**Greenhouse Gas Emissions**

*A greenhouse gas is a* [*gas*](http://en.wikipedia.org/wiki/Gas) *in an atmosphere that* [*absorbs*](http://en.wikipedia.org/wiki/Absorption_(electromagnetic_radiation)) *and* [*emits*](http://en.wikipedia.org/wiki/Emission_(electromagnetic_radiation)) *radiation within the* [*thermal infrared*](http://en.wikipedia.org/wiki/Thermal_infrared) *range. Annual per capita emissions in the industrialized countries are typically as much as ten times the average in developing countries. Due to China's fast economic development, its annual per capita emissions are quickly approaching the levels of those in the* [*Annex I group*](http://en.wikipedia.org/wiki/Kyoto_Protocol#2012_emission_targets_and_.22flexible_mechanisms.22) *of the Kyoto Protocol (i.e., the developed countries excluding the USA). Other countries with fast growing emissions are* [*South Korea*](http://en.wikipedia.org/wiki/South_Korea)*, Iran, and Australia. On the other hand, annual per capita emissions of the EU-15 and the USA are gradually decreasing over time. Emissions in Russia and the* [*Ukraine*](http://en.wikipedia.org/wiki/Ukraine) *have decreased fastest since 1990 due to economic restructuring in these countries.*

*Energy statistics for fast growing economies are less accurate than those for the industrialized countries. For China's annual emissions in 2008, the* [*Netherlands Environmental Assessment Agency*](http://en.wikipedia.org/wiki/Netherlands_Environmental_Assessment_Agency) *estimated an uncertainty range of about 10%.*

*The* [*GHG footprint*](http://en.wikipedia.org/wiki/GHG_footprint)*, or greenhouse gas footprint, refers to the amount of GHG that are emitted during the creation of products or services. It is more comprehensive than the commonly used carbon footprint, which measures only carbon dioxide, one of many greenhouse gases.*

<http://en.wikipedia.org/wiki/Greenhouse_gas>

*The following graph shows CO2 emissions in various parts of the world from 1970 to 2005. (The country shown below as the Soviet Union is now Russia together with some other republics.)*

Data from <http://ccsl.iccip.net/co2highlights.pdf>

1. Pick one country or region from the graph on page one. Give the approximate amount of CO2 emissions for that location in both 1971 and 2005, in kilograms. (Remember to take into account the scale given for the left axis; a metric ton is 1000 kilograms.)

2. Consider only the last 20 years shown in the graph on page 1. Where does it appear that CO2 emissions are increasing the fastest? Are there any countries or regions where it looks like CO2 emissions are decreasing?

3. Look at the line on the graph that represents CO2 emissions in Asia (it is shown as a light green line). It looks like it would be a good approximation to make a mathematical model for Asia by making a straight line. Find an approximate equation for this line by selecting two points on the line and finding the equation of the line between the points. (Let the variable x stand for “number of years since 1970.”)

4. In Investigation 3, you learned about linear, quadratic, and exponential growth. For each country or region in the graph, determine whether the growth in their CO2 emissions during the period 197-2005 is closest to linear, quadratic, or exponential. (Some regions may have had different patterns in growth over the period 1970-2005; give the best answer you can!)

Linear growth:

Quadratic growth:

Exponential growth:

5. Based on the graph on page 1, the following regions can be described reasonably well by using the following functions, where *x* represents the number of years since 1970 and the function represents the number of millions of metric tons of CO2 emissions:

North America: 

Pacific: 

Europe: 

China: 

1. Find the sum of the functions for North America and Europe. Give a verbal description for what this sum represents. What was the sum in 1987, and what does this sum represent?
2. Find the difference between North America and China. Give a verbal description of what this difference represents. What was the difference in 1998, and what does this difference represent?
3. Find the sum of all four regions. Give a verbal description of what this sum represents. What was the sum in 2005, and what does this sum represent?
4. For the function describing CO2 emissions in North America given above, give a verbal description of what N(x + 10) means, and of what N(x) + 10 means. (Hint: Think of “inside change” and “outside change”!)
5. Using the function given above, find N(x + 10) and N(x) + 10.
6. For the function describing CO2 emissions in North America given above, give a verbal description of what N(2x) means, and of what 2N(x) means.
7. Using the function given above, find N(2x) and 2N(x).
8. Repeat questions (d) through (g) using China instead of the United States.
9. CO2 emissions are growing faster in China than in the United States. Using the graph and the functions above, when do you think that CO2 emissions will be higher in China than in the United States?