

# Short Video Projects on Physics Education: The Applications of Impulse in Boxing and Golf

Worcester Polytechnic Institute, IQP

Hussain Bhatti, ECE

Douglas Shirakura, AE

Project Advisors:

Professor Rudra Kafle

Professor Thomas Noviello

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## **Abstract**

As the title of the project implies, the main goal of this project was to create engaging and interactive physics videos for a large variety of people. While our main target audience would be middle and high school students, as this is an Interactive Qualifying Project (IQP) our ambitions go beyond our borders, and we hope that our teachings reach students that may not have access to advanced science and mathematics education. We hope that our video will serve as steppingstone forward to creating a collective online physics resource under the guidance of Professors Rudra Kafle and Thomas Noviello. Furthermore, we also seek to write this paper in a way that will serve as a resource for future students that decide to continue this project by including and discussing our methods, research, preliminary research, and most importantly our limitations. Additionally, there was an abundance of fantastic ideas that were discussed and brought up but ultimately could not be implemented due to time and monetary constraints. However, by sharing these ideas we hope that this project will continue to evolve and inspire new ideas for increasing the quality and engagement of the video production.

## **Acknowledgements**

We would like to begin by expressing gratitude towards Professors Kafle and Noviello for the opportunity to be one of the first students to be a part of their IQP. Additionally, we would also like to thank them for their guidance and contributions to our iteration of the project. We are extremely thankful to have had such wonderful Professors to be our advisors and we highly recommend this project to anyone that is interested in making an impact on education while also wanting a high degree of creative freedom.

While it was ultimately individual external factors that lead to us forgive an international IQP; Kathleen Head, director of the WPI Global Experience Office (GEO), played a critical role in assisting us with the sudden project center change. We are extremely grateful that she was able to make our transition easy and for allowing us to complete this WPI graduation requirement without needing to make any changes to our current and future schedules.

We would also like to extend our gratitude to the Academic Technology Center (ATC) team for equipping us with the necessary hardware and software to complete this project. They were responsible for supplying us with the camera and microphone equipment that was required to record a high-quality video; as well as, giving us access to the Adobe Creative Cloud suite which allowed us to use software such as Premiere Pro, Photoshop, and Audacity to edit and render our final video.

Finally, we would like to acknowledge Varun Bhat of The Global Lab at WPI for allowing us to utilize the Mixed Reality Studio in Innovation Studio for recording the narration in our videos. Additionally, his knowledge of Premiere Pro gave us guidance for editing the videos in a more professional manner beyond what we would've achieved had we attempted to figure out the software ourselves.

Overall, WPI was able to give us resources that were beyond what was necessary to succeed, which ultimately contributed to our successful project and the continuation of our academic careers.

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## **1 Introduction**

The task of Professors Kafle and Noviello's on-campus Interactive Qualifying Project is to create educational physics videos for underprivileged children. Creating educational videos and uploading them to free online video-streaming services such as YouTube gives disadvantaged students access to learn about topics that otherwise would be unavailable to them. Given this assignment, our project objective was to produce a video that educates children about basic physics concepts in a manner that is engaging and connects the concepts to real world examples.

## **2 Background**

As athletes and engineers, we believed that creating a video about our respective sports allows us to produce a final product that is not only educational but also has an accuracy that can only be achieved through experience and long history with the subject. In this case, Doug is a golfer and Hussain is a boxer. The freedom of this project also gave us the additional benefit of being able to use this time to do further research into our sports from the perspective of engineering students unlike usual where we may see things as athletes. Overall, it allowed us to maintain our engagement and kept us interested throughout the project.

Our background and expertise on the topics begin with Doug. He has played golf since he was seven years old and has grown up playing competitive golf throughout middle and high school. Currently, Doug is the eighth-ranked adaptive golfer in the United States and 60th in the world. His research and history with the subject of golf combined with his pursuit of an Aerospace Engineering degree at WPI made golf a great subject for a part of the video. Hussain on the other hand has been training in the art of boxing for nearly 5 years as a form of fitness and self-defense. His experience in boxing along with his knowledge from what he has learned as an Electrical and Computer Engineering student at WPI was a great resource when diving into the physics of a punch.

Prior to beginning this project, we had no knowledge of videography, including production, writing, and editing. While our creative minds helped us come up with an abundance of ideas and various ways to approach this project, we knew nothing about what it took to create a video. This is why we started out by finding, researching, and investigating established content creators and similar TV shows to draw inspiration from.

### **3 Preliminary Research**

We began the project by researching and watching a variety of educational content. Through this research and our own personal opinions about these forms of educational content we ultimately settled on imitating aspects of videos and shows created by Bill Nye, ESPN, Sal Kahn, and Derek Muller. We found their respective shows to be extremely engaging and we sought out to investigate further into their success. After all, their channels/shows combined having billions of views was no coincidence. With respective domestic and even international success, there must be elements we could imitate to create engaging, educational, and informative content of our own.

#### **3.1 Bill Nye the Science Guy [1]**

We started with Bill Nye. "Bill Nye the Science Guy" was a popular educational television show created by Bill Nye that aimed to teach children about various scientific topics in a fun and engaging way. The show originally aired from 1993 to 1998 and was designed to make science more accessible to children and to get them excited about learning. The show was popular among both children and young adults and won multiple Emmy Awards for its educational content and in the process, Bill Nye became a beloved figure in popular culture and is still considered a leading advocate for science education today.

We had known about Bill Nye because his TV show was often used as a way to supplement the teachers lectures when we were in elementary and middle school. The fact that we (Hussain and Doug) had grown up three states away from each other just goes to show just how large Bill Nye's influence was on science education was. As STEM students at



WPI we also could not recall any of our close friends at WPI that had not heard or even seen at least 1 episode of “Bill Nye the Science Guy” growing up in the United States.

Each episode of the show focused on a different scientific concept, such as gravity, electricity, or the human body. The show used humor, music, and hands-on experiments to help explain complex scientific ideas in a way that was easy for kids to understand.

We sought out to incorporate some of the humorous aspects of his TV show into our video in the hopes that it would also raise our engagement and watch retention times.

### **3.2 ESPN Sports Science [2]**

"Sports Science" was a television show that was created, hosted, and produced by John Brenkus. It aired on the ESPN network from 2007 to 2018. The purpose of the show was to use scientific principles to analyze and explain the athletic abilities of professional athletes. Doug had known about this show because he had remembered watching one of his favorite golfers Rory McIlroy being a guest on the show.

Each episode of the show would feature various athletes from different sports, such as basketball, football, and baseball, and would use high-tech equipment and analysis to measure their physical abilities. The show's hosts would then break down the data and explain how each athlete's abilities were able to contribute to their success in their respective sports.

The show aimed to bridge the gap between sports and science by showing how scientific principles could be applied to the field of athletics. It was designed to appeal to sports fans who were interested in understanding the science behind the amazing feats of professional athletes. Overall, the purpose of "ESPN Sports Science" was to provide viewers with a unique and informative perspective on the world of sports by using scientific analysis to explain the physical abilities of athletes.

While we knew we would not be able to achieve this level of production and depth of scientific experimentation, we knew that we could draw inspiration from the explanations and narration that John Brenkus had provided. Additionally, it was this show that inspired us to come up with various data collection ideas for future iterations of the project. This will be further detailed in the [discussion](#).

### **3.3 Khan Academy [3]**

As WPI students or any STEM student for that matter, you will not find a single person that has never used Khan Academy. Whether it's because you do not understand a complex chemistry problem or you simply forgot how to solve a differential equation, Khan Academy has thousands of videos ranging across dozens of topics and dozens of languages for anyone to access for free.

Khan Academy is a non-profit educational organization founded by educator and entrepreneur Salman Khan. The organization believes that education is a basic human right, and that everyone should have access to the tools and resources needed to succeed in life.

The purpose of Khan Academy is to provide free, high-quality educational resources to people all around the world. The resources are designed to be accessible and flexible, allowing users to learn at their own pace and on their own schedule. Khan Academy's mission is to provide a world-class education to anyone, anywhere, regardless of their socioeconomic background.

The informative and lecture style video of Kahn Academy is what ultimately lead us to testing our interactive concepts such as quizzing the audience through animations and OneNote screen recordings.

### **3.4 Veritasium**

Veritasium is a science-based YouTube channel created by physicist and science communicator Derek Muller. The purpose of the channel is to explore and explain various scientific concepts in an engaging and accessible way. The channel's name, "Veritasium," is derived from the Latin word "veritas," meaning "truth," and the suffix "-ium," which is often used to denote elements in the periodic table, reflects the channel's focus on exploring the fundamental truths and principles of science.

The channel covers a wide range of topics in science, including physics, chemistry, biology, and earth science. Each video is carefully researched and produced, and often features engaging demonstrations and experiments to help illustrate complex concepts.

The purpose of Veritasium is to make science more accessible and interesting to a general audience. The channel aims to break down complex scientific concepts into simple, understandable terms, while still maintaining scientific accuracy.

With our objectives perfectly aligned with Veritasium, we sought out to find out the main reason why this channel was so engaging. We found that for Veritasium, the production quality and demonstrations were their main ingredients for the recipe that creates an appealing video. They also seem to have these incredibly simple yet detailed thumbnails that make you want to click on their videos in the first place.

Overall, the purpose of Veritasium is to inspire curiosity and a love of learning in people of all ages by making science engaging, accessible, and entertaining. Something that we also tried to imitate. The channel has become a popular resource for science enthusiasts, educators, and students around the world, and has helped to promote a greater understanding and appreciation of science.

## **4 Methodology**

With our preliminary research complete, it is time to go over the process that we took to complete our final deliverable. This process was full of mistakes and failures that we will go into so that future students don't do the same. We start by describing this process from

the very beginning, C-Term of 2023 to be exact where our enrollment for the project was confirmed. Knowing that we would be partners, we started by brainstorming and proposing our ideas for the project to Professor Kafle.

#### **4.1 Proposal**

We were ambitious from the beginning, coming up with tons of ideas to use high speed cameras to capture collisions, force plates to collect data, microphones for narrating, even going as far to get a professional narrator to introduce us. Ultimately, one of the main limitations for on-campus IQPs was that there are no external sponsors for our project.

In the end, we had to re-evaluate our goals and prioritize what we wanted to accomplish. That being to create a physics video for students that would be both entertaining and informative. We drafted our goals, comments, and questions, and presented our final proposal to Professors Kafle and Noviello. Finally, we were officially set to begin our IQP in D-term of 2023. The proposal document can be found in [Appendix A](#).

#### **4.2 Outlining**

We believe that outlining was by far the most important step, especially for starting something that neither of us had ever done before. Outlining allowed us to start by writing out the important topics that we needed to cover and then branching from that core idea to develop something more specific and concrete. Our outline document can be found in [Appendix B](#).

To take our project for example we started with the main topics of our video: Impulse, Momentum, Boxing, and Golfing. With impulse we knew we would have to review what impulse was and its connection to momentum. From the start, we had a good transition to allow flow within our video. In other words, we knew that we would have to explain what momentum was and then go into impulse and collisions. That became the foundation for what became the review portion at the beginning of our video. We also then began to list the important equations that would need to be addressed in the review

portion. Although we were assuming that viewers have a basic understanding and knowledge of physics, we still believed it would be a good idea to show equations for force, momentum, and impulse in the review as respectively given by the following:

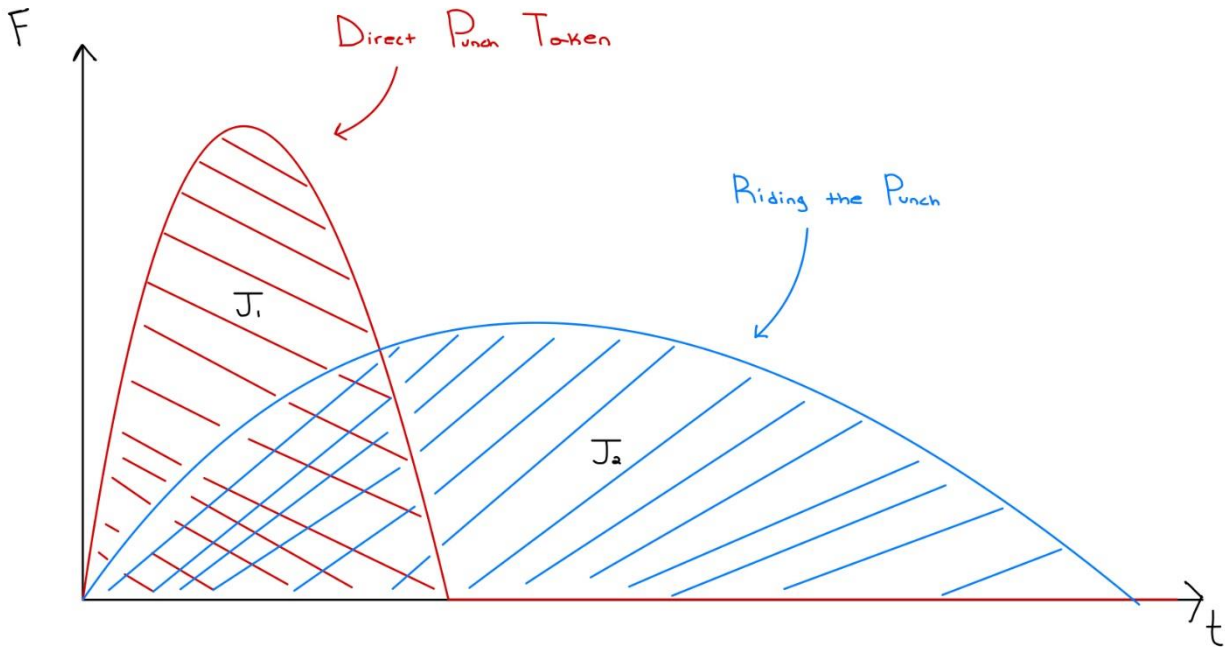
$$\vec{F} = m\vec{a} \quad (1)$$

$$\vec{p} = m\vec{v} \quad (2)$$

$$\vec{J} = \vec{F}\Delta t = \Delta\vec{p} \quad (3)$$

Then it came to the creative elements of our video. How can we represent this concept that we just explained and reviewed in an engaging way? This is where we started thinking about ways to incorporate impulse and momentum into golf and boxing.

Starting with boxing, it was obvious that the aspect most representative of the physics concepts was the punch. When you throw a punch, there is force, momentum, and most importantly a collision with a person or an object. For the videography ideas, we immediately knew to take creative inspiration from ESPN Sports Science where they would show collisions in full speed first to show the power and comparative speed. Then in the next scene, slow down the same clip to show what it looks like up closely and in detail. We were able to incorporate this element successfully in our final video. For the conceptual ideas, we knew that a punch had momentum and impulse in the collision with an object. However, Hussain with his expertise was able to connect a concept that Mohammed Ali was famous for coining “riding the punch” with the impulse of a punch. Essentially, this boxing concept known as “riding the punch” was actually a physics concept disguised in boxing terms. By moving with the punch upon impact instead of resisting the impact, you would be increasing the contact time between punch and the punched. Thus, decreasing the overall peak force that could be netted on an object at a given point. This concept can be more clearly defined in the graph below.



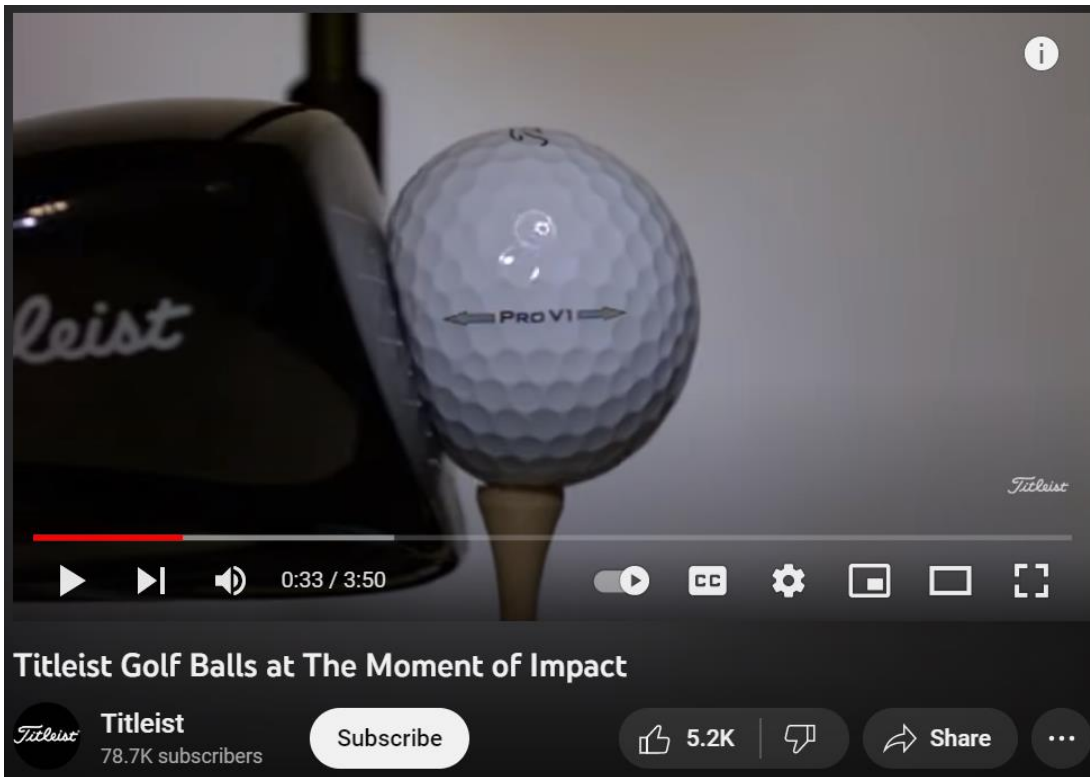
*Figure 1: Force-Time Curves: Area under an F-t curve gives Impulse of the force.*

In this graph we see two punches. Both punches have equal impulses ( $J_1 = J_2$ ) but differ in contact time between punches. The first punch, represented by the red plot, has less contact time and a higher peak force. The second punch has a significantly higher contact time and less peak force. What this shows us, graphically, given the same punch, if the contact time is increased and the person “rides the punch”, the force of the punch decreases, causing less damage.

Finally, for golf, the only collision that is in the sport and is fundamental to the sport is between the club and the ball. For our video we planned to analyze the impulse of a golf ball impacting the golf club. Again, we planned to show this in our video by showing the impact up close and in slow motion. However, we would like to give credit to the creators that have already created similar videos such as ESPN Sports Science, Titleist Performance Institute, and Martin Borgmeier. Similar to the boxing portion, we would be analyzing the impact of the golf ball and the golf club and detail its relationship to momentum and impulse.



*Figure 2: Martin Borgmeier's Instagram Reel [5] Capturing Long Drive Golf Ball Impact at 12,000 Frames Per Second*



*Figure 3: Titleist Performance Institute Capturing Golf Ball Impact at 22,000 Frames Per Second [6]*

Now, with the review and creative portion planned out, we now had to figure out how the review would be video graphed. The boxing and golf video would all be acted out and recorded by us but how do you review a concept and explain it to an audience virtually? There were many options for this such as typical online lecture style (similar to a synchronous online lecture and Khan Academy), presentation style (online asynchronous lecture), and YouTube style (Veritasium). Originally, we had planned and completed writing out a script to explain impulse and momentum in an online lecture style. To be specific, we were going to write out and do a basic impulse and momentum problem while explaining it, this would've been done by screen recording a OneNote canvas. However, at the last minute, we scrapped the idea because we thought it was too uncreative and boring. If the goal was to do something that would grab the attention of the audience, we had to do better. This was when we remembered that our mutual friend Connor had shown us his latest personal project which was a YouTube video explaining the rules of a game. To do this he had used PowerPoint to animate how the game works and showed us how exciting the visuals were. Thus, we decided to do this for not only the review portion, but also the explanation part of the boxing portion as well. Now with everything laid out, the first step was to start storyboarding.

### **4.3 What is a storyboard?**

After the outline was completed, it gave us a general idea for what topics we were going to cover in the video and how we wanted to explain them. The easy part was listing all of the topics we had to cover, now we had to come up with creative ways to tie them to our respective sports.

Firstly, we knew we needed to review the basics of momentum and impulse. We took inspiration from Bill Nye's wacky introduction and explanation for this part. While I am certain that any producer would tear us apart for this, the easiest way that we found to label title these clips was "Scene X" and "Transition X" where the X indicated which number scene or transition. Our storyboard can be viewed in [Appendix C](#).



As you can see our storyboard at this point was still very rough, there were a lot of general explanations and nothing too specific. This was done intentionally as it allowed us the freedom to change things if felt that the scene would be too complex to record or if something didn't quite fit right, which I will reiterate was the reason that allowed us to switch from a lecture style review to fully detailed animations.

We organized our storyboard where the left column would detail the scene or the shot that we imagined for that part of the video and the right column would generalize a script for that scene. Sometimes the right column would consist of quotes or phrases that would be used directly or just a general explanation for what needed to be said/covered. We found this method to be the easiest way to keep our thoughts organized and the divide between video and audio allowed us to keep track of and make independent changes to the scenes when needed.

Now, equipped with a vision for our video it was time to become directors, actors, and narrators; something we never dreamed of becoming.

#### **4.4 Lights, Camera, Action!**

Our first step was to borrow equipment. Since we had no budget to work with, we had to utilize campus resources and maximize our personal belongings. Between the two of us, we each had our own laptops and phones, and Doug had a tripod for his phone. This was a good start but for what we were looking to do it wouldn't be enough. Our first stop would be the Academic Technology Center (ATC). Funnily enough, we found out the ATC had two locations on campus because we went to the wrong one first. However, it turned out to be a great mistake because this ATC location (library) was responsible for accessing software such as the Adobe Creative Cloud suite which we would need to edit out videos later. After we got to the correct ATC location (Fuller) what we thought was going to be a lengthy process to check out equipment ended up being extremely easy and convenient. They had all the equipment we needed which consisted of a high frame rate

camera (GoPro), a camera tripod, and a microphone which took no longer than ten minutes to check out. Now, with the equipment in our possession and a sunny weekend ahead of us we opted to record the boxing clips and Hussain's house first.



*Figure 4: Doug and Hussain Setting Up the Equipment for the Boxing Scene*

Now that it was officially time to get to work, we wanted to record what would become our boxing footage. The workday began when we started taking out all the equipment for the punching bag from the shed. The equipment consisted of about 5 large steel beams and a 75lb punching bag. When everything was taken out, we soon realized that we didn't have the proper equipment to put everything together, so we made a trip to Home Depot to buy some equipment. This taught us two valuable lessons. First, that not everything goes to plan and second, tools are expensive.

We got back and started our assembly, using our engineer brains we were able to do this quickly. We then set up our GoPro and phone cameras and Hussain changed into his boxing attire. For our background, we bought a large whiteboard and were set to record. This is when we learned our third valuable lesson, when recording something, expect it

to take four times the amount of time you plan for. We took many takes outside in the cold until we got the perfect take for each shot.

Our goal with these takes was to record punches and determine the impulse they may produce. We aimed to record four jabs and four straights with different types of gloves and speeds. We did this first with the MMA gloves. Next, we did this with boxing gloves. When production was finally wrapped up, we exemplified the fourth most important lesson, always leaving a place better than the way you found it.

After sorting and storing the clips from Doug's phone and the GoPro on Doug's laptop, next up was recording the golf clips. Now, from the beginning we knew that capturing this section would be the most difficult with the equipment we had and would be one of our biggest limitations for golf. Because of the nature of the scale and speed of golf we knew that capturing the shot we needed for golf would require a lot of luck and skill.

We set up the camera in a similar fashion to the boxing clips where the GoPro was used to capture the up-close and slow-motion video and Doug's phone was used to capture the overall motion. While the phone footage was great, unfortunately, after many attempts the GoPro was not quite able to capture the impact between the club head and the golf ball. We tried different camera angles, different colored balls, moving it closer and further, and swinging slower. It all just led to the conclusion that a collision this fast could not be captured at 240 frames per second. After all, the cameras that Titleist Performance Institute and Martin Borgmeier used capture over 10,000 frames per second.

At this point, we were running out of time, and it was decided between us and the advisors that if we were to be able to add a golf section to our video, we would use videos from online with permission from the creator to show this collision.

Finally, our animated scenes. As mentioned earlier, our animations were created in Microsoft PowerPoint, and it was easy to use. PowerPoint had so much more versatility than we had ever imagined, and this will be one of the biggest takeaways from this project

for us. Being able to utilize PowerPoint to its fullest potential is a complete game changer and while the animations cannot be attached to this document, the slides can be seen in [Appendices D and E](#) below. Completing our respective animated slideshows took about a week and a half and then had to be proofread by the advisors. We would like to reiterate that having animated scenes were not a part of the original plan, however, the engagement factor that it added was too good to pass up. Although this part ended up well, we recommend giving more time to refine and polish the animations.

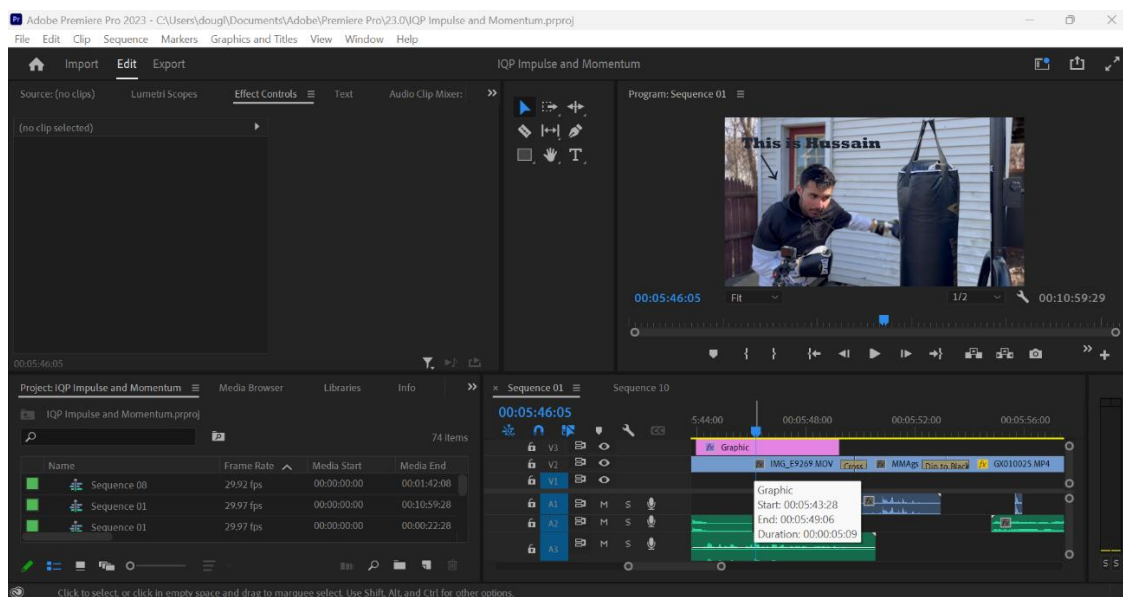


*Figure 5: Hussain Editing Animation Scene 4 inside the Global Lab at WPI*

Overall, learning videography and animation was an amazing experience and we highly recommend that you attempt to learn these skills as it gives a greater appreciation for the hard work that your favorite animators and content creators must do to produce the content we consume.

## 4.5 Editing

With only a few weeks of the term left we began to put all our work together into one coherent video. With our limited expertise and experience, we had to work harder to achieve the quality we wanted to acquire. As mentioned before, editing was quite a learning curve since neither of us had any prior editing skills. However, by the end of the term we were able to put together the full video, along with both of our narration and transitions from section to section.



*Figure 6: Premiere Pro Editing Dashboard*

This is where Varun Bhat of the Global Lab played a huge role in our project. Varun is extremely knowledgeable about video and audio editing and was our mentor when it came to bringing our imagination to fruition. In addition to Varun's technical help, we were also directed to multiple online resources that would help us to figure out any additional editing questions and elements that we were looking to add. The resources we used can be found in the references. After understanding the basics of Adobe Premiere Pro, however, combing and editing the videos together became easier the longer we worked on the project.

It was also at this point that we needed to add the narrations and voice over our videos. The transcript for the scenes and transitions can be found in [Appendices F, G, and H](#).

Overall, we believed that the editing was more complex than recording the scenes and for future projects ideally needs at least a week and half to two weeks to complete. Additionally, learning how to use Adobe Creative suite and specifically Premiere Pro turned out to be a great learning experience.

#### **4.6 The Final Video**

While there were initially doubts about whether Doug's laptop could handle the rendering of the final video, surprisingly, even an underpowered workbook was able to render the video in just under 20 minutes.

The goal of this experimental channel is to create a hub of information that would be easily accessible to the public. Ideally videos from each IQP group, every year, would be posted on this channel. Over a period of a few years the quantity of IQP videos would grow, highlighting the progression of the students who take the IQP over time. Along with that, as mentioned prior, the public will have another resource to learn about important topics through fun short videos. We hope that our video and research paper will serve as a reference for future projects and continue the legacy of what we called "Kafle's Classroom". Whether or not our name for this YouTube Channel or brand for that matter catches on we believe that this resource will serve as an incredible educator of physics topics to students all over the world.

Overall, we think that the process of creating this video was a tremendously valuable experience and made us feel like we had a direct impact on education unlike what some other IQPs may find. The best part about the final part of this project is that we are able to see the fruits of our labor directly as we watch the video viewership statics trend upwards.

The YouTube video can be found by clicking this link here: [VIDEO](#)

## **5 Discussion**

The purpose of this discussion section is to review and summarize the key takeaways from our project. While our end product may have been missing some significant parts compared to our initial vision, we believe that because of our hard work and improvisation we were still able to produce a high-quality educational video. We hope that future project students will be able to read through this section and get closer to producing a final product that is better than their initial imaginations.

### **Takeaways**

There were a lot of things that we were able accomplish throughout this journey. The project challenged us in many ways, requiring us to think beyond the plan we originally had. This project had its share of problems and setbacks we had to deal with and learn from. From the beginning we wanted to stay on top of everything we did. We did this by talking ahead of the term and creating a schedule before the term began. We believed if we did this, there would be no chance for any unsolvable problem to come up. We were partially right but could not plan for everything. However, a testament of someone's ability is how they act under pressure, and we dealt with every problem as it came. Our major problem was funding, more on this later.

### **Initial Expectations and Ambitions**

Before going into our setbacks, it's important to establish the original plan and goal. When we both envisioned this project, we had many plans and ideas. Overall, our plan assumed we had a budget. With that thought we planned to get a high-definition camera to record our punches and golf shots. Along with that, buy and incorporate a force, speed, and time under contact detector for the punches. The reason we wanted this was to be able to measure the momentum and impulse of different punches and masses. This would have provided is with actual data through our observations. Another sensor we wanted was one for golf shots. Again, this was to record data using the information gathered from the

sensor. This would've allowed us to support our claims with actual data. We also wanted to make our product look very professional, to do this we wanted to hire a professional narrator to voice our videos, and a professional editor to teach us how to edit and guide us through the process until we created the perfect product we wanted.

### **Limitations and Setbacks**

In the end our final product was a little bit different than our original idea due to the setbacks and limitations we had. As previously mentioned, the major setback we had was funding. Since this was a very new IQP and frankly very little known, there were no sponsorships to help fund the research and ambitions we had. This was our biggest issue when it came to turning our ideas into products.

Fortunately, we owned most of the equipment we needed for our project, which would've cost us no less than \$600 otherwise. One thing to note, this didn't include the detectors, sensor, camera and microphone costs.

### **Results**

In the end we were not able to get any funding and had to find other means to accomplish the fundamental goals of our project. Any tools or software had to either be purchased by us or had to be acquired another way. Although this was a hurdle, it led us to do a lot of brainstorming and make some compromises. The first of which was to only record the boxing or golf sections. This was a major letdown for us because of the passion for our individual sports. Along with that, since we could not purchase our equipment, we could no longer record our own data. This cut out a big portion of our original idea. To combat this, we had to borrow a camera from the ATC and instead recorded slow motion videos of different punches and talked idealistically about how the force and impulse should have looked like. Finally, we had to take out a lot more time to edit and voice record all our parts. This required us to have editing software and a microphone. The former was thankfully provided by the ATC and the latter by Hussain.



## **7 Conclusion**

The skills we learned, the knowledge we gained, and the memories that were made from this project were much more than we had ever expected. While this project had many ups and downs, we were able to apply our improvisation skills and compromise with ourselves and our peers to produce a final product that was beyond our own expectations. We hope that more students realize the importance of learning skills that are beyond what they might normally learn. We believe that one of the main purposes of IQP all together is to be able to step out of your comfort zone, which may become more difficult to do with an on-campus IQP. However, even though this project was started and completed on-campus, we can confidently say that there was no shortage of stepping outside of our comfort zone and needing to think outside the box.

The purpose of this project was to create fun and educational videos for kids to use and learn from. Our goal was to produce a video that would convey how integral and useful physics is in all aspects of life. It is safe to say that this goal was accomplished because of our hard work and the support of Professor Kafle, Professor Noviello, the ATC faculty and the Global Lab as well. In the end we were extremely happy with the final result of our video, and we hope that this project will continue to expand and inspire students, viewers, and even teachers, globally.

# Appendices

## Appendix A: IQP Proposal Document

### Short Video Projects on Physics Education Proposal

The task of Professor Kafle’s on-campus Interstice Qualifying Project (“IQP”) is to create educational physics videos for underprivileged children. Creating educational videos and uploading them to video-streaming services such as YouTube and Vimeo give underprivileged children access to learn about topics that otherwise would not be available to them. Given this assignment, our (Hussain and Doug) project objective will be to produce a video that educates children about basic physics concepts and engages them by explaining concepts in a manner that connects them to the world around them. We have come up with an idea that we believe will achieve our goals and the objective of the project.

Referencing content created by Bill Nye<sup>1</sup>, Veritasium<sup>2</sup>, and ESPN<sup>3</sup>, we seek to create a video that will explain the basic ideas of force, momentum, and kinematics through sports. As athletes and sports enthusiasts, we believe that creating a video about our respective sports allows us to produce a final product that is not only educational but also has an accuracy that can only be achieved through experience and long history with the subject.

Doug has played golf since he was seven years old and has grown up playing competitive golf throughout middle and high school. Currently, Doug is the eighth-ranked adaptive golfer in the United States and 60<sup>th</sup> in the world. His research and history with the subject of golf combined with his pursuit of an Aerospace Engineering degree at Worcester Polytechnic Institute (“WPI”) make golf a great subject for a part of the video.

Hussain has been training in the art of boxing for nearly 5 years as a form of fitness and self-defense. His passion for the sport arose in high school after being told he couldn’t learn and fight. This kickstarted his motivation but his love for the sport is what made him stay. His experience in the art along with his knowledge from what he has learned in his undergraduate studies in Electrical and Computer Engineering at Worcester Polytechnic Institute will be a great resource when diving into all that goes into throwing a clean punch.

With our abundant knowledge about Golf and Boxing and our formal physics education, we seek to combine the two to produce a video that is passionate, interesting, and informational.

To achieve this, we have already begun planning our project by setting ourselves deadlines to complete as much as possible even before the start of D-term to give ourselves the best possible chance at producing a great video. The storyboarding and scripting of the video will require researching similar videos to build ideas and create a reference point for us to build off of. As you can see we have already begun this process with the understanding that content creators listed previously have produced similar videos. After completing our initial research, we plan to have a storyboard and respective script drafted by mid-late C-term. Although ambitious, we believe this will put us at a significant advantage for D-term where we hope to comfortably

<sup>1</sup> Bill Nye was the host for his television show “Bill Nye the Science Guy” that created educational videos promoting a wide spectrum of science topics - [Link](#)

<sup>2</sup> Veritasium is a popular YouTube channel created by Derek Muller that explores an interesting variety of science concepts in way that is captivating and educational - [Link](#)

<sup>3</sup> ESPN is cable sports channel that released a series called “Sports Science” hosted by John Brenkus that goes in-depth about the physics concepts that are in sports - [Link](#)

complete the project on time. The next hardship we encounter will be the recording process. Unfortunately, with neither of us having any significant prior experience in videography this will be the first challenge we face. Luckily with some connections to the WPI Photo Club, we hope to reach out to them for assistance in recording certain shots for our video. Although we understand that this is unnecessary we believe that for the sake of video quality, this would be a great addition to our product. The next challenge we face will be the editing process. A lot of time will be spent researching and experimenting with programs such as Adobe Premiere Pro and Sony Vegas Pro. However, after these challenges are resolved, we believe the additional time spent improving our video quality will make our final product drastically better.

Finally, we conclude this proposal with a list of what we believe will be our limitations, final thoughts, and questions.

- i. Our seven-week timeframe is strict, hence the reason we've already taken the initiative to begin to think about our plans.
- ii. We wish to also emphasize in our project that basic physics is unintimidating and can be fun to learn about.
- iii. Finally, we would like to know more details about the formal IQP information:
  - a. Do we have a budget? If so, how much?
  - b. Who is our official sponsor? (Professor Kafle? WPI?)
  - c. Where can we find the project archives?
  - d. Are there any additional objectives for the project we are missing?
  - e. When is it due officially and how long is our final report?
  - f. Are there parts of the project that we can negotiate?

Thank you for your time and for the opportunity to fulfill our IQP on campus.

Sincerely,

Hussain Bhatti and Douglas Shirakura

## Appendix B: IQP Outline Document

### Physics Definitions

**Momentum** - Momentum is the product of an object's mass and its velocity, and is represented by the formula:

$$\text{Momentum (p)} = \text{mass} \times \text{velocity}$$

The momentum of an object can change if there is a net force acting on it, which will cause it to accelerate or decelerate. According to Newton's second law, the net force acting on an object is equal to its mass times its acceleration. Therefore, the change in momentum of an object is equal to the force applied to it multiplied by the time interval over which it is applied.

**Impulse** - Impulse is defined as the change in momentum of an object over a period of time. It is represented by the formula:

$$\text{Impulse (J)} = \text{force} \times \text{time} = \Delta p$$

When a force is applied to an object over a period of time, it will experience an impulse, which will change its momentum.

---

### Connection to Sport

Boxing:

Golf:

Impact between golf ball and clubhead – easiest to see/ represented with a driver “the trampoline effect”

---

### Outline:

Introduction:

What is Impulse and momentum?

This video will explain the concept of impulse and momentum and how it connects to the world around us.

The beauty of physics does not come from the difficult formulas and calculations, it comes from the realization that understanding this concept puts you one step closer to understanding the world around us.

Ex: Before we can get into the cool stuff, Lets begin with a little review. This will be boring but we'll keep it short we promise.

This is quite a simple problem...

## Appendix C: IQP Storyboard

# IQP: Impulse and Momentum Storyboard

Hussain Bhatti, Douglas Shirakura

Note: All time stamps are approximate and will vary significantly from the final product.

## Scene 0 Introduction + Hook: 0:00 – 0:30

### **The Scene:**

Use like a minute of stock footage ex:  
Veritasium Introduction

- Go over the objectives of the video
- Introduce the video but not ourselves (yet)

“Impulse and Momentum”

Newtons cradle

Wrecking ball

“The world around us”

City time lapse

People walking

Video of campus (?) -> Transition

## Additional Ideas Introduction (Hidden)

Use some stock footage

Maybe film some wall ball footage in the rec center?? Squash?

Wall ball

Bouncy Ball?

- What is Impulse and momentum?
- This video will explain the concept of impulse and momentum and how it connects to the world around us.
- The beauty of physics does not come from the difficult formulas and calculations, it comes from the realization that understanding this concept puts you one step closer to understanding the world around us.

## Transition 1: 0:31 – 0:40

### **The Scene:**

Hussain and Doug in front of fighting Goat Statue

- “we’re here to teach **you** about impulse and momentum. Lets get into it”

1. Hand over camera
2. Ball thrown at camera

## Transition 2: 0:41 – 0:45

### **The Scene:**

Hussain in front of camera

- “But first let’s start with a little review”

1. Hand over camera
2. Swipe up

## Scene 1: 0:46 – 1:30

### **The Scene:**

Concept review

1. The classic bug and the car example here: Newton’s Third Law, force, and momentum
2. Powerpoint narration

- Part 1: Explain the question  
Fundamental concept review->  
“Pause: Does the bug exert a greater, equal, or less force on the car compared to the car?”
- Part 2: Momentum: “Given the car weighs  $x$  and is traveling at  $x$  what is the momentum of the car? What about the bug given  $x$  and  $x$ ? pause”
- Part 3: Impulse: “What is the impulse given  $x$ ?”

## Transition 3: 1:31 – 1:35

### **The Scene:**

Extra Clip of Hussain Boxing

- “Ok, enough of the boring stuff its time to get into the fun stuff”
- “This is Hussain.”
- “He’s been boxing for 4 years and we’re about to see what his fists can do to this poor punching bag”

## Scene 2: 1:36 – 2:20

### **The Scene:**

1. Full straight normal punch with the mma gloves
2. Gopro straight with mma gloves

- Part 1: Full playback speed “did you catch that? No?” Lets look at it close up
- Part 2: “Ouch, that’s gonna leave a mark”



## Transition 4: 2:21 – 2:30

### The Scene:

1. Transition from MMA to Boxing gloves
  2. Question time scene Powerpoint narration
- Part 1: “Time for the big guns”, “Lets try something bigger”
  - Part 2: Momentum Pause: “If Hussain punches at the same speed of  $x$  with both gloves but the mma glove weighs  $x$  and the boxing glove  $x$  which one will have a greater momentum”
  - Part 3: Impulse Pause: “Boxing gloves have padding that makes them heavier but also **increases** the time of impact. What is difference in impulse”

## Scene 3: 2:31 – 3:30

### The Scene:

1. Full straight normal punch with boxing gloves
  2. Go Pro straight with boxing gloves
- Part 1: “That boxing glove packs a punch”
  - Part 2: Discussion Pause: “ you know who else packed a punch though? A guy named mohammed Ali”

## Scene 4: 3:31 – 4:30

### **The Scene:**

1. Mohammed Ali clip **or** picture

- Part 1: “Mohammed Ali was known for riding the punch, can you guys guess what he meant by this? Hint: it has to do with this equation:  $J=Ft$ ”

## Golf

### **Scene Ideas**

1. Recording full swing
2. Zoomed golf ball impact

### **Script Ideas**

- Explanation of the video

## Appendix D: Scene 1 Animation (Review Section)

# Scene 1

Douglas Shirakura



## Review Time!

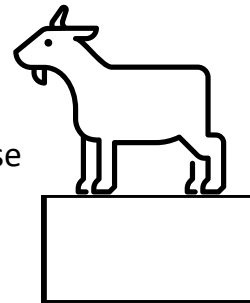
Forces



Momentum

Newton's 3<sup>rd</sup> Law

Impulse



Elastic and Inelastic Conditions

## Important Equations

Force equals mass times acceleration

$$\vec{F} = m \cdot \vec{a}$$

Momentum equals mass times velocity

$$\vec{p} = m \cdot \vec{v}$$

Impulse equals force times the change in time

$$\vec{J} = \vec{F} \cdot \Delta t = \Delta \vec{p}$$

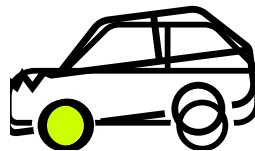


## Collision Types

### Perfectly Inelastic Collision:

A perfectly inelastic collision is a type of collision in which colliding objects stick together after the collision and move as a single object.

Kinetic energy is **not** conserved in such collisions as some of the initial kinetic energy is lost and converted into other forms of energy such as sound, friction, and deformation.



## Collision Types

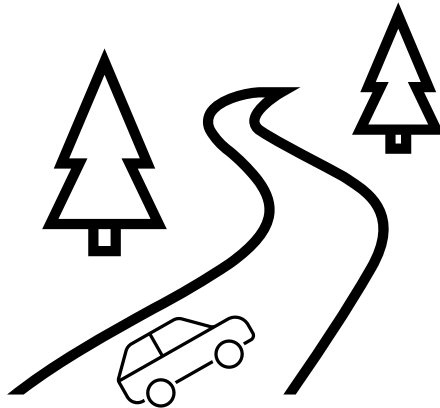
### Perfectly Elastic Collision:

A perfectly elastic collision is a type of collision in which colliding objects bounce off each other with **no** loss of kinetic energy.

Perfectly elastic collisions are **theoretical** and **idealized** because in real-life collisions because some of the kinetic energy is always lost due to factors such as friction or deformation of the objects.

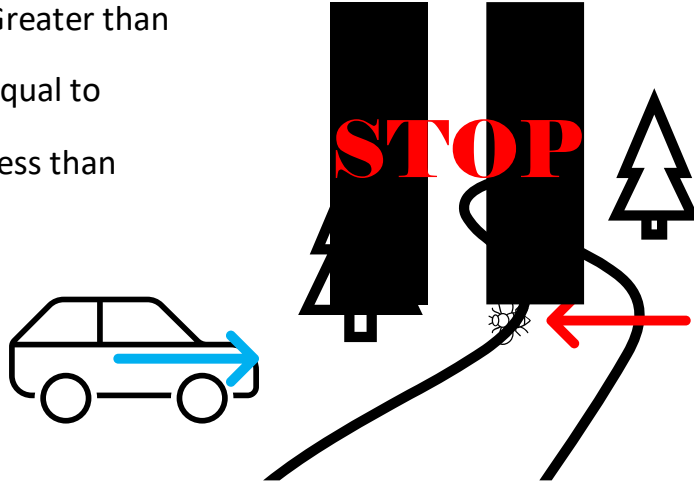


You are traveling down a beautiful and scenic highway in your freshly washed car when all the sudden you rapidly start approaching a bug.



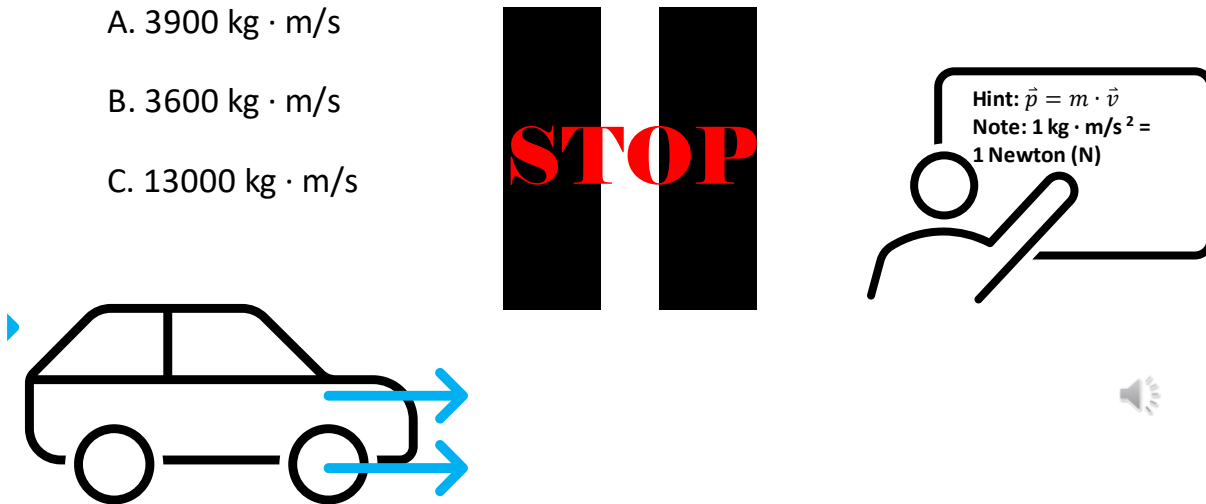
You are traveling down the highway in your freshly washed car when all the sudden you rapidly start approaching a bug.

- A. Greater than
- B. Equal to
- C. Less than



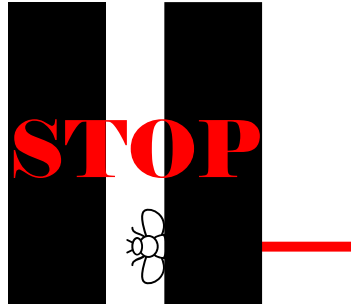
Given the car weighs 1300 kilograms and is traveling at 36 kilometers per hour what is the momentum of the car?

- A. 3900 kg · m/s
- B. 3600 kg · m/s
- C. 13000 kg · m/s



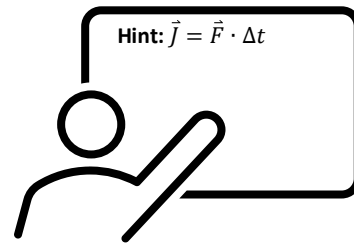
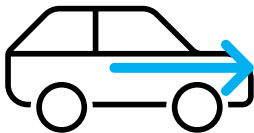
What is the momentum of the bug given that it weighs 1 gram and travels at 3 meters per second?

- A. 0.0001 kg · m/s
- B. 0.3333 kg · m/s
- C. 0.003 kg · m/s



How does the Impulse on the bug compare to the impulse on the car?

- A. Greater than
- B. Less than
- C. Equal to



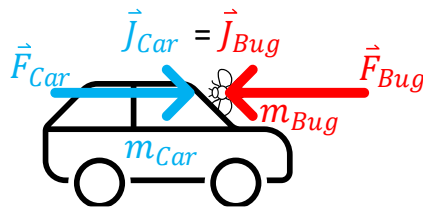
# Review Summary

$\vec{F}_{Car}$  and  $\vec{F}_{Bug}$  are equal because of Newton's 3<sup>rd</sup> law

Since  $\vec{J} = \vec{F} \cdot \Delta t$  where  $\Delta t$  is the collision time,  $\vec{J}_{Car} = \vec{J}_{Bug}$

Since  $\vec{F} = m \cdot \vec{a}$  ...

$$m_{Car} \cdot a_{Car} = m_{Bug} \cdot a_{Bug}$$



Add comments here please

The design of the slides is great Needs an update on the following:

1. In the first slide, replace 'elasticity' with 'Elastic and inelastic collisions'.
2. The unit of impulse is N.s or kg.m/s
3. In Slide 7, the unit should be  $1 \text{ N} = 1 \text{ kg.m/s}^2$ .
4. In Slide 8, the correct answer is 0.003 N.
5. In Slide 9, the question should be reworded. The impulse received by the bug assuming that the bug comes to a complete stop or the velocity of the car barely changes due to collision.
6. Also, in the stop sign, it will be clearer if 'STOP' (like a traffic sign) in red is placed on top of the two vertical bars.

-----Rudra Kafle, 04/23/2023

Slide #9: It might be best to stay consistent with units of momentum. You're using different units than in the previous slide

Slide #10: Incorrect units of impulse (should be either N•s or kg•m/s, ideally N•s for impulse)

-----TJ Noviello, 4/23/2023

Yes I fixing that now, are you available for a quick zoom I want to clarify something with you

-Doug

Final Slide:  
Professor Noviello's  
Suggestion of  
explaining how  
impulse is the same  
for both object bodies  
and how time and  
force is in relation to  
each other



## Appendix E: Scene 4 Animation (Boxing Section)

# Scene 4

Hussain Bhatti



Let's look at the Great  
Muhammad Ali



As They Can Hold On For the  
Round 15, He's Done It!  
MICHAEL ALI!!  
CHAMPIONSHIP!!  
K.O.

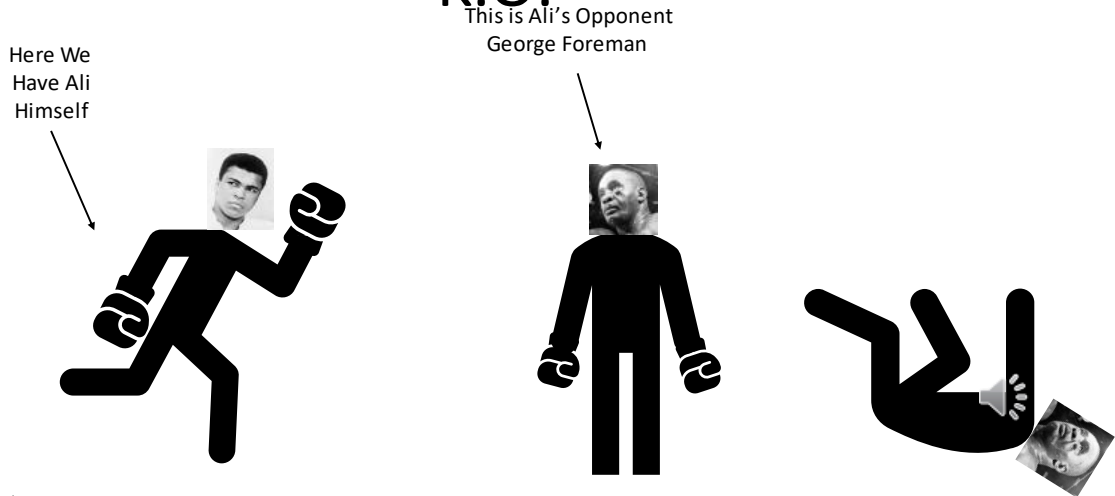


Photo Credits: Wikipedia

To Fully Understand this, We Must Answer a Few Questions



If Ali Throws Two Purely Horizontal Jabs at Foreman Both with a Force of 300N. The First Having a Contact Time of 0.5 Seconds and the Other with a Contact Time of 0.8 Seconds. Which Punch has a Higher **IMPULSE**?

- A. The 0.5 Second Punch
- B. The 0.8 Second Punch
- C. Both punches have the same impulse

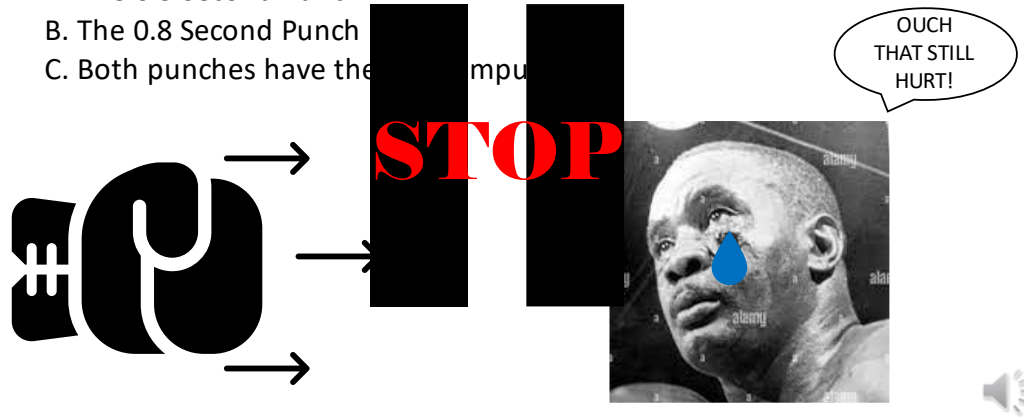


Photo Credits: Wikipedia

What is Ali doing here? Ali is moving back with the punch which is known as "riding the punch", this increases the time of contact of the punch. Since the impulse does not change, the force of the punch decreases.

Maybe Something like This??

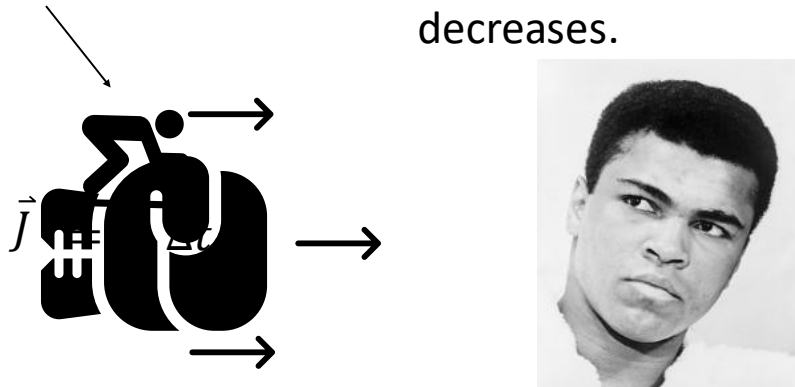


Photo Credits: Wikipedia

## Let's Look at an Example



If Ali in his Match Against George Foreman “Rides the Punch” on Two Different Occasions. Assuming Both Punches Have the Same Impulse, Which Punch has a **LOWER FORCE**? The First Punch that Ali Rides for 6 Seconds or the Second Punch that he Rides for 3 Seconds.

- A. The First Punch
- B. The Second Punch
- C. Doug KO's Everyone

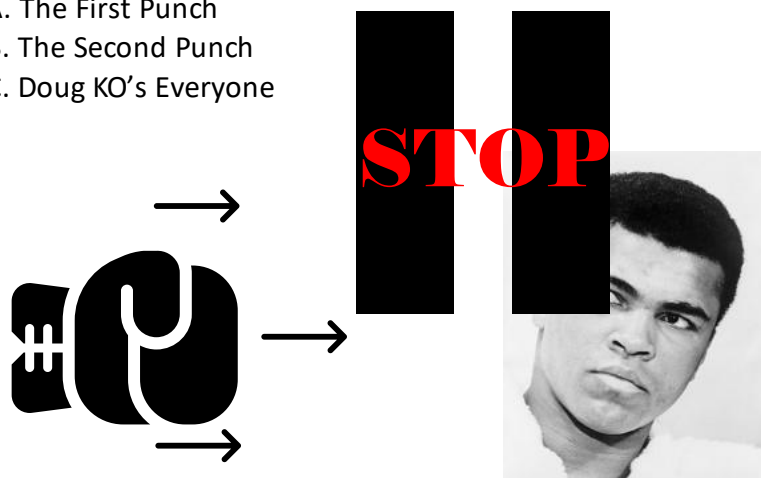


Photo Credits: Wikipedia

## Now Let's Summarize What We Learned Today

- Impulse is the effect of a force on an object over a period of time.
  - This can be quantified as the change in momentum
  - The product of force and time interval
- How are these used in real life
  - We looked at the real-world boxing example and riding the punch and how impulse can change how much damage is inflicted.
    - The conclusion we came to is that when riding the punch, the impulse stays the same. This means a longer time interval lowers the impact force.



## Appendix F: Scene 1 Transcript

Slide 1:

Scene 1 Take \_ Action!

Slide 2:

Before we get into the fun stuff, we'll briefly be going over some of the key concepts such as forces, momentum, newtons laws, impulse, and elastic and inelastic conditions.

Slide 3:

Let's start out by going over some important equations. Take note of them as you will need these for the review questions that will follow. The first one doesn't get any more fundamental, force equals mass times acceleration, easy enough. How about the second one, that's right momentum equals mass times velocity. And last but not least, impulse equals force times the change in time which also happens to be the change in momentum.

Slide 4:

Now, let's look over 2 key collision types. The first one is a perfectly inelastic collision. A perfectly inelastic collision is a type of collision in which colliding objects stick together after the collision and move as a single object. In this situation, Kinetic energy is **not** conserved as some of the initial kinetic energy is lost and converted into other forms of energy such as sound, friction, and deformation.

Slide 5:

The second type is a perfectly elastic collision. A perfectly elastic collision is a type of collision in which colliding objects bounce off each other with **no** loss of kinetic energy. In other words, the total kinetic energy before and after the collision remains the same. Perfectly elastic collisions are theoretical and idealized because in real-life collisions some of the kinetic energy is always lost due to factors such as friction or deformation of the objects. The collision types won't be asked about in the following questions, but it will be good to know if you want to learn more about conservation of momentum. Let's get into the review.

Slide 6:

Let me set the scene. You are traveling down a beautiful and scenic highway in your freshly washed car when all the sudden you rapidly start approaching a bug.

Slide 7:

Oh man. you hit the bug and he splattered all over what used to be a crystal-clear windshield. During the collision How did the force on the bug compare to the force on the car? Is it A. greater than, B. Equal to, or C. Less than. Take a moment to pause the video and figure it out. If you got B equal to, you would be correct! Let's move on to the next question.

Slide 8:

If the car weighs 1300 kilograms and is traveling at 36 kilometers per hour what is the momentum of the car? Is it A. 3900 kilogram-meters per second, B. 3600 kilogram-meters per second, or C. 13000

kilogram-meters per second. Take your time to find the correct answer I will even throw a hint up on the screen. If you answered C 13000-kilogram meters per second you would be correct!

Slide 9:

Now what about the bug? What is the momentum of the bug given that it weighs 1 gram and travels at 3 meters per second? Is it A. 0.0001 kilogram-meters per second, B. 0.3333 kilogram-meters per second, or C. 0.003 kilogram-meters per second.

Pause the video and find the right answer. If you answered C 0.003 kilogram meters per second you would be correct. On to the last question.

Slide 10:

Final question, so, how does the impulse on the bug compare to the impulse on the car? Is it A. greater than, B. Less Than, or C. Equal to. If you answered C. equal to you would be correct! How did you guys do? Now let's look at an overview of what we reviewed.

Slide 11:

In summary, the force of the bug on the car and force of the car on the bug are equal because of newton's 3<sup>rd</sup> law. And since impulse is the force times the change in time, the impulse of the car on the bug and the bug on the car are also equal. Finally, since force is equal to mass time acceleration, we can conclude that the mass of the car times the acceleration of the car is equal to the mass of the bug times the acceleration of the bug. However, since the mass of the car is large it means the acceleration for the car will be very small and unfortunately for the bug since its mass is very small the huge acceleration is what results in it ultimately getting squashed. Now that were done with the review, its time for the fun stuff.

## Appendix G: Scene 4 Transcript

### Slide 1:

- Now lets take a look at the Great Muhammad Ali

### Slide 2

- x
- Here we have Ali himself
- And his opponent George Foreman
- AS THEY COMPETE FOR THE WORLD HEAVYWEIGHT CHAMPIONSHIP
- Ali goes for a punch... Foreman doesn't know what hit him, NO NEED FOR A COUNT!!
- OUR WINNER AND CHAMP MOHAMMED ALI
- How did he do this so easily? Lets take a closer look.

### Slide 3

- To full understand how Ali was able to do this, we need to know the answers to the following questions

### Slide 4

- Now if...
- Does A, B, or C happen
- Lets take a moment to answer this
- In reality the 0.8 second punch has the higher impulse.
- So in this demonstration, when we see the punch being used, it still hurts, but not as bad as it could've.
- Why is that? Well, we're about to answer that right now.

### Slide 5

- This brings us to something known as riding the punch.
- What is it?
- Could be something like this? Woahhhh, prob not.
- In reality, riding the punch is a very smart technique many boxers use but Ali was known for using
- What happens is when a boxer throws a punch at his opponent, they move back with the punch, this increases the contact time. However, since he impulse does not change, the force of the punch decreases.

### Slide 6

- Now lets look at an example



Slide 7

- If Ali...
- What would happen, A B or C
- Or C, our friend Doug, just KO's everyone.
- (wait)
- Exactly and it would look something like this, yea, Ali's right, that barely did hurt.

Slide 8

- Now lets Summarize everything we learned today.

## Appendix H: Narration Transcript (All other transcripts)

1.

D:

Physics is the fundamental driver of our universe.

H:

And it exists in the world around us.

D:

My name is Doug!

H:

My name is Hussain!

2.

D:

This is Hussain! He's been boxing for 5 years and he's gonna show us what he can do to a punching bag.

3.

H:

The MMA gloves might pack a punch and they certainly are big...

4.

H:

We can see that these gloves certainly do pack a punch, and no one exemplifies this better than this man right here.

6.

H:

We just explained how physics can give you an edge in boxing.

D:

Now it's your turn to think about where physics applies in your life

Both: Thanks for watching!

## References

### Preliminary Research

[1] Bill Nye Official Website: <https://www.billnye.com/the-science-guy>

[2] ESPN Sports Science Video Archive:

[http://www.espn.com/video/archive/\\_/channel/sport-science](http://www.espn.com/video/archive/_/channel/sport-science)

[3] Kahn Academy Official Website: <https://www.khanacademy.org/>

[4] Derrick Muller's "Veritasium" YouTube Channel:

<https://www.youtube.com/c/veritasium>

### Methodology

[5] Martin Borgmeier's Instagram Reel Capturing Long Drive Golf Ball Impact at 12,000 Frames Per Second: <https://www.instagram.com/reel/CrLO9i6gML5/?hl=en>

[6] Titleist Performance Institute Capturing Golf Ball Impact at 22,000 Frames Per Second: [https://www.youtube.com/watch?v=6TA1s1oNpbk&ab\\_channel=Titleist](https://www.youtube.com/watch?v=6TA1s1oNpbk&ab_channel=Titleist)

### Editing

[7] Adobe Premiere Pro Tutorials Resource: <https://helpx.adobe.com/premiere-pro/tutorials.html>

[8] Adobe Stock: <https://stock.adobe.com/>

[9] Berkley Advanced Media Institute – Premiere Pro Tutorial:

<https://multimedia.journalism.berkeley.edu/tutorials/adobe-premiere-pro/#:~:text=You%20can%20move%20video%20clips,clip%20to%20the%20desired%20length.>