Fathom Instructions
Life Expectancy of Canadians Linear Activity

Background Information

Life expectancy refers to the average number of years an individual is expected to live, as determined by statistics regarding mortality by age group. For instance, if the life expectancy in 1955 was 65, that would mean that people born in 1955 would be expected to live until they were 65 years old, on average.
The life expectancy of Canadians is among the highest in the world. Why do you think this is?

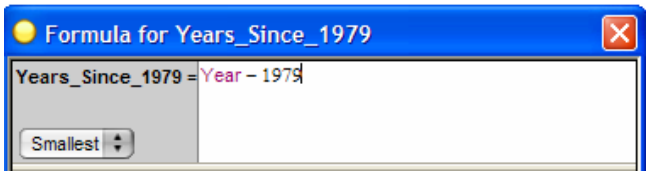
Part 1: Overall Life Expectancy

In this section, you will retrieve data on the life expectancy of Canadians from 1979 to 1999 from E-STAT. Then, you will import your data into Fathom and perform analysis, using your knowledge of linear equations, to see if a linear model provides a good approximation of this data.

Fathom Analysis

Retrieving, copying, and pasting the data

1) On the **E-STAT Output specification** page, under **Screen output – table:**, select **Plain text: Table, time as rows.**
2) Click on the **Retrieve now** button.
3) Highlight only the data, but not the attribute names, legend at the top of the page, or the source line at the bottom of the page
4) Right-click and select **Copy**.
5) Switch to **Fathom**. If Fathom isn't already running, you will need to launch it.
6) Create a new collection by dragging and dropping the **Collection** icon onto the workspace.
7) Double-click on the pre-assigned collection name to rename it **Life Expectancy Total**.
8) Right-click on the collection and select **Paste Cases**.
9) Double-click on the collection to inspect it.
10) Double-click on the pre-assigned attribute names to rename them **Year** and **Life_Expectancy**.
11) Click on the attribute labelled **<new>** and rename it **Years_Since_1979.** Right-click on this attribute name and select **Edit Formula**.
12) Click on the **+ sign** beside the word **Attributes**. This shows all the attributes available. Double-click on **Year** so it appears in the display window (Note that Fathom turns the word Year blue (if using Fathom 1) or purple (if using Fathom 2) because it recognizes it as an attribute name). Then, type **– 1979**. Your display window should look like this:



13) Click on **OK.** You will now see your formula appear in the third column of your table.
14) Save your Fathom collection as **Life Expectancy Total**.

Graphing and modelling the data

1) Create a new graph by dragging and dropping the **Graph** icon onto the workspace.
2) Create a scatter plot of life expectancy by year by dragging and dropping the attribute **Years_Since_1979** on the **x-axis** and the attribute **Life_Expectancy** on the **y-axis**.
3) Drag the values on the x-axis until the zero lines up with the y-axis (no space).
4) Right-click on the graph and select **Movable Line** (if using Fathom 1) or **Add Movable Line** (if using Fathom 2).
5) Move the line using the associated arrows to approximate the line of best fit.

******* Go to Worksheet #1 and answer questions #1 to 7. *******

6) Right-click on your graph and select **Least-Squares Line.** This plots the line of best fit on your graph.

******* Go to Worksheet #1 and answer questions #8 to 14. Question #14 requires that you paste your graph. To do this, click on the graph, then go to the Edit menu, and select Copy Picture (if using Fathom 1) or Copy As Picture (if using Fathom 2). When you are in the worksheet document, right-click and paste your graph. *******

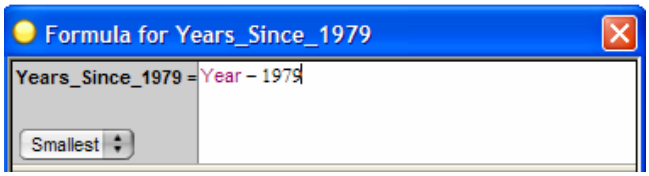
Part 2: Life Expectancy by Sex

In this section, you will retrieve the life expectancy data for males and females separately. You will compare the equations of the lines of best fit of the two sexes. You will see where the two lines of best fit intersect and perform data analysis based on this graph.

Fathom Analysis

Retrieving, copying, and pasting the data

1) On the **E-STAT Output specification** page, under **Screen output – table:**, select **Plain text: Table, time as rows.**
2) Click on the **Retrieve now** button.
3) Highlight only the data, but not the attribute names, legend at the top of the page, or the source line at the bottom of the page
4) Right-click and select **Copy**.
5) Switch to Fathom. If Fathom isn't already running, you will need to launch it.
6) Create a new collection by dragging and dropping the **Collection** icon onto the workspace.
7) Double-click on the pre-assigned collection name to rename it **Life Expectancy by Sex**.
8) Right-click on the collection and select **Paste Cases**.
9) Double-click on the collection to inspect it.
10) Double-click on the pre-assigned attribute names to rename them **Year, Life_Expectancy_Males,** and **Life_Expectancy_Females**. Be careful that you do not mix up the males and females; double-check with your E-STAT output to be sure.
11) Click on the attribute labelled **<new>** and rename it **Years_Since_1979.** Right-click on this attribute name and select **Edit Formula**.
12) Click on the **+ sign** beside the word **Attributes**. This shows all the attributes available. Double-click on **Year** so it appears in the display window (Note that Fathom turns the word Year blue (if using Fathom 1) or purple (if using Fathom 2) because it recognizes it as an attribute name). Then, type **– 1979**. Your display window should look like this:



13) Click on **OK.** You will now see your formula appear in the third column of your table.
14) Save your Fathom collection as **Life Expectancy by Sex.**

Graphing and modelling the data

***** The instructions in this section differ depending on the version of Fathom that your school has installed. Ask your teacher which steps to follow. *****

Fathom 1 Instructions

1) Create two new graphs by dragging and dropping the **Graph** icon onto the workspace twice.
2) On the first graph, create a scatter plot of the life expectancy of males by year by dragging and dropping the attribute **Years_Since_1979** on the **x-axis** and the attribute **Life_Expectancy_Males** on the **y-axis**.
3) On the second graph, create a scatter plot of the life expectancy of females by year by dragging and dropping the attribute **Years_Since_1979** on the **x-axis** and the attribute **Life_Expectancy_Females** on the **y-axis**.
4) Drag the values on the x-axis of each graph until the zero lines up with the y-axis (no space).

   ******* Go to Worksheet #2 and answer questions #1 to 3. *******

5) Right-click on each graph and select **Least-Squares Line.**

   ******* Go to Worksheet #2 and answer questions #4 to 7. Question #7 requires that you paste your graph. To do this, click on the graph, then go to the Edit menu, and select Copy Picture. When you are in the worksheet document, right-click and paste your graph. *******

Fathom 2 Instructions

1) Create a new graph by dragging and dropping the **Graph** icon onto the workspace.
2) Create a scatter plot of the life expectancy of males and the life expectancy of female by year by dragging and dropping the attribute **Years_Since_1979** on the **x-axis** and the attribute **Life_Expectancy_Males** on the **y-axis**. Now, drag and drop the attribute **Life_Expectancy_Females** to the **top of the y-axis** and drop it where the **plus sign (+)** appears (a black box will appear around *only* around the plus sign if you are in the right spot). Be careful not to drop the female attribute on top of the male attribute (a black box will appear on the whole axis if you do this) or you will just switch them instead of displaying both.
3) Drag the values on the x-axis until the zero lines up with the y-axis (no space).

   ******* Go to Worksheet #2 and answer questions #1 to 3. *******

4) Right-click on the graph and select **Least-Squares Lines.**

   ******* Go to Worksheet #2 and answer questions #4 to 6. *******

5) Click on the x-axis (you will see a sideways hand) and then the y-axis (you will see a vertical hand) and drag the values until you can see where the lines intersect. You may need to re-size your graph as well to help you see the point of intersection.

******* Go to Worksheet #2 and answer question #7. *******

6) Now, click on the point of intersection and a red dot will appear, coupled with an ordered pair (you must hold down the left mouse button for the ordered pair to appear).

******* Go to Worksheet #2 and answer questions #8 to 10. Question #10 requires that you paste your graph. To do this, click on the graph, then go to the Edit menu, and select Copy As Picture. When you are in the worksheet document, right-click and paste your graph. *******

Student Worksheet #1: Overall Life Expectancy
Life Expectancy of Canadians Linear Activity

1) What variable represents **x**?

2) What variable represents **y**?

3) What is the equation of your approximated line of best fit (using the movable line), as displayed under your graph? Note: You may need to re-size your graph to see the entire equation.

4) Rewrite your equation as **y = mx + b**.

5) What is the slope of the line? What does this represent?

6) What is the y-intercept of the line? What does this represent?

7) Write the equation of your approximated line of best fit in standard form (**Ax + By + C = 0**).

******* RETURN TO YOUR INSTRUCTION SHEET AND COMPLETE STEP #6 BEFORE ANSWERING QUESTIONS #8 TO 14. *******

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8) Write the equation of the software-generated line of best fit (least-squares line) here, both as it is displayed under the graph and in **y = mx + b** form.

9) How does the software-generated line of best fit compare to your approximated line of best fit? How specifically do the differences in slope and y-intercept relate?

10) Why do you think the graph of life expectancy follows the trend it does? Provide at least three possible reasons for this trend.

11) Using the equation of the software-generated line of best fit, what does the model predict your life expectancy will be? Be sure to indicate your year of birth and show all calculations. Remember that the x value in your equation is the **number of years since 1979**, not the actual year of your birth.

12) Will this equation still be a valid model for someone who is born in 2107? Explain why or why not. Use calculations to support your claim. Remember that the x value in your equation is the **number of years since 1979**, not the actual year of birth.

13) If the model is assumed to be correct, in what birth year will Canadians have a life expectancy of 90 years on average? Round your answer to the nearest year. Remember that the x value in your equation is the **number of years since 1979**, not the actual year of birth.

14) Paste your graph with both your estimated line of best fit and the software-generated line of best fit here.

Student Worksheet #2: Life Expectancy by Sex
Life Expectancy of Canadians Linear Activity
Fathom 1 Version

1) Who has a higher life expectancy, males or females? Approximately how many years of difference are there between the life expectancies of males and females (over the period from 1979 to 1999)?

2) By inspection, which line (life expectancy of males or females) appears to have a higher slope?

3) Select two points on each line (click on the points to obtain exact co-ordinates) and estimate the slope using the equation $m = \frac{y_2 - y_1}{x_2 - x_1}$. Show all calculations and be sure to note which points you chose for each line, as an ordered pair. Describe what each ordered pair means. Which line has a higher slope, according to your calculations? Was your guess by inspection correct?

******* RETURN TO YOUR INSTRUCTION SHEET AND COMPLETE STEP #5 BEFORE ANSWERING QUESTIONS #4 TO 7. *******

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4) For the graph of the life expectancy of males, write the equation of the line of best fit in three ways:
   - As it is displayed under the graph
   - Slope-intercept form (y = mx + b)
   - Standard form (Ax + By + C = 0)

5) For the graph of the life expectancy of females, write the equation of the line of best fit in three ways:
   - As it is displayed under the graph
   - Slope-intercept form (y = mx + b)
   - Standard form (Ax + By + C = 0)

6) Which line of best fit has a higher slope? What does this higher slope represent?

7) Paste your graphs here.

Student Worksheet #2: Life Expectancy by Sex
Life Expectancy of Canadians Linear Activity
Fathom 2 Version

1) Who has a higher life expectancy, males or females? Approximately how many years of difference are there between the life expectancies of males and females (over the period from 1979 to 1999)?

2) By inspection, which line (life expectancy of males or females) appears to have a higher slope?

3) Select two points on each line (click on the points to obtain exact co-ordinates) and estimate the slope using the equation $m = \frac{y_2 - y_1}{x_2 - x_1}$. Show all calculations and be sure to note which points you chose for each line, as an ordered pair. Describe what each ordered pair means. Which line has a higher slope, according to your calculations? Was your guess by inspection correct?

******* RETURN TO YOUR INSTRUCTION SHEET AND COMPLETE STEP #4 BEFORE ANSWERING QUESTIONS #4 TO 6. *******

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4) For the graph of the life expectancy of males, write the equation of the line of best fit in three ways:

- As it is displayed under the graph
- Slope-intercept form (y = mx + b)
- Standard form (Ax + By + C = 0)

5) For the graph of the life expectancy of females, write the equation of the line of best fit in three ways:

- As it is displayed under the graph
- Slope-intercept form (y = mx + b)
- Standard form (Ax + By + C = 0)

6) Which line of best fit has a higher slope? What does this higher slope represent?

******* RETURN TO YOUR INSTRUCTION SHEET AND COMPLETE STEP #5 BEFORE ANSWERING QUESTION #7. *******

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7) By inspection, approximately where do the lines intersect (as an ordered pair)? What does this represent?

******* RETURN TO YOUR INSTRUCTION SHEET AND COMPLETE STEP #6 BEFORE ANSWERING QUESTIONS #8 TO 10. *******

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8) What are the actual co-ordinates of the point of intersection?

9) Substitute the number of years since 1979 value (round to the nearest year) into your lines of best fit equations to confirm the life expectancy at the point of intersection.

10) Paste your graph here.

Student Worksheet #1
Life Expectancy of Canadians Linear Activity
TEACHER VERSION

1) What variable represents **x**?

   Years_Since_1979

2) What variable represents **y**?

   Life_Expectancy

3) What is the equation of your approximated line of best fit (using the movable line), as displayed under your graph? Note: You may need to re-size your graph to see the entire equation.

   Answers vary – e.g., Life_Expectancy = 0.204Years_Since_1979 + 75.05 is used in this example

4) Rewrite your equation as **y = mx + b**.

   y = 0.204x + 75.05

5) What is the slope of the line? What does this represent?

   The slope of the line is 0.204. This means that for each year in the future since 1979 that babies are born, they will have a life expectancy of 0.204 years longer on average. For example, someone who is born in 1982 will live 0.204 years longer on average than someone who is born in 1981.

6) What is the y-intercept of the line? What does this represent?

   The y-intercept of the line is 75.05. This means that, in 1979 (the base year), the life expectancy was 75.05 years.

7) Write the equation of your estimated line of best fit in standard form (**Ax + By + C = 0**).

   0.204x – y + 75.05 = 0

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8) Write the equation of the software-generated line of best fit (least-squares line) here, both as it is displayed under the graph and in **y = mx + b** form.

   Life_Expectancy = 0.193Years_Since_1979 + 75.23
   y = 0.193x + 75.23

9) How does the software-generated line of best fit compare to your estimated line of best fit? How specifically do the differences in slope and y-intercept relate?

   My line of best fit had a slightly higher slope, which means that I approximated a greater increase in life expectancy for each year of birth. My y-intercept was slightly

lower, which means I approximated a lower life expectancy for the base year (1979). Overall, my approximated line of best fit was a very close approximation.

10) Why do you think the graph of life expectancy follows the trend it does? Provide at least three possible reasons for this trend.

Answers vary. Possible answers include better health care (particularly in regard to treatments for heart problems), increased exercise, technological advances, medical discoveries, better diet and lifestyle choices, and decreased infant mortality.

See 'Life Expectancy' article (p. 45 of pdf file) in Health Reports (Vol. 17, No. 1, 2002) at http://www.statcan.ca/english/freepub/82-003-XIE/0010582-003-XIE.pdf.

11) Using the equation of the software-generated line of best fit, what does the model predict your life expectancy will be? Be sure to indicate your year of birth and show all calculations. Remember that the x value in your equation is the **number of years since 1979**, not the actual year of your birth.

Answers vary. For instance, for a student born in 1992:

$$\begin{aligned} Years\_Since\_1979 &= 1992 - 1979 \\ &= 13 \end{aligned}$$

$$\begin{aligned} y &= 0.193x + 75.23 \\ y &= 0.193(13) + 75.23 \\ y &= 2.509 + 75.23 \\ y &= 77.739 \end{aligned}$$

The life expectancy of a student born in 1992 is predicted to be approximately 77.7 years, according to this model.

12) Will this equation still be a valid model for someone who is born in 2107? Explain why or why not. Use calculations to support your claim. Remember that the x value in your equation is the **number of years since 1979**, not the actual year of birth.

$$\begin{aligned} Years\_Since\_1979 &= 2107 - 1979 \\ &= 128 \end{aligned}$$

$$\begin{aligned} y &= 0.193x + 75.23 \\ y &= 0.193(128) + 75.23 \\ y &= 24.704 + 75.23 \\ y &= 99.934 \end{aligned}$$

The life expectancy for someone who is born in 2107 would be approximately 100 years. This is likely not a valid model because, regardless of improvements in health care, cures for diseases, and other medical improvements that may occur in the next 100 years, it is highly unlikely that the average life expectancy would be 100 years. Human bodies simply would not survive for that long on average, plus there will always be accidents and other accidental causes of death that will lower the life expectancy, regardless of medical improvements.

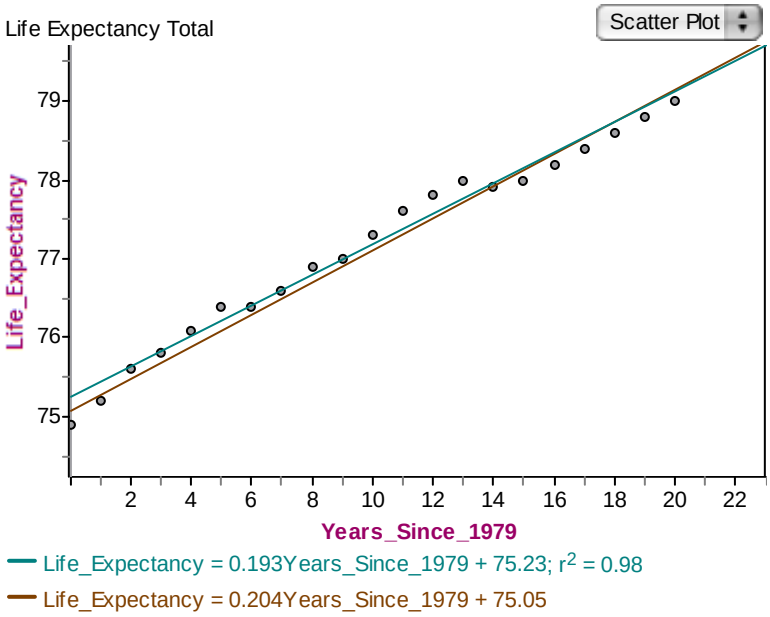
13) If the model is assumed to be correct, in what birth year will Canadians have a life expectancy of 90 years on average? Round your answer to the nearest year. Remember that the x value in your equation is the **number of years since 1979**, not the actual year of birth.

90 = 0.193x + 75.23
14.77 = 0.193x
x = 14.77/0.193
x =~ 76

Year = 1979 + 76
= 2055

Canadians born in 2055 are predicted to have a life expectancy of 90 years, according to this model.

14) Paste your graph with both your estimated line of best fit and the software-generated line of best fit here.

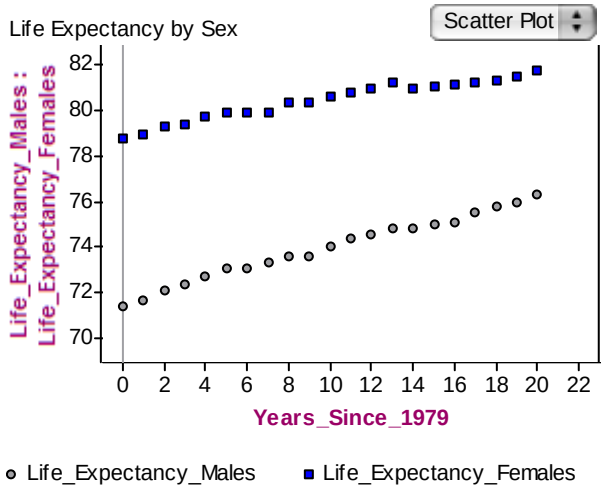


Student Worksheet #2: Life Expectancy by Sex
Life Expectancy of Canadians Linear Activity
TEACHER VERSION

Note: The Fathom 1 worksheet is identical to the Fathom 2 worksheet, but is missing questions #7 to 9 as Fathom 1 does not have the capabilities to allow students that type of exploration (graphing two data sets on one graph and finding the point of intersection).

1) Who has a higher life expectancy, males or females? Approximately how many years of difference are there between the life expectancies of males and females (over the period from 1979 to 1999)?

Females have a higher life expectancy by approximately six years. See graph below.



2) By inspection, which line (life expectancy of males or females) appears to have a higher slope?

The line of male life expectancy appears to have a higher slope.

3) Select two points on each line (click on the points to obtain exact co-ordinates) and estimate the slope using the equation $m = \frac{y_2 - y_1}{x_2 - x_1}$. Show all calculations and be sure to note which points you chose for each line, as an ordered pair. Describe what each ordered pair means. Which line has a higher slope, according to your calculations? Was your guess by inspection correct?

Note: It is important to select points that are far apart from each other, but close to the line of best fit in order to accurately estimate slope.

Males: Points selected were (2, 72.1) and (19, 76). This means that for boys born two years after 1979 (1981), their life expectancy is 72.1 years whereas the life expectancy for boys born 19 years after 1979 (1998) is 76 years.

$$m = \frac{76 - 72.1}{19 - 2}$$
$$= \frac{3.9}{17}$$
=~ 0.2294

Females: Points selected were (3, 79.4) and (18, 81.3). This means that for girls born three years after 1979 (1982), their life expectancy is 79.4 years whereas the life expectancy for girls born 18 years after 1979 (1997) is 81.3 years.

$$m = \frac{81.3 - 79.4}{18 - 3}$$
$$= \frac{1.9}{15}$$
=~0.1267

The slope of the line for males is 0.2294 which is higher than the slope of the line for females (0.1267). My guess by inspection was correct.

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4) For the graph of the life expectancy of males, write the equation of the line of best fit in three ways:
   - As it is displayed under the graph
   - Slope-intercept form (y = mx + b)
   - Standard form (Ax + By + C = 0)

   Life_Expectancy_Males = 0.230Years_Since_1979 + 71.67
   y = 0.230x + 71.67
   0.230x – y + 71.67 = 0

5) For the graph of the life expectancy of females, write the equation of the line of best fit in three ways:
   - As it is displayed under the graph
   - Slope-intercept form (y = mx + b)
   - Standard form (Ax + By + C = 0)

   Life_Expectancy_Females = 0.136Years_Since_1979 + 79
   y = 0.136x + 79
   0.136x – y + 79 = 0

6) Which line of best fit has a higher slope? What does this higher slope represent?

   The line of best fit for the life expectancy of males has a higher slope. This represents that for each year later that a child is born, the life expectancy will have a greater increase (0.2299 years for males versus 0.1357 years for females).

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7) By inspection, approximately where do the lines intersect (as an ordered pair)? What does this represent?

The lines appear to intersect at the point (80, 90). This means that for babies born 80 years after 1979 (in the year 2059), life expectancies of both males and females are predicted to be 90 years, according to the linear model.

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8) What are the actual co-ordinates of the point of intersection?

(78.266, 89.659)

9) Substitute the number of years since 1979 value (round to the nearest year) into your lines of best fit equations to confirm the life expectancy at the point of intersection.

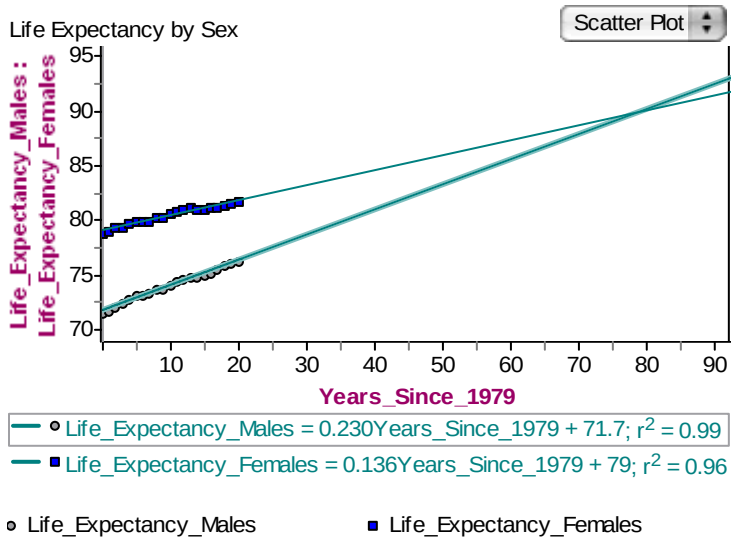
Year = 2057

Life_Expectancy_Males = 0.230Years_Since_1979 + 71.67
Life_Expectancy_Males = 0.230(78) + 71.67
Life_Expectancy_Males = 17.94 + 71.67
Life_Expectancy_Males = 89.61

Life_Expectancy_Females = 0.136Years_Since_1979 + 79
Life_Expectancy_Females = 0.136(78) + 79
Life_Expectancy_Females = 10.608 + 79
Life_Expectancy_Females = 89.608

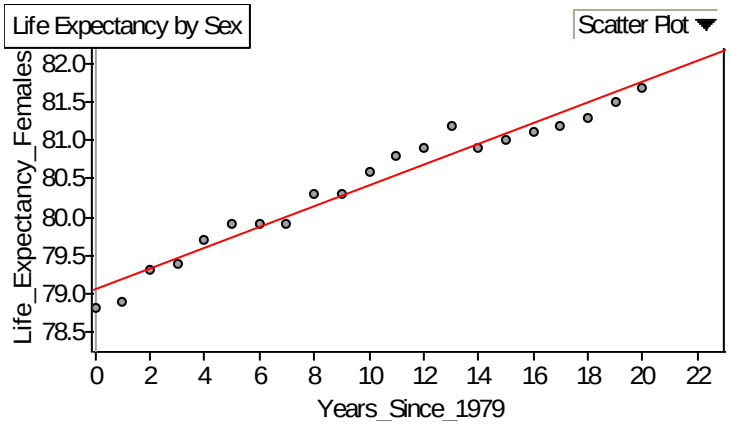
Note: These values are slightly off from the actual life expectancy at the point of intersection due to rounding to the nearest year.

10) Paste your graph here.



Fathom 1 Graphs (Question #7)

Life_Expectancy_Males = 0.230Years_Since_1979 + 71.67; r^2 = 0.99



Life_Expectancy_Females = 0.136Years_Since_1979 + 79.05; r^2 = 0.96