more momentum
    - Faster things have more momentum

# Impulse and Momentum

# Impulse and Momentum

- Impulse causes a change in momentum of an object

# Impulse and Momentum

- Impulse causes a change in momentum of an object
- Impulse = the change in momentum

# Impulse and Momentum

- Impulse causes a change in momentum of an object
- Impulse = the change in momentum

$$I = p_{final} - p_{initial}$$

# Impulse and Momentum

- Impulse causes a change in momentum of an object
- Impulse = the change in momentum

$$I = p_{final} - p_{initial}$$

$$F\ t = m\ v_{final} - m\ v_{initial}$$

What average force is required to push a 20-kg stroller with your toddler in it for 5 seconds if the mass of the toddler is 15 kg? You push the stroller up to a speed of 1 m/s from rest.

- Initial velocity - m/s, starting from rest, initially/beginning, how fast...
- Final velocity - m/s, comes to a stop/rest, finally/end, how fast...
- Mass - kg, how much stuff
- Time - s, how long…
- Force - N, a push or pull

| Givens | Work |
|---|---|
| $v_i$ =<br><br>$v_f$ =<br><br>m =<br><br>t =<br><br>F = | |

What average force is required to push a 20-kg stroller with your toddler in it for 5 seconds if the mass of the toddler is 15 kg? You push the stroller up to a speed of 1 m/s from rest.

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- Time - s, how long…
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| Givens | Work |
|---|---|
| $v_i$ = 0 m/s<br><br>$v_f$ =<br><br>m =<br><br>t =<br><br>F = | |

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|---|---|
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- Force - N, a push or pull

| Givens | Work |
| --- | --- |
| $v_i$ = 0 m/s<br>$v_f$ = 1 m/s<br>m = 20 kg + 15 kg<br>t =<br>F = | |

What average force is required to push a 20-kg stroller with your toddler in it for 5 seconds if the mass of the toddler is 15 kg? You push the stroller up to a speed of 1 m/s from rest.

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| --- | --- |
| $v_i$ = 0 m/s<br><br>$v_f$ = 1 m/s<br><br>m = 20 kg + 15 kg<br><br>t = 5 s<br><br>F = ? | |

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- Force - N, a push or pull

| Givens | Work |
| --- | --- |
| $v_i$ = 0 m/s<br>$v_f$ = 1 m/s<br>m = 20 kg + 15 kg<br>t = 5 s<br>F = ? | $F\ t = m\ v_{final} - m\ v_{initial}$ |

What average force is required to push a 20-kg stroller with your toddler in it for 5 seconds if the mass of the toddler is 15 kg? You push the stroller up to a speed of 1 m/s from rest.

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- Mass - kg, how much stuff
- Time - s, how long…
- Force - N, a push or pull

| Givens | Work |
| --- | --- |
| $v_i = 0$ m/s<br>$v_f = 1$ m/s<br>m = 20 kg + 15 kg<br>t = 5 s<br>F = ? | $F\,t = m\,v_{final} - m\,v_{initial}$<br>$F\,(5) = (35)\,(1) + (35)\,(0)$ |

What average force is required to push a 20-kg stroller with your toddler in it for 5 seconds if the mass of the toddler is 15 kg? You push the stroller up to a speed of 1 m/s from rest.

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| Givens | Work |
|---|---|
| $v_i$ = 0 m/s<br>$v_f$ = 1 m/s<br>m = 20 kg + 15 kg<br>t = 5 s<br>F = ? | $F\ t = m\ v_{final} - m\ v_{initial}$<br>F (5) = (35) (1) + (35) (0)<br>F = 7 N |

A 0.350 kg volleyball is spiked so that its incoming velocity of -3.70 m/s is changed to an outgoing velocity of 18.0 m/s. If the volleyball player is able to exert 30 N of force, how long does her hand need to be in contact with the ball?

- Initial velocity - m/s, starting from rest, initially/beginning, how fast...
- Final velocity - m/s, comes to a stop/rest, finally/end, how fast...
- Mass - kg, how much stuff
- Time - s, how long…
- Force - N, a push or pull

| Givens | Work |
| --- | --- |
| $v_i$ = | |
| $v_f$ = | |
| m = | |
| t = | |
| F = | |

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- Time - s, how long…
- Force - N, a push or pull

| Givens | Work |
| --- | --- |
| $v_i$ = -3.7 m/s<br>$v_f$ =<br>m =<br>t =<br>F = | |

A 0.350 kg volleyball is spiked so that its incoming velocity of -3.70 m/s is changed to an outgoing velocity of 18.0 m/s. If the volleyball player is able to exert 30 N of force, how long does her hand need to be in contact with the ball?

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| Givens | Work |
|---|---|
| $v_i$ = -3.7 m/s<br><br>$v_f$ = 18.0 m/s<br><br>m =<br><br>t =<br><br>F = | |

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| Givens | Work |
| --- | --- |
| $v_i$ = -3.7 m/s<br>$v_f$ = 18.0 m/s<br>m = 0.350 kg<br>t =<br>F = | |

A 0.350 kg volleyball is spiked so that its incoming velocity of -3.70 m/s is changed to an outgoing velocity of 18.0 m/s. If the volleyball player is able to exert 30 N of force, how long does her hand need to be in contact with the ball?

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| Givens | Work |
| --- | --- |
| $v_i$ = -3.7 m/s<br><br>$v_f$ = 18.0 m/s<br><br>m = 0.350 kg<br><br>t = ?<br><br>F = 30 N | |

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| Givens | Work |
| --- | --- |
| $v_i$ = -3.7 m/s<br>$v_f$ = 18.0 m/s<br>m = 0.350 kg<br>t = ?<br>F = 30 N | $F\ t = m\ v_{final} - m\ v_{initial}$ |

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- Force - N, a push or pull

| Givens | Work |
| --- | --- |
| $v_i = -3.7$ m/s<br>$v_f = 18.0$ m/s<br>$m = 0.350$ kg<br>$t = ?$<br>$F = 30$ N | $F\ t = m\ v_{final} - m\ v_{initial}$<br>$30\ t = (0.350)\ (18) - (0.350)\ (-3.7)$ |

A 0.350 kg volleyball is spiked so that its incoming velocity of -3.70 m/s is changed to an outgoing velocity of 18.0 m/s. If the volleyball player is able to exert 30 N of force, how long does her hand need to be in contact with the ball?

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| Givens | Work |
|---|---|
| $v_i = -3.7$ m/s<br>$v_f = 18.0$ m/s<br>$m = 0.350$ kg<br>$t = ?$<br>$F = 30$ N | $F\,t = m\,v_{final} - m\,v_{initial}$<br>$30\,t = (0.350)\,(18) - (0.350)\,(-3.7)$<br>$t = 0.253$ s |

## **Summary Worksheet:** What is a crumple zone in a car?

**…to prepare for tomorrow's "What is a crumple zone?" Concept Check!**

# Why is tailgating bad?

**Learning Objective:** SWBAT determine why tailgating is a bad idea.

**distance = velocity × time**

**Get a Chromebook and click on the link entitled "Reaction Time and Stopping Distance Activity." Use the interactive it links to and follow its instructions carefully to find out exactly why following someone closely (especially at high speeds) is an incredible foolish idea.**

**Closing Question:** Why is tailgating bad?

# Egg Drop Project

**Learning Objective:** SWBAT protect an egg when dropped from three different heights using a parachute and cushioning and then just cushioning.

**Activity:** Presentation, Overview/ Rubric, Student Lab Presentation

**Closing Question:** When driving what is better for protecting you and your passengers, safety features or slowing down?

# Why is tailgating bad?

# Notes: Conservation of Momentum

**Learning Objective**: SWBAT understand the impact of a box hitting the car, by looking at the conservation of momentum.

# The Law of Conservation of Momentum

# The Law of Conservation of Momentum

- The Law of Conservation of Momentum states that the total momentum, before and after a collision, must be the same amount.

# The Law of Conservation of Momentum

- The Law of Conservation of Momentum states that the total momentum, before and after a collision, must be the same amount.

$$m_1v_{1initial} + m_2v_{2initial} = m_1v_{1final} + m_2v_{2final}$$

If the objects move together after the collision

# If the objects move together after the collision

$$m_1v_{1initial} + m_2v_{2initial} = (m_1 + m_2)\ v_{final}$$

$v_{final}$ is not labeled 1 or 2 because they are moving together

# If the objects move together after the collision

$$m_1 v_{1initial} + m_2 v_{2initial} = (m_1 + m_2)\, v_{final}$$

$v_{final}$ is not labeled 1 or 2 because they are moving together

# If the objects move together after the collision

$$m_1 v_{1initial} + m_2 v_{2initial} = (m_1 + m_2)\ v_{final}$$

$v_{final}$ is not labeled 1 or 2 because they are moving together

A group of students are performing an experiment in class using collision carts on a track. An 8.0 kg cart moving to the right at 4.0 m/s hits a 4.0 kg cart moving to the left at 6.0 m/s. Immediately after the collision, the 4.0 kg cart moves to the right at 3.0 m/s. What are the speed and direction of the 8.0 kg cart after the collision?

| Givens | Work |
| --- | --- |
| $v_{1initial}$ = | |
| $v_{2intial}$ = | |
| $v_{1final}$ = | |
| $v_{2final}$ = | |
| $m_1$ = | |
| $m_2$ = | |

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| Givens | Work |
|---|---|
| $v_{1initial}$ = 4.0 m/s<br>$v_{2intial}$ =<br>$v_{1final}$ =<br>$v_{2final}$ =<br>$m_1$ =<br>$m_2$ = | |

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| Givens | Work |
|---|---|
| $v_{1initial}$ = 4.0 m/s<br>$v_{2intial}$ = - 6.0 m/s<br>$v_{1final}$ =<br>$v_{2final}$ =<br>$m_1$ =<br>$m_2$ = | |

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| Givens | Work |
|---|---|
| $v_{1initial}$ = 4.0 m/s<br>$v_{2intial}$ = - 6.0 m/s<br>$v_{1final}$ = 3.0 m/s<br>$v_{2final}$ =<br>$m_1$ =<br>$m_2$ = | |

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| Givens | Work |
|---|---|
| $v_{1initial}$ = 4.0 m/s<br>$v_{2intial}$ = - 6.0 m/s<br>$v_{1final}$ = 3.0 m/s<br>$v_{2final}$ = ?<br>$m_1$ =<br>$m_2$ = | |

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| Givens | Work |
|---|---|
| $v_{1initial}$ = 4.0 m/s<br>$v_{2intial}$ = - 6.0 m/s<br>$v_{1final}$ = 3.0 m/s<br>$v_{2final}$ = ?<br>$m_1$ = 8.0 kg<br>$m_2$ = | |

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| Givens | Work |
| --- | --- |
| $v_{1initial}$ = 4.0 m/s<br>$v_{2intial}$ = - 6.0 m/s<br>$v_{1final}$ = 3.0 m/s<br>$v_{2final}$ = ?<br>$m_1$ = 8.0 kg<br>$m_2$ = 4.0 kg | |

A group of students are performing an experiment in class using collision carts on a track. An 8.0 kg cart moving to the right at 4.0 m/s hits a 4.0 kg cart moving to the left at 6.0 m/s. Immediately after the collision, the 4.0 kg cart moves to the right at 3.0 m/s. What are the speed and direction of the 8.0 kg cart after the collision?

| Givens | Work |
| --- | --- |
| $v_{1initial} = 4.0$ m/s<br>$v_{2intial} = -6.0$ m/s<br>$v_{1final} = 3.0$ m/s<br>$v_{2final} = ?$<br>$m_1 = 8.0$ kg<br>$m_2 = 4.0$ kg | $m_1v_{1initial} + m_2v_{2initial} = m_1v_{1final} + m_2v_{2final}$ |

A group of students are performing an experiment in class using collision carts on a track. An 8.0 kg cart moving to the right at 4.0 m/s hits a 4.0 kg cart moving to the left at 6.0 m/s. Immediately after the collision, the 4.0 kg cart moves to the right at 3.0 m/s. What are the speed and direction of the 8.0 kg cart after the collision?

| Givens | Work |
| --- | --- |
| $v_{1initial} = 4.0$ m/s | $m_1 v_{1initial} + m_2 v_{2initial} = m_1 v_{1final} + m_2 v_{2final}$ |
| $v_{2intial} = -6.0$ m/s | $(8.0)(4.0) + (4.0)(-6.0) = (8.0)(v_{1final}) + (4.0)(3.0)$ |
| $v_{1final} = ?$ | |
| $v_{2final} = 3.0$ m/s | |
| $m_1 = 8.0$ kg | |
| $m_2 = 4.0$ kg | |

A group of students are performing an experiment in class using collision carts on a track. An 8.0 kg cart moving to the right at 4.0 m/s hits a 4.0 kg cart moving to the left at 6.0 m/s. Immediately after the collision, the 4.0 kg cart moves to the right at 3.0 m/s. What are the speed and direction of the 8.0 kg cart after the collision?

Givens

$v_{1initial}$ = 4.0 m/s

$v_{2intial}$ = - 6.0 m/s

$v_{1final}$ = ?

$v_{2final}$ = 3.0 m/s

$m_1$ = 8.0 kg

$m_2$ = 4.0 kg

Work

$$m_1 v_{1initial} + m_2 v_{2initial} = m_1 v_{1final} + m_2 v_{2final}$$

$$(8.0)\,(4.0) + (4.0)\,(-6.0) = (8.0)\,(v_{1final}) + (4.0)\,(3.0)$$

$$v_{1final} = -0.5 \text{ m/s}$$

A 136 kg defensive lineman is about to tackle a 100 kg quarterback. Right before impact, the lineman is moving north at 6.0 m/s and the quarterback is moving north at 1.0 m/s. Determine the speed and direction of the two players immediately after the tackle.

| Givens | Work |
|---|---|
| $v_{1initial}$ = | |
| $v_{2intial}$ = | |
| $v_{1final}$ = | |
| $v_{2final}$ = | |
| $m_1$ = | |
| $m_2$ = | |

A 136 kg defensive lineman is about to tackle a 100 kg quarterback. Right before impact, the lineman is moving north at 6.0 m/s and the quarterback is moving north at 1.0 m/s. Determine the speed and direction of the two players immediately after the tackle.

| Givens | Work |
|---|---|
| $v_{1initial}$ = 6.0 m/s<br>$v_{2intial}$ =<br>$v_{1final}$ =<br>$v_{2final}$ =<br>$m_1$ =<br>$m_2$ = | |

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| Givens | Work |
|---|---|
| $v_{1initial}$ = 6.0 m/s<br>$v_{2intial}$ = 1.0 m/s<br>$v_{1final}$ =<br>$v_{2final}$ =<br>$m_1$ =<br>$m_2$ = | |

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| Givens | Work |
| --- | --- |
| $v_{1initial}$ = 6.0 m/s<br>$v_{2intial}$ = 1.0 m/s<br>$v_{1final}$ = ?<br>$v_{2final}$ =<br>$m_1$ =<br>$m_2$ = | |

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| Givens | Work |
|---|---|
| $v_{1initial}$ = 6.0 m/s<br>$v_{2intial}$ = 1.0 m/s<br>$v_{1final}$ = ?<br>$v_{2final}$ = ?<br>$m_1$ =<br>$m_2$ = | |

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| Givens | Work |
|---|---|
| $v_{1initial}$ = 6.0 m/s<br>$v_{2intial}$ = 1.0 m/s<br>$v_{1final}$ = ?<br>$v_{2final}$ = ?<br>$m_1$ = 136 kg<br>$m_2$ = | |

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|---|---|
| $v_{1initial}$ = 6.0 m/s<br>$v_{2intial}$ = 1.0 m/s<br>$v_{1final}$ = ?<br>$v_{2final}$ = ?<br>$m_1$ = 136 kg<br>$m_2$ = 100 kg | |

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| Givens | Work |
|---|---|
| $v_{1initial} = 6.0$ m/s<br>$v_{2intial} = 1.0$ m/s<br>$v_{1final} = ?$<br>$v_{2final} = ?$<br>$m_1 = 136$ kg<br>$m_2 = 100$ kg | $m_1 v_{1initial} + m_2 v_{2initial} = m_1 v_{1final} + m_2 v_{2final}$ |

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| Givens | Work |
| --- | --- |
| $v_{1initial} = 6.0$ m/s<br>$v_{2intial} = 1.0$ m/s<br>$v_{1final} = ?$<br>$v_{2final} = ?$<br>$m_1 = 136$ kg<br>$m_2 = 100$ kg | $m_1v_{1initial} + m_2v_{2initial} = m_1v_{1final} + m_2v_{2final}$<br>$m_1v_{1initial} + m_2v_{2initial} = (m_1 + m_2)v_{final}$ |

A 136 kg defensive lineman is about to tackle a 100 kg quarterback. Right before impact, the lineman is moving north at 6.0 m/s and the quarterback is moving north at 1.0 m/s. Determine the speed and direction of the two players immediately after the tackle.

| Givens | Work |
| --- | --- |
| $v_{1initial} = 6.0$ m/s<br>$v_{2intial} = 1.0$ m/s<br>$v_{1final} = ?$<br>$v_{2final} = ?$<br>$m_1 = 136$ kg<br>$m_2 = 100$ kg | $m_1v_{1initial} + m_2v_{2initial} = m_1v_{1final} + m_2v_{2final}$<br>$m_1v_{1initial} + m_2v_{2initial} = (m_1 + m_2)v_{final}$<br>$(136)(6.0) + (100)(1.0) = (136 + 100)v_{final}$ |

A 136 kg defensive lineman is about to tackle a 100 kg quarterback. Right before impact, the lineman is moving north at 6.0 m/s and the quarterback is moving north at 1.0 m/s. Determine the speed and direction of the two players immediately after the tackle.

| Givens | Work |
|---|---|
| $v_{1initial}$ = 6.0 m/s<br>$v_{2intial}$ = 1.0 m/s<br>$v_{1final}$ = ?<br>$v_{2final}$ = ?<br>$m_1$ = 136 kg<br>$m_2$ = 100 kg | $m_1 v_{1initial} + m_2 v_{2initial} = m_1 v_{1final} + m_2 v_{2final}$<br>$m_1 v_{1initial} + m_2 v_{2initial} = (m_1 + m_2) v_{final}$<br>$(136)(6.0) + (100)(1.0) = (136 + 100)\, v_{final}$<br>$v_{final} = 3.88$ m/s |

**Worksheet:** Conservation of Momentum

# Objects Falling off a Truck

Learning Objective: SWBAT understand the impact of a box hitting the car, by looking at the conservation of momentum.

# Video: Box falling from a truck

# Equations for determining the force of a collision

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1) $m_1v_{1initial} + m_2v_{2initial} = (m_1 + m_2)v_{final}$

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2) $Ft=mv_f - mv_i$

# Equations for determining force of a collision

1) $m_1 v_{1initial} + m_2 v_{2initial} = (m_1 + m_2) v_{final}$

2) $Ft = mv_f - mv_i$

An 8.2 kg (18 lbs) computer tower fell off of the truck. The computer is traveling at - 10 m/s and hits your 1400 kg car traveling at 29 m/s (65 mph). What is the final velocity of the car and computer, if the computer tower sticks to the hood of the car?

$m_1v_1 + m_2v_2 = (m_1 + m_2)v_f$

| Givens | Work |
| --- | --- |
| | |

Answer

An 8.2 kg (18 lbs) computer tower fell off of the truck. The computer is traveling at - 10 m/s and hits your 1400 kg car traveling at 29 m/s (65 mph). What is the final velocity of the car and computer, if the computer tower sticks to the hood of the car?

$m_1v_1 + m_2v_2 = (m_1 + m_2)v_f$

| Givens | Work |
| --- | --- |
| $m_1=8.2$<br>$v_1= -10$ m/s<br>$m_2= 1400$<br>$v_2= 29$<br>$V_f =?$ | $m_1v_1 + m_2v_2 = (m_1 + m_2)v_f$<br>$8.2(-10) + 1400(29)= (1400 + 8.2)v_f$<br>$-82 + 40600= 1408.2v_f$<br>$40518=1408.2v_f$<br>$v_f= 28.8$ m/s |

Answer

The collision took place over 0.10 seconds. What was the force on the 1400 kg car?

$$F = \frac{m_{car} v_{car\ final} - m_{car} v_{car\ initial}}{t}$$

| Givens | Work |
| --- | --- |
| | |

Answer

The collision took place over 0.10 seconds. What was the force on the 1400 kg car?

$$F = \frac{m_{car} v_{car\ final} - m_{car} v_{car\ initial}}{t}$$

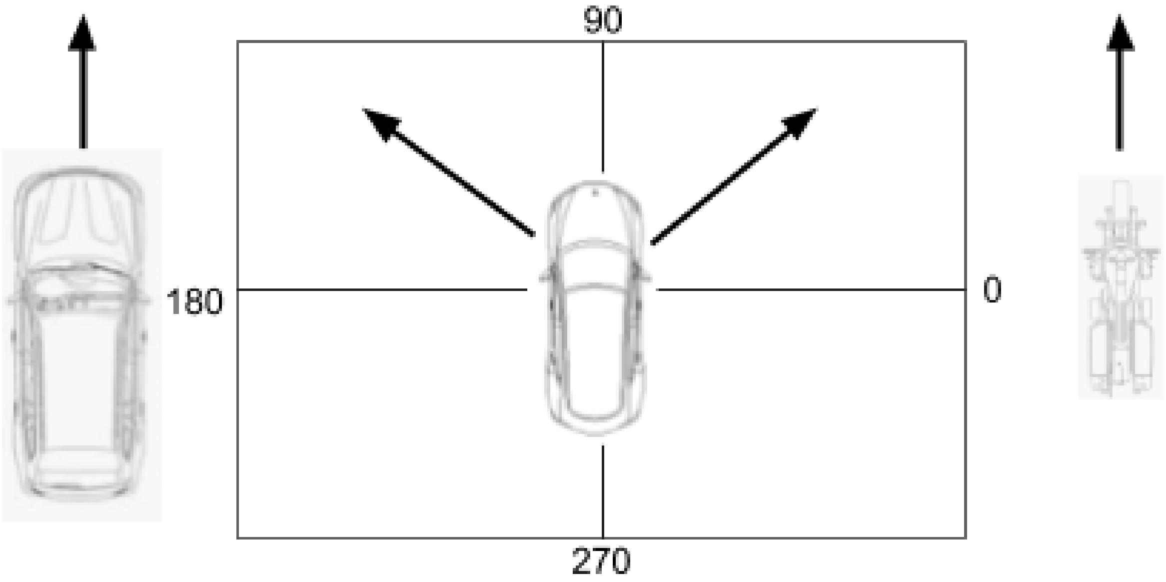
| Givens | Work |
|---|---|
| $m_{car}$= 1400<br>$V_{car\ final}$ =28.8<br>$V_{car\ iniitial}$= 29.0<br>t= .1s | F= ($mv_f$ - $mv_i$ )/t<br>F= (1400*28.8 -1400*28)/.1<br>F=(40320 - 39200)/.1<br>F= -280 N |

Answer F= 280 N

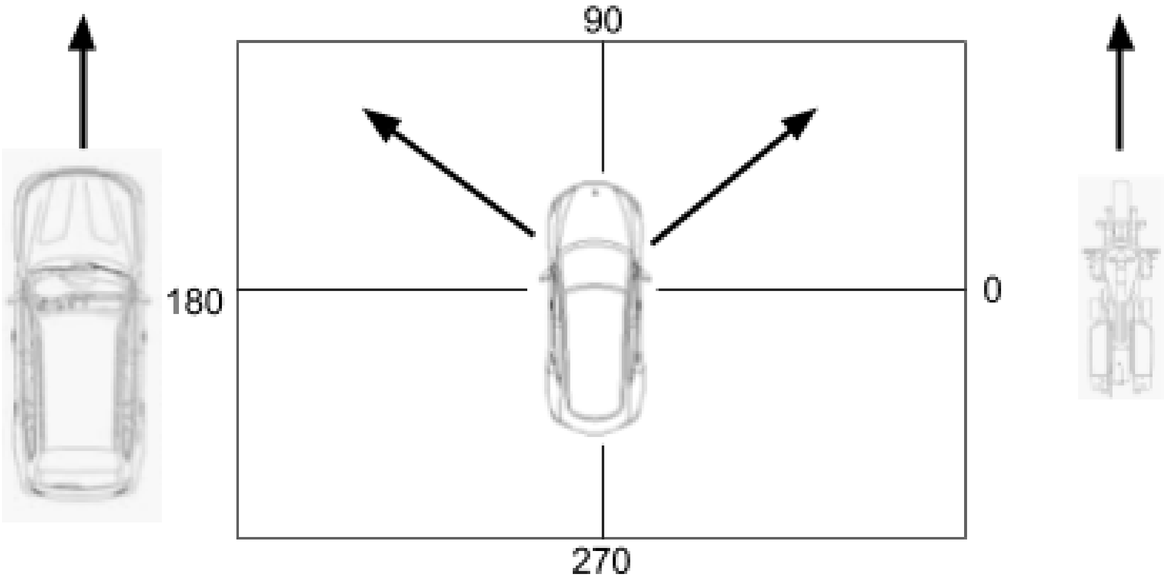
# Worksheet: Practice Collision with a Fridge

# Force on the car due to hitting the SUV and motorcycle (Conservation of Momentum in 2-D)

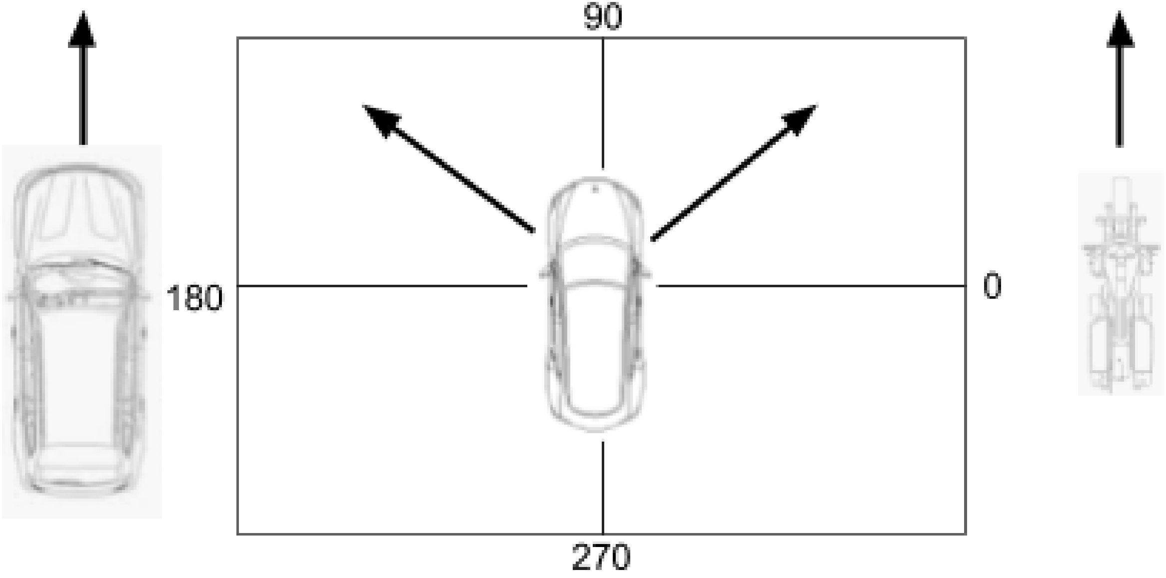
**Learning Objective:** SWBAT determine the forces when the sedan hits the SUV or the motorcycle.




- When velocity is not on the x or y axis we have to break it apart into an x and y portion




- When velocity is not on the x or y axis we have to break it apart into an x and y portion
- This means using triangles with sine and cosine




- We are not going to do the math for that, but rather let a spreadsheet do that work and just plug those numbers into equations we have already used

| Conservation of Momentum (sticking together) | Impulse and change in Momentum |
| --- | --- |
| | |

| Conservation of Momentum (sticking together) | Impulse and change in Momentum |
|---|---|
| $m_1v_1+m_2v_2=(m_1+m_2)v_f$ | |

| Conservation of Momentum (sticking together) | Impulse and change in Momentum |
| --- | --- |
| $m_1v_1+m_2v_2=(m_1+m_2)v_f$ | $Ft=mv_f - mv_i$ |

| Conservation of Momentum (sticking together) | Impulse and change in Momentum |
|---|---|
| $m_1v_1+m_2v_2=(m_1+m_2)v_f$ | $Ft=mv_f - mv_i$ |

**Worksheet:** Crashing into the SUV and Motorcycle , Presentation and Spreadsheet

Closing Questions: How do the forces of hitting an SUV or motorcycle compare to the forces in hitting the computer tower or fridge that fell from the truck?

Does this change your mind about which one you would hit?

Summary Chart: 07e Why is tailgating bad? What is in the box?

# Concept Check: Google Form and Document

# Final Project: Presentation and Grading Rubric

# Assessment