ECE 111 - Homework #4

Math 129 Linear Algebra. Due Tuesday, September 19th
Please submit via email, via hard copy, or on BlackBoard

N equations & N unknowns

1) Solve for {x, y}

$$3x + 7y = 2$$

$$9x + 6y = -2$$

Place in matrix form

$$\begin{bmatrix} 3 & 7 \\ 9 & 6 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 2 \\ -2 \end{bmatrix}$$

Solve using Matlab

```
>> B = [3,7 ; 9,6]

     3     7
     9     6

>> A = [2;-2]

     2
    -2

>> inv(B)*A

x   -0.5778
y    0.5333

>>
```

2) Solve for {x, y, z}

$$2x - 9y - 8z = -3$$
$$-6x - 5y + 7z = 10$$
$$5x - 9y = -9$$

Place in matrix form

$$\begin{bmatrix} 2 & -9 & -8 \\ -6 & -5 & 7 \\ 5 & -9 & 0 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} -3 \\ 10 \\ -9 \end{bmatrix}$$

Solve using Matlab

```
>> B = [2,-9,-8 ; -6,-5,7 ; 5,-9,0]

B =

     2    -9    -8
    -6    -5     7
     5    -9     0

>> A = [-3;10;-9]

A =

    -3
    10
    -9

>> inv(B)*A

ans =

x   -1.7759
y    0.0134
z   -0.0840

>>
```

3) Solve for {a, b, c, d}

$$a - 6b + 5c + 4d = 10$$
$$-2a + 6b - 6d = -3$$
$$6a - b - 4c - 7d = 2$$
$$6a + 3b + 4d = -5$$

Place in matrix form

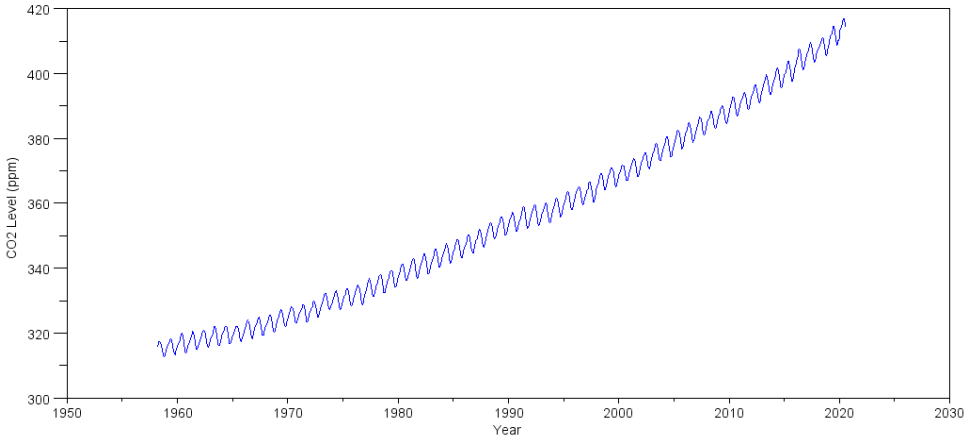
$$\begin{bmatrix} 1 & -6 & 5 & 4 \\ -2 & 6 & 0 & -6 \\ 6 & -1 & -4 & -7 \\ 6 & 3 & 0 & 4 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \\ d \end{bmatrix} = \begin{bmatrix} 10 \\ -3 \\ 2 \\ -5 \end{bmatrix}$$

Solve using Matlab

```
>> B = [1,-6,5,4;-2,6,0,-6;6,-1,-4,-7;6,3,0,4]

B =

     1    -6     5     4
    -2     6     0    -6
     6    -1    -4    -7
     6     3     0     4

>> A = [10;-3;2;-5]

A =

    10
    -3
     2
    -5

>> inv(B)*A

ans =

a    0.1590
b   -1.1060
c    1.1682
d   -0.6590
```

Global CO2 Levels

The CO2 levels measured at Mauna Loa observatory for the past 52 years are:



https://gml.noaa.gov/webdata/ccgg/trends/co2/co2_mm_mlo.txt
http://www.bisonacademy.com/ECE111/Code/CO2%20Levels.txt

Problem 4) Determine a parabolic curve fit for this data in the form of

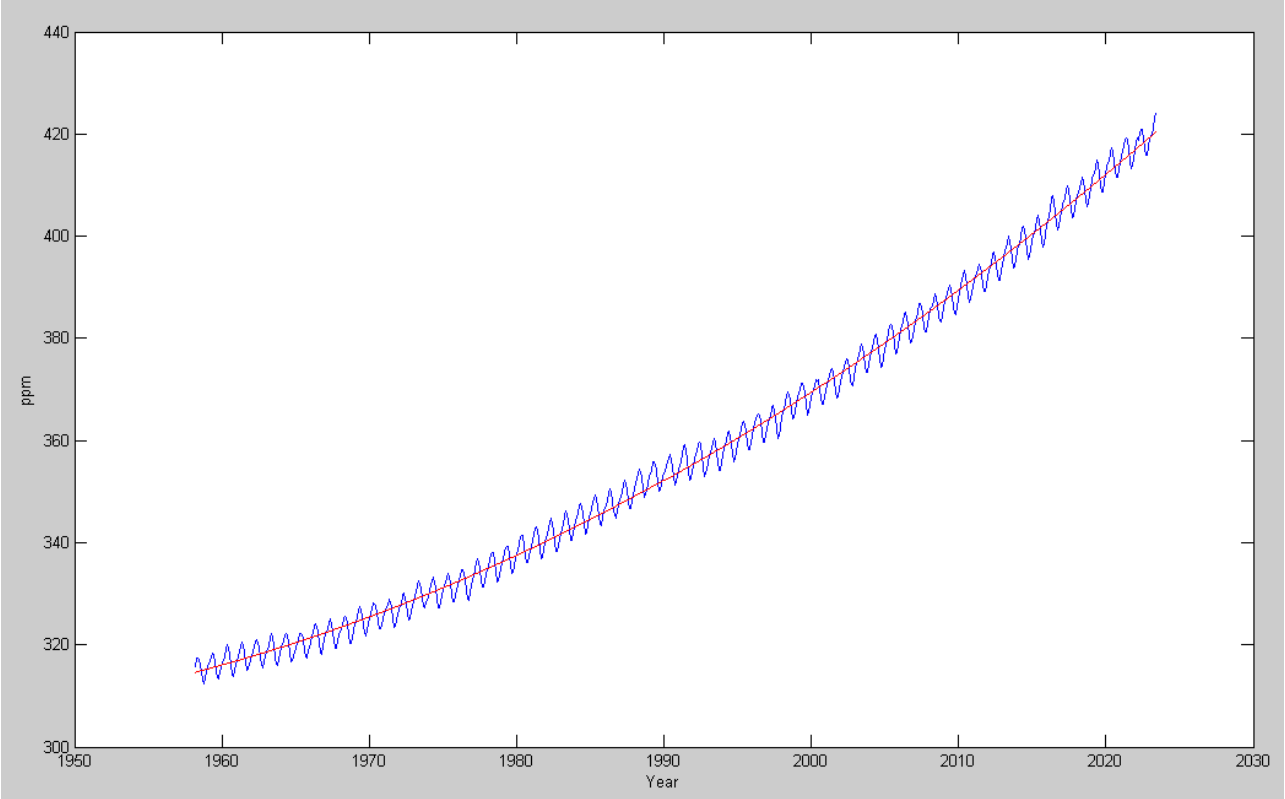
$$CO_2 \approx ay^2 + by + c$$

where 'y' is the year. From this data, when do you predict that we will hit

- 400ppm?
- 2000 ppm of CO2? (the same as what was observed during the Permian extinction)

Note: Column #3 of the data set is year, #4 is CO2

```
year = DATA(:,3);
CO2 = DATA(:,4);

>> year = DATA(:,3);
>> CO2 = DATA(:,4);
>> plot(year,DATA)
>> plot(year,CO2)
>> B = [year.^2, year, year.^0];
>> format short e
>> A = inv(B'*B)*B'*CO2

a  1.3232e-002
b -5.1063e+001
c  4.9567e+004

>> plot(year,CO2,'b',year,B*A,'r')
>> xlabel('Year');
>> ylabel('ppm');
>>
```



When we hit 400ppm?

- Year 2014.8

```
>> roots(A - [0;0;400])

   2.0148e+003
   1.8442e+003
```

When we hit 2000ppm?

- Year 2287.5

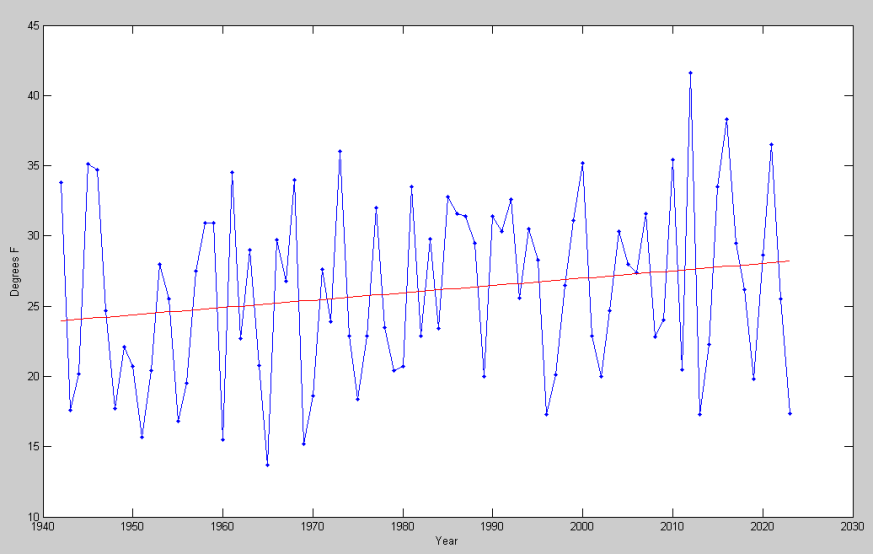
```
>> roots(A - [0;0;2000])

   2.2875e+003
   1.5715e+003
```

Fargo Temperatures

5) Using the average temperature in Fargo,

5a) Determine a curve fit of the form of $T = ay + b$

```
>> year = DATA(:,1);
>> March = DATA(:,4);
>> B = [year, year.^0];
>> A = inv(B'*B)*B'*March

   5.2308e-002
  -7.7622e+001

>> plot(year, March, 'b.-', year, B*A, 'r');
>> xlabel('Year');
                                >> ylabel('Degrees F');
```



5b) How much has Fargo warmed up over the past 80 years?

```
>> 80 * A(1)

ans =  4.1847e+000
```

March is 4.18F warmer today than 80 years ago

5c) What will the average temperature in Fargo be in May in the year 2050?

```
>> y = 2050;
>> [y, 1] * A

   2.9610e+001
```

In the year 2050, the average temperature in March should be 29.61F

- vs. 17.38F in 2023

Problem 6-7) Sea Ice: The area covered by sea ice is recored by the National Snow and Ice Data Center:

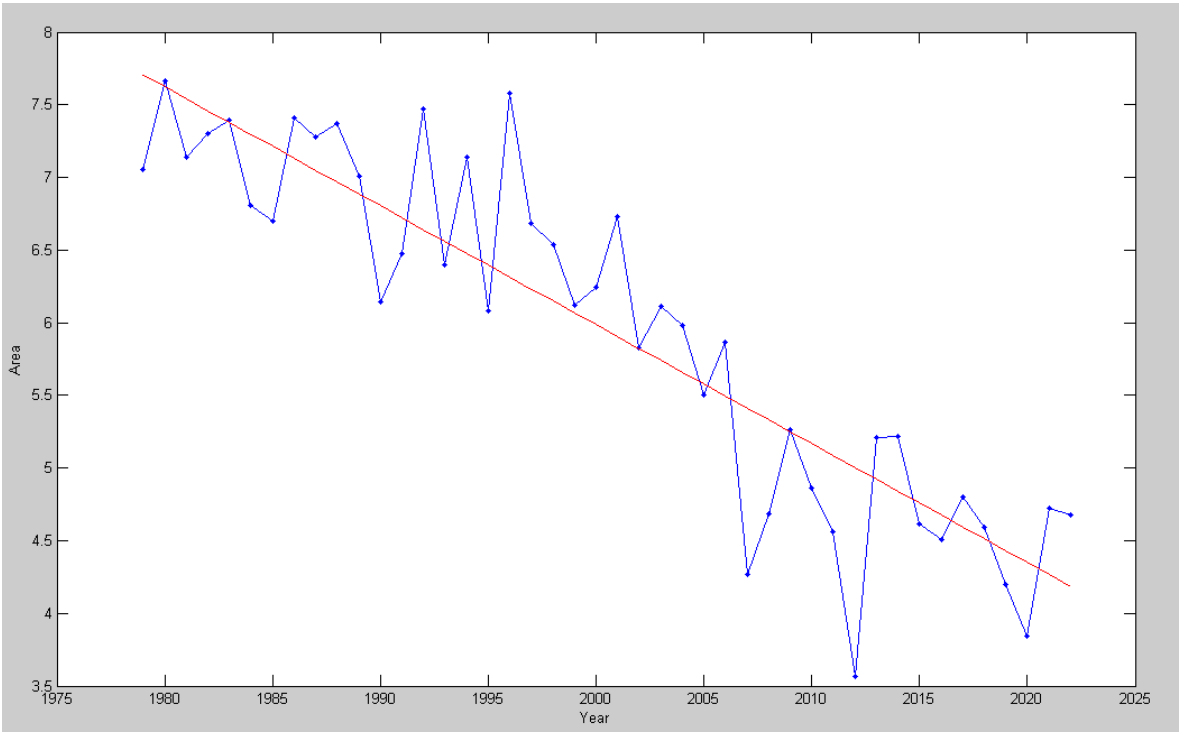
http://nsidc.org/arcticseaicenews/charctic-interactive-sea-ice-graph/
http://www.bisonacademy.com/ECE111/Code/SeaIce.txt

6) Approximate this data from the years 1979 - 2022 with a line

$$Area \approx ay + b$$

From this curve fit, when do you expect the Arctic to be ice free? (First time in 5 million years)

```
>> year = DATA(:,1);
>> ICE = DATA(:,2);
>> B = [year, year.^0];
>> A = inv(B'*B)*B'*ICE

A =

 -8.1835e-002
  1.6966e+002

>> plot(year, ICE, 'b.-', year, B*A, 'r');
>> xlabel('Year');
>> ylabel('Area');
>> roots(A)

ans =

  2.0732e+003
```

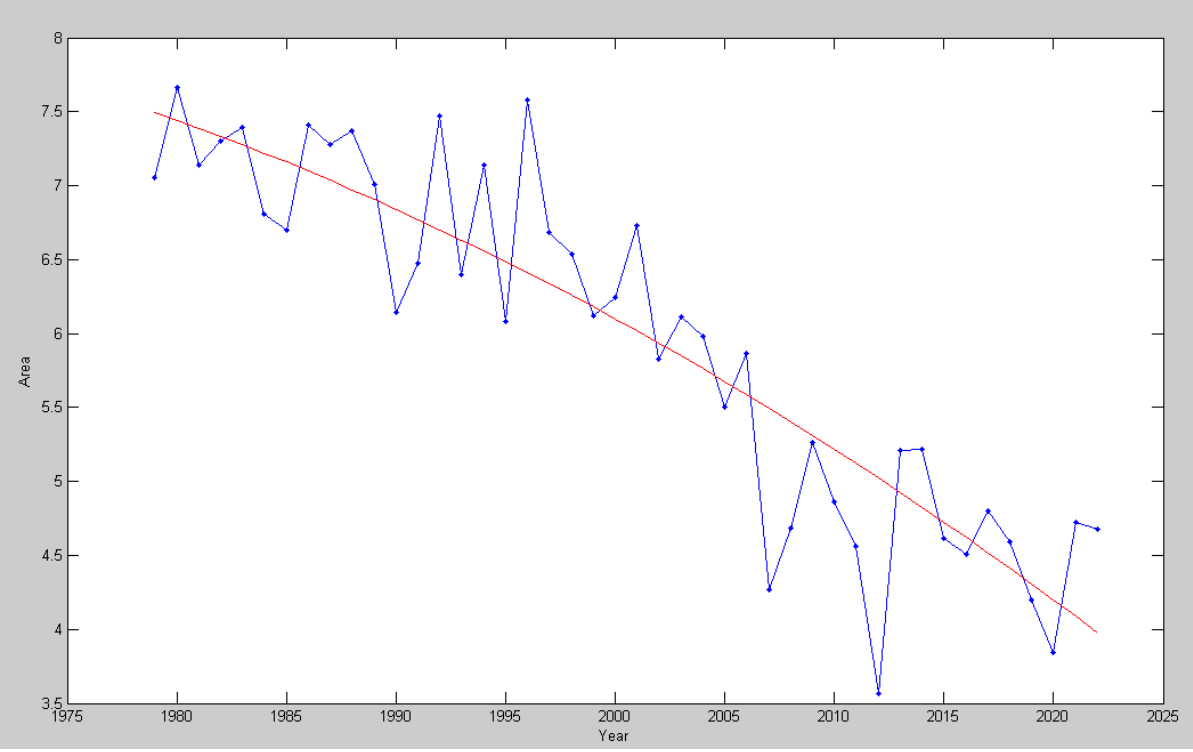


7) Approximate this data with a parabolic curve fit:

$$Area \approx ay^2 + by + c$$

From this curve fit, when do you expect the Arctic to be ice free?

```
>> B = [year.^2, year, year.^0];
>> A = inv(B'*B)*B'*ICE
Warning: Matrix is close to singular or badly scaled.
         Results may be inaccurate. RCOND = 8.082987e-023.

A =

 -6.9420e-004
  2.6957e+000
 -2.6084e+003

>> roots(A)

ans =

  2.0520e+003
  1.8311e+003

>> plot(year, ICE, 'b.-', year, B*A, 'r');
>> xlabel('Year');
>> ylabel('Area');
```



Problem 8-9: World Temperatures. NASA Goddard has been keep records since 1880 (139 years of data).

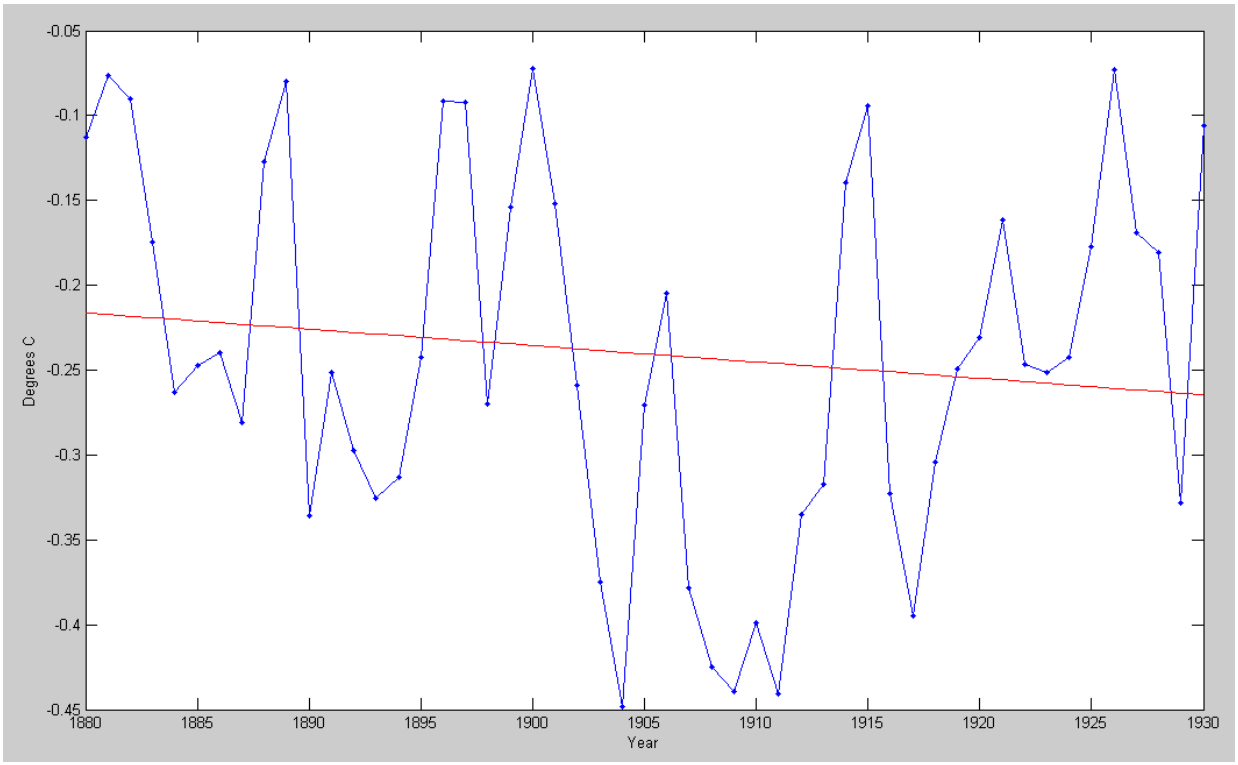
8) Determine a least-squares curve fit for this data from the year 1880 - 1930 in the form of

$$\delta T = ay + b$$

Based upon this data, what *should* the temperature deviation be in the year 2022?

```
>> year = DATA(:,1);
>> dT = DATA(:,2);
>> B = [year, year.^0];
>> A = inv(B'*B)*B'*dT

A =

 -9.6729e-004
  1.6024e+000

>> plot(year, dT, 'b.-', year, B*A, 'r');
>> xlabel('Year');
>> ylabel('Degrees C');
>>
>> y = 2023;
>> [y, 1] * A

ans = -3.5449e-001
```

Based upon the trend from 1880 - 1930, the year 2023 *should* be -0.3544C. It's actually +1.015C, meaning 1.369C above the trend (+1.369C warming)



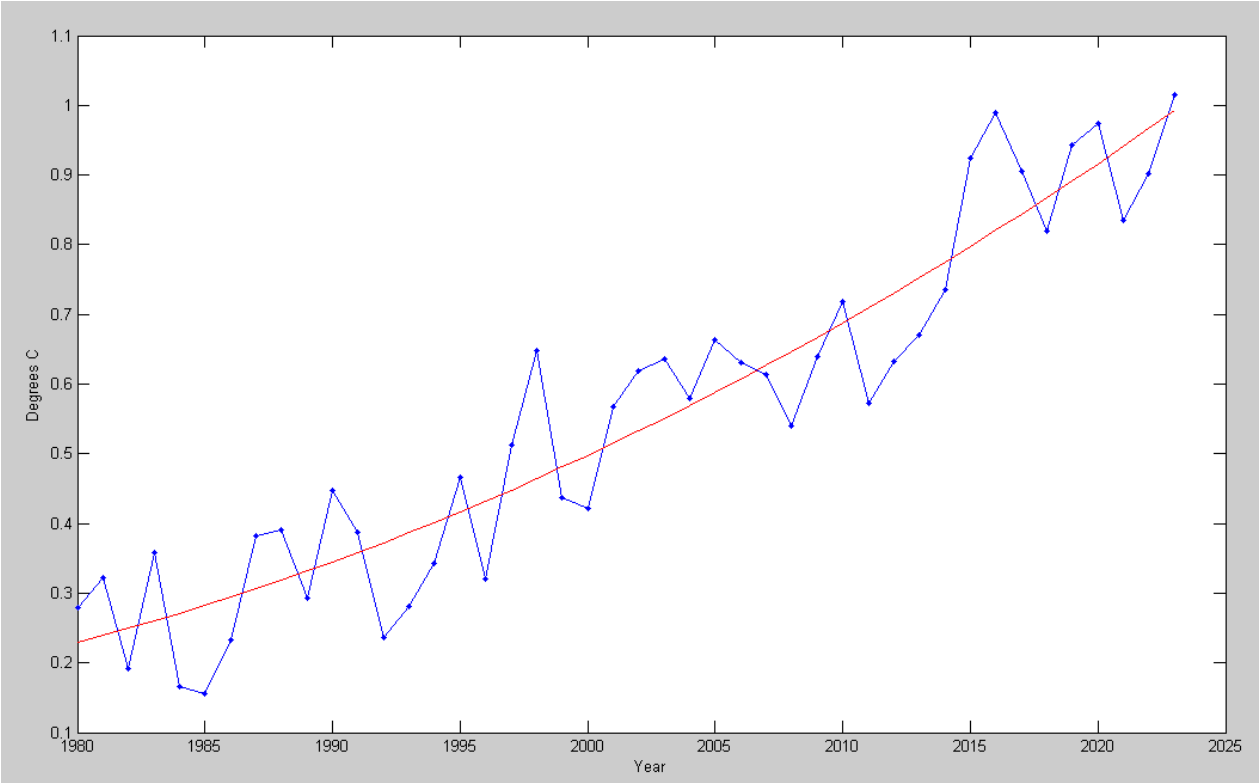
9) Determine a least-squares curve fit for this data from the year 1980 - 2022 in the form of

$$\delta T \approx ay^2 + by + c$$

Based upon this data, predict when we will see a 10 degree temperature increase if nothing changes?

```
>> year = DATA(:,1);
>> dT = DATA(:,2);
>> B = [year.^2, year, year.^0];
>> A = inv(B'*B)*B'*dT

   1.8810e-004
  -7.3524e-001
   7.1857e+002

>> roots(A - [0;0;10])

   2.1837e+003
   1.7250e+003

>> plot(year, dT, 'b.-', year, B*A, 'r');
>> xlabel('Year');
>> ylabel('Degrees C');
```

If the trend continues, we'll hit +10C in the year 2183



10) What does a temperature rise of 10 degrees mean for the planet?

not graded - too political

The Permian Extinction Event suggests that it's not good: no animals larger than a mouse survived the Permian Extinction - which was triggered by CO2 levels at 2000ppm and a +10 degree C temerature rise.

One Degree: 2023 Summers like 2003 where a heat wave in France caused 10,000 deaths become the norm. Flows of the Po and Rhine river decrease. Crop production drops.

```
-->roots(A - [0;0;1])

  2023.9
  1872.3
```

Two Degrees: 2054. Oceans absorb less CO2 (too hot) and soils start to release CO2. Vacations to the Mediterranean in the summer are just too hot. Crop failures in Africa and Central America cause mass migration. Coastal cities flood. 1/3rd of species face extinction.

```
>> roots(A - [0;0;2])

  2054.7
  1854.0
```

Three Degrees: 2078. Crop failures in China cause the migration of more than 1 billion people. Collapse of equatorial governments.

```
>> roots(A - [0;0;3])

  2078.4
  1830.3
```

Four Degrees: 2098. Spain becomes a desert. Mass migration to Northern latitudes. Rain forests burn up.

```
>> roots(A - [0;0;4])

  2098.2
  1810.5
```

Six Degrees: 2131. Ice caps are gone. Methane hydrates become unstable raising temperatures in a positive-feedback loop. Ocean circulation stops. Hydrogen sulfide producing bacteria flourish poisoning the air. The Ozone layer dissipates leaving the land sterilized with UV radiation. End-Permian-like conditions make life nearly impossible.

```
>> roots(A - [0;0;6])

  2131.4
  1777.4
```

Scary? Yes. That's why the rest of the world sees the Paris Climate Accord as being important. That's why the United Nations sees Global Warming as the #1 threat - far greater than terrorism. Far greater than COVID.