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AP Physics C – Mechanics

PhET Calculus Grapher

Objective: I can describe the motion of an object with nonuniform acceleration by analyzing the relation between position, velocity, and acceleration through the relations between integrals of functions, the functions themselves, and their derivatives.

Some of you have taken calculus before. However, some of you have not yet completed calculus. It is important to practice and apply the skills that we have talked about over the past couple of days in practice problems, and to see the concepts in a more interactive setting. Today we will be working on conceptual and application questions regarding non-uniform acceleration and calculus. There will be questions designed to get you thinking outside of kinematics, as well. For example, you'll be able to sketch graphs quickly after analyzing this simulation!

PROCEDURE

1. First, open up the PhET Calculus Grapher at https://phet.colorado.edu/en/simulation/calculus-grapher . Click on the "Lab" tab.
2. Click on the box that says "f''(x)" near the left side of your screen. You will be manipulating f(x) and watching how f'(x) and f"(x) change (these are *derivatives* of f(x)).
3. Draw different graphs for f(x) and determine how the extrema, rate of change, asymptotes/discontinuities/sharp points, and concavity of f(x) relate to important features of the two derivatives. In the Results and Conclusion section, screenshot your graphs and write descriptions for these conclusions.
4. Click on the integral (squiggly symbol on the left) and repeat step 3.

RESULTS AND CONCLUSIONS

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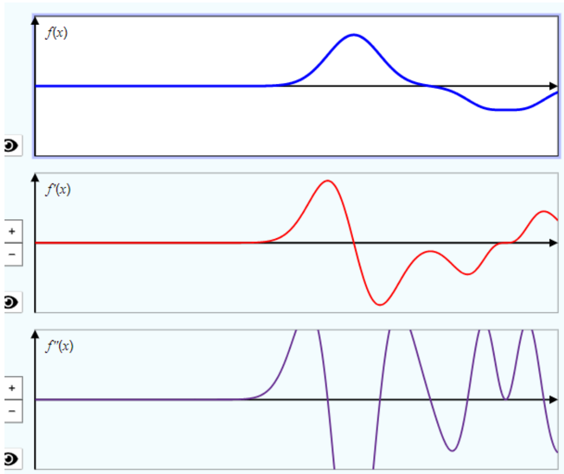

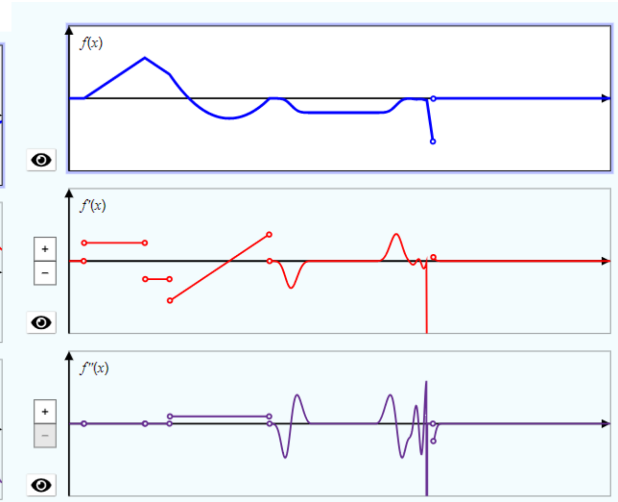

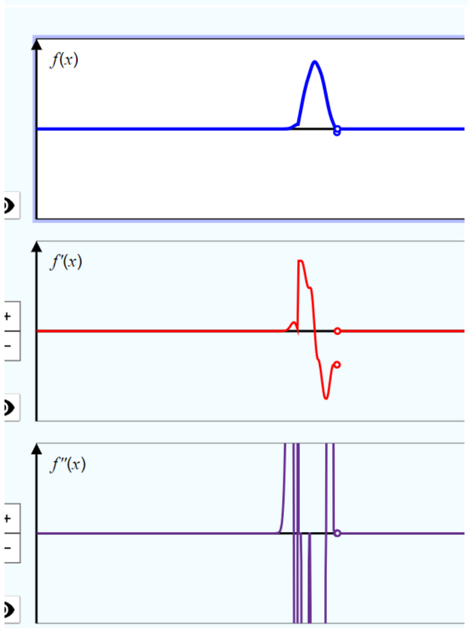

At the extrema of f(x) f'(x) has a constant value (sometimes zero). The instantaneous rate of change of one function is represented in its derivative. An asymptote in one function results in a discontinuity in its derivative and sharp points in its second derivative. A discontinuity in f(x) results in sharp points in its derivative. Sharp points in f(x) result in sharp points in it's derivative. f(x) is concave up if f''(x) is positive and concave down if f''(x) is negative.

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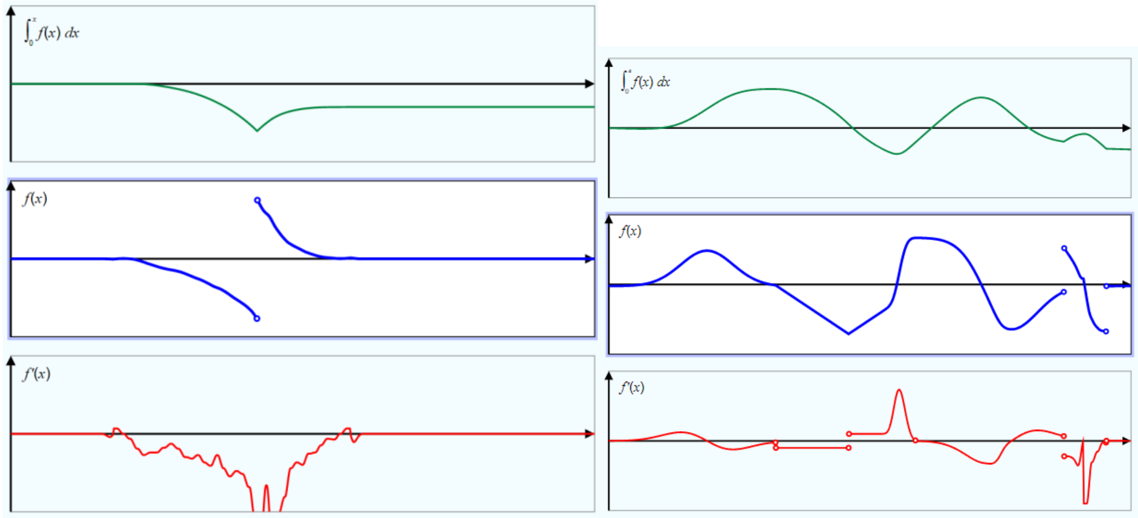

At the extrema of F(x), f(x) has a constant value (sometimes zero). F(x) is concave up if f'(x) is positive and concave down if f'(x) is negative. This combined with the previous results suggests that F'(x)=f(x) (though there is a constant term that is lost).

An extrema on the original function causes the integral of that function to increase or decrease depending on its sign. The larger the concavity of the original function, the faster the integral changes. This also applies to the rate of change of both functions, which are correlated directly. Discontinuities in the original function cause a sharp change in the integral of that function. Asymptotes on the original function cause the integral to sharply change value.

Post Lab Questions to answer

1. Based on your observations, if f(x) represents the position of an object with respect to time, what should f'(x) and f''(x) both represent in terms of the object's motion?
   f'(x) is velocity
   f''(x) is acceleration
2. What should the derivative of f(x) = mx+b be? What about the second derivative? How does this match your answers to Question 1, physically?
   m, and then 0. This matches physically because if an object starts at a distance b away from the origin and has a constant velocity of m, there is no acceleration (because there is no t^2 term)
3. Repeat Question 2, but for f(x) = ax^2+bx+c.
   2a+b, This matches physically because if an object starts at a distance c away from the origin, has an initial velocity of b, and has an ax^2 term which is the ½ ht^2 term, showing us that the velocity at a point in time is equal to the initial velocity plus the acceleration which can be found by setting equal the two quadratic terms.