THE RELEVANCY OF CALCULUS IN THE SCIENCE CLASSROOM; HOW CCSS/NGSS CAN HELP BRIDGE THE GAP

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Math CCSS/NGSS Connections to Calculus Fundamentals

Key areas where Calculus concepts align with *Common Core State Standards* and *Next Generation Science Standards* include;

-*Measurement;* standard measurements and units, scientific notation and conversions

-*Exponential Growth and Decay*

-*Rates and Proportional Relationships*

-*Basic Algebra and Functions;* preview of Calculus terminology

-*Analyzing and Interpreting Data;* using mathematics and computational thinking

Rationale

* Students typically view math as a necessary task to endure in earning a high school diploma, but irrelevant in the big picture of life.

* This mindset presents a huge roadblock to effectively teach science standards required at the 9th and 10th grade levels as many students possess low math conceptualization skills, evidenced by standardized test scores.

* It is crucial for teachers to find avenues to convince students that math is quite relevant in all facets of life, not just in the math classroom. The Math CCSS and NGSS, by design, strongly support such student outcomes.

Example Problem 1

Students are challenged to calculate the amount of money that would result from doubling a penny monthly for 1 year and then after 5 years. (Correlates to population growth predictions)

$$f(x) = 1(2)^x$$

where x = the number of months the penny is being doubled.

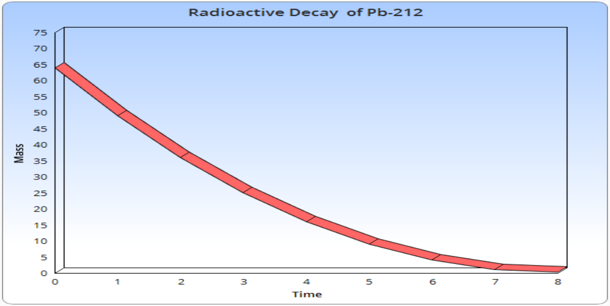
- after 1 year (x=12) the amount = 4096 cents or 40.96 dollars
- after 5 years (x=60) the amount =
- $$1,152,921,504,607,000,000 pennies = (Quintillioncents)$$
- or expressed as $1.152921504607 \times 10^{18}$ exa-cents

The Calculus Connection

- * Students are exposed to the concept of positive infinity in this example.
- * Learning to equate logarithmic values used in scientific notation to specific measurement prefixes will familiarize students with the skill of making a ”u-substitution”, as required in higher level math classes.

Example Problem 2

Students are asked to find the amount of radioactive Pb-212 remaining in a 64g sample after 20 days if 1 half-life is 10.5 hours.



The Calculus Connection

- Using the formula;

$$Mass = \frac{OriginalMass}{2^n} = \frac{64g}{2^{45.7}}$$

  where n = the number of half lives expired
- This gives a mass of 0.000000000001119719321g that remains radioactive or
-

$$1.119719321 \times 10^{-12} g$$

  or

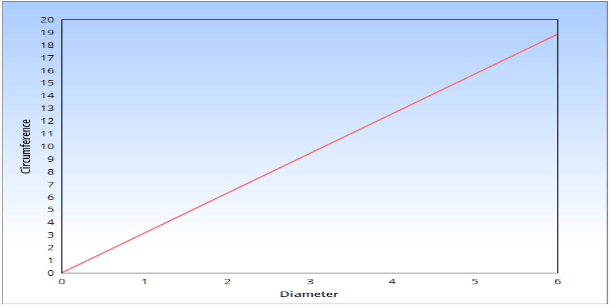
$$1.119719321 picograms$$

- In this example students can visualize and ponder the idea of ***negative infinity*** as well as a great time to introduce the term ***Asymptote***, which allows for better understanding of the calculus concept of a limit.

Example Problem 3

Students perform an activity called Calculating Pi to practice indirect measurement using circular objects of various sizes, then are asked to construct a graph of their data in terms of

Circumference with respect to ***Diameter***



The Calculus Connection

- Students must determine independent and dependent variables and appropriately label them on the axes using appropriate units.
- This is a good time to introduce the Calculus concept of rates of change in terms of

$$\frac{dy}{dx}$$

- in other words,

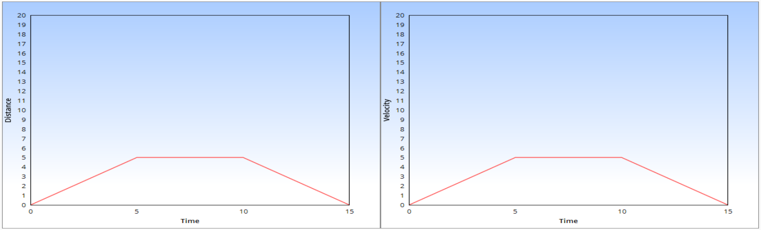
$$\frac{rise}{run}$$

- giving us the slope (m) of the line
- The learning target is to have students correlate the ratio proportion of ***Pi*** to the slope of the line.

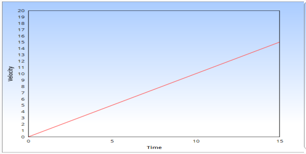
Example Problem 4

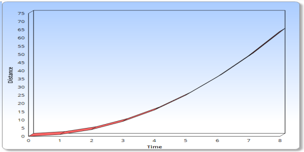
Students are instructed to write a story which explains the motion of the moving object(s) that would result in graphs such as these. *a discussion about the corner points should emphasize how the lines are averages of the actual motion.

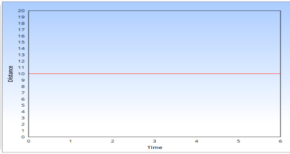
Distance vs. Time——————Velocity vs. Time



These Distance-Time graphs illustrate the following:

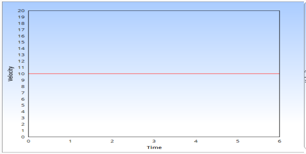


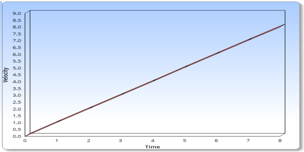


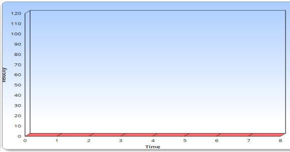


constant velocity ////// acceleration ////// no motion

These Velocity-Time graphs illustrate the same:







In this case the concepts of average rate of velocity and average rate of acceleration can be stressed in terms of the slope of the secent line formula:

$$\frac{d(b) - d(a)}{b - a}$$

Also, the manner in which the shape and slope of the graphs are transformed as the units used to label the y-axis are changed is perfect for introducing how Newton developed equations that would calculate the velocity, acceleration and position of such an object in motion from a single graph. Thus, no need for the variety of graphs to analyze all aspects of the moving object, and students would be better prepared for learning to calculate the derivatives and integrals in order to fully analyze the moving body.

Acknowledgements and References

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Questions?