Homework Problem Set #2

Due: Friday 10/13 at noon.

Instructions: Do all your calculations and plotting in MATLAB.

Background: In this problem set you will be analyzing population data collected by the World Bank. The data provides populations by country (or group of countries) for the period 1961-2016.

1. Download the population data from the GauchoSpace website. Open the data set in MATLAB.
a) Find the columns corresponding to the population of the following three sets of countries: Low income, lower middle income, and high income. Plot the population of these countries (in millions of people) on a semi-log plot (population on y-axis on log scale, time on x-axis on linear scale). Label the plot appropriately.
b) Calculate the growth rates (in millions of people/year) of each set of countries in (a) and plot them as a function of time on a separate semi-log plot. Label the plot appropriately.
c) Examine the plots. Which set of countries (low income, lower middle income, or high income) is growing exponentially over the past 5 decades? How can you tell?
d) When did the population growth rate of low-mid income countries slow down?
e) Assume an exponential growth model of the form $P(t) = P_o e^{(a*t)}$ for the population of low-income countries since 1960. Find the values of the constants P_o and a by fitting a linear model to the log-transformed population data (use the MATLAB function polyfit).
f) Write an expression for the growth rate of low-income countries based on the model you derived in (e).
g) Compare the actual population of low-income countries with that predicted by the model you derived in (e) (i.e. plot both model and data on the same plot). Using the exponential growth model, predict what the population of low-income countries will be in 2050.

2. Analyze the population of Japan.
a) Plot the population of Japan (in millions of people) over time.
b) Fit a 2nd-degree polynomial to describe the population of Japan as a function of time since 1960 (use the MATLAB function polyfit). Write the equation. Plot the modeled population of Japan on the same plot as (a).
c) Expand the polynomial you determined in (b) in a Taylor series at year 2016. Write the expression.
d) Predict the population of Japan in 2050 in 3 different ways: (i) Using the polynomial model you determined in (b), (ii) using only the first 2 terms in the Taylor series you determined in (c), and (iii) using the first 3 terms in the Taylor series you determined in (c). Discuss how the answers compare.

Data source: https://data.worldbank.org/indicator/SP.POP.TOTL