**The Mathematics of Global Warming**

**Introduction**

The term “global warming” refers to the increase in the average temperature of the Earth. In May of 2006, Al Gore, former senator, vice president, and presidential candidate, created a movie documentary, *An Inconvenient Truth*. The movie was designed to alert the public about the global warming crisis and to halt its progress. For more information about *An Inconvenient Truth* and global warming, visit <http://www.takepart.com/an-inconvenient-truth> to see the trailer for the movie.

**Modeling Carbon Dioxide Data**

Global warming is related to amount of CO2 (carbon dioxide) in the atmosphere. To project what is ahead for future temperatures, we’ll look at recent CO2 levels. Notice that these all are far above 300 ppmv (parts per million by volume).

The data below was gathered at Mauna Loa in Hawaii:

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| --- |
| Source: [http://en.wikipedia.org/wiki/File:Mauna\_Loa\_Carbon\_Dioxide-en.svg](http://en.wikipedia.org/wiki/File%3AMauna_Loa_Carbon_Dioxide-en.svg)The lighter line that moves up and down accounts for the annual natural increase and decrease in the CO2 level in our atmosphere. The darker line represents the average CO2 level. |

1. Fill in the with the average CO2 values. **Take these values from the darker curve*.***

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | 1960 | 1965 | 1970 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2008 |
| **# of Years since 1960** |  |  |  |  |  |  |  |  |  |  |  |
| **CO2 level****(ppmv)** |  |  |  |  |  |  |  |  |  |  |  |

1. Looking at the graph or numerical data, do you think a linear model or an exponential model (or neither) would be best for modeling the CO2 data over time? Explain.
2. Enter the data into your graphing calculator and examine a plot of the data. Then, find a model that will fit the data as closely as possible. Write the equation for your model, in function notation, here and explain how you arrived at your equation.
3. What is the real world meaning for the value of each parameter in your equation? (What are the parameters?) Use complete sentences.

Parameter: \_\_\_\_\_\_\_\_\_\_\_

Meaning:

Parameter: \_\_\_\_\_\_\_\_\_\_\_

Meaning:

1. By what percent is the CO2 level changing each year?
2. Use your model to project the CO2 level in the year 2020. Show how you arrived at your projection.
3. Now, project ahead to the year 2050 (perhaps a good approximation for Gore’s projection in “less than 50 years”). Write the predicted CO2 level here.

**Modeling Global Temperature Data**

There are several ways to measure the average temperature of the entire earth. One method, used by the Goddard Institute for Space Study, collects data from stations all over the world. It shows that the earth’s average surface temperature for the years 1951–1980 was 57.2° Fahrenheit. Since there are fluctuations from year to year, a more accurate picture of how the global temperature changes over time can be found by looking at 10-year periods (decades). The table below summarizes the data collected for the years 1910-2009.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  |  |  |
| --- | --- | --- |
| **Decade starting with year** | **Years since 1900** | **Average****Temperature****(°F)** |
| 1910 | 10 | 56.70 |
| 1920 | 20 | 56.88 |
| 1930 | 30 | 57.12 |
| 1940 | 40 | 57.26 |
| 1950 | 50 | 57.16 |
| 1960 | 60 | 57.13 |
| 1970 | 70 | 57.20 |
| 1980 | 80 | 57.52 |
| 1990 | 90 | 57.86 |
| 2000 | 100 | 58.12 |

 |  |

1. Enter the data into your calculator and graph it. Include a sketch of the graph above. Clearly label your axes and choose appropriate scales. (Hint: Let Ymin = 56.5 and Ymax = 58.5)
2. Looking at the graph above, do you think a linear model or an exponential model (or neither) would be best for modeling the surface temperature data over time? Explain.
3. Find a function that will fit the data as closely as possible. Explain how you arrived at your function.

Function:

Explanation:

1. Use your function to project the temperature of the earth for the decade starting in 2010. Show how you arrived at your projection.
2. Now, project ahead to the decade starting in 2050. Write the predicted temperature here. Do you think it is a good prediction? Explain why or why not.

**The Ice Cap at Mount Kilimanjaro**

Although near the equator, Mount Kilimanjaro in Tanzania, Africa, is covered with ice. For the past century, however, its ice has been melting. Some scientists believe this is due to global warming; others believe that there are other causes such as deforestation. Nevertheless the fact that the glacier (large body of ice) is melting is undisputable. (<http://dailymaverick.co.za/article/2010-09-28-revealed-the-real-cause-of-kilimanjaros-melting-ice-cap>)

Between 1912 and 1989 the extent of ice covering Mount Kilimanjaro decreased 75%. It then decreased further so that by 2000 its extent was only 19% of what it had been in 1912. Using an index number of 100 for 1912 we have the following data.

(Source: <http://www.geo.umass.edu/climate/kibo.html>)

|  |  |  |
| --- | --- | --- |
| **Year** | **Years since 1912** | **Ice cover (1912 = 100)** |
| 1912 |  | 100 |
| 1989 |  | 25 |
| 2000 |  | 19 |
| 2010 |  | 15 |

1. Find a linear model that fits these data.
2. Find an exponential model that fits these data.
3. Predict the ice cover in the year 2015 for both models.
4. By what percent is the ice cover changing each year?
5. Will the ice cover on Mount Kilimanjaro completely disappear some day? Defend your answer.