Don't Be a Jerk
MA121 Project – Fall 2015

Carroll College Mathematics

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Contents

1 Project Description

We all know the relationship between position, velocity, and acceleration. The velocity is the derivative of position and the acceleration is the derivative of velocity. Using our well-known mathematical notation we can write this as

$$\begin{aligned} v(t) &= s'(t), \quad \text{and} \\ a(t) &= v'(t) = s''(t). \end{aligned}$$

But what is the third derivative of position? It turns out, the third derivative of position is called **jerk**!

$$j(t) = s'''(t) = v''(t) = a'(t)$$

Moreover, there are many fabulous natural phenomenon that can be described by jerk. Your job for this project will be to explore some of the applications of jerk.

2 Who Is That Jerk?

For the project, your team will choose 2 of the following 3 jerk contexts to explore, as well as creating a new jerk context.

- Your team will create a poster to share your findings,
- your team will write a 2 page summary of the project, and
- your team will include a 1 page full explanation of the work required to find the first derivative of one of the functions from 2.1-2.3.

To be clear: Your team must choose two (2) of 2.1, 2.2, and 2.3. Then your team must do 2.4.

2.1 The Big Jerk

Some adventurous Carroll students decided to ride a carnival ride called the "Big Drop". For this ride, the students sit in a seat suspended high above the ground. At some point in time the seat is released and drops to a position near the ground. There is a cable that arrests the fall just before the end.

One of the students stayed on the ground and used a digital range finder to determine the distance from the ground to the bottom of the seat. The data for the range finder can be found in the Excel file for this project. Being well-trained Calculus students, they propose that the position belongs to the family of functions

$$s(t) = \frac{A}{1 + e^{B \cdot (t-C)}} + D,$$

but they don't know A, B, C, or D.

1. Use the Excel Solver to find approximations for A, B, C, and D.
2. Find and plot the velocity, acceleration, and jerk for the function that you find.
3. What would a person riding this ride feel, and how does that relate to the position, velocity, acceleration, and (most importantly) the jerk?
4. What could the carnival ride engineer do to increase the *jerk factor* of this carnival ride? Would it be safe? You may want to research the amount of jerk a human body can withstand.

2.2 That Jerk on the Road

A driver slams on the accelerator and speeds up from 0 to about 40 mph in about 10 seconds. He then realizes that the next traffic light turned red and he slams on the brakes. The velocity has been measured by a device attached to his speedometer (in the Excel document) and can be estimated by a function of the form

$$v(t) = \frac{A}{1 + e^{B(t-C)}} - \frac{D}{1 + e^{E(t-F)}}$$

where t is time measured in second, $v(t)$ is velocity measured in miles per hour, and $A, B, ..., F$ are parameters that need to be determined.

1. Use the Excel Solver to find approximations for all of the parameters A, B, C, D, E, and F.
2. Find and plot the acceleration and jerk for the function that you find.
3. What would a passenger riding in this car feel during the 20 second car ride?
4. How would the functions (especially the jerk) change if the maximum velocity were 60mph instead of 40mph?
5. Explain where a driver would feel the effects of jerk during the terrifying car ride.

2.3 Bungee Jerk

A bungee jumper took the big leap! A much more sane friend stayed on the ground and used a digital range finder to measure the jumper's position (data found in the Excel document). After doing some labs in Math 121 at Carroll, the friends know that the function modeling the position takes the form

$$s(t) = Ae^{-kt}\sin(B(t-C)) + D$$

but they don't know A, B, C, D, or k.

1. Use the Excel Solver to find approximations for A, B, C, D and k.
2. Find and plot the velocity, acceleration, and jerk for the function that you find.
3. What would a bungee jumper feel, and how does that relate to the position, velocity, acceleration, and (most importantly) the jerk?
4. How much jerk is too much? If you were working for the people that own the bungee setup and you wanted to increase the jerk that people feel, how would you do it and would it be safe. What about decreasing the jerk?

2.4 And One More Jerk

Go find your own jerk! For this part of the project, your team will discuss a new jerk context of your choosing.

- Your new jerk context must be a "real world" context that is different from any of the three contexts listed above. Highlight the importance of jerk within the context of your choosing.
- Your jerk must be non-trivial. In other words, your jerk function should be non-constant for some portion of the time.
- Your team shall provide descriptions, graphs, and equations for position, velocity, acceleration, and jerk as they relate to your context. You are not required to find or generate a chart of data for your context, as the graphs and equations should be sufficient.

3 Grading Rubrics and Deadlines

3.1 The Two-Page Paper

Each group will write a 2-page paper (3 pages with figures) that covers all of the mathematics and problems they completed. The paper will be 50% of your overall grade. The following rubric will be used for grading. Please use Microsoft Word to write your paper. Use the mathematical typesetting in Word to make sure that your mathematics looks pretty. Failure to submit a paper will amount to a zero for this portion of the project.

Papers are due on Moodle at 11:55 pm, Tuesday, December 1.

Project Requirements	**Score**	**Possible Points**
Abstract: The abstract is clearly stated; written to someone who doesn't know what the project is.		3
The Fitted Solution: You have clearly followed all of the steps to find the best fit solution to all the problems in question. The best fit solution seems reasonable.		10
Your Problem: You completed a problem with non-trivial jerk.		5
Mathematical Understanding: You have shown that you have an understanding of all of the topics that were covered in this class.		10
The Mathematics: The mathematics is correct and complete.		10
Conclusion: The main results are stated and tied together at the end of the paper.		2
Overall Quality: This includes spelling, grammar, organization, quality of prose, and demonstration of mathematical understanding.		5
Creativity: Your solutions are creative.		5
References: The textbook and any other references you used are documented. Any "borrowed" images are clearly credited		5
Total		**55**

3.2 The Derivative Write Up

We acknowledge that you will likely use mathematical software to find the derivatives of your functions, or at least to check your work. However, you also have the skill set to find the derivatives using the derivative rules from Chapter 2. You will demonstrate this understanding by chosing one of the functions from part 2.1, 2.2, or 2.3 and writing up a derivation for the first derivative.

The written derivation for your selected first derivative will be graded out of 10 total points. You must show all of your work and clearly describe why each step is being taken, highlighting which derivative rules are being used. This must be properly typeset in MS Word or similar.

3.3 Poster Rubric

Each group will create a poster to present their project to the class. The poster will be graded 40% by your peers and 60% by your instructor(s). The highest and lowest peer evaluations will be dropped from your grade. The following rubric will be used for grading. The poster will be worth 20 points of your total grade. Please use the PowerPoint template for the poster that is provided on Moodle. Your group should be prepared to give a 2-minute summary of your project with the poster. Posters not turned in by the deadline will receive a score of zero points.

Posters are due on Moodle at 11:55 pm, Tuesday, December 1.

Category	1: Poor or Absent	2: Poorly Done	3:Multiple Minor Mistakes	4: Few Minor Mistakes, but good	5: Perfect	Comments
Mathematical Reasoning						
Mathematical Correctness						
Oral Presentation						
Appropriate Solutions to 3 problems						
Overall Appearance						

3.4 Project Deadlines

1. For this project you will work in a new group of 3, which should not include your current lab partner. You may select your own group.
2. The poster and paper are due digitally on Tuesday, Dec 1st.
3. A class presentation of posters will occur Monday Dec 7th.

3.5 Total Project Points

- Poster: 25 points (40% averaged from peer grades and 60% averaged from professor grades)
- Two page paper: 55 points
- One page showing how to find a first derivative of one of your functions: 10 points
- **Total:** 25+55+10 = 90 points