Radioactive Contamination

The Data

Table

In[895]:=
```
Clear[list1, listDeaths, listIndex, location];
listIndex = {2.5, 2.6, 3.4, 1.3, 1.6, 3.8, 11.6, 6.4, 8.3};
listDeaths = {147, 130, 130, 114, 138, 162, 208, 178, 210};
location = {"Umatilla", "Morrow", "Gilliam", "Sherman", "Wasco", "Hood
River", "Portland", "Columbia", "Clatsop"};
list1 = Transpose[{location, listIndex, listDeaths}];
list2 = Transpose[{listIndex, listDeaths}];
Text[Grid[Prepend[list1, {"Location", "Index", "Deaths"}],
  Alignment → Center, Dividers -> {All, All}, Spacings → {1, 1}]]
```

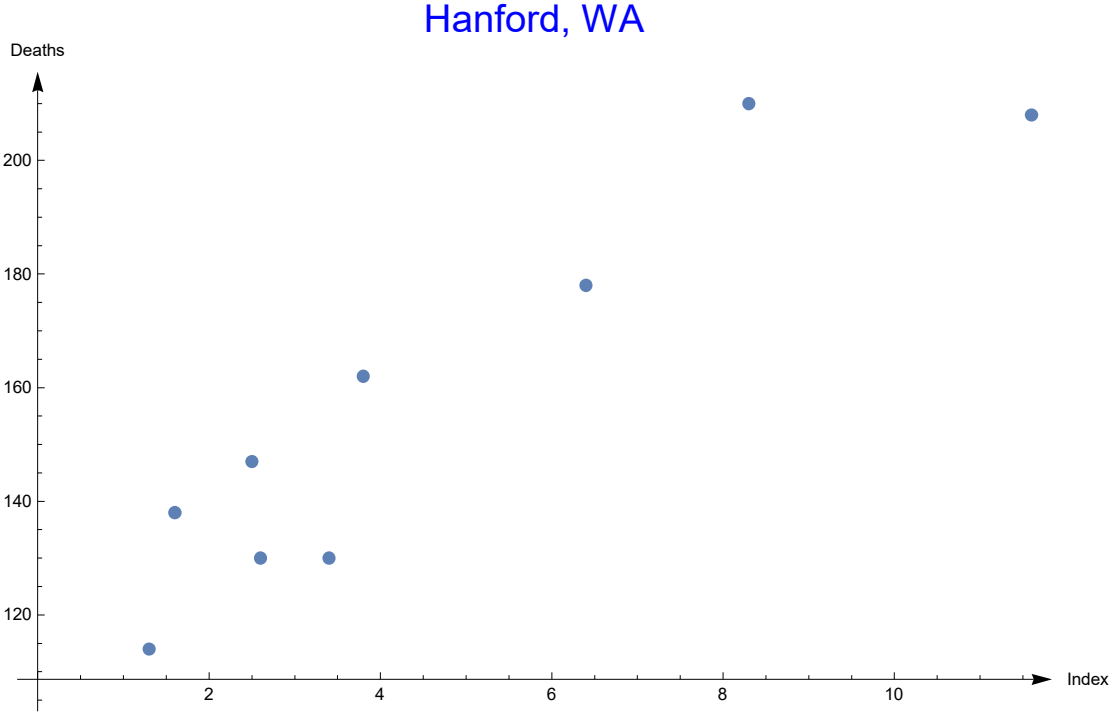
Out[901]=

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

Graph

In[971]:=
```
Clear[lplot1]
lplot1 = ListPlot[list2, PlotLabel → Style["Hanford, WA", Blue, 20], LabelStyle → {Black},
   AxesStyle → Arrowheads[0.02], ImageSize → Large, AxesLabel → {"Index", "Deaths"}];
Show[lplot1]
```

Out[973]=



Two-Point Line

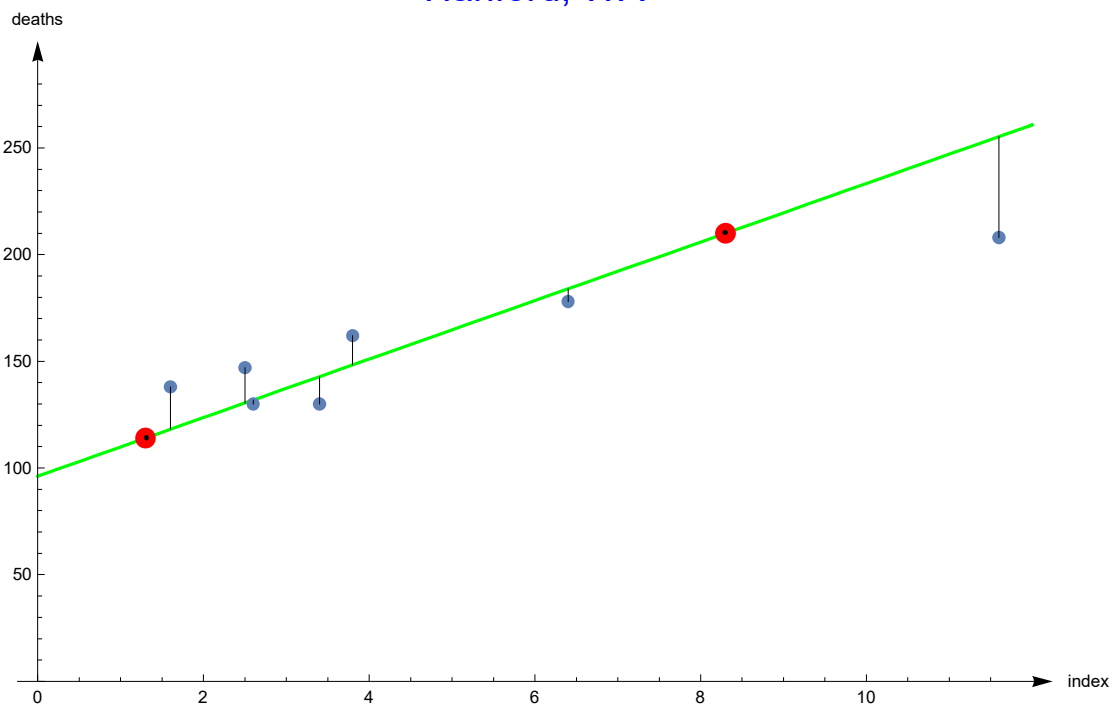
Calculations

In[974]:=
```
Clear[plot1, twoPtLine, lplot2, residuals1, resplot1]
list2 = SortBy[list2, First];
twoPtLine[x_] =
  (list1[[9]][[3]] - list1[[4]][[3]])/(list1[[9]][[2]] - list1[[4]][[2]]) (x - list1[[4]][[2]]) + list1[[4]][[3]];
plot1 = Plot[Tooltip[twoPtLine[x], "Two Point Line"], {x, 0, 12},
   PlotRange → {0, 300}, PlotStyle → Green, AxesOrigin → {0, 0},
   PlotLabel → Style["Hanford, WA", Blue, 20], LabelStyle → {Black},
   AxesStyle → Arrowheads[0.02], ImageSize → Large, AxesLabel → {"index", "deaths"}];
lplot2 = ListPlot[{{list1[[9]][[2]], list1[[9]][[3]]},
    {list1[[4]][[2]], list1[[4]][[3]]}}, PlotStyle → {PointSize → 0.02, Red}];
residuals1 = Table[list2[[x, 2]] - twoPtLine[ list2[[x, 1]] ], {x, 1, 9}];
resplot1 = Graphics[{Black, Line[{
      {{list2[[1, 1]], twoPtLine[list2[[1, 1]]]}, {list2[[1, 1]], list2[[1, 2]]}},
      {{list2[[2, 1]], twoPtLine[list2[[2, 1]]]}, {list2[[2, 1]], list2[[2, 2]]}},
      {{list2[[3, 1]], twoPtLine[list2[[3, 1]]]}, {list2[[3, 1]], list2[[3, 2]]}},
      {{list2[[4, 1]], twoPtLine[list2[[4, 1]]]}, {list2[[4, 1]], list2[[4, 2]]}},
      {{list2[[5, 1]], twoPtLine[list2[[5, 1]]]}, {list2[[5, 1]], list2[[5, 2]]}},
      {{list2[[6, 1]], twoPtLine[list2[[6, 1]]]}, {list2[[6, 1]], list2[[6, 2]]}},
      {{list2[[7, 1]], twoPtLine[list2[[7, 1]]]}, {list2[[7, 1]], list2[[7, 2]]}},
      {{list2[[8, 1]], twoPtLine[list2[[8, 1]]]}, {list2[[8, 1]], list2[[8, 2]]}},
      {{list2[[9, 1]], twoPtLine[list2[[9, 1]]]}, {list2[[9, 1]], list2[[9, 2]]}}
     }]}];
Print["The total of the Two-Point Line Residuals is ", Total[residuals1]]
Show[plot1, lplot1, lplot2, resplot1]
resplotR1 = ListPlot[residuals1, PlotLabel → Style["Two-Point Line Residuals", Blue, 20],
  LabelStyle → {Black}, AxesStyle → Arrowheads[0.02], ImageSize → Large,
  AxesLabel → {"Index", "Deaths"}, PlotRange → {-30, 30}]
```

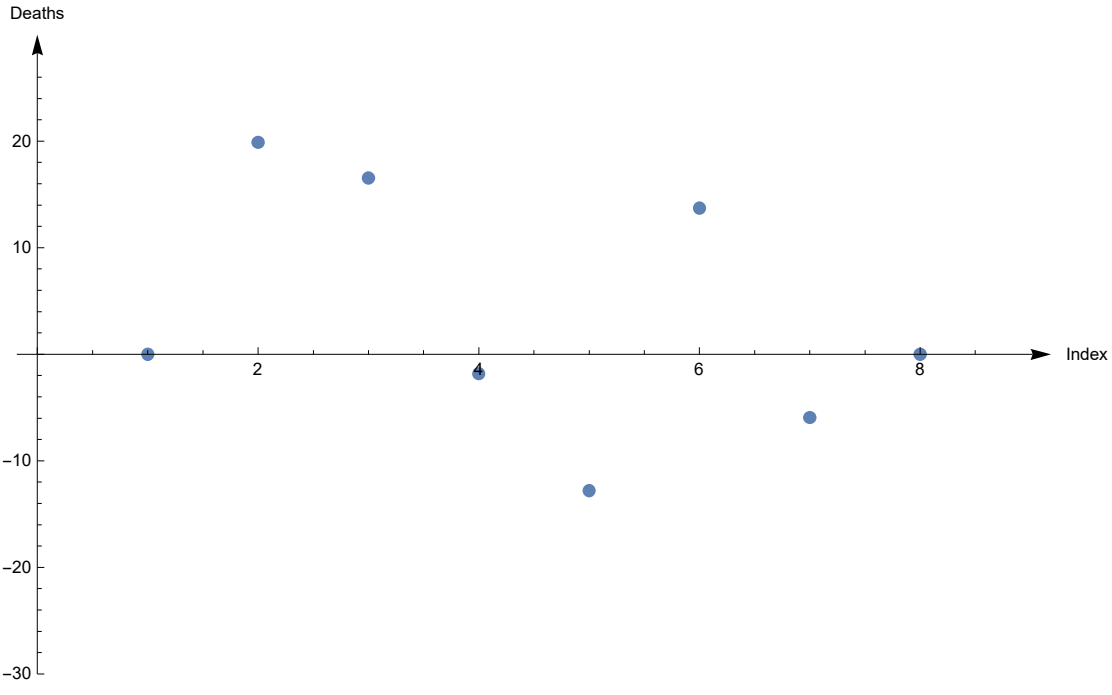
```
The total of the Two-Point Line Residuals is -17.6857
```

Graphs

Out[858]=



Out[859]=



In[915]:=

Median-Median Line

In[916]:=
```
Clear[pt1, pt2, pt3, medianMedian, lplot3, plot2, vertShift, medianMedian2]
```

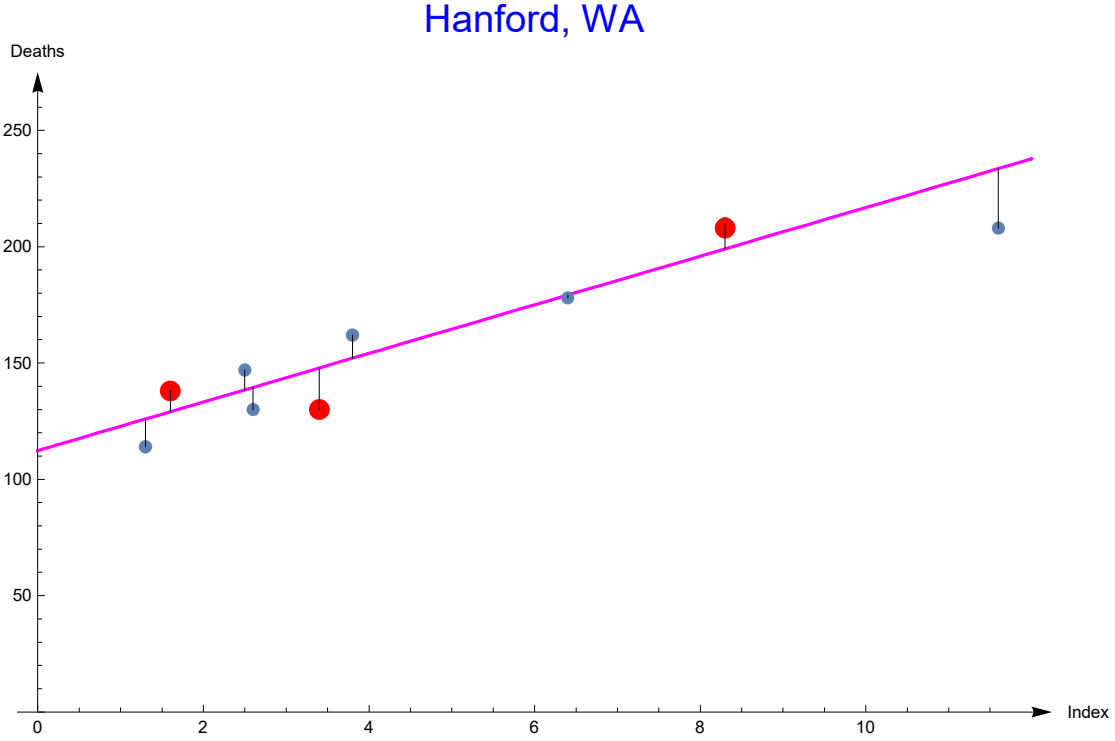
In[917]:=
```
pt1 = {Median[list2[[1 ;; 3, 1]]],
   Median[list2[[1 ;; 3, 2]]]};
pt2 = {Median[list2[[4 ;; 6, 1]]],
   Median[list2[[4 ;; 6, 2]]]};
pt3 = {Median[list2[[7 ;; 9, 1]]],
   Median[list2[[7 ;; 9, 2]]]};
lplot3 = ListPlot[{pt1, pt2, pt3}, PlotStyle → {PointSize → 0.02, Red}];
medianMedian[x_] = (pt3[[2]] - pt1[[2]])/(pt3[[1]] - pt1[[1]]) (x - pt1[[1]]) + pt1[[2]];
vertShift = (pt2[[2]] - medianMedian[pt2[[1]]]) / 3;
medianMedian2[x_] = medianMedian[x] + vertShift
plot2 = Plot[Tooltip[medianMedian2[x], "Median-Median Line"],
   {x, 0, 12}, PlotRange → {0, 275}, PlotStyle → Magenta, AxesOrigin → {0, 0},
   PlotLabel → Style["Hanford, WA", Blue, 20], LabelStyle → {Black},
   AxesStyle → Arrowheads[0.02], ImageSize → Large, AxesLabel → {"Index", "Deaths"}];
residuals2 = Table[list2[[x, 2]] - medianMedian2[ list2[[x, 1]] ], {x, 1, 9}];
resplot2 = Graphics[{Black, Line[{
      {{list2[[1, 1]], medianMedian2[list2[[1, 1]]]}, {list2[[1, 1]], list2[[1, 2]]}},
      {{list2[[2, 1]], medianMedian2[list2[[2, 1]]]}, {list2[[2, 1]], list2[[2, 2]]}},
      {{list2[[3, 1]], medianMedian2[list2[[3, 1]]]}, {list2[[3, 1]], list2[[3, 2]]}},
      {{list2[[4, 1]], medianMedian2[list2[[4, 1]]]}, {list2[[4, 1]], list2[[4, 2]]}},
      {{list2[[5, 1]], medianMedian2[list2[[5, 1]]]}, {list2[[5, 1]], list2[[5, 2]]}},
      {{list2[[6, 1]], medianMedian2[list2[[6, 1]]]}, {list2[[6, 1]], list2[[6, 2]]}},
      {{list2[[7, 1]], medianMedian2[list2[[7, 1]]]}, {list2[[7, 1]], list2[[7, 2]]}},
      {{list2[[8, 1]], medianMedian2[list2[[8, 1]]]}, {list2[[8, 1]], list2[[8, 2]]}},
      {{list2[[9, 1]], medianMedian2[list2[[9, 1]]]}, {list2[[9, 1]], list2[[9, 2]]}}
     }]}];
Print["The total of the Median-Median Line Residuals is ", Total[residuals2]]
Show[plot2, lplot1, lplot3, resplot2]
resplotR2 =
 ListPlot[residuals2, PlotLabel → Style["Median-Median Line Residuals", Blue, 20],
  LabelStyle → {Black}, AxesStyle → Arrowheads[0.02], ImageSize → Large,
  AxesLabel → {"Index", "Deaths"}, PlotRange → {-30, 30}]
```

Out[923]=
$$129.065 + 10.4478\ (-1.6 + x)$$

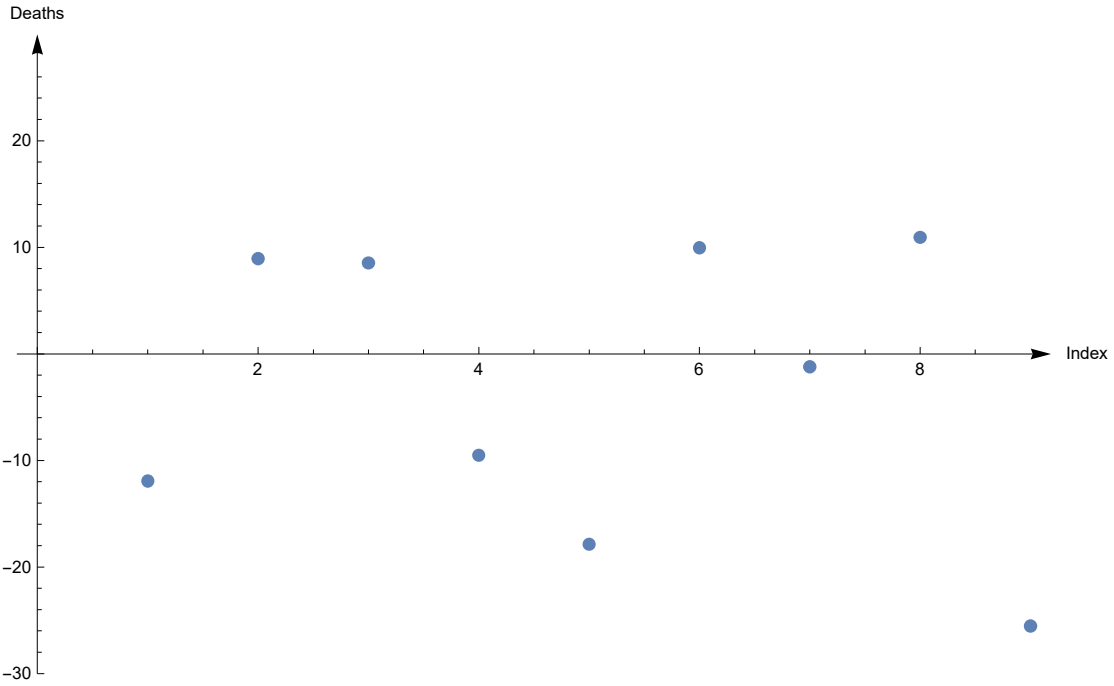
```
The total of the Median-Median Line Residuals is -27.7164
```

Graphs

Out[884]=



Out[885]=



Least Squares Line

Finding the Line

In[953]:=
```
Clear[x2sum, ysum, xsum, xysum, m, b, leastSquaresRegression]
list2
xsum = Total[list2][[1]];
Print["xsum is ", xsum]
ysum = Total[list2][[2]];
Print["ysum is ", ysum]
x2sum = 0;
For[i = 1, i < 10, i++, x2sum += Power[list2[[i, 1]], 2]];
Print["x2sum is ", x2sum]
xysum = 0;
For[i = 1, i < 10, i++, xysum += (list2[[i, 1]] * list2[[i, 2]])];
Print["xysum is ", xysum]
num = Length[list2];
m = (num * xysum - xsum * ysum) / (num * x2sum - Power[xsum, 2]);
b = (ysum - m * xsum) / num;
leastSquaresRegression[x_] = m * x + b
plot3 = Plot[Tooltip[leastSquaresRegression[x], "Least Squares Regression"],
   {x, 0, 12}, PlotRange → {0, 275}, PlotStyle → Brown, AxesOrigin → {0, 0},
   PlotLabel → Style["Hanford, WA", Blue, 20], LabelStyle → {Black},
   AxesStyle → Arrowheads[0.02], ImageSize → Large, AxesLabel → {"Index", "Deaths"}];
Show[
 plot3,
 lplot1]
```

Out[954]=
```
{{1.3, 114}, {1.6, 138}, {2.5, 147}, {2.6, 130},
 {3.4, 130}, {3.8, 162}, {6.4, 178}, {8.3, 210}, {11.6, 208}}
```

```
xsum is 41.5
```

```
ysum is 1417
```

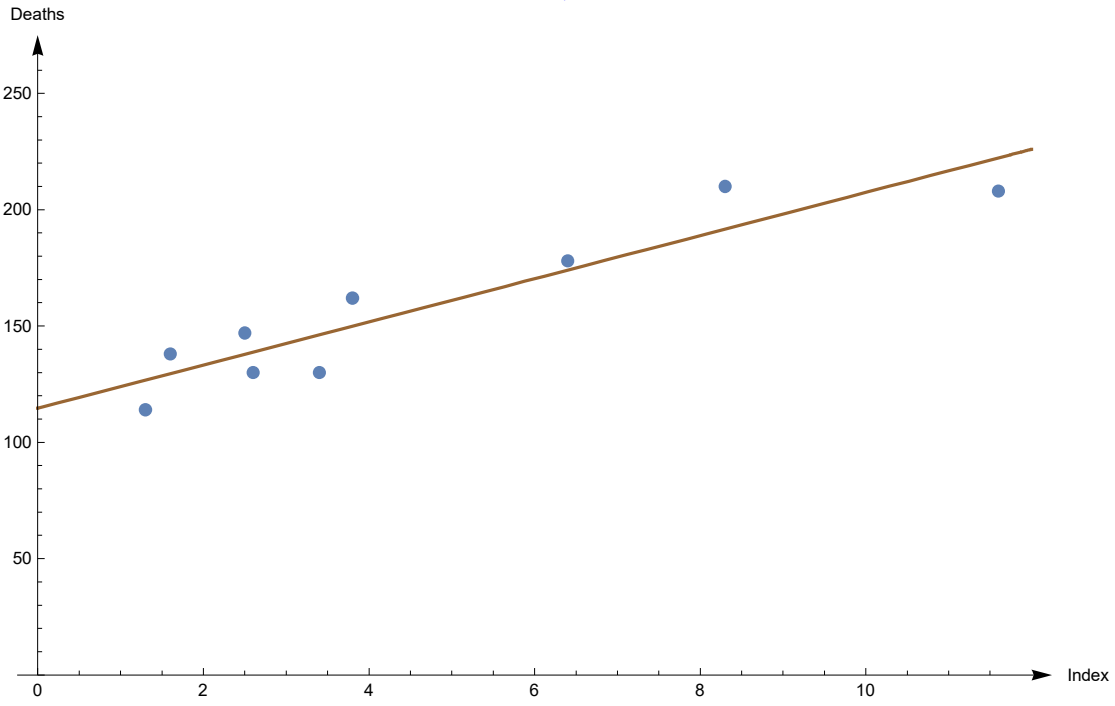
```
x2sum is 287.67
```

```
xysum is 7427.1
```

Out[968]= $114.682 + 9.27386\,x$

Graph

Out[970]=

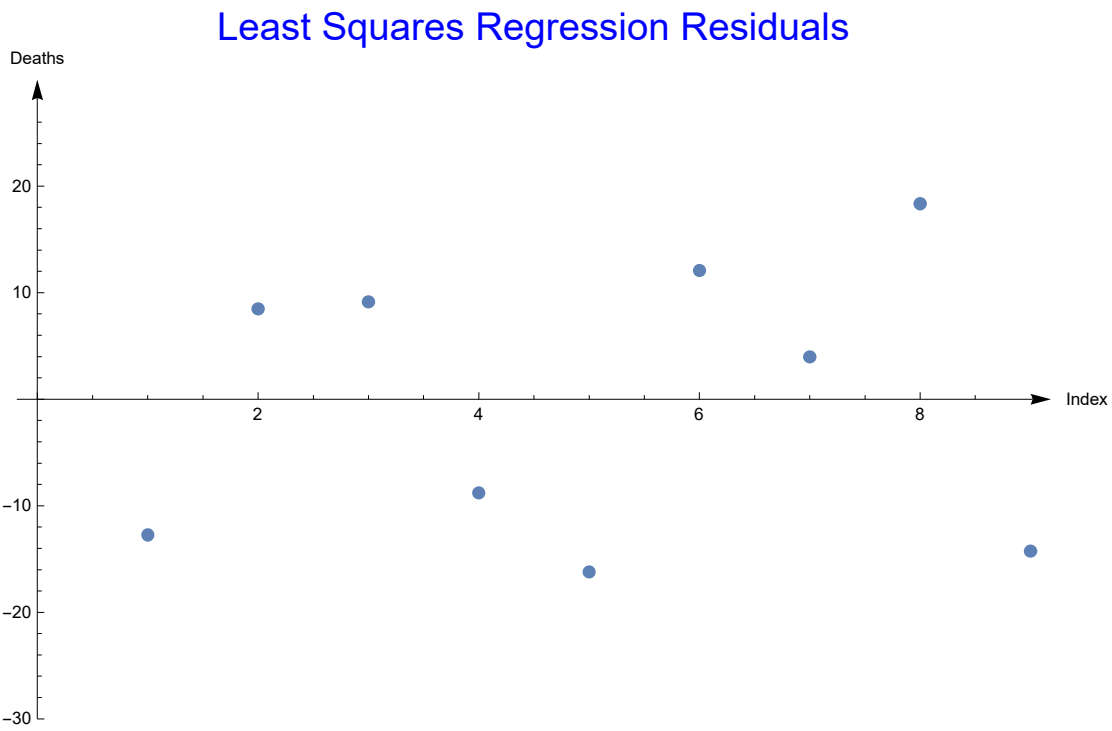


Finding Residuals

In[988]:=
```
Clear[residuals3, resplotR3]
residuals3 = Table[list2[[x, 2]] - leastSquaresRegression[ list2[[x, 1]] ], {x, 1, 9}];
Print["The total of the Least Squares Regression Residuals is ", Total[residuals3]]
resplotR3 =
 ListPlot[residuals3, PlotLabel → Style["Least Squares Regression Residuals", Blue, 20],
  LabelStyle → {Black}, AxesStyle → Arrowheads[0.02], ImageSize → Large,
  AxesLabel → {"Index", "Deaths"}, PlotRange → {-30, 30}, ImageSize → Full]
```

```
The total of the Least Squares Regression Residuals is 0.
```

Out[991]=



Residuals Comparison

In[1071]:=
```
Clear[resplotC1, resplotC2, resplotC3]
resplotC3 =
  ListPlot[residuals3, PlotLabel → Style["Least Squares", Blue, 10], LabelStyle → {Black},
   AxesStyle → Arrowheads[0.02], ImageSize → Large, AxesLabel → {"Index", "Deaths"},
   PlotRange → {-30, 30}, ImageSize → Full, PlotStyle → {PointSize → 0.03, Red}];
resplotC2 = ListPlot[residuals2, PlotLabel → Style["Median-Median", Blue, 10],
   LabelStyle → {Black}, AxesStyle → Arrowheads[0.02], ImageSize → Large,
   AxesLabel → {"Index", "Deaths"}, PlotRange → {-30, 30},
   ImageSize → Full, PlotStyle → {PointSize → 0.03, Blue}];
resplotC1 = ListPlot[residuals1, PlotLabel → Style["Two-Point", Blue, 10],
   LabelStyle → {Black}, AxesStyle → Arrowheads[0.02], ImageSize → Large,
   AxesLabel → {"Index", "Deaths"}, PlotRange → {-30, 30},
   ImageSize → Full, PlotStyle → {PointSize → 0.03, Green}];
GraphicsRow[{resplotC1, resplotC2, resplotC3}, ImageSize → Full, Frame -> All]
```

Out[1075]=