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| **Title**  | Man vs. Beast: The Calculus of Animal Movement |
| **Introduction**  | This project is designed to help students understand the relationship between the graphs of a function and its first and second derivatives and how to accurately approximate derivatives from a table of values. Students will develop this understanding in the context of analyzing the velocity and acceleration of animal movement as compared to the velocity and acceleration of different human movements. Connection to Research: I worked with Dr. Laura Miller and Dr. Michael Minion of the University of North Carolina at Chapel Hill. Both Dr. Miller and Dr. Minion work in fluids dynamics research. Specifically, Dr. Miller uses video analysis software to study how organisms interact with fluids. This project is designed to bring her research of mathematics and biology into the Calculus classroom. Specifically, students are using similar video analysis software to analyze the motion of organisms. |
| **Curriculum Alignment**  | **These are the standards from the College Board AP Calculus AB Syllabus*** 1. Understanding the relationship between the graphs of $f, f^{'}, f''$
	2. Graphing a function’s 1st and 2nd derivatives using critical values and sign charts.
	3. Use data to approximate $f^{'}and f''$
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| **Learning Outcomes**  | I will use eight 90-minute class periods to complete this project. However, the lessons listed will use four 90-minute class periods. This difference is due to the project process at Hillside New Tech High School. I am factoring in one day for “project kick-off,” one day for completing the end product, one day to present the final product and to the class and complete project reflections, and one day for the summative assessment (The New Tech Specific Days will be detailed in the Activities Section).  |
| **Time Required and Location**  | Eight, 90 minute periods |
| **Materials Needed**  | * + Computer
	+ Rulers
	+ CB-L Motion Sensors (this could also be completed using the Logger Pro 3 lab equipment)
	+ Ti-84 Graphing Calculators
	+ Logger Pro 3 software
	+ Access to Animal Videos (see websites)
	+ Use of a digital video camera (optional)

**Technology Resources*** + Logger Pro 3 software
	+ CB-L Motion Sensors
	+ Ti-84 Graphing Calculators
	+ Access to Animal Videos (see websites and attached videos)
	+ Use of a digital video camera (optional)
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| **Activities**  | * 1. **Day One: Project Kick-Off (these were created by the New Tech Network, but I do not know how to cite them).**

Entry Document – Students will watch a video that introduces the objectives for the Animal Motion Project (the video is attached). Knows and Need to Knows: Once students have watched the video, they will make a list of Knows and Need to Knows. The Knows and Need to Knows are things that students know they need to do to complete the project, as learned in the entry document, and that they will need to know in order to complete the project. The Need to Knows are designed to focus the students on the mathematical content that they have to know to be able to create the final product (a pamphlet that compares the velocity and acceleration of different human and animal movements). Group Contract: After completing a class list of what they know and need to know, students will create a group contract. The group contract dictates student codes of conduct, the process for delegating tasks, procedures to follow if a group member is not carrying his/her load, and individual student roles.Start of the Research: Students will begin experimenting with Logger Pro 3, using the collection of animal videos and physics videos. This will be an opportunity to learn what Logger Pro 3 can do and how they will use it for their projects.* 1. **Day Two: Motion Sensor Lesson (see attached)**
	2. **Day Three: Stations Activity (see attached)**
	3. **Day Four: Derivative Approximation Activity (see attached)**
	4. **Day Five: Derivative Approximation Activity: Part II (see attached)**
	5. **Day Six: Completing the Project**

During the final days of all projects we allow students time to work on compiling the final product. This class period will be used by students to analyze any remaining video, type up video analysis, and address any group concerns. Additionally, as students work on completing their projects, I will offer in class workshops as remediation. Students that are still unclear on any of the topics learned during the previous four days will have the opportunity to receive more focused assistance.* 1. **Day Seven: Presentations and Project Reflection**

A goal of Hillside New Tech High School is to bring in community members and professionals in the project field to assess the projects. During this class period, students will present their finished pamphlets to members of the community, faculty members, and their peers. Students will also complete a project reflection after the presentations.* 1. **Day Eight: Summative Assessment**
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| **Assessment**  | * Individual Lesson assessments (see attached lessons)
* Final Pamphlet (see attached rubric)
* Summative Assessment – formal test containing AP exam problems.
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| **Critical Vocabulary**  | * Position – the net distance traveled by an object
* Acceleration – the rate of change of an object’s velocity
* Velocity – the rate of change of an object’s position
* Speed – the absolute value of an object’s velocity
* Derivative – the slope of the line tangent to a curve at a given point
* Critical Points – points on a function including extrema, inflection points, and zeros
* Local Maximum/Minimum – the point on a function where the 1st derivative is 0 and the points surrounding that point are positive before the point and negative after or vice versa.
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| **Modifications**  | * Calculators to assist graphing functions and weakness in computation
* Group collaboration to assist struggling students
* Opportunities for one on one teaching during the stations – Advanced students can move independently, while extra assistance can be provided for those students that are having difficulty.
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| **References** |  Websites for animal videos:Bruce C. Jayne, University of Cincinnati, Videos of Locomotion & Behaviorhttp://www.artsci.uc.edu/collegedepts/biology/fac\_staff/jayne/videos.aspx |
| **Author Info**  | My name is Michael Belcher. I teach Algebra 1 and AP Calculus AB at Hillside New Tech High School in Durham, NC. We are a wall to wall project based learning school. Our goal is to foster academic success through real world applications of the Standard Course of Study. I am currently in my 3rd year of teaching at Hillside New Tech High School and my 6th year of teaching overall. I graduated with a B.A. in Mathematics and minors in Physics and Secondary Education from Wake Forest University in Winston-Salem, NC. I earned an M.A. from Teachers College Columbia University in New York, NY. |