AMDM

Units 4 & 5 Culminating Activity **Name:** KEY 12-1-16

Caffeine Elimination Rate

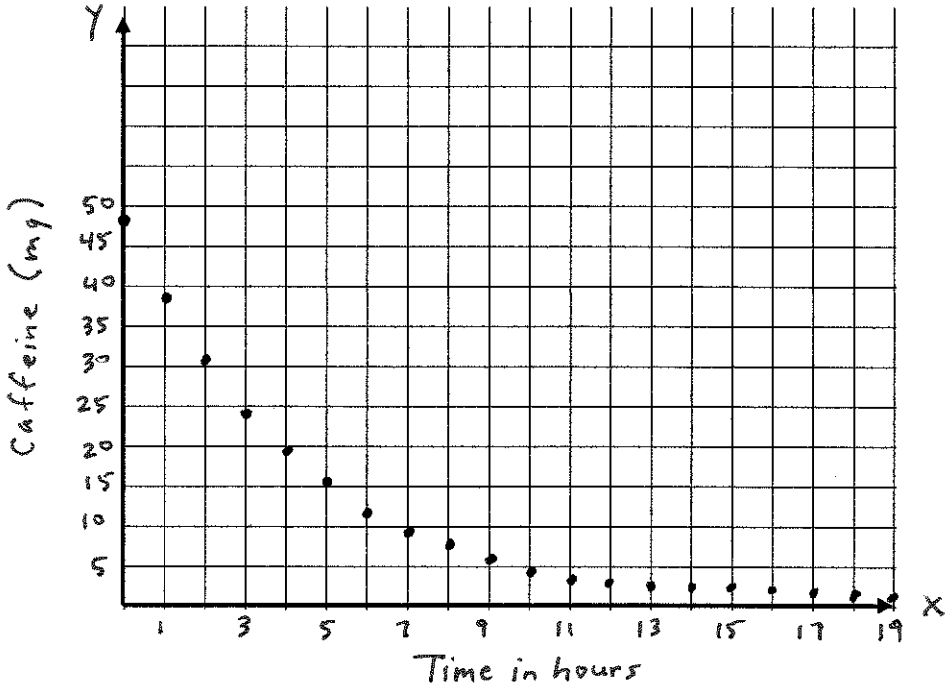
The human body processes different drugs in different ways. Most of you have probably observed that a drunken person does not stay drunk forever. Sooner or later, the blood alcohol concentration (BAC) returns to zero. Alcohol is a rather unusual chemical in terms of how the body processes it. To understand it better, let's compare it with the caffeine in an average soft drink.

Assume that you quickly drink a 12 oz soft drink containing about 48 mg of caffeine. If the amount of caffeine in your body were monitored over the next 19 hours, the result would be similar to the data in the following table.

Time (hrs)	0	1	2	3	4	5	6	7	8	9
Caffeine (mg)	48.0	38.14	30.26	24.03	19.08	15.15	12.03	9.55	7.58	6.02

Time (hrs)	10	11	12	13	14	15	16	17	18	19
Caffeine (mg)	4.78	3.80	3.01	2.39	1.90	1.51	1.20	0.95	0.76	0.60

1. Make a scatter plot of the data (x = time, y = Caffeine) from the table.



2. Examine the scatter plot and the table. How would you best describe the shape of the data? Discuss form, direction, and strength of the correlation.

The shape of the data is exponential decay.

3. Using your graphing calculator, determine the best-fit regression equation for the graph.

The "best fit" regression model is exponential.

4. Taking note of the quantities you graphed, explain the meaning of the constants a and b in this equation.

a= 47.9

b= .794

[b] indicates decay in this exponential function.

$0 < b < 1$ = decay

$b > 1$ = growth

$y = ab^x$

$y = 47.9(.794)^x$

$r = -.9999$ [strong negative correlation]

[a] represents the y-intercept, or how much caffeine was in the body when you finished drinking the soft drink.

5. When will your body have eliminated all the caffeine? Explain how you know.

Your body will never eliminate all of the caffeine. Since we are using an exponential model, the x-axis serves as an asymptote and the graph will never touch that axis. Therefore $y > 0$; meaning there will be caffeine in the body.

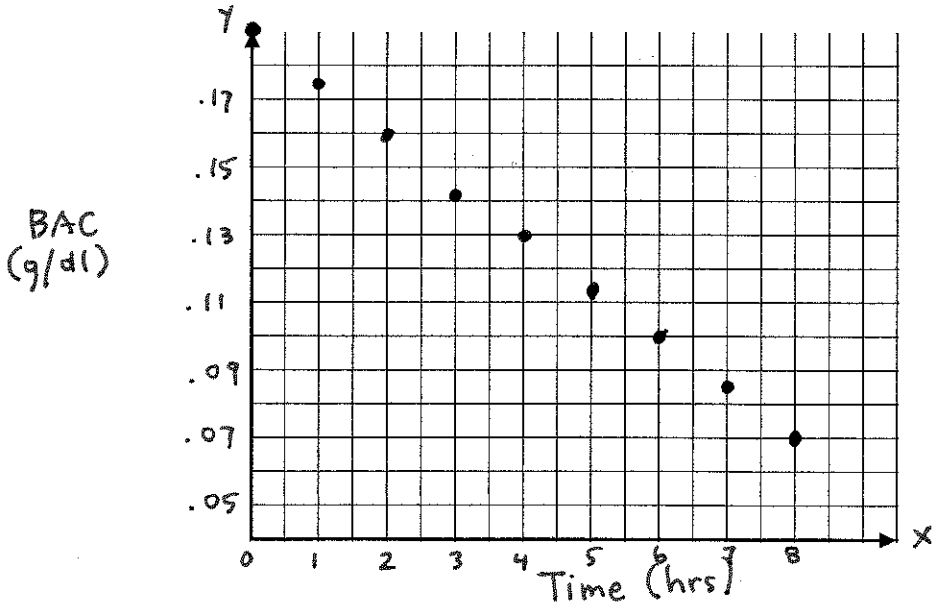
Caffeine, like most drugs, is classified as a first-order drug because exponential decay accurately models its elimination from the human body. Alcohol, on the other hand, is a zero-order drug. Let's look at what the difference is.

Alcohol Elimination Rate

Assume that 24-year old Bryan has been eating and drinking for most of the evening and by midnight has a blood alcohol concentration (BAC) of 0.19 g/dl (grams/deciliter) – far above the legal driving limit of 0.08 g/dl. If Bryan weighs 140 lbs, it would take approximately seven drinks for his BAC to reach 0.19 g/dl. Fortunately for Bryan, a friend has already taken his car keys. The question now is, when should the keys be given back to Bryan? If someone were to monitor Bryan's BAC over the next 8 hours, it would most likely look like the data in the following table.

Time (hrs)	0	1	2	3	4	5	6	7	8
BAC (g/dl)	0.190	0.175	0.160	0.145	0.130	0.115	0.100	0.085	0.070

6. Make a scatter plot of the data (x = time, y = BAC) from the table.



7. How would you best describe the shape of the data? Discuss form, direction, and strength of the correlation.

The shape of the data can be best modeled by a linear regression. The direction is negative, and the correlation between x and y is strong.

8. Determine the best-fit regression equation for this graph.

The model of best fit appears to be a linear regression.

9. Taking note of the quantities you graphed, explain the meaning of the constants a and b in this equation.

a= slope (rate of change)

b= y-intercept

$y = -.015x + .19$

$r = -1$

10. As mentioned, Bryan wisely stopped drinking at midnight. Legally, Bryan cannot drive home until his BAC is at or below 0.08 g/dl. When will he be sober enough, legally, to drive home? [Note that the 0.08 g/dl BAC level is statutory in all states; however, many states have "zero tolerance" for persons under the age of 21. Under these laws, drivers who are not yet 21 cannot have *any* alcohol in their body while driving.]

Bryan will be sober enough to drive home at 8:00 am, or 8 hours after he stopped drinking.

11. When was all the alcohol eliminated from Bryan's body? How do you know?

All of the alcohol was eliminated from his body before 1:00 pm, or 13 hours after he stopped drinking.

~~12.~~ The elimination rate of alcohol from the human body is highly variable. The rate we found here is an average value, but elimination rates as low as 0.01 g/dl are common. Write a new regression equation using 0.01 as the elimination rate. At this conservative rate, at what time would the alcohol have been eliminated from Bryan's body? Explain how you determined the answer to this question.

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~~13.~~ What are the differences between zero-order drugs (such as alcohol) and first-order drugs (such as caffeine)? Discuss these differences in terms of how your body handles the drugs, as well as in mathematical terms using the vocabulary from the standards of Units 4 and 5.

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