The Arctic's Changing Ozone Layer

Table of Ozone Column Changes

Year	Column (Dobson Units)
1970	470
1972	466
1974	463
1976	460
1978	458
1980	455
1982	430
1984	445
1986	430
1988	445
1990	390
1992	395
1994	400
1996	375
1998	420
2000	370

This past spring, scientists using a variety of instruments witnessed an unprecedented depletion in Arctic stratospheric ozone levels. In a *Nature* paper published online on October 2, 2011, Dr. Gloria Manney of NASA's Jet Propulsion Laboratory in Pasadena and more than two dozen coauthors described the 2011 loss as "an Arctic ozone hole."

This table shows the changes in the Arctic ozone abundance for the month of March between 1970 and 2000 based on data provided by Dr. Paul Newman (NASA/GSFC). March is the coldest month of the Arctic year, and the time when the chemistry of the ozone layer favors the destruction of ozone molecules. The Antarctic ozone hole appears in September when it is mid-winter in the southern hemisphere.

Problem 1 - Graph the data in the table, and explain what kind of trend you see in the data. Is the amount of Arctic ozone detected in March generally increasing with time, decreasing with time, or remaining about the same?

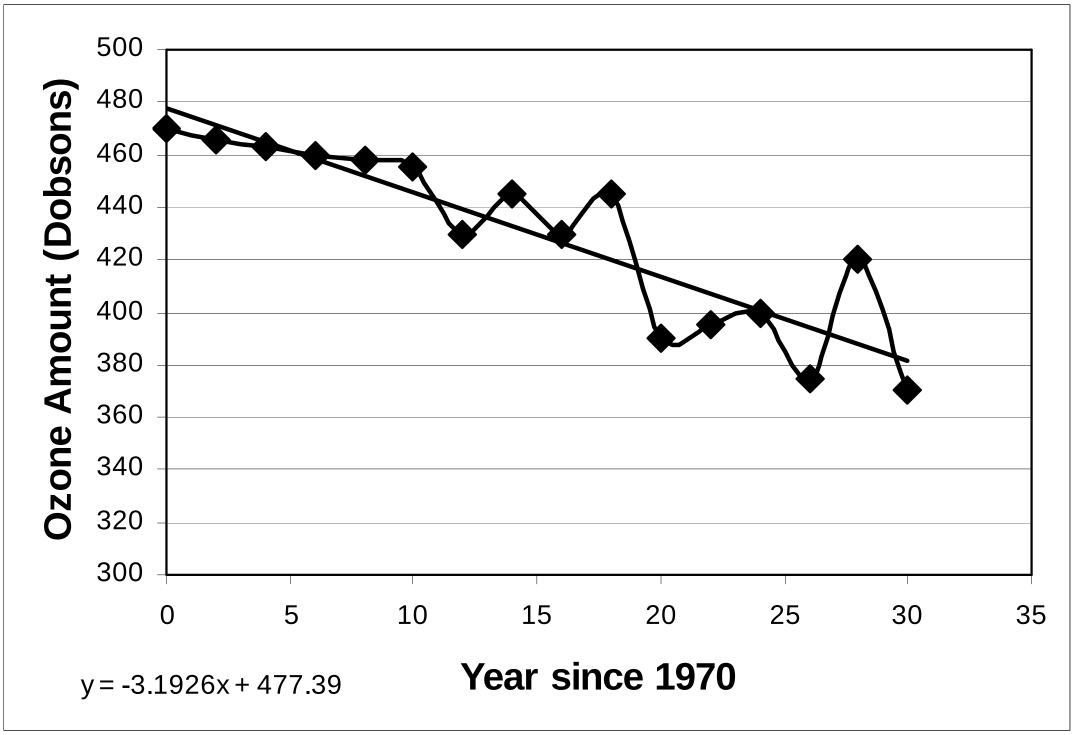
Problem 2 - Draw a slanted line through the plotted data so that half of the points are above the line and half are below the line. This represents a 'linear' regression model for the data. What does the slope of the line represent physically? What are the physical units for this slope?

Problem 3 - What is the formula for the line that you drew in Problem 2? What does the y-intercept for this line represent physically? What does the x-intercept for this line represent physically?

Problem 4 - From your linear model for the ozone data, what would you predict as the amount of ozone above the Arctic region in the year 2010?

Tabulated data from:
1970 - 1997: Paul Newman/NASA Goddard Space Flight Center. The figure is taken from P.A. Newman, J.F. Gleason, R.D. McPeters, and R.S. Stolarski, "Anomalously low ozone over the Arctic," Geophysical Research Letters, *Vol. 24, No. 22, pp. 2689-2692, November 15, 1997.*

1998-2010:



Problem 1 - Answer: See above. The amount of ozone is generally decreasing with time.

Problem 2 - Answer: Students can use a straight-edge and measure the slope of the line from its endpoints. In the example above the points are (30, 380) and (0, 480) so s = (380-480)/(30-0) = -3.3. The slope represents how fast the amount of ozone is decreasing over time. It is a negative number, so the amount is decreasing in time. The units for the slope are Dobsons/year.

Problem 3 - Answer: D = 477 - 3.3T where T is the year. The Y intercept, 477 Dobsons, is the amount of ozone predicted for 'Year 0', which is 1970, while the x-intercept, 145, (or 1970+145 = 2115 is the year when the amount of ozone will be 0.0 Dobsons.

Problem 4 - Answer: D = 477 - 3.3(41) so D = **342 Dobsons**.

Note: The actual amount of ozone detected in March, 2011 was found to be about 250 Dobsons! This is why it is called an ' Ozone hole' since similar readings are found over the Antarctic region.