

Passage 24 A #6

In this course, we have learnt,

- 1) An overview of the world population in the past.
- 2) Simple population dynamics model as exponential growth.
- 3) Other models in which annual growth decreases or increases with time.
- 4) Age structured population dynamics model using vector and matrix.

Today, we work on the following problem.

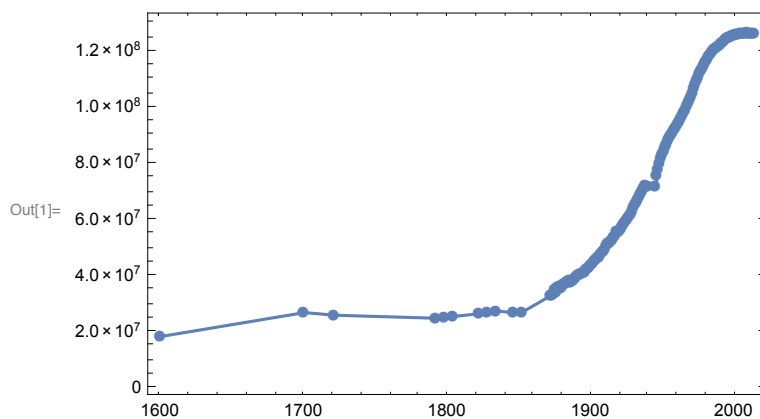
■ Problem

- 1) Pick up a country and describe the country's demographic change in the past for available data.
- 2) Calculate annual growth rates for each year and examine its trend (Is the annual growth rate increasing or decreasing?).
- 3) Predict the country population size under the assumption that the present trend continues in the future.
- 4) Make a brief report about the country's demography in past and future, mentioning the proportion of elder people.

Example Japan

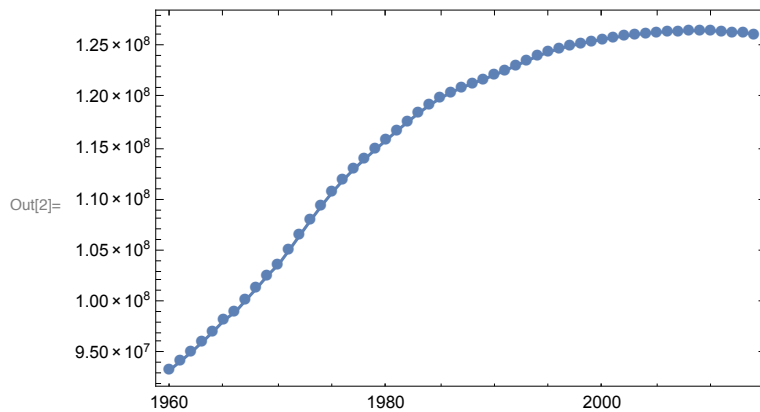
Let's choose Japan and draw its demographic change for all available data.

```
In[1]:= DateListPlot[CountryData["Japan", {"Population", All}], PlotMarkers -> Automatic]
```



We focus on a narrower time span from 1960 to 2014.

```
In[2]:= DateListPlot[CountryData["Japan", {"Population", {1960, 2014}}],
  PlotMarkers -> Automatic]
```



From the demographic data, we calculate annual growth rate for each year.

```
In[3]:= dataCountry = CountryData["Japan", {"Population", {1960, 2014}}]
```

Out[3]=

```
In[34]:= CountryData["Japan", "AdultPopulation"]
```

Out[34]= 7.83259×10^7 people

```
In[35]:= CountryData["Japan", "ElderlyPopulation"]
```

Out[35]= 3.14053×10^7 people

```
In[36]:= CountryData["Japan", "ChildPopulation"]
```

Out[36]= 1.6614×10^7 people

We can pick up the population size from the data.

```
In[4]:= dataCountry["1990"]
```

Out[4]= 122 251 184 people

```
In[5]:= dataCountry["2014"]
```

Out[5]= 126 225 259 people

```
In[6]:= tableYears = Table[TextString[t], {t, 1960, 2014}]
```

Out[6]= {1960, 1961, 1962, 1963, 1964, 1965, 1966, 1967, 1968, 1969, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014}

List the population sizes from 1960 to 2014 (there are 55 data).

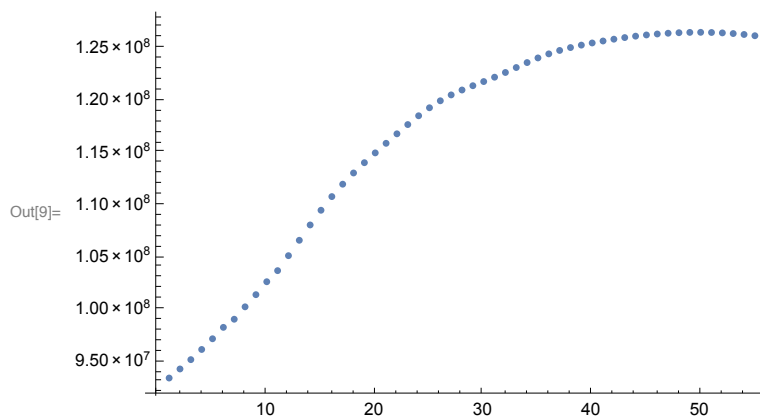
```
In[7]:= dataCountryPopSize = dataCountry[tableYears]
Length[dataCountryPopSize]
```

```
Out[7]= { 93 418 500 people , 94 287 000 people , 95 181 000 people ,
          96 156 000 people , 97 182 000 people , 98 275 000 people , 99 054 000 people ,
          100 243 000 people , 101 408 000 people , 102 648 000 people , 103 710 287 people ,
          105 145 914 people , 106 619 818 people , 108 089 192 people , 109 498 615 people ,
          110 808 090 people , 111 996 339 people , 113 071 149 people , 114 057 650 people ,
          114 996 088 people , 115 914 688 people , 116 823 958 people , 117 711 145 people ,
          118 554 190 people , 119 320 901 people , 119 990 547 people , 120 553 260 people ,
          121 023 579 people , 121 434 677 people , 121 832 924 people , 122 251 184 people ,
          122 703 017 people , 123 177 552 people , 123 653 405 people , 124 097 649 people ,
          124 486 744 people , 124 814 986 people , 125 091 571 people , 125 325 617 people ,
          125 531 619 people , 125 720 310 people , 125 893 623 people , 126 048 366 people ,
          126 184 149 people , 126 299 414 people , 126 392 944 people , 126 464 789 people ,
          126 515 486 people , 126 544 640 people , 126 551 705 people , 126 535 920 people ,
          126 497 241 people , 126 434 653 people , 126 345 235 people , 126 225 259 people }
```

```
Out[8]= 55
```

And visualize the list of the population sizes from 1960.

```
In[9]:= gPast = ListPlot[dataCountryPopSize]
```



We calculate annual growth rate for each year.

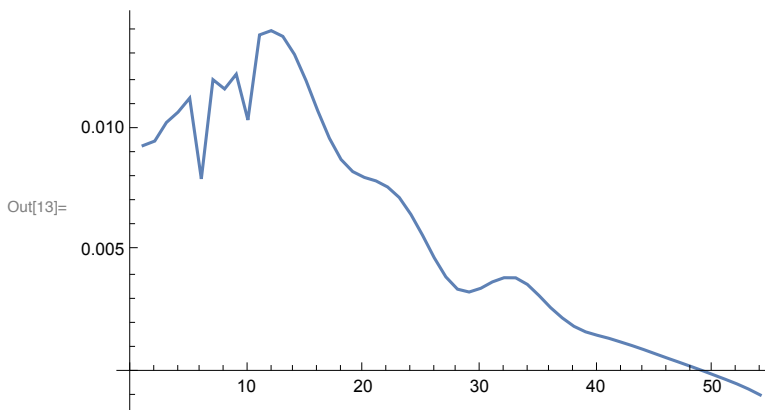
```
In[10]:= dataAnnualGrowthRate = {};
Do[
  AppendTo[dataAnnualGrowthRate,
    N[(dataCountryPopSize[[i + 1]] - dataCountryPopSize[[i]]) /
      dataCountryPopSize[[i]]], {i, 1, Length[dataCountryPopSize] - 1}
]
```

dataAnnualGrowthRate

```
Out[12]:= {0.00929687, 0.00948169, 0.0102436, 0.0106702, 0.0112469, 0.00792674, 0.0120036,
  0.0116218, 0.0122278, 0.0103488, 0.0138427, 0.0140177, 0.0137814, 0.0130394,
  0.0119588, 0.0107235, 0.00959683, 0.0087246, 0.00822775, 0.0079881,
  0.0078443, 0.00759422, 0.00716198, 0.00646718, 0.00561214, 0.00468964,
  0.00390134, 0.00339684, 0.00327952, 0.00343306, 0.00369594, 0.00386735,
  0.00386315, 0.00359265, 0.00313539, 0.00263676, 0.00221596, 0.001871,
  0.00164373, 0.00150314, 0.00137856, 0.00122916, 0.00107723, 0.000913467,
  0.000740542, 0.000568426, 0.000400878, 0.000230438, 0.0000558301,
  -0.000124732, -0.000305676, -0.000494778, -0.000707227, -0.000949589}
```

Visualize the annual growth rate from 1960 to 2014 (The year 1960 is 1st year in the graph).

```
In[13]:= ListPlot[dataAnnualGrowthRate, Joined → True, PlotRange → All]
```



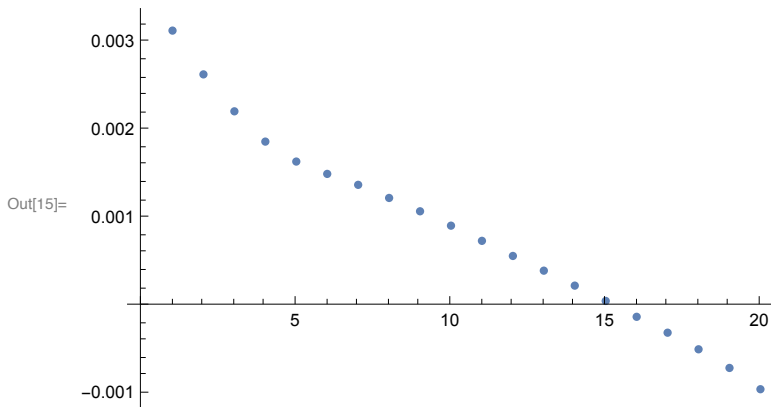
We focus on the recent 20 years to calculate the trend of the annual growth rate change.

```
In[14]:= dataLast = Take[dataAnnualGrowthRate, -20]
```

```
Out[14]:= {0.00313539, 0.00263676, 0.00221596, 0.001871, 0.00164373,
  0.00150314, 0.00137856, 0.00122916, 0.00107723, 0.000913467,
  0.000740542, 0.000568426, 0.000400878, 0.000230438, 0.0000558301,
  -0.000124732, -0.000305676, -0.000494778, -0.000707227, -0.000949589}
```

Visualize the recent annual growth rate.

```
In[15]:= gDataAnnualGrowthRate = ListPlot[dataLast]
```



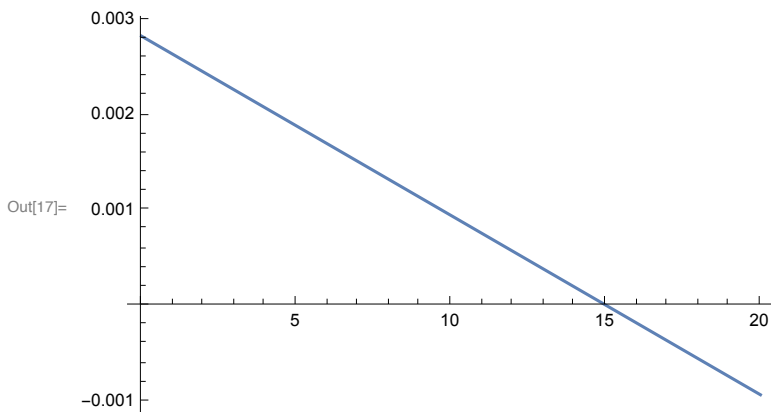
We fit the data with a linear function (straight line) of the year t .

```
In[16]:= fitted = Fit[dataLast, {1, t}, t]
```

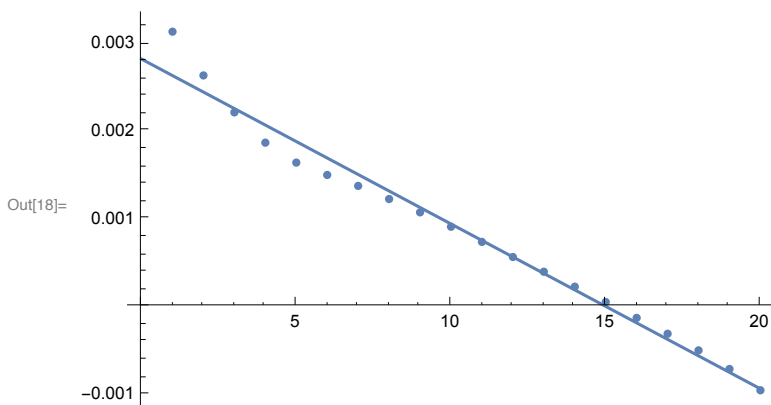
```
Out[16]= 0.00282285 - 0.000187802 t
```

The annual growth rate decreases by 0.000187802 every year.

```
In[17]:= gFitted = Plot[fitted, {t, 0, 20}]
```



```
In[18]:= Show[gDataAnnualGrowthRate, gFitted]
```



We calculate the predicted annual growth rate for 50 years in future based on the trend.

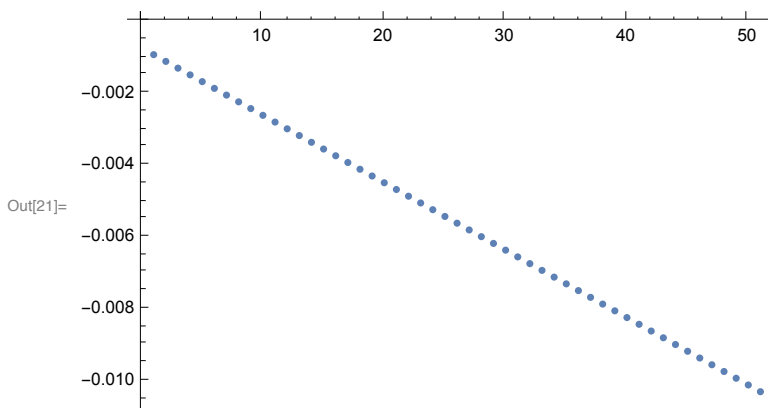
```
In[19]:= tPeriod = 50;
```

```
seqGrowthRate = Table[fitted, {t, 20, 20 + tPeriod}]
```

```
Out[20]= {-0.000933194, -0.001121, -0.0013088, -0.0014966, -0.0016844, -0.0018722,
-0.00206001, -0.00224781, -0.00243561, -0.00262341, -0.00281121, -0.00299902,
-0.00318682, -0.00337462, -0.00356242, -0.00375023, -0.00393803, -0.00412583,
-0.00431363, -0.00450143, -0.00468924, -0.00487704, -0.00506484, -0.00525264,
-0.00544044, -0.00562825, -0.00581605, -0.00600385, -0.00619165, -0.00637945,
-0.00656726, -0.00675506, -0.00694286, -0.00713066, -0.00731846,
-0.00750627, -0.00769407, -0.00788187, -0.00806967, -0.00825748,
-0.00844528, -0.00863308, -0.00882088, -0.00900868, -0.00919649,
-0.00938429, -0.00957209, -0.00975989, -0.00994769, -0.0101355, -0.0103233}
```

Visualize the predicted annual growth rate.

```
In[21]= ListPlot[seqGrowthRate]
```



We calculate the population size in the future starting from the size at the year 2014.

```
In[22]= dataCountry["2014"]
```

```
Out[22]= 126 225 259 people
```

```

In[23]:= data = {};
popSize = 126 225 259 people ;

Do[
  AppendTo[data, popSize];
  popSize = popSize * (1 + seqGrowthRate[[i]]);, {i, 1, tPeriod}
]

dataPredicted = Transpose[{Table[t, {t, 56, 56 + tPeriod - 1}], data]}

```

```

Out[26]= {{56, 126 225 259 people }, {57, 1.26107 × 108 people },
  {58, 1.25966 × 108 people }, {59, 1.25801 × 108 people }, {60, 1.25613 × 108 people },
  {61, 1.25401 × 108 people }, {62, 1.25167 × 108 people }, {63, 1.24909 × 108 people },
  {64, 1.24628 × 108 people }, {65, 1.24324 × 108 people }, {66, 1.23998 × 108 people },
  {67, 1.2365 × 108 people }, {68, 1.23279 × 108 people }, {69, 1.22886 × 108 people },
  {70, 1.22471 × 108 people }, {71, 1.22035 × 108 people }, {72, 1.21577 × 108 people },
  {73, 1.21099 × 108 people }, {74, 1.20599 × 108 people }, {75, 1.20079 × 108 people },
  {76, 1.19538 × 108 people }, {77, 1.18978 × 108 people }, {78, 1.18397 × 108 people },
  {79, 1.17798 × 108 people }, {80, 1.17179 × 108 people }, {81, 1.16541 × 108 people },
  {82, 1.15886 × 108 people }, {83, 1.15212 × 108 people }, {84, 1.1452 × 108 people },
  {85, 1.13811 × 108 people }, {86, 1.13085 × 108 people }, {87, 1.12342 × 108 people },
  {88, 1.11583 × 108 people }, {89, 1.10808 × 108 people }, {90, 1.10018 × 108 people },
  {91, 1.09213 × 108 people }, {92, 1.08393 × 108 people }, {93, 1.07559 × 108 people },
  {94, 1.06712 × 108 people }, {95, 1.05851 × 108 people }, {96, 1.04976 × 108 people },
  {97, 1.0409 × 108 people }, {98, 1.03191 × 108 people }, {99, 1.02281 × 108 people },
  {100, 1.0136 × 108 people }, {101, 1.00427 × 108 people },
  {102, 9.9485 × 107 people }, {103, 9.85328 × 107 people },
  {104, 9.75711 × 107 people }, {105, 9.66005 × 107 people }}

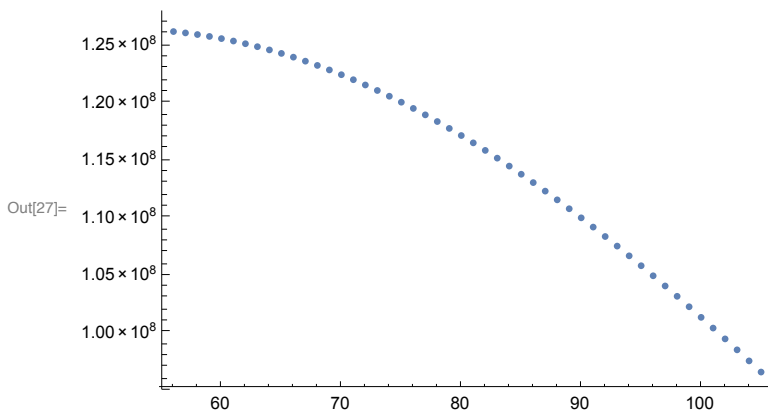
```

Visualize the predicted demography.

```

In[27]:= gPredicted = ListPlot[dataPredicted]

```



```
In[28]:= dataPast =  

Transpose[{{Table[t, {t, 1, Length[dataCountryPopSize]}], dataCountryPopSize}}
```

```
Out[28]:= {{1, 93 418 500 people }, {2, 94 287 000 people },  

{3, 95 181 000 people }, {4, 96 156 000 people }, {5, 97 182 000 people },  

{6, 98 275 000 people }, {7, 99 054 000 people }, {8, 100 243 000 people },  

{9, 101 408 000 people }, {10, 102 648 000 people }, {11, 103 710 287 people },  

{12, 105 145 914 people }, {13, 106 619 818 people },  

{14, 108 089 192 people }, {15, 109 498 615 people }, {16, 110 808 090 people },  

{17, 111 996 339 people }, {18, 113 071 149 people }, {19, 114 057 650 people },  

{20, 114 996 088 people }, {21, 115 914 688 people }, {22, 116 823 958 people },  

{23, 117 711 145 people }, {24, 118 554 190 people }, {25, 119 320 901 people },  

{26, 119 990 547 people }, {27, 120 553 260 people }, {28, 121 023 579 people },  

{29, 121 434 677 people }, {30, 121 832 924 people }, {31, 122 251 184 people },  

{32, 122 703 017 people }, {33, 123 177 552 people }, {34, 123 653 405 people },  

{35, 124 097 649 people }, {36, 124 486 744 people }, {37, 124 814 986 people },  

{38, 125 091 571 people }, {39, 125 325 617 people }, {40, 125 531 619 people },  

{41, 125 720 310 people }, {42, 125 893 623 people }, {43, 126 048 366 people },  

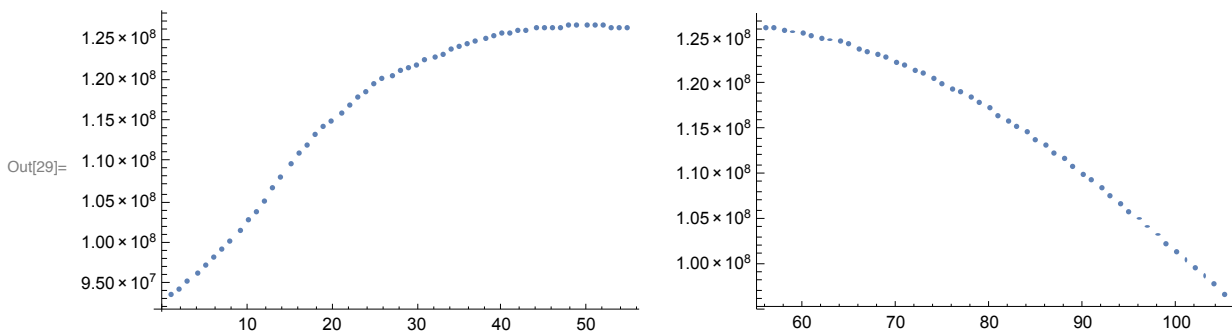
{44, 126 184 149 people }, {45, 126 299 414 people }, {46, 126 392 944 people },  

{47, 126 464 789 people }, {48, 126 515 486 people }, {49, 126 544 640 people },  

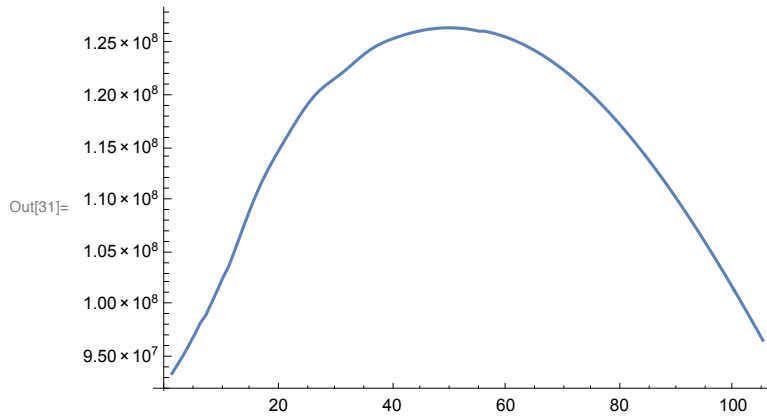
{50, 126 551 705 people }, {51, 126 535 920 people }, {52, 126 497 241 people },  

{53, 126 434 653 people }, {54, 126 345 235 people }, {55, 126 225 259 people }}
```

```
In[29]:= GraphicsGrid[{{gPast, gPredicted}}, ImageSize -> 600]
```




```
In[30]:= dataJoined = Join[dataPast, dataPredicted];  
ListPlot[dataJoined, Joined → True]
```



Example Germany

Example The World