Hanford Part #1a

Introduction

In an article taken from the Journal of Environmental Health, May-June 1965, Volume 27, Number 6, pages 883-897, author Robert Fadely explains that the Atomic Energy Plant in Hanford, Washington has been a plutonium production facility since the Second World War. Some of the waste have been stored underground in the same area. Radioactive waste has been seeping into the Columbia River, and eight Oregon counties and the city of Portland have been exposed to radioactive contamination. The table below lists the number of cancer deaths per 100,000 residents for Portland and these counties. The table also includes an index of exposure that measures the proximity of the residents to the contamination. The index is based on the assumption that city or county exposure is directly proportional to river frontage and inversely proportional both to the distance from Hanford, WA site and to the square of the county's or city's average distance from the river.

Data Table

```
In[19]:= index = {2.5, 2.6, 3.4, 1.3, 1.6, 3.8, 11.6, 6.4, 8.3} (*x-values*)
deaths = {147, 130, 130, 114, 138, 162, 208, 178, 210}(*y-values*)
locations = {"Locations", "Umatilla", "Morrow", "Gilliam",
  "Sherman", "Wasco", "Hood River", "Portland", "Columbia", "Clatsop"}

Out[19]= {2.5, 2.6, 3.4, 1.3, 1.6, 3.8, 11.6, 6.4, 8.3}

Out[20]= {147, 130, 130, 114, 138, 162, 208, 178, 210}

Out[21]= {Locations, Umatilla, Morrow, Gilliam,
 Sherman, Wasco, Hood River, Portland, Columbia, Clatsop}

In[22]:= Grid[{locations, Join[{"Index"}, index], Join[{"Deaths"}, deaths]},
 Alignment → {Left}, Spacings → {1, 1}, Frame → All, ItemStyle → "Text",
 Background → {{RGBColor[0.88, 0.51, 0.49], None}, {LightRed, None}},
 ItemSize → Tiny, Spacings → {0, 0}]
```

Out[22]=

Locations	Umatilla	Morrow	Gilliam	Sherman	Wasco	Hood River	Portland	Columbia	Clatsop
Index	2.5	2.6	3.4	1.3	1.6	3.8	11.6	6.4	8.3
Deaths	147	130	130	114	138	162	208	178	210

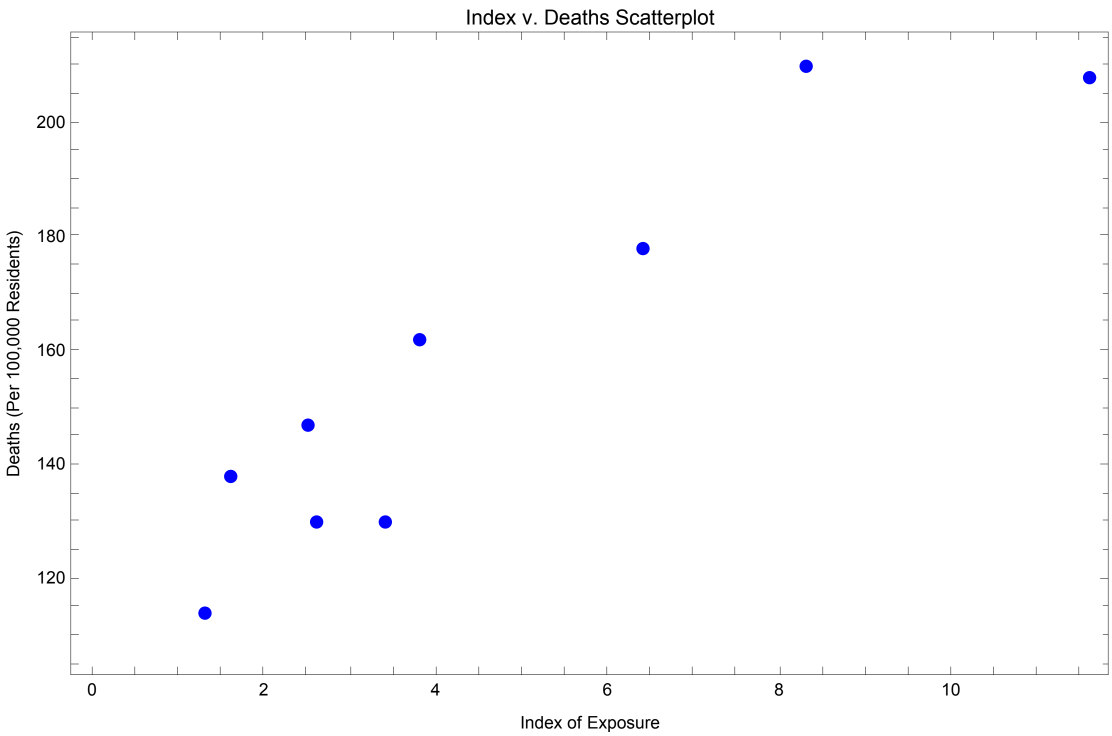
Plotting Data

In[23]:=
```
dataset = Transpose[{index, deaths}]
  (*this converts the index and death arrays into coordinate points*)
```

Out[23]=
```
{{2.5, 147}, {2.6, 130}, {3.4, 130}, {1.3, 114},
  {1.6, 138}, {3.8, 162}, {11.6, 208}, {6.4, 178}, {8.3, 210}}
```

In[24]:=
```
datasetPlot =
  ListPlot[dataset, Frame → True, PlotLabel → "Index v. Deaths Scatterplot",
   FrameLabel → {"Index of Exposure", "Deaths (Per 100,000 Residents)"},
   Ticks → Automatic, PlotStyle → {Blue}, ImageSize → Large]
```

Out[24]=



Least Squares Line Calculation

In[25]:=
```
n = Length[index]
```
Out[25]= 9

The calculation of the slope follows equation with summations: $\frac{n(\sum xy)-\sum x)\sum y}{n\sum x^2-(\sum x)^2}$.

In[26]:=
$$m = \frac{n\left(\sum_{a=1}^{n} \text{index}[[a]] * \text{deaths}[[a]]\right) - \left(\sum_{j=1}^{n} \text{index}[[j]]\right) * \left(\sum_{k=1}^{n} \text{deaths}[[k]]\right)}{n\left(\sum_{l=1}^{n} \text{index}[[l]]^2\right) - \left(\sum_{m=1}^{n} \text{index}[[m]]\right)^2}$$

Out[26]= 9.27386

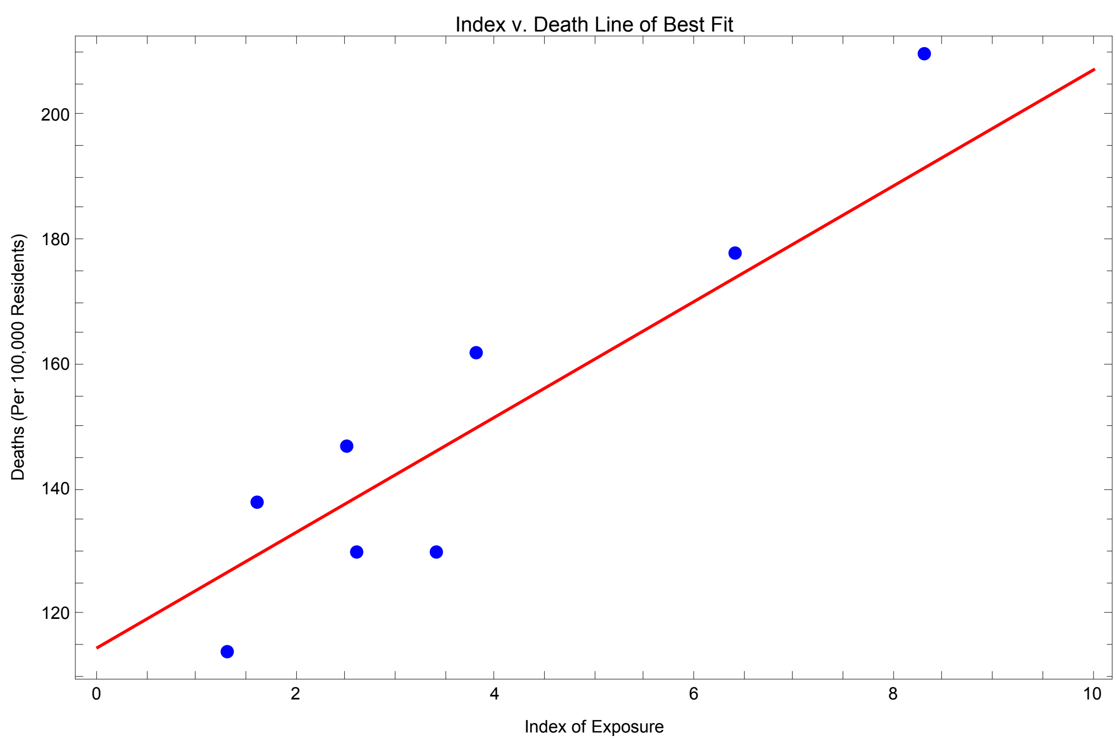
The calculation of the y-intercept follows this equation with summations: $\frac{\sum y - m\sum x}{n}$.

In[27]:=
$$b = \frac{\left(\sum_{a=1}^{n} \text{deaths}[[a]]\right) - m\left(\sum_{a=1}^{n} \text{index}[[a]]\right)}{n}$$

Out[27]= 114.682

In[28]:=
```
f[x_] = m (x) + b (*This is the linear regression model*)
```
Out[28]= 114.682 + 9.27386 x

In[29]:=
```
Show[leastSqLinePlot = Plot[f[x], {x, 0, 10}, Frame → True,
   FrameLabel → {"Index of Exposure", "Deaths (Per 100,000 Residents)"},
   Ticks → Automatic, PlotStyle → Red, ImageSize → Large],
 datasetPlot, PlotLabel → "Index v. Death Line of Best Fit"]
```
Out[29]=



Least Squares Line Residuals

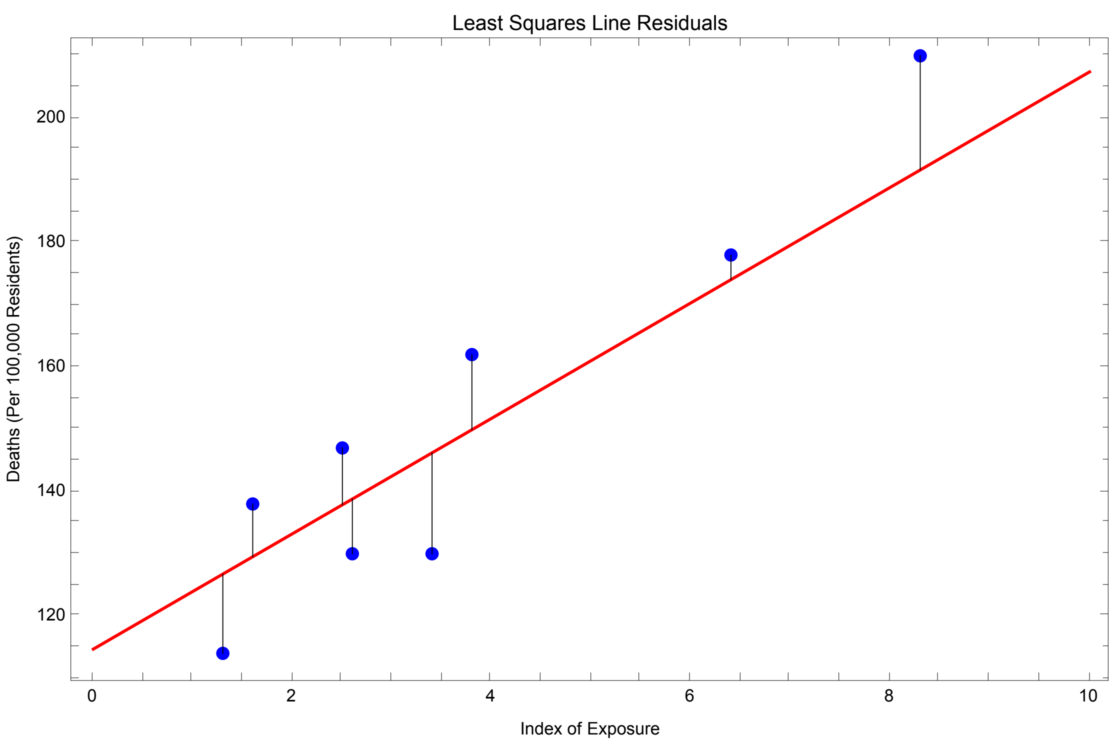
Residuals Plot

In[30]:=
```
leastSqResiduals = {} (*This contains an array of line objects.*)
For[i = 1, i ≤ n, i++, AppendTo[leastSqResiduals,
  Graphics[Line[{{index⟦i⟧, deaths⟦i⟧}, {index⟦i⟧, f[index⟦i⟧]}}]]]]
```

Out[30]= { }

In[35]:=
```
Show[leastSqLinePlot, datasetPlot,
 leastSqResiduals, PlotLabel → "Least Squares Line Residuals"]
```

Out[35]=



Residuals Summation

In[33]:= residualsSum = $\sum_{i=1}^{n}$ (f[index⟦i⟧] - deaths⟦i⟧)

Out[33]= 0.

In[34]:= ClearAll

Out[34]= ClearAll