In[764]:=
```
ClearAll["Global`*"]
```

We can define the constraints of the plane the DC is in

In[771]:=
```
ClearAll[θ];
```

In[772]:=
```
θ = 40;
```

In[790]:=
```
θ = 40;
```

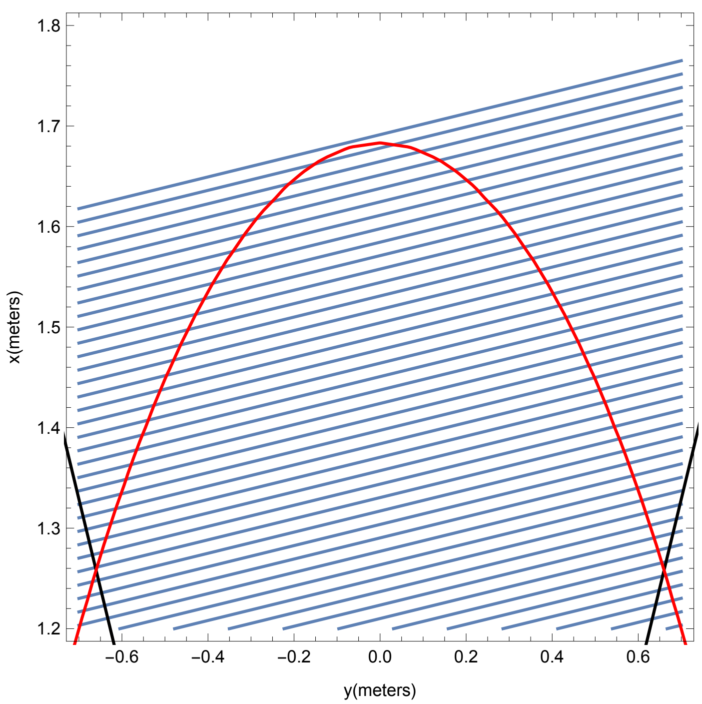
In[791]:=
```
ellipse40 = ContourPlot[(x_40degree + Δa_40degree)^2/a_40degree^2 + y_40degree^2/b_40degree^2 == 1,
    {y_40degree, -1, 1}, {x_40degree, .2, 1.8},
    FrameLabel → {"y(meters)", "x(meters)"}, ContourStyle → Red];
```

In[792]:=
```
ClearAll
```

Out[792]=
```
ClearAll
```

In[793]:=
```
Show[Table[ContourPlot[xWire[number] == Tan[6 °] yWire[number] + x0forWires[number],
    {yWire[number], -0.7, 0.7}, {xWire[number], 1.2, 1.8},
    FrameLabel → {"y(meters)", "x(meters)"}],
  {number, 55, 110}], bottom, right, left, ellipse40]
```

Out[793]=

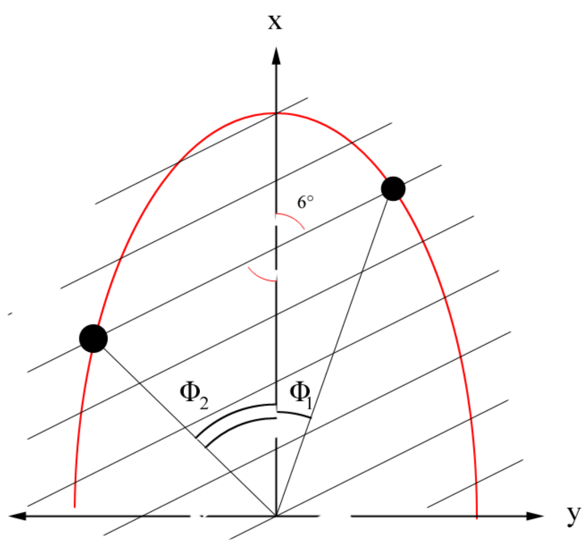


In[794]:=
```
Degree40LineRight = Sort[Table[
    {ϕ /. Solve[Sqrt[a_40degree^2 (1 - y_40degree^2/b_40degree^2)] - Δa_40degree == Tan[6 °] y_40degree +
        x0forWireMiddles[number] && ϕ > .01 && ϕ < 30, ϕ]}, {number, 73, 109}]]
```

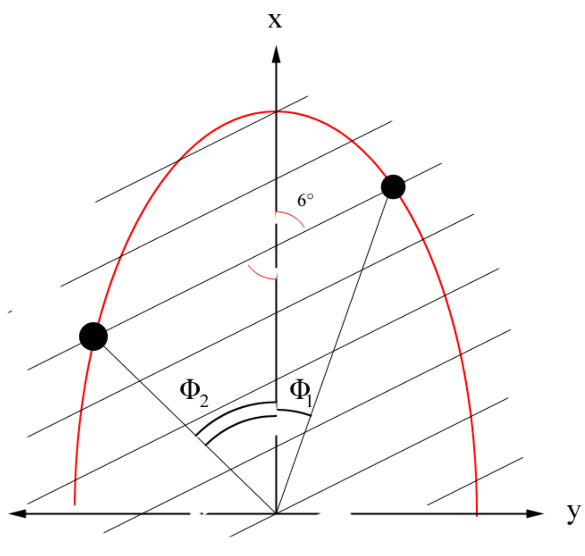
Out[794]= {{{2.64046}}, {{4.46211}}, {{5.88012}}, {{7.08111}}, {{8.14077}}, {{9.09882}}, {{9.97917}}, {{10.7975}}, {{11.5649}}, {{12.2894}}, {{12.9771}}, {{13.6327}}, {{14.2601}}, {{14.8624}}, {{15.442}}, {{16.0012}}, {{16.5418}}, {{17.0652}}, {{17.573}}, {{18.0661}}, {{18.5457}}, {{19.0127}}, {{19.4678}}, {{19.9118}}, {{20.3454}}, {{20.769}}, {{21.1833}}, {{21.5888}}, {{21.9858}}, {{22.3748}}, {{22.7561}}, {{23.1301}}, {{23.497}}, {{23.8573}}, {{24.2111}}, {{24.5587}}, {{24.9003}}}

The fact the equation for the y component in the plane of the detector uses a square root function, we know there must be two solutions. Due to the use of inverse trigonometric functions within Mathematica, only the positive values of y will be used.

In[795]:=



Out[795]=



Here we know that ϕ=0, we can use the equation shown above for θ and wire number

In[796]:= n

Out[796]= n

This implies that for θ=40, we know that the wire number to be 109.72. This corresponds to the position being greater than the halfway point inbetween wire 109 and 110. We can prepend this point to the data.

By symmetry, we know that the positions within the 2nd quadrant can be reflected into the 1st quadrant by taking the opposite slope of the wire function

In[797]:=
```
Solve[
 Sqrt[a_40degree^2 (1 - y^2/b_40degree^2)] - Δa_40degree == Tan[6 °] y + x0forWireMiddles[109] , y]
```

$$\text{Solve}\left[\sqrt{a\_40degree^2\left(1-\frac{y^2}{b\_40degree^2}\right)} - \Delta a\_40degree == \text{Tan}[6\,°]\,y + \text{x0forWireMiddles}[109],\ y\right]$$

Out[797]= {{y → -0.186361}, {y → 0.0702975}}

In[798]:=
```
Solve[Sqrt[a_40degree^2 (1 - y^2/b_40degree^2)] - Δa_40degree ==
  -Tan[6 °] y + x0forWireMiddles[109] , y]
```

Out[798]= {{y → -0.0702975}, {y → 0.186361}}

In[799]:=
```
Degree40LineLeft = Sort[Table[
   {ϕ /. Solve[Sqrt[a_40degree^2 (1 - y_40degree^2/b_40degree^2)] - Δa_40degree == -Tan[6 °] y_40degree +
        x0forWireMiddles[number]  && ϕ > .01 && ϕ < 30, ϕ]}, {number, 84, 109}]]
```

Out[799]= {{{7.00229}}, {{8.80492}}, {{10.2039}}, {{11.3859}}, {{12.4265}}, {{13.3654}}, {{14.2267}}, {{15.0259}}, {{15.7742}}, {{16.4795}}, {{17.1481}}, {{17.7845}}, {{18.3927}}, {{18.9757}}, {{19.5361}}, {{20.0761}}, {{20.5974}}, {{21.1015}}, {{21.59}}, {{22.0638}}, {{22.524}}, {{22.9716}}, {{23.4074}}, {{23.832}}, {{24.2461}}, {{24.6503}}}

In[800]:=
```
ϕ /. Solve[Sqrt[a_40degree^2 (1 - y_40degree^2/b_40degree^2)] - Δa_40degree ==
   -Tan[6 °] y_40degree + x0forWireMiddles[110]  && ϕ > .01 && ϕ < 30, ϕ]
```

Out[800]= {0.641038, 3.73979}

In[801]:=
```
Degree40LineLeft = Prepend[Degree40LineLeft, {{3.7397893216718088`}}];
```

In[802]:=
```
Degree40LineLeft = Prepend[Degree40LineLeft, {{0.6410383384625715`}}];
```

In[803]:=
```
Degree40LineLeft = -1 Degree40LineLeft
```

Out[803]= {{{-0.641038}}, {{-3.73979}}, {{-7.00229}}, {{-8.80492}}, {{-10.2039}}, {{-11.3859}}, {{-12.4265}}, {{-13.3654}}, {{-14.2267}}, {{-15.0259}}, {{-15.7742}}, {{-16.4795}}, {{-17.1481}}, {{-17.7845}}, {{-18.3927}}, {{-18.9757}}, {{-19.5361}}, {{-20.0761}}, {{-20.5974}}, {{-21.1015}}, {{-21.59}}, {{-22.0638}}, {{-22.524}}, {{-22.9716}}, {{-23.4074}}, {{-23.832}}, {{-24.2461}}, {{-24.6503}}}

In[804]:=
```
Degree40LineLeft = Prepend[Degree40LineLeft, {{0}}]
```

Out[804]= {{{0}}, {{-0.641038}}, {{-3.73979}}, {{-7.00229}}, {{-8.80492}}, {{-10.2039}}, {{-11.3859}}, {{-12.4265}}, {{-13.3654}}, {{-14.2267}}, {{-15.0259}}, {{-15.7742}}, {{-16.4795}}, {{-17.1481}}, {{-17.7845}}, {{-18.3927}}, {{-18.9757}}, {{-19.5361}}, {{-20.0761}}, {{-20.5974}}, {{-21.1015}}, {{-21.59}}, {{-22.0638}}, {{-22.524}}, {{-22.9716}}, {{-23.4074}}, {{-23.832}}, {{-24.2461}}, {{-24.6503}}}

In[805]:=
```
Degree40Line = Union[Degree40LineLeft, Degree40LineRight]
```

```
Out[805]= {{{-24.6503}}, {{-24.2461}}, {{-23.832}}, {{-23.4074}}, {{-22.9716}},
  {{-22.524}}, {{-22.0638}}, {{-21.59}}, {{-21.1015}}, {{-20.5974}},
  {{-20.0761}}, {{-19.5361}}, {{-18.9757}}, {{-18.3927}}, {{-17.7845}},
  {{-17.1481}}, {{-16.4795}}, {{-15.7742}}, {{-15.0259}}, {{-14.2267}},
  {{-13.3654}}, {{-12.4265}}, {{-11.3859}}, {{-10.2039}}, {{-8.80492}},
  {{-7.00229}}, {{-3.73979}}, {{-0.641038}}, {{0}}, {{2.64046}}, {{4.46211}},
  {{5.88012}}, {{7.08111}}, {{8.14077}}, {{9.09882}}, {{9.97917}},
  {{10.7975}}, {{11.5649}}, {{12.2894}}, {{12.9771}}, {{13.6327}}, {{14.2601}},
  {{14.8624}}, {{15.442}}, {{16.0012}}, {{16.5418}}, {{17.0652}}, {{17.573}},
  {{18.0661}}, {{18.5457}}, {{19.0127}}, {{19.4678}}, {{19.9118}}, {{20.3454}},
  {{20.769}}, {{21.1833}}, {{21.5888}}, {{21.9858}}, {{22.3748}}, {{22.7561}},
  {{23.1301}}, {{23.497}}, {{23.8573}}, {{24.2111}}, {{24.5587}}, {{24.9003}}}

In[806]:= TableOfValues40a =
  Prepend[Replace[Degree40Line, {x_List} :> x, {0, -1}], {"ϕ(degrees)"}]

Out[806]= {{ϕ(degrees)}, {-24.6503}, {-24.2461}, {-23.832}, {-23.4074}, {-22.9716}, {-22.524},
  {-22.0638}, {-21.59}, {-21.1015}, {-20.5974}, {-20.0761}, {-19.5361},
  {-18.9757}, {-18.3927}, {-17.7845}, {-17.1481}, {-16.4795}, {-15.7742},
  {-15.0259}, {-14.2267}, {-13.3654}, {-12.4265}, {-11.3859}, {-10.2039},
  {-8.80492}, {-7.00229}, {-3.73979}, {-0.641038}, {0}, {2.64046}, {4.46211},
  {5.88012}, {7.08111}, {8.14077}, {9.09882}, {9.97917}, {10.7975}, {11.5649},
  {12.2894}, {12.9771}, {13.6327}, {14.2601}, {14.8624}, {15.442}, {16.0012},
  {16.5418}, {17.0652}, {17.573}, {18.0661}, {18.5457}, {19.0127}, {19.4678},
  {19.9118}, {20.3454}, {20.769}, {21.1833}, {21.5888}, {21.9858}, {22.3748},
  {22.7561}, {23.1301}, {23.497}, {23.8573}, {24.2111}, {24.5587}, {24.9003}}
```

We can add the number of successive crossings

```
In[807]:= TableOfValues40b =
  MapThread[Prepend, {TableOfValues40a, {"Crossing", -28, -27, -26, -25, -24, -23,
     -22, -21, -20, -19, -18, -17, -16, -15, -14, -13, -12, -11, -10, -9, -8, -7,
     -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17,
     18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37}}]
```

```
Out[807]= {{Crossing, ϕ(degrees)}, {-28, -24.6503}, {-27, -24.2461}, {-26, -23.832},
  {-25, -23.4074}, {-24, -22.9716}, {-23, -22.524}, {-22, -22.0638}, {-21, -21.59},
  {-20, -21.1015}, {-19, -20.5974}, {-18, -20.0761}, {-17, -19.5361},
  {-16, -18.9757}, {-15, -18.3927}, {-14, -17.7845}, {-13, -17.1481},
  {-12, -16.4795}, {-11, -15.7742}, {-10, -15.0259}, {-9, -14.2267},
  {-8, -13.3654}, {-7, -12.4265}, {-6, -11.3859}, {-5, -10.2039}, {-4, -8.80492},
  {-3, -7.00229}, {-2, -3.73979}, {-1, -0.641038}, {0, 0}, {1, 2.64046},
  {2, 4.46211}, {3, 5.88012}, {4, 7.08111}, {5, 8.14077}, {6, 9.09882}, {7, 9.97917},
  {8, 10.7975}, {9, 11.5649}, {10, 12.2894}, {11, 12.9771}, {12, 13.6327},
  {13, 14.2601}, {14, 14.8624}, {15, 15.442}, {16, 16.0012}, {17, 16.5418},
  {18, 17.0652}, {19, 17.573}, {20, 18.0661}, {21, 18.5457}, {22, 19.0127},
  {23, 19.4678}, {24, 19.9118}, {25, 20.3454}, {26, 20.769}, {27, 21.1833},
  {28, 21.5888}, {29, 21.9858}, {30, 22.3748}, {31, 22.7561}, {32, 23.1301},
  {33, 23.497}, {34, 23.8573}, {35, 24.2111}, {36, 24.5587}, {37, 24.9003}}

In[808]:= TableOfValues40c = MapThread[Append,
   {TableOfValues40a, {"Wire Number", 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96,
     97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 110, 109.72,
     109, 108, 107, 106, 105, 104, 103, 102, 101, 100, 99, 98, 97, 96, 95, 94, 93,
     92, 91, 90, 89, 88, 87, 86, 85, 84, 83, 82, 81, 80, 79, 78, 77, 76, 75, 74, 73}}]

Out[808]= {{ϕ(degrees), Wire Number}, {-24.6503, 84}, {-24.2461, 85}, {-23.832, 86},
  {-23.4074, 87}, {-22.9716, 88}, {-22.524, 89}, {-22.0638, 90}, {-21.59, 91},
  {-21.1015, 92}, {-20.5974, 93}, {-20.0761, 94}, {-19.5361, 95}, {-18.9757, 96},
  {-18.3927, 97}, {-17.7845, 98}, {-17.1481, 99}, {-16.4795, 100}, {-15.7742, 101},
  {-15.0259, 102}, {-14.2267, 103}, {-13.3654, 104}, {-12.4265, 105},
  {-11.3859, 106}, {-10.2039, 107}, {-8.80492, 108}, {-7.00229, 109},
  {-3.73979, 110}, {-0.641038, 110}, {0, 109.72}, {2.64046, 109}, {4.46211, 108},
  {5.88012, 107}, {7.08111, 106}, {8.14077, 105}, {9.09882, 104}, {9.97917, 103},
  {10.7975, 102}, {11.5649, 101}, {12.2894, 100}, {12.9771, 99}, {13.6327, 98},
  {14.2601, 97}, {14.8624, 96}, {15.442, 95}, {16.0012, 94}, {16.5418, 93},
  {17.0652, 92}, {17.573, 91}, {18.0661, 90}, {18.5457, 89}, {19.0127, 88},
  {19.4678, 87}, {19.9118, 86}, {20.3454, 85}, {20.769, 84}, {21.1833, 83},
  {21.5888, 82}, {21.9858, 81}, {22.3748, 80}, {22.7561, 79}, {23.1301, 78},
  {23.497, 77}, {23.8573, 76}, {24.2111, 75}, {24.5587, 74}, {24.9003, 73}}

In[809]:= Table40degree = Labeled[Grid[TableOfValues40b, Frame → All],
   "Crossing Number as a function of ϕ", Top]
```

Crossing Number as a function of ϕ

Crossing	ϕ(degrees)
-28	-24.6503
-27	-24.2461
-26	-23.832
-25	-23.4074
-24	-22.9716
-23	-22.524
-22	-22.0638

Out[809]=

−21	−21.59
−20	−21.1015
−19	−20.5974
−18	−20.0761
−17	−19.5361
−16	−18.9757
−15	−18.3927
−14	−17.7845
−13	−17.1481
−12	−16.4795
−11	−15.7742
−10	−15.0259
−9	−14.2267
−8	−13.3654
−7	−12.4265
−6	−11.3859
−5	−10.2039
−4	−8.80492
−3	−7.00229
−2	−3.73979
−1	−0.641038
0	0
1	2.64046
2	4.46211
3	5.88012
4	7.08111
5	8.14077
6	9.09882
7	9.97917
8	10.7975
9	11.5649
10	12.2894
11	12.9771
12	13.6327
13	14.2601
14	14.8624
15	15.442
16	16.0012
17	16.5418
18	17.0652
19	17.573
20	18.0661
21	18.5457
22	19.0127
23	19.4678
24	19.9118
25	20.3454
26	20.769
27	21.1833
28	21.5888
29	21.9858
30	22.3748
31	22.7561
32	23.1301
33	23.497
34	23.8573
35	24.2111

35	24.2111
36	24.5587
37	24.9003

In[810]:=
```
Table40degreeWire = Labeled[Grid[TableOfValues40c, Frame → All],
  "Midpoint Wire Number as a function of ϕ", Top]
```

Out[810]=

Midpoint Wire Number as a function of ϕ

ϕ(degrees)	Wire Number
-24.6503	84
-24.2461	85
-23.832	86
-23.4074	87
-22.9716	88
-22.524	89
-22.0638	90
-21.59	91
-21.1015	92
-20.5974	93
-20.0761	94
-19.5361	95
-18.9757	96
-18.3927	97
-17.7845	98
-17.1481	99
-16.4795	100
-15.7742	101
-15.0259	102
-14.2267	103
-13.3654	104
-12.4265	105
-11.3859	106
-10.2039	107
-8.80492	108
-7.00229	109
-3.73979	110
-0.641038	110
0	109.72
2.64046	109
4.46211	108
5.88012	107
7.08111	106
8.14077	105
9.09882	104
9.97917	103
10.7975	102
11.5649	101
12.2894	100
12.9771	99
13.6327	98
14.2601	97
14.8624	96
15.442	95
16.0012	94
16.5418	93
17.0652	92
17.573	91

[illegible]	91
18.0661	90
18.5457	89
19.0127	88
19.4678	87
19.9118	86
20.3454	85
20.769	84
21.1833	83
21.5888	82
21.9858	81
22.3748	80
22.7561	79
23.1301	78
23.497	77
23.8573	76
24.2111	75
24.5587	74
24.9003	73

In[811]:=
```
ClearAll[θ];
```

In[812]:=
```
θ = 35;
```

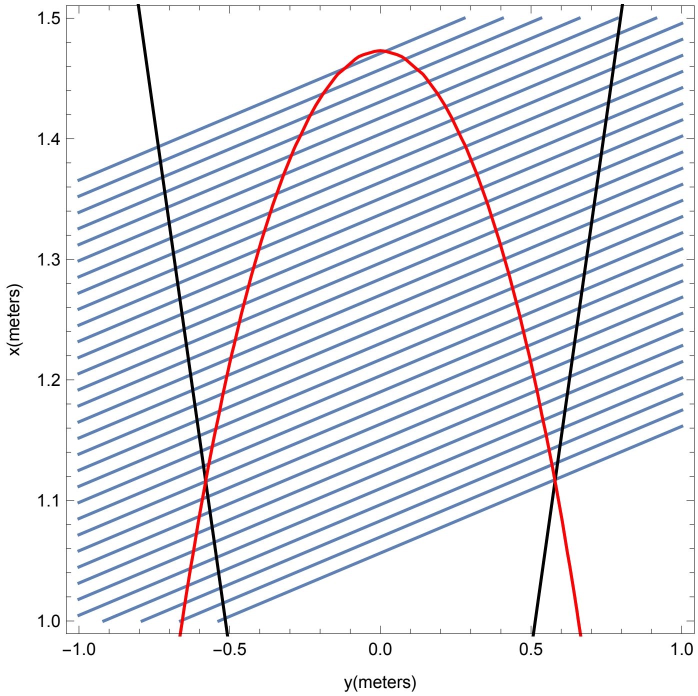
```
In[813]:= Δa_35degree = (2.52934271645 Sin[θ °]) / 2 (Csc[65 ° - θ °] - Csc[115 ° - θ °]);
e_35degree = Sin[25 °] / Cos[θ °];
a_35degree = (2.52934271645 Sin[θ °]) / 2 (Csc[65 ° - θ °] + Csc[115 ° - θ °]);
rD1_35degree = (a_35degree e_35degree - Δa_35degree) Tan[65 °] Cos[θ °];
rD2_35degree = (a_35degree e_35degree + Δa_35degree) Tan[65 °] Cos[θ °];
xD1_35degree = rD1_35degree Cos[ϕ °];
yD1_35degree = rD1_35degree Sin[ϕ °];
zD1_35degree = rD1_35degree Cot[θ °];
xD2_35degree = rD2_35degree Cos[ϕ °];
yD2_35degree = rD2_35degree Sin[ϕ °];
zD2_35degree = rD2_35degree Cot[θ °];
xP_35degree = (2.52934271645 Cos[ϕ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
yP_35degree = (2.52934271645 Sin[ϕ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
zP_35degree = (2.52934271645 Cot[θ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
x1_35degree =
  (rD2_35degree^2 - rD1_35degree^2 + Cot[θ °]^2 (rD2_35degree^2 - rD1_35degree^2) -
      2 xP_35degree (xD2_35degree - xD1_35degree) - 2 yP_35degree
       (yD2_35degree - yD1_35degree) - 2 zP_35degree (zD2_35degree - zD1_35degree)) /
    (4 a_35degree e_35degree) - a_35degree e_35degree ;
x_35degree = x1_35degree - Δa_35degree + a_35degree e_35degree // N;
n_35degree = -957.412 / (Tan[θ °] + 2.14437) + 430.626;
D2P_35degree = √((xD2_35degree - xP_35degree)^2 +
      (yD2_35degree - yP_35degree)^2 + (zD2_35degree - zP_35degree)^2) // N;
D1P_35degree = √((xP_35degree - xD1_35degree)^2 + (yP_35degree - yD1_35degree)^2 +
      (zP_35degree - zD1_35degree)^2) // N;
y_35degree = Sqrt[D1P_35degree ^ 2 - x1_35degree ^ 2] // N;
b_35degree = a_35degree (1 - e_35degree);

In[830]:= n = -957.412 / (Tan[θ °] + 2.14437) + 430.626

Out[830]= 94.0516

In[831]:= θlower = 4.49876 + 0.293001 ( n1) + 0.000679074 (n1)^2 - 3.57132*^-6 (n1)^3 /. n1 → 94

Out[831]= 35.0749

In[832]:= θupper = 4.49876 + 0.293001 (n1) + 0.000679074 (n1)^2 - 3.57132*^-6 (n1)^3 /. n1 → 95

Out[832]= 35.4005
```

We can define the xy position on the DC plane as a function of ϕ for θ=10°

```
In[833]:= ellipse35 = ContourPlot[(x_35degree + Δa_35degree)^2 / a_35degree^2 + y_35degree^2 / b_35degree^2 == 1,
    {y_35degree, -1, 1}, {x_35degree, .2, 1.8},
    FrameLabel → {"y(meters)", "x(meters)"}, ContourStyle → Red];
```

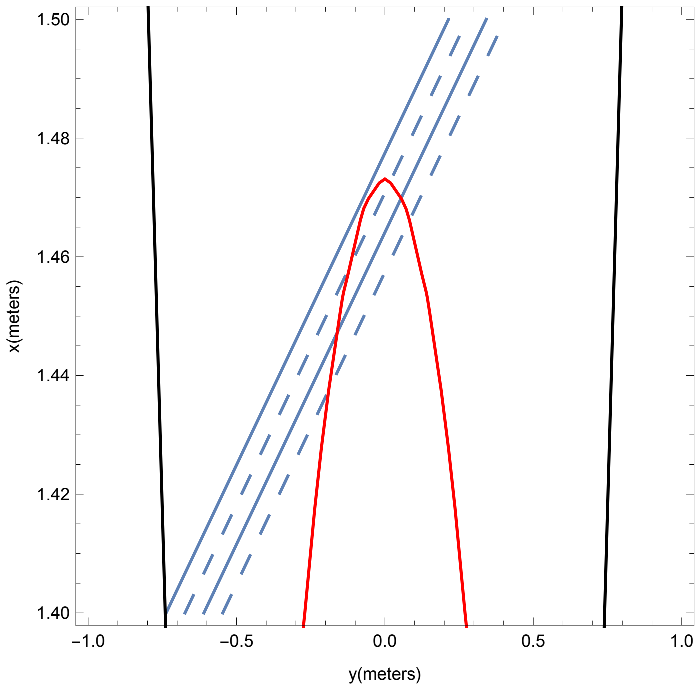
In[834]:=
```
Show[Table[
  ContourPlot[xWire[number] == Tan[6 °] yWire[number] + x0forWireMiddles[number],
   {yWire[number], -1, 1}, {xWire[number], 1, 1.5},
   FrameLabel → {"y(meters)", "x(meters)"}],
  {number, 63, 94}], bottom, right, left, ellipse35]
```

Out[834]=



In[835]:=
```
Show[Table[ContourPlot[xWire[number] == Tan[6 °] yWire[number] + x0forWires[number],
   {yWire[number], -1, 1}, {xWire[number], 1.4, 1.5},
   FrameLabel → {"y(meters)", "x(meters)"}], {number, 93, 94}], Table[
  ContourPlot[xWire[number2] == Tan[6 °] yWire[number2] + x0forWireMiddles[number2],
   {yWire[number2], -1, 1}, {xWire[number2], 1.4, 1.5},
   ContourStyle → {Dashing[Large]}], {number2, 93, 94}],
 bottom, right, left, ellipse35]
```

Out[835]=



The θ = 35 ° elliptical path hits the right wall at ϕ=25.0944°, hence no further wires will be crossed after this angle

In[836]:=

In[837]:=
```
Solve[Sqrt[a_35degree^2 (1 - y_35degree^2/b_35degree^2)] - Δa_35degree ==
   Cot[29.5 °] y_35degree + .09156 && ϕ > .1 && ϕ < 30, ϕ]
```

Out[837]= {{ϕ → 25.0944}}

In[838]:=
```
Degree35LineRight = Sort[Table[
   {ϕ /. Solve[Sqrt[a_35degree^2 (1 - y_35degree^2/b_35degree^2)] - Δa_35degree == Tan[6 °] y_35degree +
         x0forWireMiddles[number] && ϕ > .01 && ϕ < 30 , ϕ]}, {number, 63, 94}]]
```

Out[838]= {{{0.8177}}, {{3.60607}}, {{5.44715}}, {{6.9249}}, {{8.19335}}, {{9.3209}}, {{10.3451}}, {{11.2892}}, {{12.1687}}, {{12.9948}}, {{13.7756}}, {{14.5173}}, {{15.2249}}, {{15.9023}}, {{16.5527}}, {{17.1787}}, {{17.7827}}, {{18.3666}}, {{18.9319}}, {{19.4801}}, {{20.0124}}, {{20.53}}, {{21.0338}}, {{21.5245}}, {{22.0031}}, {{22.4702}}, {{22.9264}}, {{23.3723}}, {{23.8084}}, {{24.2352}}, {{24.6531}}, {{25.0624}}}

In[839]:=
```
Degree35LineLeft = Sort[Table[
  {ϕ /. Solve[Sqrt[a_35degree^2 (1 - y_35degree^2/b_35degree^2)] - Δa_35degree == -Tan[6 °] y_35degree +
     x0forWireMiddles[number] && ϕ > .01 && ϕ < 30 , ϕ]}, {number, 73, 94}]]
```

Out[839]=
```
{{{5.42671}}, {{8.19147}}, {{10.0089}}, {{11.4629}}, {{12.7076}},
 {{13.8114}}, {{14.8117}}, {{15.7319}}, {{16.5875}}, {{17.3895}},
 {{18.1462}}, {{18.8638}}, {{19.5472}}, {{20.2003}}, {{20.8264}}, {{21.4282}},
 {{22.0078}}, {{22.5672}}, {{23.108}}, {{23.6316}}, {{24.1393}}, {{24.6322}}}
```

In[840]:=
```
Degree35LineLeft = -1 Degree35LineLeft
```

Out[840]=
```
{{{-5.42671}}, {{-8.19147}}, {{-10.0089}}, {{-11.4629}},
 {{-12.7076}}, {{-13.8114}}, {{-14.8117}}, {{-15.7319}},
 {{-16.5875}}, {{-17.3895}}, {{-18.1462}}, {{-18.8638}},
 {{-19.5472}}, {{-20.2003}}, {{-20.8264}}, {{-21.4282}}, {{-22.0078}},
 {{-22.5672}}, {{-23.108}}, {{-23.6316}}, {{-24.1393}}, {{-24.6322}}}
```

In[841]:=
```
Degree35LineLeft = Prepend[Degree35LineLeft, {{0}}];
```

In[842]:=
```
Degree35Line = Union[Degree35LineLeft, Degree35LineRight]
```

Out[842]=
```
{{{-24.6322}}, {{-24.1393}}, {{-23.6316}}, {{-23.108}}, {{-22.5672}},
 {{-22.0078}}, {{-21.4282}}, {{-20.8264}}, {{-20.2003}}, {{-19.5472}},
 {{-18.8638}}, {{-18.1462}}, {{-17.3895}}, {{-16.5875}}, {{-15.7319}},
 {{-14.8117}}, {{-13.8114}}, {{-12.7076}}, {{-11.4629}}, {{-10.0089}},
 {{-8.19147}}, {{-5.42671}}, {{0}}, {{0.8177}}, {{3.60607}}, {{5.44715}},
 {{6.9249}}, {{8.19335}}, {{9.3209}}, {{10.3451}}, {{11.2892}}, {{12.1687}},
 {{12.9948}}, {{13.7756}}, {{14.5173}}, {{15.2249}}, {{15.9023}},
 {{16.5527}}, {{17.1787}}, {{17.7827}}, {{18.3666}}, {{18.9319}}, {{19.4801}},
 {{20.0124}}, {{20.53}}, {{21.0338}}, {{21.5245}}, {{22.0031}}, {{22.4702}},
 {{22.9264}}, {{23.3723}}, {{23.8084}}, {{24.2352}}, {{24.6531}}, {{25.0624}}}
```

In[843]:=
```
TableOfValues35a =
 Prepend[Replace[Degree35Line, {x_List} :> x, {0, -1}], {"ϕ(degrees)"}]
```

Out[843]=
```
{{ϕ(degrees)}, {-24.6322}, {-24.1393}, {-23.6316}, {-23.108}, {-22.5672},
 {-22.0078}, {-21.4282}, {-20.8264}, {-20.2003}, {-19.5472}, {-18.8638},
 {-18.1462}, {-17.3895}, {-16.5875}, {-15.7319}, {-14.8117}, {-13.8114},
 {-12.7076}, {-11.4629}, {-10.0089}, {-8.19147}, {-5.42671}, {0},
 {0.8177}, {3.60607}, {5.44715}, {6.9249}, {8.19335}, {9.3209}, {10.3451},
 {11.2892}, {12.1687}, {12.9948}, {13.7756}, {14.5173}, {15.2249},
 {15.9023}, {16.5527}, {17.1787}, {17.7827}, {18.3666}, {18.9319},
 {19.4801}, {20.0124}, {20.53}, {21.0338}, {21.5245}, {22.0031}, {22.4702},
 {22.9264}, {23.3723}, {23.8084}, {24.2352}, {24.6531}, {25.0624}}
```

```
In[844]:= TableOfValues35b = MapThread[Prepend, {TableOfValues35a,
    {"Crossing", -22, -21, -20, -19, -18, -17, -16, -15, -14, -13, -12, -11, -10,
     -9, -8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,
     13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32}}]

Out[844]= {{Crossing, ϕ(degrees)}, {-22, -24.6322}, {-21, -24.1393}, {-20, -23.6316},
  {-19, -23.108}, {-18, -22.5672}, {-17, -22.0078}, {-16, -21.4282},
  {-15, -20.8264}, {-14, -20.2003}, {-13, -19.5472}, {-12, -18.8638},
  {-11, -18.1462}, {-10, -17.3895}, {-9, -16.5875}, {-8, -15.7319},
  {-7, -14.8117}, {-6, -13.8114}, {-5, -12.7076}, {-4, -11.4629},
  {-3, -10.0089}, {-2, -8.19147}, {-1, -5.42671}, {0, 0}, {1, 0.8177},
  {2, 3.60607}, {3, 5.44715}, {4, 6.9249}, {5, 8.19335}, {6, 9.3209}, {7, 10.3451},
  {8, 11.2892}, {9, 12.1687}, {10, 12.9948}, {11, 13.7756}, {12, 14.5173},
  {13, 15.2249}, {14, 15.9023}, {15, 16.5527}, {16, 17.1787}, {17, 17.7827},
  {18, 18.3666}, {19, 18.9319}, {20, 19.4801}, {21, 20.0124}, {22, 20.53},
  {23, 21.0338}, {24, 21.5245}, {25, 22.0031}, {26, 22.4702}, {27, 22.9264},
  {28, 23.3723}, {29, 23.8084}, {30, 24.2352}, {31, 24.6531}, {32, 25.0624}}

In[845]:= n

Out[845]= 94.0516

In[846]:= TableOfValues35c = MapThread[Append,
   {TableOfValues35a, {"Wire Number", 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85,
     86, 87, 88, 89, 90, 91, 92, 93, 94, 94.052, 94, 93, 92, 91, 90, 89, 88, 87, 86, 85, 84,
     83, 82, 81, 80, 79, 78, 77, 76, 75, 74, 73, 72, 71, 70, 69, 68, 67, 66, 65, 64, 63}}]

Out[846]= {{ϕ(degrees), Wire Number}, {-24.6322, 73}, {-24.1393, 74}, {-23.6316, 75},
  {-23.108, 76}, {-22.5672, 77}, {-22.0078, 78}, {-21.4282, 79}, {-20.8264, 80},
  {-20.2003, 81}, {-19.5472, 82}, {-18.8638, 83}, {-18.1462, 84},
  {-17.3895, 85}, {-16.5875, 86}, {-15.7319, 87}, {-14.8117, 88},
  {-13.8114, 89}, {-12.7076, 90}, {-11.4629, 91}, {-10.0089, 92},
  {-8.19147, 93}, {-5.42671, 94}, {0, 94.052}, {0.8177, 94}, {3.60607, 93},
  {5.44715, 92}, {6.9249, 91}, {8.19335, 90}, {9.3209, 89}, {10.3451, 88},
  {11.2892, 87}, {12.1687, 86}, {12.9948, 85}, {13.7756, 84}, {14.5173, 83},
  {15.2249, 82}, {15.9023, 81}, {16.5527, 80}, {17.1787, 79}, {17.7827, 78},
  {18.3666, 77}, {18.9319, 76}, {19.4801, 75}, {20.0124, 74}, {20.53, 73},
  {21.0338, 72}, {21.5245, 71}, {22.0031, 70}, {22.4702, 69}, {22.9264, 68},
  {23.3723, 67}, {23.8084, 66}, {24.2352, 65}, {24.6531, 64}, {25.0624, 63}}

In[847]:= Table35degree = Labeled[Grid[TableOfValues35b, Frame → All],
   "Crossing number as a function of ϕ", Top]
```

Crossing number as a function of ϕ

Crossing	ϕ(degrees)
-22	-24.6322
-21	-24.1393
-20	-23.6316
-19	-23.108

Out[847]=

-18	-22.5672
-17	-22.0078
-16	-21.4282
-15	-20.8264
-14	-20.2003
-13	-19.5472
-12	-18.8638
-11	-18.1462
-10	-17.3895
-9	-16.5875
-8	-15.7319
-7	-14.8117
-6	-13.8114
-5	-12.7076
-4	-11.4629
-3	-10.0089
-2	-8.19147
-1	-5.42671
0	0
1	0.8177
2	3.60607
3	5.44715
4	6.9249
5	8.19335
6	9.3209
7	10.3451
8	11.2892
9	12.1687
10	12.9948
11	13.7756
12	14.5173
13	15.2249
14	15.9023
15	16.5527
16	17.1787
17	17.7827
18	18.3666
19	18.9319
20	19.4801
21	20.0124
22	20.53
23	21.0338
24	21.5245
25	22.0031
26	22.4702
27	22.9264
28	23.3723
29	23.8084
30	24.2352
31	24.6531
32	25.0624

In[848]:=
```
Table35degreeWires =
  Labeled[Grid[TableOfValues35c, Frame → All], "Wire Number as a function of ϕ", Top]
```

Wire Number as a function of ϕ

Out[848]=

ϕ (degrees)	Wire Number
-24.6322	73
-24.1393	74
-23.6316	75
-23.108	76
-22.5672	77
-22.0078	78
-21.4282	79
-20.8264	80
-20.2003	81
-19.5472	82
-18.8638	83
-18.1462	84
-17.3895	85
-16.5875	86
-15.7319	87
-14.8117	88
-13.8114	89
-12.7076	90
-11.4629	91
-10.0089	92
-8.19147	93
-5.42671	94
0	94.052
0.8177	94
3.60607	93
5.44715	92
6.9249	91
8.19335	90
9.3209	89
10.3451	88
11.2892	87
12.1687	86
12.9948	85
13.7756	84
14.5173	83
15.2249	82
15.9023	81
16.5527	80
17.1787	79
17.7827	78
18.3666	77
18.9319	76
19.4801	75
20.0124	74
20.53	73
21.0338	72
21.5245	71
22.0031	70
22.4702	69
22.9264	68
23.3723	67
23.8084	66
24.2352	65
24.6531	64
25.0624	63

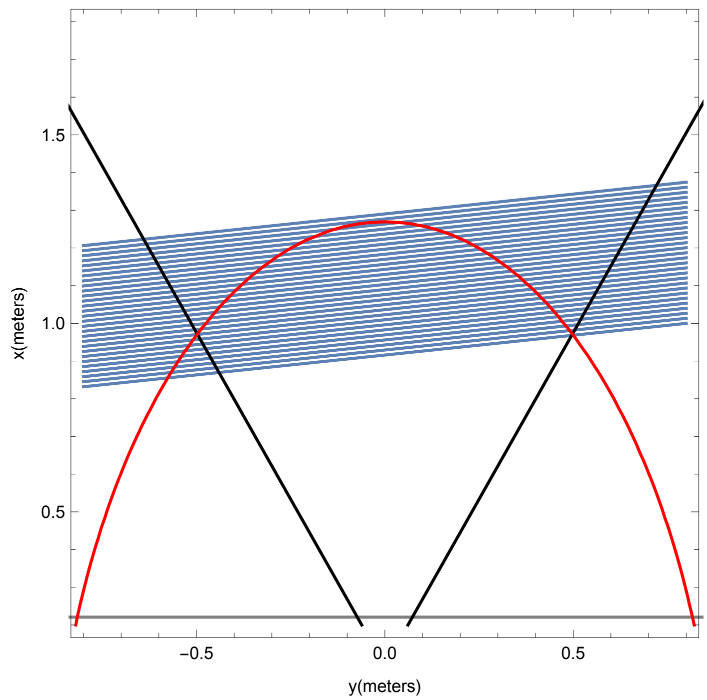
```
In[849]:= ClearAll[θ];

In[850]:= θ = 30;

In[851]:= Δa_30degree = (2.52934271645 Sin[θ °]) / 2 (Csc[65 ° - θ °] - Csc[115 ° - θ °]);
          e_30degree = Sin[25 °] / Cos[θ °];
          a_30degree = (2.52934271645 Sin[θ °]) / 2 (Csc[65 ° - θ °] + Csc[115 ° - θ °]);
          rD1_30degree = (a_30degree e_30degree - Δa_30degree) Tan[65 °] Cos[θ °];
          rD2_30degree = (a_30degree e_30degree + Δa_30degree) Tan[65 °] Cos[θ °];
          xD1_30degree = rD1_30degree Cos[ϕ °];
          yD1_30degree = rD1_30degree Sin[ϕ °];
          zD1_30degree = rD1_30degree Cot[θ °];
          xD2_30degree = rD2_30degree Cos[ϕ °];
          yD2_30degree = rD2_30degree Sin[ϕ °];
          zD2_30degree = rD2_30degree Cot[θ °];
          xP_30degree = (2.52934271645 Cos[ϕ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
          yP_30degree = (2.52934271645 Sin[ϕ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
          zP_30degree = (2.52934271645 Cot[θ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
          x1_30degree =
            (rD2_30degree^2 - rD1_30degree^2 + Cot[θ °]^2 (rD2_30degree^2 - rD1_30degree^2) -
                 2 xP_30degree (xD2_30degree - xD1_30degree) - 2 yP_30degree
                   (yD2_30degree - yD1_30degree) - 2 zP_30degree (zD2_30degree - zD1_30degree)) /
               (4 a_30degree e_30degree) - a_30degree e_30degree ;
          x_30degree = x1_30degree - Δa_30degree + a_30degree e_30degree // N;
          n_30degree = -957.412 / (Tan[θ °] + 2.14437) + 430.626;
          D2P_30degree = √((xD2_30degree - xP_30degree)^2 +
                (yD2_30degree - yP_30degree)^2 + (zD2_30degree - zP_30degree)^2) // N;
          D1P_30degree = √((xP_30degree - xD1_30degree)^2 + (yP_30degree - yD1_30degree)^2 +
                (zP_30degree - zD1_30degree)^2) // N;
          y_30degree = Sqrt[D1P_30degree^2 - x1_30degree^2] // N;
          b_30degree = a_30degree (1 - e_30degree);

In[868]:= n = -957.412 / (Tan[θ °] + 2.14437) + 430.626

Out[868]= 78.8588

In[869]:= θlower = 4.49876 + 0.293001 ( n1) + 0.000679074 (n1)^2 - 3.57132*^-6 (n1)^3 /. n1 → 78

Out[869]= 29.7895

In[870]:= θupper = 4.49876 + 0.293001 (n1) + 0.000679074 (n1)^2 - 3.57132*^-6 (n1)^3 /. n1 → 79

Out[870]= 30.1231
```

We can define the xy position on the DC plane as a function of ϕ for θ=10°

In[871]:=
```
ellipse30 = ContourPlot[(x_30degree + Δa_30degree)^2/a_30degree^2 + y_30degree^2/b_30degree^2 == 1,
   {y_30degree, -1, 1}, {x_30degree, .2, 1.8},
   FrameLabel → {"y(meters)", "x(meters)"}, ContourStyle → Red];
```

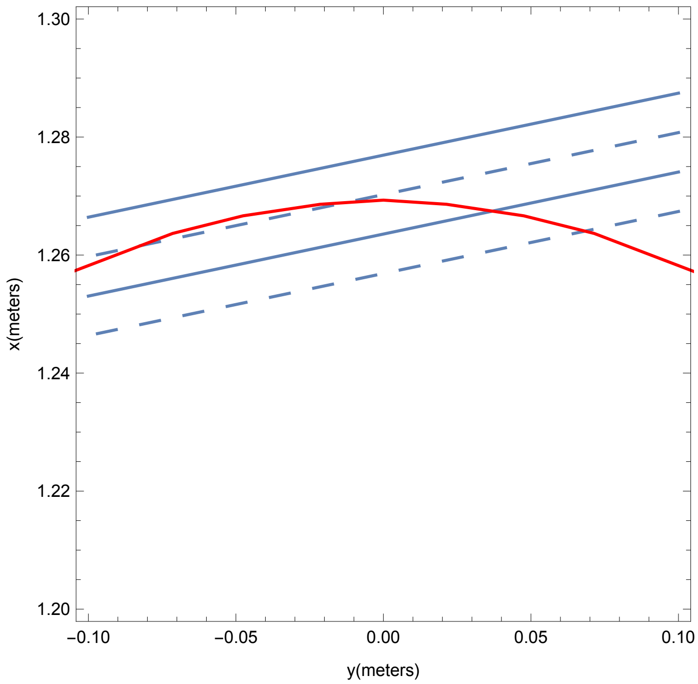
In[872]:=
```
Show[Table[ContourPlot[xWire[number] == Tan[6 °] yWire[number] + x0forWires[number],
   {yWire[number], -0.8, 0.8}, {xWire[number], .2, 1.8},
   FrameLabel → {"y(meters)", "x(meters)"}],
  {number, 52, 80}], bottom, right, left, ellipse30]
```

Out[872]=



In[873]:=
```
Show[Table[ContourPlot[xWire[number] == Tan[6 °] yWire[number] + x0forWires[number],
   {yWire[number], -0.1, 0.1}, {xWire[number], 1.2, 1.3},
   FrameLabel → {"y(meters)", "x(meters)"}], {number, 78, 79}], Table[
  ContourPlot[xWire[number2] == Tan[6 °] yWire[number2] + x0forWireMiddles[number2],
   {yWire[number2], -0.1, 0.1}, {xWire[number2], 1.2, 1.3},
   ContourStyle → {Dashing[Large]}], {number2, 78, 79}],
 bottom, right, left, ellipse30]
```

Out[873]=

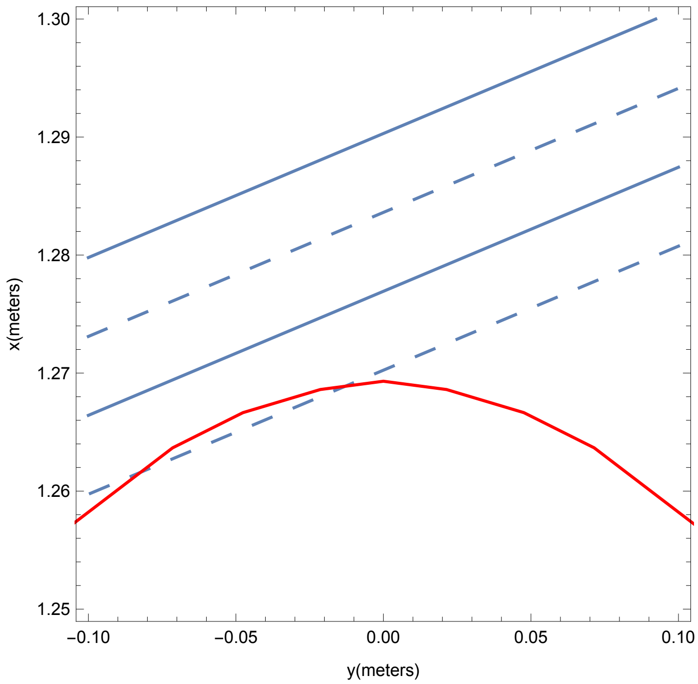


In[874]:=
```
Solve[Sqrt[a_30degree^2 (1 - y_30degree^2/b_30degree^2)] - Δa_30degree ==
   Cot[29.5 °] y_30degree + .09156 && ϕ > .1 && ϕ < 30, ϕ]
```

Out[874]= {{ϕ → 25.0963}}

In[875]:=
```
Show[Table[
   ContourPlot[xWire[number] == Tan[6 °] yWire[number] + x0forWireMiddles[number],
    {yWire[number], -0.1, 0.1}, {xWire[number], 1.25, 1.3},
    FrameLabel → {"y(meters)", "x(meters)"},
    ContourStyle → {Dashing[Large]}], {number, 79, 80}],
  Table[ContourPlot[xWire[number2] == Tan[6 °] yWire[number2] + x0forWires[number2],
    {yWire[number2], -0.1, 0.1}, {xWire[number2], 1.25, 1.3},
    FrameLabel → {"y(meters)", "x(meters)"}],
   {number2, 79, 80}], bottom, right, left, ellipse30]
```

Out[875]=



In[876]:=
```
Degree30LineRight = Sort[Table[
  {ϕ /. Solve[Sqrt[a_30degree^2 (1 - y_30degree^2/b_30degree^2)] - Δa_30degree == Tan[6 °] y_30degree +
      x0forWireMiddles[number] && ϕ > .01 && ϕ < 30, ϕ]}, {number, 53, 78}]]
```

Out[876]=
```
{{{3.46387}}, {{5.63665}}, {{7.33076}}, {{8.76593}}, {{10.0319}},
 {{11.1759}}, {{12.2265}}, {{13.2023}}, {{14.1166}}, {{14.979}},
 {{15.7968}}, {{16.5757}}, {{17.3202}}, {{18.0341}}, {{18.7204}},
 {{19.3817}}, {{20.0201}}, {{20.6376}}, {{21.2356}}, {{21.8157}},
 {{22.379}}, {{22.9266}}, {{23.4595}}, {{23.9786}}, {{24.4846}}, {{24.9783}}}
```

In[877]:=
```
Degree30LineLeft = Sort[Table[
  {ϕ /. Solve[Sqrt[a_30degree^2 (1 - y_30degree^2/b_30degree^2)] - Δa_30degree == -Tan[6 °] y_30degree +
      x0forWireMiddles[number] && ϕ > .01 && ϕ < 30, ϕ]}, {number, 61, 78}]]
```

Out[877]=
```
{{{8.19208}}, {{10.336}}, {{12.0012}}, {{13.4073}}, {{14.6441}}, {{15.7588}},
 {{16.7799}}, {{17.7263}}, {{18.6109}}, {{19.4435}}, {{20.2314}}, {{20.9803}},
 {{21.6947}}, {{22.3784}}, {{23.0343}}, {{23.6651}}, {{24.2729}}, {{24.8595}}}
```

In[878]:=
```
ϕ /. Solve[Sqrt[a_30degree^2 (1 - y_30degree^2/b_30degree^2)] - Δa_30degree ==
   -Tan[6 °] y_30degree + x0forWireMiddles[79] && ϕ > .01 && ϕ < 30, ϕ]
```

Out[878]=
```
{0.382656, 4.37428}
```

```
In[879]:= Degree30LineLeft = Prepend[Degree30LineLeft, {{4.374281180578439`}}]

Out[879]= {{{4.37428}}, {{8.19208}}, {{10.336}}, {{12.0012}},
  {{13.4073}}, {{14.6441}}, {{15.7588}}, {{16.7799}}, {{17.7263}},
  {{18.6109}}, {{19.4435}}, {{20.2314}}, {{20.9803}}, {{21.6947}},
  {{22.3784}}, {{23.0343}}, {{23.6651}}, {{24.2729}}, {{24.8595}}}

In[880]:= Degree30LineLeft = Prepend[Degree30LineLeft, {{0.38265551404846865`}}]

Out[880]= {{{0.382656}}, {{4.37428}}, {{8.19208}}, {{10.336}}, {{12.0012}},
  {{13.4073}}, {{14.6441}}, {{15.7588}}, {{16.7799}}, {{17.7263}},
  {{18.6109}}, {{19.4435}}, {{20.2314}}, {{20.9803}}, {{21.6947}},
  {{22.3784}}, {{23.0343}}, {{23.6651}}, {{24.2729}}, {{24.8595}}}

In[881]:= Degree30LineLeft = Prepend[Degree30LineLeft, {{0}}]

Out[881]= {{{0}}, {{0.382656}}, {{4.37428}}, {{8.19208}}, {{10.336}}, {{12.0012}},
  {{13.4073}}, {{14.6441}}, {{15.7588}}, {{16.7799}}, {{17.7263}},
  {{18.6109}}, {{19.4435}}, {{20.2314}}, {{20.9803}}, {{21.6947}},
  {{22.3784}}, {{23.0343}}, {{23.6651}}, {{24.2729}}, {{24.8595}}}

In[882]:= Degree30LineLeft = -1 Degree30LineLeft

Out[882]= {{{0}}, {{-0.382656}}, {{-4.37428}}, {{-8.19208}}, {{-10.336}}, {{-12.0012}},
  {{-13.4073}}, {{-14.6441}}, {{-15.7588}}, {{-16.7799}}, {{-17.7263}},
  {{-18.6109}}, {{-19.4435}}, {{-20.2314}}, {{-20.9803}}, {{-21.6947}},
  {{-22.3784}}, {{-23.0343}}, {{-23.6651}}, {{-24.2729}}, {{-24.8595}}}

In[883]:= Degree30LineLeft

Out[883]= {{{0}}, {{-0.382656}}, {{-4.37428}}, {{-8.19208}}, {{-10.336}}, {{-12.0012}},
  {{-13.4073}}, {{-14.6441}}, {{-15.7588}}, {{-16.7799}}, {{-17.7263}},
  {{-18.6109}}, {{-19.4435}}, {{-20.2314}}, {{-20.9803}}, {{-21.6947}},
  {{-22.3784}}, {{-23.0343}}, {{-23.6651}}, {{-24.2729}}, {{-24.8595}}}

In[884]:= Degree30Line = Union[Degree30LineLeft, Degree30LineRight]

Out[884]= {{{-24.8595}}, {{-24.2729}}, {{-23.6651}}, {{-23.0343}}, {{-22.3784}},
  {{-21.6947}}, {{-20.9803}}, {{-20.2314}}, {{-19.4435}}, {{-18.6109}},
  {{-17.7263}}, {{-16.7799}}, {{-15.7588}}, {{-14.6441}}, {{-13.4073}},
  {{-12.0012}}, {{-10.336}}, {{-8.19208}}, {{-4.37428}}, {{-0.382656}},
  {{0}}, {{3.46387}}, {{5.63665}}, {{7.33076}}, {{8.76593}}, {{10.0319}},
  {{11.1759}}, {{12.2265}}, {{13.2023}}, {{14.1166}}, {{14.979}},
  {{15.7968}}, {{16.5757}}, {{17.3202}}, {{18.0341}}, {{18.7204}},
  {{19.3817}}, {{20.0201}}, {{20.6376}}, {{21.2356}}, {{21.8157}},
  {{22.379}}, {{22.9266}}, {{23.4595}}, {{23.9786}}, {{24.4846}}, {{24.9783}}}

In[885]:= TableOfValues30a =
  Prepend[Replace[Degree30Line, {x_List} :> x, {0, -1}], {"ϕ(degrees)"}];
```

We can add the number of successive crossings

In[886]:=
```
TableOfValues30b =
  MapThread[Prepend, {TableOfValues30a, {"Crossing", -20, -19, -18, -17, -16, -15,
     -14, -13, -12, -11, -10, -9, -8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5,
     6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26}}]
```

Out[886]=
```
{{Crossing, ϕ(degrees)}, {-20, -24.8595}, {-19, -24.2729}, {-18, -23.6651},
 {-17, -23.0343}, {-16, -22.3784}, {-15, -21.6947}, {-14, -20.9803},
 {-13, -20.2314}, {-12, -19.4435}, {-11, -18.6109}, {-10, -17.7263},
 {-9, -16.7799}, {-8, -15.7588}, {-7, -14.6441}, {-6, -13.4073}, {-5, -12.0012},
 {-4, -10.336}, {-3, -8.19208}, {-2, -4.37428}, {-1, -0.382656}, {0, 0},
 {1, 3.46387}, {2, 5.63665}, {3, 7.33076}, {4, 8.76593}, {5, 10.0319}, {6, 11.1759},
 {7, 12.2265}, {8, 13.2023}, {9, 14.1166}, {10, 14.979}, {11, 15.7968},
 {12, 16.5757}, {13, 17.3202}, {14, 18.0341}, {15, 18.7204}, {16, 19.3817},
 {17, 20.0201}, {18, 20.6376}, {19, 21.2356}, {20, 21.8157}, {21, 22.379},
 {22, 22.9266}, {23, 23.4595}, {24, 23.9786}, {25, 24.4846}, {26, 24.9783}}
```

In[887]:=
```
n
```

Out[887]=
```
78.8588
```

In[888]:=
```
TableOfValues30c =
  MapThread[Append, {TableOfValues30a, {"Wire Number", 61, 62, 63, 64, 65, 66, 67, 68,
     69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 79, 78.8588, 78, 77, 76, 75, 74, 73,
     72, 71, 70, 69, 68, 67, 66, 65, 64, 63, 62, 61, 60, 59, 58, 57, 56, 55, 54, 53}}]
```

Out[888]=
```
{{ϕ(degrees), Wire Number}, {-24.8595, 61}, {-24.2729, 62}, {-23.6651, 63},
 {-23.0343, 64}, {-22.3784, 65}, {-21.6947, 66}, {-20.9803, 67},
 {-20.2314, 68}, {-19.4435, 69}, {-18.6109, 70}, {-17.7263, 71}, {-16.7799, 72},
 {-15.7588, 73}, {-14.6441, 74}, {-13.4073, 75}, {-12.0012, 76}, {-10.336, 77},
 {-8.19208, 78}, {-4.37428, 79}, {-0.382656, 79}, {0, 78.8588}, {3.46387, 78},
 {5.63665, 77}, {7.33076, 76}, {8.76593, 75}, {10.0319, 74}, {11.1759, 73},
 {12.2265, 72}, {13.2023, 71}, {14.1166, 70}, {14.979, 69}, {15.7968, 68},
 {16.5757, 67}, {17.3202, 66}, {18.0341, 65}, {18.7204, 64}, {19.3817, 63},
 {20.0201, 62}, {20.6376, 61}, {21.2356, 60}, {21.8157, 59}, {22.379, 58},
 {22.9266, 57}, {23.4595, 56}, {23.9786, 55}, {24.4846, 54}, {24.9783, 53}}
```

In[889]:=
```
Table30degree = Labeled[Grid[TableOfValues30b, Frame → All],
   "Crossing Number as a function of ϕ", Top]
```

Crossing Number as a function of ϕ

Out[889]=

Crossing	ϕ(degrees)
-20	-24.8595
-19	-24.2729
-18	-23.6651
-17	-23.0343
-16	-22.3784
-15	-21.6947
-14	-20.9803
-13	-20.2314
-12	-19.4435
-11	-18.6109
-10	-17.7263
-9	-16.7799
-8	-15.7588
-7	-14.6441
-6	-13.4073
-5	-12.0012
-4	-10.336
-3	-8.19208
-2	-4.37428
-1	-0.382656
0	0
1	3.46387
2	5.63665
3	7.33076
4	8.76593
5	10.0319
6	11.1759
7	12.2265
8	13.2023
9	14.1166
10	14.979
11	15.7968
12	16.5757
13	17.3202
14	18.0341
15	18.7204
16	19.3817
17	20.0201
18	20.6376
19	21.2356
20	21.8157
21	22.379
22	22.9266
23	23.4595
24	23.9786
25	24.4846
26	24.9783

In[890]:=
```
Table30degreeWire = Labeled[Grid[TableOfValues30c, Frame → All],
  "Midpoint Wire Number as a function of ϕ", Top]
```

Midpoint Wire Number as a function of ϕ

Out[890]=

ϕ(degrees)	Wire Number
-24.8595	61
-24.2729	62
-23.6651	63
-23.0343	64
-22.3784	65
-21.6947	66
-20.9803	67
-20.2314	68
-19.4435	69
-18.6109	70
-17.7263	71
-16.7799	72
-15.7588	73
-14.6441	74
-13.4073	75
-12.0012	76
-10.336	77
-8.19208	78
-4.37428	79
-0.382656	79
0	78.8588
3.46387	78
5.63665	77
7.33076	76
8.76593	75
10.0319	74
11.1759	73
12.2265	72
13.2023	71
14.1166	70
14.979	69
15.7968	68
16.5757	67
17.3202	66
18.0341	65
18.7204	64
19.3817	63
20.0201	62
20.6376	61
21.2356	60
21.8157	59
22.379	58
22.9266	57
23.4595	56
23.9786	55
24.4846	54
24.9783	53

In[891]:=
```
ClearAll[θ];
```

In[892]:=
```
θ = 25;
```

```
In[893]:= Δa_25degree = (2.52934271645 Sin[θ °]) / 2 (Csc[65 ° - θ °] - Csc[115 ° - θ °]);
e_25degree = Sin[25 °] / Cos[θ °];
a_25degree = (2.52934271645 Sin[θ °]) / 2 (Csc[65 ° - θ °] + Csc[115 ° - θ °]);
rD1_25degree = (a_25degree e_25degree - Δa_25degree) Tan[65 °] Cos[θ °];
rD2_25degree = (a_25degree e_25degree + Δa_25degree) Tan[65 °] Cos[θ °];
xD1_25degree = rD1_25degree Cos[ϕ °];
yD1_25degree = rD1_25degree Sin[ϕ °];
zD1_25degree = rD1_25degree Cot[θ °];
xD2_25degree = rD2_25degree Cos[ϕ °];
yD2_25degree = rD2_25degree Sin[ϕ °];
zD2_25degree = rD2_25degree Cot[θ °];
xP_25degree = (2.52934271645 Cos[ϕ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
yP_25degree = (2.52934271645 Sin[ϕ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
zP_25degree = (2.52934271645 Cot[θ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
x1_25degree =
  (rD2_25degree^2 - rD1_25degree^2 + Cot[θ °]^2 (rD2_25degree^2 - rD1_25degree^2) -
       2 xP_25degree (xD2_25degree - xD1_25degree) - 2 yP_25degree
        (yD2_25degree - yD1_25degree) - 2 zP_25degree (zD2_25degree - zD1_25degree)) /
     (4 a_25degree e_25degree) - a_25degree e_25degree ;
x_25degree = x1_25degree - Δa_25degree + a_25degree e_25degree // N;
n_25degree = -957.412 / (Tan[θ °] + 2.14437) + 430.626;
D2P_25degree = √((xD2_25degree - xP_25degree)^2 +
      (yD2_25degree - yP_25degree)^2 + (zD2_25degree - zP_25degree)^2) // N;
D1P_25degree = √((xP_25degree - xD1_25degree)^2 + (yP_25degree - yD1_25degree)^2 +
      (zP_25degree - zD1_25degree)^2) // N;
y_25degree = Sqrt[D1P_25degree^2 - x1_25degree^2] // N;
b_25degree = a_25degree (1 - e_25degree);
```

```
In[910]:= n = -957.412 / (Tan[θ °] + 2.14437) + 430.626
Out[910]= 63.8967
```

```
In[911]:= θlower = 4.49876 + 0.293001 ( n1) + 0.000679074 (n1)^2 - 3.57132*^-6 (n1)^3 /. n1 → 63
Out[911]= 24.7601
```

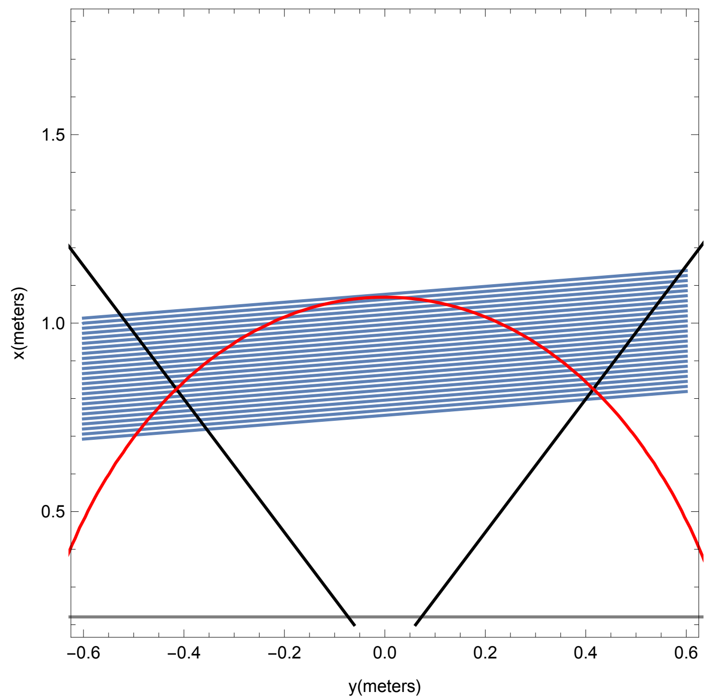
```
In[912]:= θupper = 4.49876 + 0.293001 (n1) + 0.000679074 (n1)^2 - 3.57132*^-6 (n1)^3 /. n1 → 64
Out[912]= 25.0961
```

We can define the xy position on the DC plane as a function of ϕ for θ=10°

```
In[913]:= ellipse25 = ContourPlot[(x_25degree + Δa_25degree)^2 / a_25degree^2 + y_25degree^2 / b_25degree^2 == 1,
    {y_25degree, -1, 1}, {x_25degree, .2, 1.8},
    FrameLabel → {"y(meters)", "x(meters)"}, ContourStyle → Red];
```

In[914]:=
```
Show[Table[ContourPlot[xWire[number] == Tan[6 °] yWire[number] + x0forWires[number],
    {yWire[number], -0.6, 0.6}, {xWire[number], .2, 1.8},
    FrameLabel → {"y(meters)", "x(meters)"}],
  {number, 40, 64}], bottom, right, left, ellipse25]
```

Out[914]=



In[915]:=
$$\text{Solve}\left[\sqrt{a\_25degree^2\left(1-\frac{y\_25degree^2}{b\_25degree^2}\right)}-\Delta a\_25degree == \text{Cot}[29.5\,°]\, y\_25degree + .09156\ \&\&\ \phi > .1\ \&\&\ \phi < 30,\ \phi\right]$$

Out[915]= {{ϕ → 24.9324}}

In[916]:=
$$\text{Degree25LineRight} = \text{Sort}\Big[\text{Table}\Big[\Big\{\phi\ /.\ \text{Solve}\Big[\sqrt{a\_25degree^2\left(1-\frac{y\_25degree^2}{b\_25degree^2}\right)}-\Delta a\_25degree == \text{Tan}[6\,°]\, y\_25degree + \text{x0forWireMiddles}[number]\ \&\&\ \phi > .01\ \&\&\ \phi < 30,\ \phi\Big]\Big\},\ \{number, 43, 63\}\Big]\Big]$$

Out[916]=
```
{{{3.92083}}, {{6.32663}}, {{8.19472}}, {{9.77397}}, {{11.165}},
 {{12.4205}}, {{13.5722}}, {{14.641}}, {{15.6413}}, {{16.5839}},
 {{17.4769}}, {{18.3266}}, {{19.1379}}, {{19.915}}, {{20.6612}},
 {{21.3794}}, {{22.072}}, {{22.741}}, {{23.3881}}, {{24.015}}, {{24.6229}}}
```

In[917]:=
```
Degree25LineLeft = Sort[Table[
    {ϕ /. Solve[Sqrt[a_25degree^2 (1 - y_25degree^2/b_25degree^2)] - Δa_25degree == -Tan[6 °] y_25degree +
        x0forWireMiddles[number] && ϕ > .01 && ϕ < 30, ϕ]}, {number, 49, 63}]]
```

Out[917]= {{{8.71215}}, {{11.0828}}, {{12.9154}}, {{14.4591}}, {{15.8142}}, {{17.0336}}, {{18.149}}, {{19.1812}}, {{20.1447}}, {{21.0503}}, {{21.9059}}, {{22.718}}, {{23.4916}}, {{24.2306}}, {{24.9386}}}

In[918]:=
```
ϕ /. Solve[Sqrt[a_25degree^2 (1 - y_25degree^2/b_25degree^2)] - Δa_25degree ==
    -Tan[6 °] y_25degree + x0forWireMiddles[64] && ϕ > .01 && ϕ < 30, ϕ]
```

Out[918]= {0.466146, 4.36014}

In[919]:=
```
Degree25LineLeft = Prepend[Degree25LineLeft, {{4.360135722768276`}}]
```

Out[919]= {{{4.36014}}, {{8.71215}}, {{11.0828}}, {{12.9154}}, {{14.4591}}, {{15.8142}}, {{17.0336}}, {{18.149}}, {{19.1812}}, {{20.1447}}, {{21.0503}}, {{21.9059}}, {{22.718}}, {{23.4916}}, {{24.2306}}, {{24.9386}}}

In[920]:=
```
Degree25LineLeft = Prepend[Degree25LineLeft, {{0.46614634503807817`}}]
```

Out[920]= {{{0.466146}}, {{4.36014}}, {{8.71215}}, {{11.0828}}, {{12.9154}}, {{14.4591}}, {{15.8142}}, {{17.0336}}, {{18.149}}, {{19.1812}}, {{20.1447}}, {{21.0503}}, {{21.9059}}, {{22.718}}, {{23.4916}}, {{24.2306}}, {{24.9386}}}

In[921]:=
```
Degree25LineLeft = -1 Degree25LineLeft
```

Out[921]= {{{-0.466146}}, {{-4.36014}}, {{-8.71215}}, {{-11.0828}}, {{-12.9154}}, {{-14.4591}}, {{-15.8142}}, {{-17.0336}}, {{-18.149}}, {{-19.1812}}, {{-20.1447}}, {{-21.0503}}, {{-21.9059}}, {{-22.718}}, {{-23.4916}}, {{-24.2306}}, {{-24.9386}}}

In[922]:=
```
Degree25LineLeft = Prepend[Degree25LineLeft, {{0}}]
```

Out[922]= {{{0}}, {{-0.466146}}, {{-4.36014}}, {{-8.71215}}, {{-11.0828}}, {{-12.9154}}, {{-14.4591}}, {{-15.8142}}, {{-17.0336}}, {{-18.149}}, {{-19.1812}}, {{-20.1447}}, {{-21.0503}}, {{-21.9059}}, {{-22.718}}, {{-23.4916}}, {{-24.2306}}, {{-24.9386}}}

In[923]:=
```
Degree25Line = Union[Degree25LineLeft, Degree25LineRight]
```

Out[923]= {{{-24.9386}}, {{-24.2306}}, {{-23.4916}}, {{-22.718}}, {{-21.9059}}, {{-21.0503}}, {{-20.1447}}, {{-19.1812}}, {{-18.149}}, {{-17.0336}}, {{-15.8142}}, {{-14.4591}}, {{-12.9154}}, {{-11.0828}}, {{-8.71215}}, {{-4.36014}}, {{-0.466146}}, {{0}}, {{3.92083}}, {{6.32663}}, {{8.19472}}, {{9.77397}}, {{11.165}}, {{12.4205}}, {{13.5722}}, {{14.641}}, {{15.6413}}, {{16.5839}}, {{17.4769}}, {{18.3266}}, {{19.1379}}, {{19.915}}, {{20.6612}}, {{21.3794}}, {{22.072}}, {{22.741}}, {{23.3881}}, {{24.015}}, {{24.6229}}}

```
In[924]:= TableOfValues25a =
   Prepend[Replace[Degree25Line, {x_List} :→ x, {0, -1}], {"ϕ(degrees)"}];
```

We can add the number of successive crossings

```
In[925]:= TableOfValues25b = MapThread[Prepend, {TableOfValues25a,
    {"Crossing", -17, -16, -15, -14, -13, -12, -11, -10, -9, -8, -7, -6, -5, -4, -3,
     -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21}}]

Out[925]= {{Crossing, ϕ(degrees)}, {-17, -24.9386}, {-16, -24.2306}, {-15, -23.4916},
  {-14, -22.718}, {-13, -21.9059}, {-12, -21.0503}, {-11, -20.1447}, {-10, -19.1812},
  {-9, -18.149}, {-8, -17.0336}, {-7, -15.8142}, {-6, -14.4591}, {-5, -12.9154},
  {-4, -11.0828}, {-3, -8.71215}, {-2, -4.36014}, {-1, -0.466146}, {0, 0},
  {1, 3.92083}, {2, 6.32663}, {3, 8.19472}, {4, 9.77397}, {5, 11.165}, {6, 12.4205},
  {7, 13.5722}, {8, 14.641}, {9, 15.6413}, {10, 16.5839}, {11, 17.4769},
  {12, 18.3266}, {13, 19.1379}, {14, 19.915}, {15, 20.6612}, {16, 21.3794},
  {17, 22.072}, {18, 22.741}, {19, 23.3881}, {20, 24.015}, {21, 24.6229}}

In[926]:= n

Out[926]= 63.8967

In[927]:= TableOfValues25c =
  MapThread[Append, {TableOfValues25a, {"Wire Number", 49, 50, 51, 52,
     53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 64, 63.897, 63, 62, 61,
     60, 59, 58, 57, 56, 55, 54, 53, 52, 51, 50, 49, 48, 47, 46, 45, 44, 43}}]

Out[927]= {{ϕ(degrees), Wire Number}, {-24.9386, 49}, {-24.2306, 50}, {-23.4916, 51},
  {-22.718, 52}, {-21.9059, 53}, {-21.0503, 54}, {-20.1447, 55}, {-19.1812, 56},
  {-18.149, 57}, {-17.0336, 58}, {-15.8142, 59}, {-14.4591, 60}, {-12.9154, 61},
  {-11.0828, 62}, {-8.71215, 63}, {-4.36014, 64}, {-0.466146, 64}, {0, 63.897},
  {3.92083, 63}, {6.32663, 62}, {8.19472, 61}, {9.77397, 60}, {11.165, 59},
  {12.4205, 58}, {13.5722, 57}, {14.641, 56}, {15.6413, 55}, {16.5839, 54},
  {17.4769, 53}, {18.3266, 52}, {19.1379, 51}, {19.915, 50}, {20.6612, 49},
  {21.3794, 48}, {22.072, 47}, {22.741, 46}, {23.3881, 45}, {24.015, 44}, {24.6229, 43}}

In[928]:= Table25degree = Labeled[Grid[TableOfValues25b, Frame → All],
   "Crossing Number as a function of ϕ", Top]
```

Crossing Number as a function of ϕ

Out[929]=

Crossing	ϕ(degrees)
-17	-24.9386
-16	-24.2306
-15	-23.4916
-14	-22.718
-13	-21.9059
-12	-21.0503
-11	-20.1447
-10	-19.1812
-9	-18.149
-8	-17.0336
-7	-15.8142
-6	-14.4591
-5	-12.9154
-4	-11.0828
-3	-8.71215
-2	-4.36014
-1	-0.466146
0	0
1	3.92083
2	6.32663
3	8.19472
4	9.77397
5	11.165
6	12.4205
7	13.5722
8	14.641
9	15.6413
10	16.5839
11	17.4769
12	18.3266
13	19.1379
14	19.915
15	20.6612
16	21.3794
17	22.072
18	22.741
19	23.3881
20	24.015
21	24.6229

In[929]:=
```
Table25degreeWire = Labeled[Grid[TableOfValues25c, Frame → All],
  "Midpoint Wire Number as a function of ϕ", Top]
```

Midpoint Wire Number as a function of ϕ

Out[929]=

ϕ(degrees)	Wire Number
-24.9386	49
-24.2306	50
-23.4916	51
-22.718	52
-21.9059	53
-21.0503	54
-20.1447	55
-19.1812	56
-18.149	57
-17.0336	58
-15.8142	59
-14.4591	60
-12.9154	61
-11.0828	62
-8.71215	63
-4.36014	64
-0.466146	64
0	63.897
3.92083	63
6.32663	62
8.19472	61
9.77397	60
11.165	59
12.4205	58
13.5722	57
14.641	56
15.6413	55
16.5839	54
17.4769	53
18.3266	52
19.1379	51
19.915	50
20.6612	49
21.3794	48
22.072	47
22.741	46
23.3881	45
24.015	44
24.6229	43

In[930]:=
```
ClearAll[θ]
```

In[931]:=
```
θ = 20;
```

All of the conditions dependent on θ and ϕ, where ϕ is left as a variable

In[932]:=

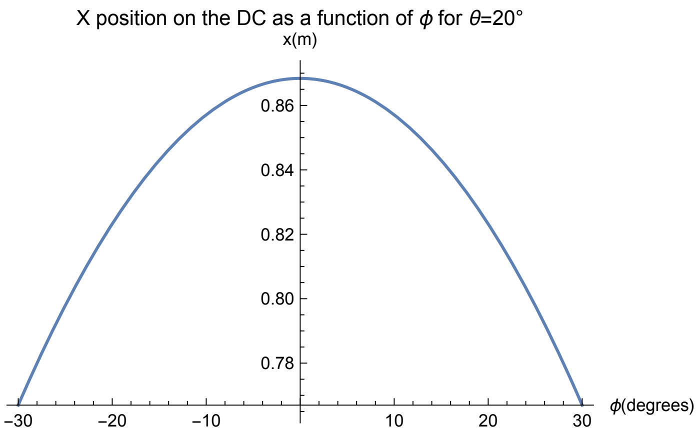
```
Δa_20degree = (2.52934271645 Sin[θ °]) / 2 (Csc[65 ° - θ °] - Csc[115 ° - θ °]);
e_20degree = Sin[25 °] / Cos[θ °];
a_20degree = (2.52934271645 Sin[θ °]) / 2 (Csc[65 ° - θ °] + Csc[115 ° - θ °]);
rD1_20degree = (a_20degree e_20degree - Δa_20degree) Tan[65 °] Cos[θ °];
rD2_20degree = (a_20degree e_20degree + Δa_20degree) Tan[65 °] Cos[θ °];
xD1_20degree = rD1_20degree Cos[ϕ °];
yD1_20degree = rD1_20degree Sin[ϕ °];
zD1_20degree = rD1_20degree Cot[θ °];
xD2_20degree = rD2_20degree Cos[ϕ °];
yD2_20degree = rD2_20degree Sin[ϕ °];
zD2_20degree = rD2_20degree Cot[θ °];
xP_20degree = (2.52934271645 Cos[ϕ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
yP_20degree = (2.52934271645 Sin[ϕ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
zP_20degree = (2.52934271645 Cot[θ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
x1_20degree =
  (rD2_20degree ^ 2 - rD1_20degree ^ 2 + Cot[θ °] ^ 2 (rD2_20degree ^ 2 - rD1_20degree ^ 2) -
       2 xP_20degree (xD2_20degree - xD1_20degree) - 2 yP_20degree
         (yD2_20degree - yD1_20degree) - 2 zP_20degree (zD2_20degree - zD1_20degree)) /
     (4 a_20degree e_20degree) - a_20degree e_20degree;
x_20degree = x1_20degree - Δa_20degree + a_20degree e_20degree // N;
n_20degree = -957.412 / (Tan[θ °] + 2.14437) + 430.626;
D2P_20degree = √((xD2_20degree - xP_20degree)^2 +
        (yD2_20degree - yP_20degree)^2 + (zD2_20degree - zP_20degree)^2) // N;
D1P_20degree = √((xP_20degree - xD1_20degree)^2 + (yP_20degree - yD1_20degree)^2 +
        (zP_20degree - zD1_20degree)^2) // N;
y_20degree = Sqrt[D1P_20degree^2 - x1_20degree^2] // N;
b_20degree = a_20degree (1 - e_20degree);
```

We can examine the x and y position as a function of ϕ

In[953]:=

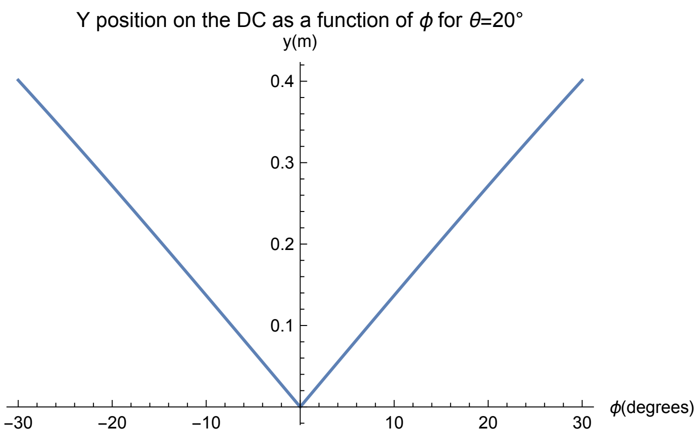
```
Plot[x_20degree, {ϕ, -30, 30}, AxesLabel → {"ϕ(degrees)", "x(m)"},
 PlotLabel → "X position on the DC as a function of ϕ for θ=20°"]
```

Out[953]=




```
In[954]:= Plot[y_20degree, {ϕ, -30, 30}, AxesLabel → {"ϕ(degrees)", "y(m)"},
  PlotLabel → "Y position on the DC as a function of ϕ for θ=20°"]
```

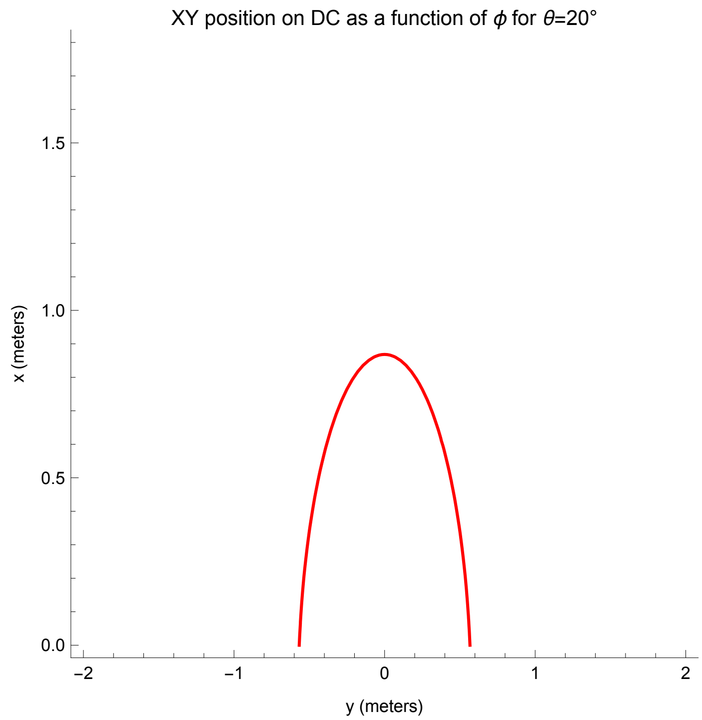
Out[954]=



We can use the x and y coordinates to plot the ellipse they mark out on the conic section

```
In[955]:= ellipse20 = ContourPlot[(x_20degree + Δa_20degree)^2/a_20degree^2 + y_20degree^2/b_20degree^2 == 1,
   {y_20degree, -2, 2}, {x_20degree, 0, 1.8}, Frame → {True, True, False, False},
   PlotLabel → "XY position on DC as a function of ϕ for θ=20°",
   FrameLabel → {"y (meters)", "x (meters)"},
   ContourStyle → Red, PlotLegends → Automatic]
```

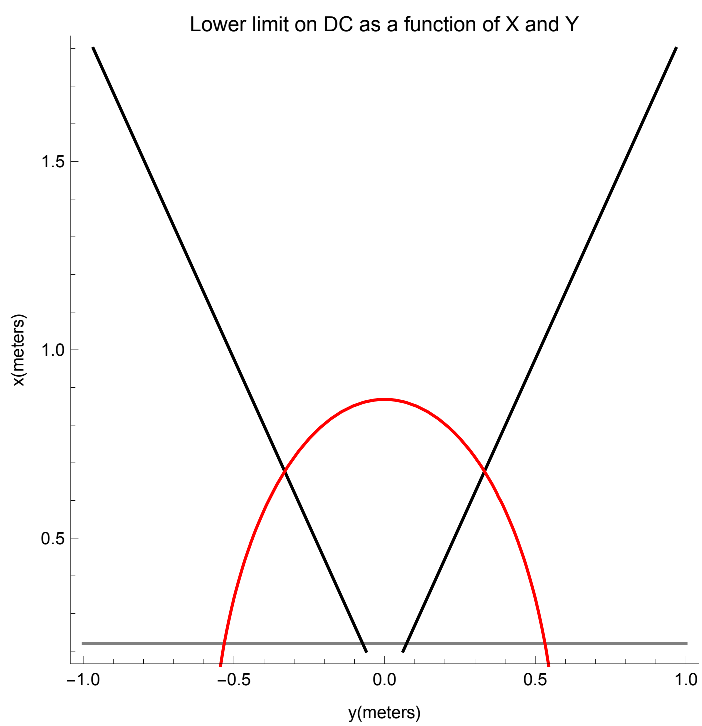
Out[955]=



In[956]:=

```
Show[bottom, right, left, ellipse20]
```

Out[956]=



The cone of constant θ=20° cross the midpoint plane of the DC at ϕ=0. At this position, we know that the wire number for this area is

In[957]:=

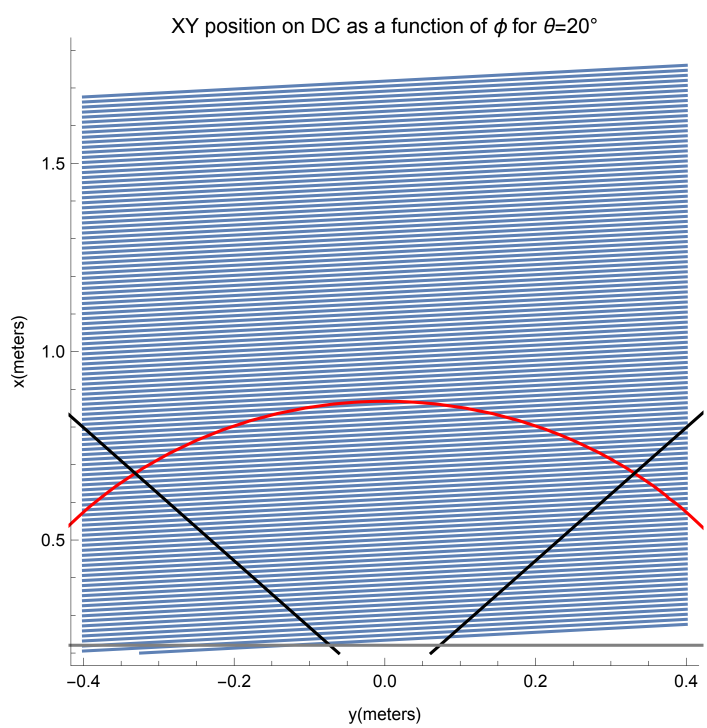
$$n = \frac{-957.412}{\text{Tan}[\theta\,°] + 2.14437} + 430.626$$

Out[957]= 48.9346

This corresponds to lower and upper limits on θ which agree with θ=20°

```
In[958]:= θlower = 4.49876 + 0.293001 ( n1) + 0.000679074 (n1)^2 - 3.57132*^-6 (n1)^3 /. n1 → 48
Out[958]= 19.7324

In[959]:= θupper = 4.49876 + 0.293001 (n1) + 0.000679074 (n1)^2 - 3.57132*^-6 (n1)^3 /. n1 → 49
Out[959]= 20.0661

In[960]:=
Show[Table[ContourPlot[xWire[number] == Tan[6 °] yWire[number] + x0forWires[number],
    {yWire[number], -0.4, 0.4}, {xWire[number], .2, 1.8},
    Frame → {True, True, False, False},
    PlotLabel → "XY position on DC as a function of ϕ for θ=20°",
    FrameLabel → {"y(meters)", "x(meters)"}],
  {number, 1, 112}], ellipse20, right, left, bottom]
```

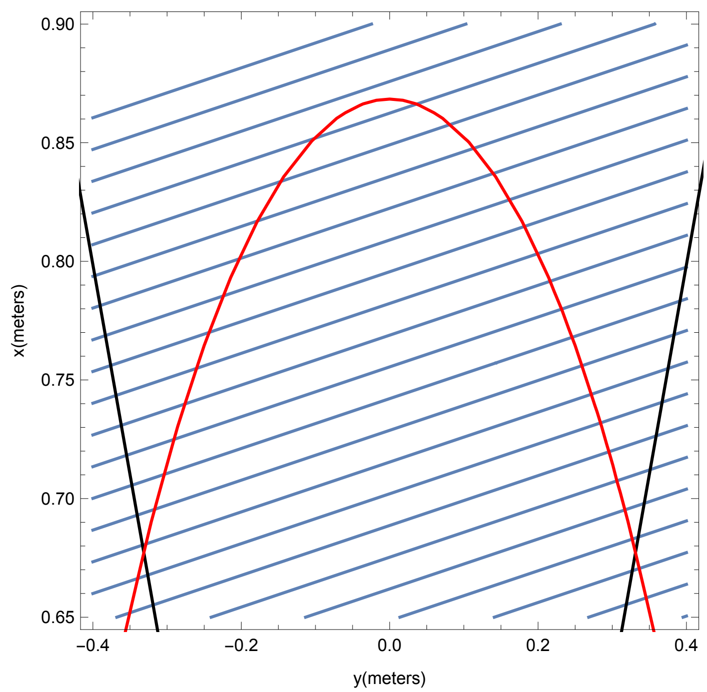
Out[960]=



Zooming in

```
In[961]:= Show[Table[ContourPlot[xWire[number] == Tan[6 °] yWire[number] + x0forWires[number],
    {yWire[number], -0.4, 0.4}, {xWire[number], .65, .9},
    FrameLabel → {"y(meters)", "x(meters)"}],
  {number, 22, 51}], bottom, right, left, ellipse20]
```

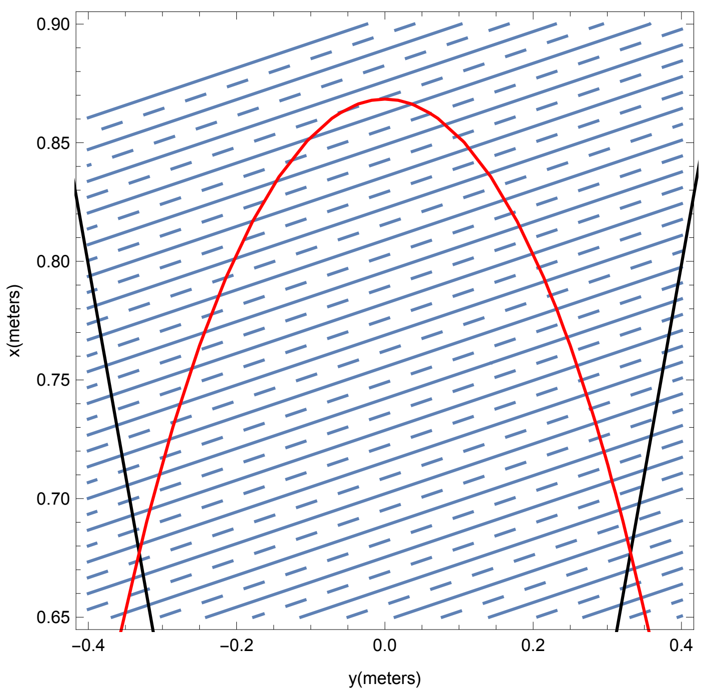
Out[961]=



Viewing this

In[962]:=
```
Show[Table[ContourPlot[xWire[number] == Tan[6 °] yWire[number] + x0forWires[number],
   {yWire[number], -0.4, 0.4}, {xWire[number], .65, .9},
   FrameLabel → {"y(meters)", "x(meters)"}], {number, 22, 51}], Table[
  ContourPlot[xWire[number2] == Tan[6 °] yWire[number2] + x0forWireMiddles[number2],
   {yWire[number2], -0.4, 0.4}, {xWire[number2], .65, .9},
   ContourStyle → {Dashing[Large]}], {number2, 22, 51}],
 bottom, right, left, ellipse20]
```

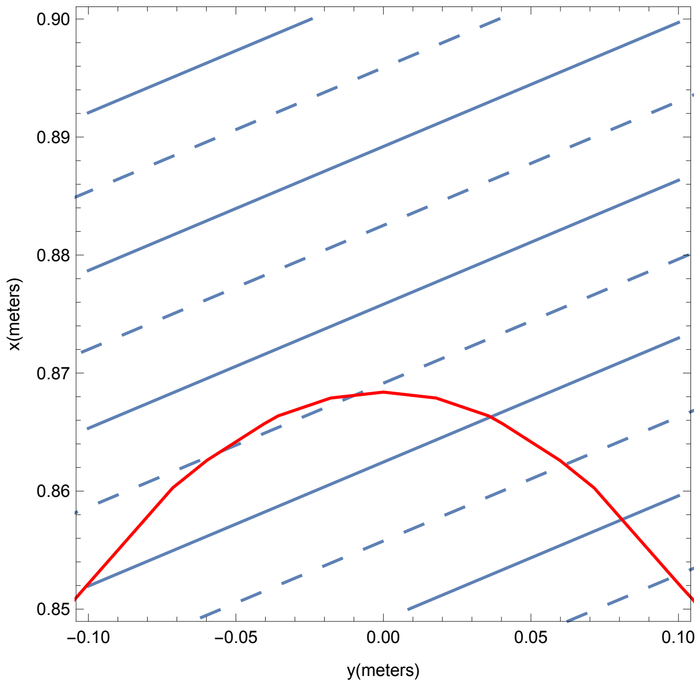
Out[962]=



The ellipse for θ=20° does cross over the wire midpoint twice

In[963]:=
```
Show[Table[ContourPlot[xWire[number] == Tan[6 °] yWire[number] + x0forWires[number],
    {yWire[number], -0.1, 0.1}, {xWire[number], .85, .9},
    FrameLabel → {"y(meters)", "x(meters)"}], {number, 22, 51}], Table[
  ContourPlot[xWire[number2] == Tan[6 °] yWire[number2] + x0forWireMiddles[number2],
    {yWire[number2], -0.4, 0.4}, {xWire[number2], .65, .9},
    ContourStyle → {Dashing[Large]}], {number2, 22, 51}],
 bottom, right, left, ellipse20]
```

Out[963]=



As was done for the θ=40° line, we can do the same for θ=20°

The θ = 20 ° elliptical path hits the right wall at ϕ=24.5611°, hence no further wires will be crossed after this angle

In[964]:=

In[965]:=
```
Solve[Sqrt[a_20degree^2 (1 - y_20degree^2/b_20degree^2)] - Δa_20degree ==
    Cot[29.5 °] y_20degree + .09156 && ϕ > .1 && ϕ < 30, ϕ]
```

Out[965]= {{ϕ → 24.5611}}

In[966]:=
```
Degree20LineRight = Sort[Table[
    {ϕ /. NSolve[Sqrt[a_20degree^2 (1 - y_20degree^2/b_20degree^2)] - Δa_20degree == Tan[6 °] y_20degree +
          x0forWireMiddles[number] && ϕ > .01 && ϕ < 30 , ϕ]}, {number, 33, 48}]]
```

Out[966]=
```
{{{4.51922}}, {{7.21621}}, {{9.30026}}, {{11.0575}}, {{12.6025}},
  {{13.9946}}, {{15.2697}}, {{16.4512}}, {{17.5554}}, {{18.5943}},
  {{19.577}}, {{20.5105}}, {{21.4003}}, {{22.2512}}, {{23.0667}}, {{23.8501}}}
```

In[967]:=
```
ϕ /. Solve[Sqrt[a_20degree^2 (1 - y_20degree^2/b_20degree^2)] - Δa_20degree ==
   -Tan[6 °] y_20degree + x0forWireMiddles[49] && ϕ > .1 && ϕ < 30 , ϕ]
```

Out[967]= {0.595741, 4.24005}

In[968]:=
```
Degree20LineLeft = Sort[Table[
  {ϕ /. Solve[Sqrt[a_20degree^2 (1 - y_20degree^2/b_20degree^2)] - Δa_20degree == -Tan[6 °] y_20degree +
      x0forWireMiddles[number] && ϕ > .1 && ϕ < 30 , ϕ]}, {number, 38, 48}]]
```

Out[968]=
```
{{{9.31161}}, {{11.9648}}, {{14.0045}}, {{15.7171}}, {{17.2168}},
 {{18.5633}}, {{19.7922}}, {{20.9271}}, {{21.9843}}, {{22.9756}}, {{23.9103}}}
```

In[969]:=
```
Degree20LineLeft = Prepend[Degree20LineLeft, {{4.240053353652899`}}]
```

Out[969]=
```
{{{4.24005}}, {{9.31161}}, {{11.9648}}, {{14.0045}}, {{15.7171}}, {{17.2168}},
 {{18.5633}}, {{19.7922}}, {{20.9271}}, {{21.9843}}, {{22.9756}}, {{23.9103}}}
```

In[970]:=
```
Degree20LineLeft = Prepend[Degree20LineLeft, {{0.5957412339502922`}}]
```

Out[970]=
```
{{{0.595741}}, {{4.24005}}, {{9.31161}}, {{11.9648}},
 {{14.0045}}, {{15.7171}}, {{17.2168}}, {{18.5633}},
 {{19.7922}}, {{20.9271}}, {{21.9843}}, {{22.9756}}, {{23.9103}}}
```

In[971]:=
```
Degree20LineLeft = Prepend[Degree20LineLeft, {{0}}]
```

Out[971]=
```
{{{0}}, {{0.595741}}, {{4.24005}}, {{9.31161}},
 {{11.9648}}, {{14.0045}}, {{15.7171}}, {{17.2168}}, {{18.5633}},
 {{19.7922}}, {{20.9271}}, {{21.9843}}, {{22.9756}}, {{23.9103}}}
```

In[972]:=
```
Degree20LineLeft = -1 * Degree20LineLeft;
```

In[973]:=
```
Degree20Line = Union[Degree20LineLeft, Degree20LineRight];
```

In[974]:=
```
TableOfValues20a =
 Prepend[Replace[Degree20Line, {x_List} :> x, {0, -1}], {"ϕ(degrees)"}]
```

Out[974]=
```
{{ϕ(degrees)}, {-23.9103}, {-22.9756}, {-21.9843}, {-20.9271},
 {-19.7922}, {-18.5633}, {-17.2168}, {-15.7171}, {-14.0045}, {-11.9648},
 {-9.31161}, {-4.24005}, {-0.595741}, {0}, {4.51922}, {7.21621}, {9.30026},
 {11.0575}, {12.6025}, {13.9946}, {15.2697}, {16.4512}, {17.5554},
 {18.5943}, {19.577}, {20.5105}, {21.4003}, {22.2512}, {23.0667}, {23.8501}}
```

In[975]:=
```
TableOfValues20b =
 MapThread[Prepend, {TableOfValues20a, {"Crossing", -13, -12, -11, -10, -9, -8, -7,
    -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16}}]
```

Out[975]=
```
{{Crossing, ϕ(degrees)}, {-13, -23.9103}, {-12, -22.9756}, {-11, -21.9843},
 {-10, -20.9271}, {-9, -19.7922}, {-8, -18.5633}, {-7, -17.2168}, {-6, -15.7171},
 {-5, -14.0045}, {-4, -11.9648}, {-3, -9.31161}, {-2, -4.24005}, {-1, -0.595741},
 {0, 0}, {1, 4.51922}, {2, 7.21621}, {3, 9.30026}, {4, 11.0575}, {5, 12.6025},
 {6, 13.9946}, {7, 15.2697}, {8, 16.4512}, {9, 17.5554}, {10, 18.5943}, {11, 19.577},
 {12, 20.5105}, {13, 21.4003}, {14, 22.2512}, {15, 23.0667}, {16, 23.8501}}
```

In[976]:=
```
n
```

Out[976]= 48.9346

```
In[977]:= TableOfValues20c = MapThread[Append,
   {TableOfValues20a, {"Wire Number", 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49,
     49, 48.9346, 48, 47, 46, 45, 44, 43, 42, 41, 40, 39, 38, 37, 36, 35, 34, 33}}]
```

```
Out[977]= {{ϕ(degrees), Wire Number}, {-23.9103, 38}, {-22.9756, 39},
  {-21.9843, 40}, {-20.9271, 41}, {-19.7922, 42}, {-18.5633, 43},
  {-17.2168, 44}, {-15.7171, 45}, {-14.0045, 46}, {-11.9648, 47},
  {-9.31161, 48}, {-4.24005, 49}, {-0.595741, 49}, {0, 48.9346}, {4.51922, 48},
  {7.21621, 47}, {9.30026, 46}, {11.0575, 45}, {12.6025, 44}, {13.9946, 43},
  {15.2697, 42}, {16.4512, 41}, {17.5554, 40}, {18.5943, 39}, {19.577, 38},
  {20.5105, 37}, {21.4003, 36}, {22.2512, 35}, {23.0667, 34}, {23.8501, 33}}
```

```
In[978]:= Table20degree = Labeled[Grid[TableOfValues20b, Frame → All],
   "Crossing Number as a function of ϕ", Top]
```

Out[978]=

Crossing Number as a function of ϕ

Crossing	ϕ(degrees)
-13	-23.9103
-12	-22.9756
-11	-21.9843
-10	-20.9271
-9	-19.7922
-8	-18.5633
-7	-17.2168
-6	-15.7171
-5	-14.0045
-4	-11.9648
-3	-9.31161
-2	-4.24005
-1	-0.595741
0	0
1	4.51922
2	7.21621
3	9.30026
4	11.0575
5	12.6025
6	13.9946
7	15.2697
8	16.4512
9	17.5554
10	18.5943
11	19.577
12	20.5105
13	21.4003
14	22.2512
15	23.0667
16	23.8501

```
In[979]:= Table20degreeWires =
  Labeled[Grid[TableOfValues20c, Frame → All], "Wire Number as a function of ϕ", Top]
```

Wire Number as a function of ϕ

Out[979]=

ϕ (degrees)	Wire Number
-23.9103	38
-22.9756	39
-21.9843	40
-20.9271	41
-19.7922	42
-18.5633	43
-17.2168	44
-15.7171	45
-14.0045	46
-11.9648	47
-9.31161	48
-4.24005	49
-0.595741	49
0	48.9346
4.51922	48
7.21621	47
9.30026	46
11.0575	45
12.6025	44
13.9946	43
15.2697	42
16.4512	41
17.5554	40
18.5943	39
19.577	38
20.5105	37
21.4003	36
22.2512	35
23.0667	34
23.8501	33

In[980]:=
```
ClearAll[θ];
```

In[981]:=
```
θ = 17.5;
```

In[1011]:=
```
ClearAll[θ];
```

In[1012]:=
```
θ = 15;
```

In[1013]:=
```
Δa_15degree = (2.52934271645 Sin[θ °]) / 2 (Csc[65 ° - θ °] - Csc[115 ° - θ °]);
e_15degree = Sin[25 °] / Cos[θ °];
a_15degree = (2.52934271645 Sin[θ °]) / 2 (Csc[65 ° - θ °] + Csc[115 ° - θ °]);
rD1_15degree = (a_15degree e_15degree - Δa_15degree) Tan[65 °] Cos[θ °];
rD2_15degree = (a_15degree e_15degree + Δa_15degree) Tan[65 °] Cos[θ °];
xD1_15degree = rD1_15degree Cos[ϕ °];
yD1_15degree = rD1_15degree Sin[ϕ °];
zD1_15degree = rD1_15degree Cot[θ °];
xD2_15degree = rD2_15degree Cos[ϕ °];
yD2_15degree = rD2_15degree Sin[ϕ °];
zD2_15degree = rD2_15degree Cot[θ °];
xP_15degree = (2.52934271645 Cos[ϕ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
yP_15degree = (2.52934271645 Sin[ϕ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
zP_15degree = (2.52934271645 Cot[θ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
x1_15degree =
  (rD2_15degree^2 - rD1_15degree^2 + Cot[θ °]^2 (rD2_15degree^2 - rD1_15degree^2) -
      2 xP_15degree (xD2_15degree - xD1_15degree) - 2 yP_15degree
       (yD2_15degree - yD1_15degree) - 2 zP_15degree (zD2_15degree - zD1_15degree)) /
    (4 a_15degree e_15degree) - a_15degree e_15degree ;
x_15degree = x1_15degree - Δa_15degree + a_15degree e_15degree // N;
n_15degree = -957.412 / (Tan[θ °] + 2.14437) + 430.626;
D2P_15degree = √((xD2_15degree - xP_15degree)^2 +
      (yD2_15degree - yP_15degree)^2 + (zD2_15degree - zP_15degree)^2) // N;
D1P_15degree = √((xP_15degree - xD1_15degree)^2 + (yP_15degree - yD1_15degree)^2 +
      (zP_15degree - zD1_15degree)^2) // N;
y_15degree = Sqrt[D1P_15degree ^ 2 - x1_15degree ^ 2] // N;
b_15degree = a_15degree (1 - e_15degree);
```

In[1030]:=
```
n = -957.412 / (Tan[θ °] + 2.14437) + 430.626
```

Out[1030]= 33.7415

In[1031]:=
```
θlower = 4.49876 + 0.293001 ( n1) + 0.000679074 (n1)^2 - 3.57132*^-6 (n1)^3 /. n1 → 33
```

Out[1031]= 14.779

In[1032]:=
```
θupper = 4.49876 + 0.293001 (n1) + 0.000679074 (n1)^2 - 3.57132*^-6 (n1)^3 /. n1 → 34
```

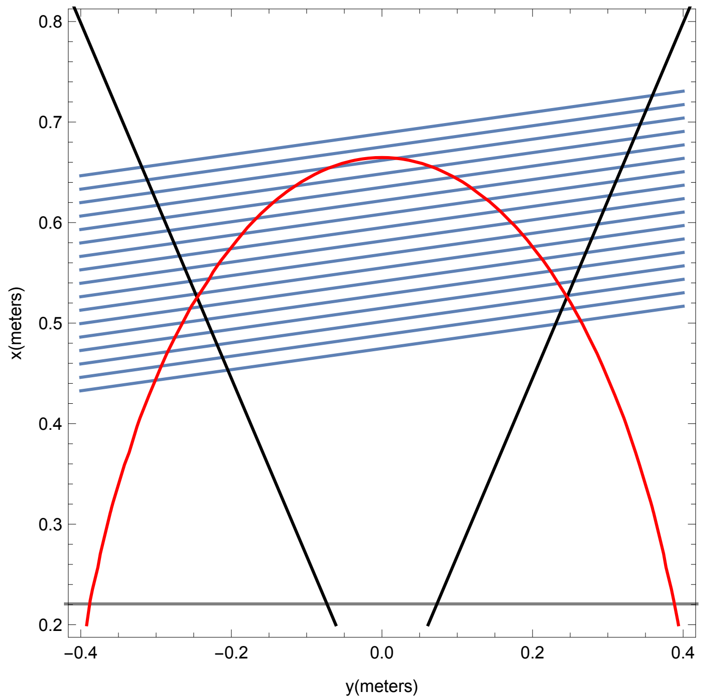
Out[1032]= 15.1054

We can define the xy position on the DC plane as a function of ϕ for θ=15°

In[1033]:=
```
ellipse15 = ContourPlot[(x_15degree + Δa_15degree)^2 / a_15degree^2 + y_15degree^2 / b_15degree^2 == 1,
   {y_15degree, -1, 1}, {x_15degree, .2, 1.8},
   FrameLabel → {"y(meters)", "x(meters)"}, ContourStyle → Red];
```

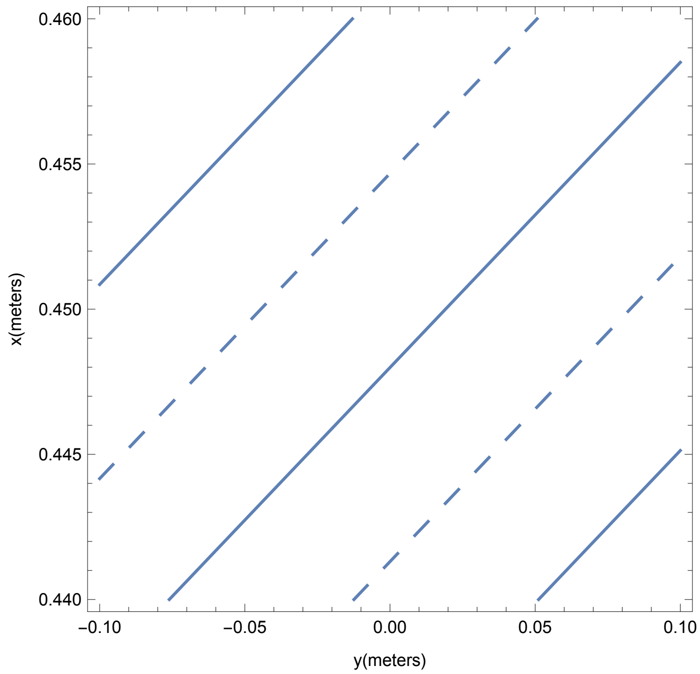
In[1034]:=
```
Show[Table[ContourPlot[xWire[number] == Tan[6 °] yWire[number] + x0forWires[number],
    {yWire[number], -0.4, 0.4}, {xWire[number], .2, .8},
    FrameLabel → {"y(meters)", "x(meters)"}],
  {number, 19, 35}], bottom, right, left, ellipse15]
```

Out[1034]=



In[1035]:=
```
Show[Table[ContourPlot[xWire[number] == Tan[6 °] yWire[number] + x0forWires[number],
    {yWire[number], -0.1, 0.1}, {xWire[number], .44, .46},
    FrameLabel → {"y(meters)", "x(meters)"}], {number, 1, 35}], Table[
  ContourPlot[xWire[number2] == Tan[6 °] yWire[number2] + x0forWireMiddles[number2],
    {yWire[number2], -0.1, 0.1}, {xWire[number2], .44, .46},
    ContourStyle → {Dashing[Large]}], {number2, 5, 18}],
 bottom, right, left, ellipse15]
```

Out[1035]=



In[1036]:=
$$\text{Solve}\left[\sqrt{\text{a\_15degree}^2\left(1-\frac{\text{y\_15degree}^2}{\text{b\_15degree}^2}\right)}-\Delta\text{a\_15degree}==\text{Cot}[29.5\,°]\ \text{y\_15degree}+.09156\ \&\&\ \phi>.1\ \&\&\ \phi<30,\ \phi\right]$$

Out[1036]= {{ϕ → 23.8517}}

In[1037]:=
$$\text{Degree15LineRight}=\text{Sort}\left[\text{Table}\left[\left\{\phi\ /.\ \text{Solve}\left[\sqrt{\text{a\_15degree}^2\left(1-\frac{\text{y\_15degree}^2}{\text{b\_15degree}^2}\right)}-\Delta\text{a\_15degree}==\text{Tan}[6\,°]\ \text{y\_15degree}+\text{x0forWireMiddles}[\text{number}]\ \&\&\ \phi>.01\ \&\&\ \phi<30,\ \phi\right]\right\},\ \{\text{number},22,33\}\right]\right]$$

```
Out[1037]= {{{4.46228}}, {{7.84575}}, {{10.3484}}, {{12.4213}}, {{14.2247}}, {{15.8378}},
  {{17.3069}}, {{18.6615}}, {{19.9218}}, {{21.1028}}, {{22.2152}}, {{23.2678}}}
```

In[1038]:=
$$\text{Degree15LineLeft}=\text{Sort}\left[\text{Table}\left[\left\{\phi\ /.\ \text{Solve}\left[\sqrt{\text{a\_15degree}^2\left(1-\frac{\text{y\_15degree}^2}{\text{b\_15degree}^2}\right)}-\Delta\text{a\_15degree}==-\text{Tan}[6\,°]\ \text{y\_15degree}+\text{x0forWireMiddles}[\text{number}]\ \&\&\ \phi>.01\ \&\&\ \phi<30,\ \phi\right]\right\},\ \{\text{number},26,33\}\right]\right]$$

```
Out[1038]= {{{9.21376}}, {{12.5399}}, {{14.9844}}, {{16.9981}},
  {{18.7414}}, {{20.2935}}, {{21.7005}}, {{22.992}}}
```

```
In[1039]:= Degree15LineLeft = -1 Degree15LineLeft
```

```
Out[1039]= {{{-9.21376}}, {{-12.5399}}, {{-14.9844}}, {{-16.9981}},
  {{-18.7414}}, {{-20.2935}}, {{-21.7005}}, {{-22.992}}}
```

```
In[1040]:= Degree15LineLeft = Prepend[Degree15LineLeft, {{0}}]

Out[1040]= {{{0}}, {{-9.21376}}, {{-12.5399}}, {{-14.9844}},
  {{-16.9981}}, {{-18.7414}}, {{-20.2935}}, {{-21.7005}}, {{-22.992}}}

In[1041]:= Degree15LineLeft

Out[1041]= {{{0}}, {{-9.21376}}, {{-12.5399}}, {{-14.9844}},
  {{-16.9981}}, {{-18.7414}}, {{-20.2935}}, {{-21.7005}}, {{-22.992}}}

In[1042]:= Degree15Line = Union[Degree15LineLeft, Degree15LineRight]

Out[1042]= {{{-22.992}}, {{-21.7005}}, {{-20.2935}}, {{-18.7414}}, {{-16.9981}},
  {{-14.9844}}, {{-12.5399}}, {{-9.21376}}, {{0}}, {{4.46228}}, {{7.84575}},
  {{10.3484}}, {{12.4213}}, {{14.2247}}, {{15.8378}}, {{17.3069}},
  {{18.6615}}, {{19.9218}}, {{21.1028}}, {{22.2152}}, {{23.2678}}}

In[1043]:= TableOfValues15a =
  Prepend[Replace[Degree15Line, {x_List} :→ x, {0, -1}], {"ϕ(degrees)"}];
```

We can add the number of successive crossings

```
In[1044]:= TableOfValues15b =
  MapThread[Prepend, {TableOfValues15a, {"Crossing", -8, -7, -6, -5, -4,
     -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12}}];

In[1045]:= n

Out[1045]= 33.7415

In[1046]:= TableOfValues15c =
  MapThread[Append, {TableOfValues15a, {"Wire Number", 26, 27, 28, 29, 30,
     31, 32, 33, 33.7415, 33, 32, 31, 30, 29, 28, 27, 26, 25, 24, 23, 22}}]

Out[1046]= {{ϕ(degrees), Wire Number}, {-22.992, 26}, {-21.7005, 27},
  {-20.2935, 28}, {-18.7414, 29}, {-16.9981, 30}, {-14.9844, 31},
  {-12.5399, 32}, {-9.21376, 33}, {0, 33.7415}, {4.46228, 33}, {7.84575, 32},
  {10.3484, 31}, {12.4213, 30}, {14.2247, 29}, {15.8378, 28}, {17.3069, 27},
  {18.6615, 26}, {19.9218, 25}, {21.1028, 24}, {22.2152, 23}, {23.2678, 22}}

In[1047]:= Table15degree = Labeled[Grid[TableOfValues15b, Frame → All],
  "Crossing Number as a function of ϕ", Top]
```

Crossing Number as a function of ϕ

Out[1047]=

Crossing	ϕ(degrees)
-8	-22.992
-7	-21.7005
-6	-20.2935
-5	-18.7414
-4	-16.9981
-3	-14.9844
-2	-12.5399
-1	-9.21376
0	0
1	4.46228
2	7.84575
3	10.3484
4	12.4213
5	14.2247
6	15.8378
7	17.3069
8	18.6615
9	19.9218
10	21.1028
11	22.2152
12	23.2678

In[1048]:=
```
Table15degreeWire = Labeled[Grid[TableOfValues15c, Frame → All],
  "Midpoint Wire Number as a function of ϕ", Top]
```

Midpoint Wire Number as a function of ϕ

Out[1048]=

ϕ(degrees)	Wire Number
-22.992	26
-21.7005	27
-20.2935	28
-18.7414	29
-16.9981	30
-14.9844	31
-12.5399	32
-9.21376	33
0	33.7415
4.46228	33
7.84575	32
10.3484	31
12.4213	30
14.2247	29
15.8378	28
17.3069	27
18.6615	26
19.9218	25
21.1028	24
22.2152	23
23.2678	22

In[1049]:=
```
ClearAll[θ];
```

In[1050]:=
```
θ = 12.5;
```

In[1395]:=
```
ClearAll[θ];
```

In[1670]:=
```
θ = 10;
```

All of the conditions dependent on θ and ϕ, where ϕ is left as a variable

In[1671]:=
```
Δa_10degree = (2.52934271645 Sin[θ °]) / 2 (Csc[65 ° - θ °] - Csc[115 ° - θ °]);
e_10degree = Sin[25 °] / Cos[θ °];
a_10degree = (2.52934271645 Sin[θ °]) / 2 (Csc[65 ° - θ °] + Csc[115 ° - θ °]);
rD1_10degree = (a_10degree e_10degree - Δa_10degree) Tan[65 °] Cos[θ °];
rD2_10degree = (a_10degree e_10degree + Δa_10degree) Tan[65 °] Cos[θ °];
xD1_10degree = rD1_10degree Cos[ϕ °];
yD1_10degree = rD1_10degree Sin[ϕ °];
zD1_10degree = rD1_10degree Cot[θ °];
xD2_10degree = rD2_10degree Cos[ϕ °];
yD2_10degree = rD2_10degree Sin[ϕ °];
zD2_10degree = rD2_10degree Cot[θ °];
xP_10degree = (2.52934271645 Cos[ϕ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
yP_10degree = (2.52934271645 Sin[ϕ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
zP_10degree = (2.52934271645 Cot[θ °]) / (Cot[θ °] + Cos[ϕ °] Cot[65 °]);
x1_10degree =
  (rD2_10degree^2 - rD1_10degree^2 + Cot[θ °]^2 (rD2_10degree^2 - rD1_10degree^2) -
      2 xP_10degree (xD2_10degree - xD1_10degree) - 2 yP_10degree
       (yD2_10degree - yD1_10degree) - 2 zP_10degree (zD2_10degree - zD1_10degree)) /
    (4 a_10degree e_10degree) - a_10degree e_10degree;
x_10degree = x1_10degree - Δa_10degree + a_10degree e_10degree // N;
n_10degree = -957.412 / (Tan[θ °] + 2.14437) + 430.626;
D2P_10degree = √((xD2_10degree - xP_10degree)^2 +
      (yD2_10degree - yP_10degree)^2 + (zD2_10degree - zP_10degree)^2) // N;
D1P_10degree = √((xP_10degree - xD1_10degree)^2 + (yP_10degree - yD1_10degree)^2 +
      (zP_10degree - zD1_10degree)^2) // N;
y_10degree = Sqrt[D1P_10degree^2 - x1_10degree^2] // N;
b_10degree = a_10degree (1 - e_10degree);
```

In[1101]:=
$$n = \frac{-957.412}{\mathrm{Tan}[\theta °] + 2.14437} + 430.626$$

Out[1101]= 18.0724

In[1102]:=
```
θlower = 4.49876 + 0.293001 ( n1) + 0.000679074 (n1)^2 - 3.57132*^-6 (n1)^3 /. n1 → 18
```

Out[1102]= 9.97197

In[1103]:=
```
θupper = 4.49876 + 0.293001 (n1) + 0.000679074 (n1)^2 - 3.57132*^-6 (n1)^3 /. n1 → 19
```

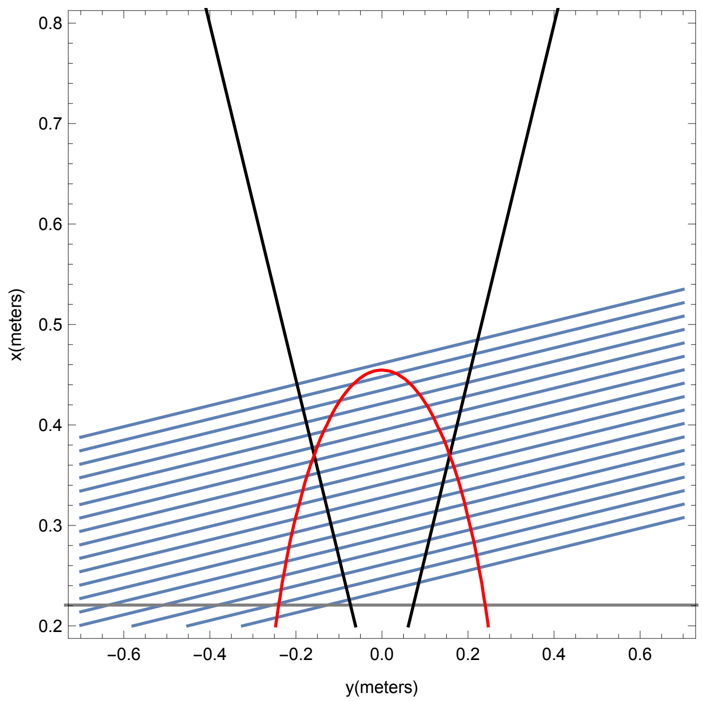
Out[1103]= 10.2864

We can define the xy position on the DC plane as a function of ϕ for θ=10°

In[1104]:=
```
ellipse10 = ContourPlot[(x_10degree + Δa_10degree)^2/a_10degree^2 + y_10degree^2/b_10degree^2 == 1,
   {y_10degree, -1, 1}, {x_10degree, .2, 1.8},
   FrameLabel → {"y(meters)", "x(meters)"}, ContourStyle → Red];
```

In[1105]:=
```
Show[Table[ContourPlot[xWire[number] == Tan[6 °] yWire[number] + x0forWires[number],
   {yWire[number], -0.7, 0.7}, {xWire[number], .2, .8},
   FrameLabel → {"y(meters)", "x(meters)"}],
  {number, 1, 18}], bottom, right, left, ellipse10]
```

Out[1105]=

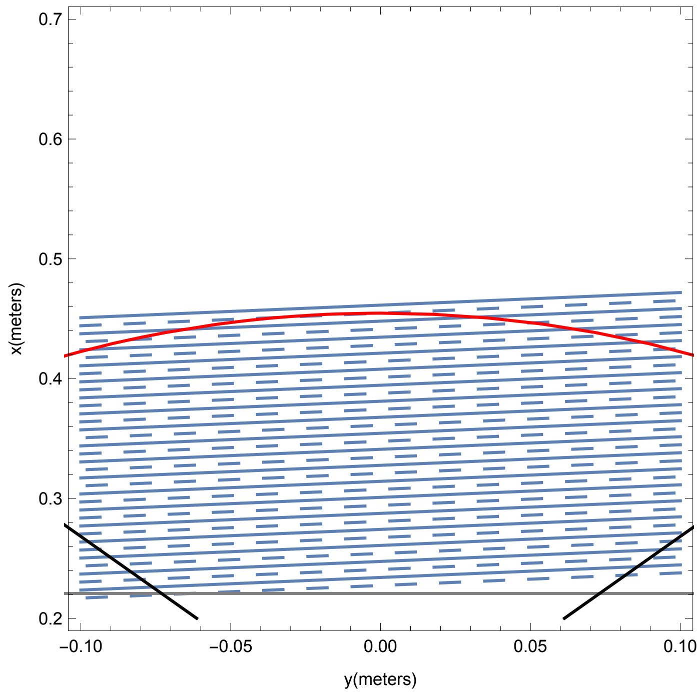


In[1413]:=
```
Solve[Sqrt[a_10degree^2 (1 - y_10degree^2/b_10degree^2)] - Δa_10degree ==
   Cot[29.5 °] y_10degree + .09156 && ϕ > .1 && ϕ < 30, ϕ]
```

Out[1413]= {{ϕ → 22.3762}}

In[1107]:=
```
Show[Table[
  ContourPlot[xWire[number] == Tan[6 °] yWire[number] + x0forWireMiddles[number],
   {yWire[number], -0.1, 0.1}, {xWire[number], .2, .7},
   FrameLabel → {"y(meters)", "x(meters)"},
   ContourStyle → {Dashing[Large]}], {number, 1, 18}],
 Table[ContourPlot[xWire[number2] == Tan[6 °] yWire[number2] + x0forWires[number2],
   {yWire[number2], -0.1, 0.1}, {xWire[number2], .2, .7},
   FrameLabel → {"y(meters)", "x(meters)"}],
  {number2, 1, 18}], bottom, right, left, ellipse10]
```

Out[1107]=



In[1687]:=
```
Degree10LineRight = Sort[Table[
  {ϕ /. Solve[Sqrt[a_10degree^2 (1 - y_10degree^2/b_10degree^2)] - Δa_10degree == Tan[6 °] y_10degree +
      x0forWireMiddles[number] && ϕ > .01 && ϕ < 30, ϕ]}, {number, 11, 18}]]
```

Out[1687]=
```
{{{0.045343}}, {{7.07936}}, {{10.7465}}, {{13.5653}},
 {{15.9292}}, {{17.9949}}, {{19.8442}}, {{21.5257}}}
```

In[1688]:=
```
Degree10LineLeft = Sort[Table[
  {ϕ /. Solve[Sqrt[a_10degree^2 (1 - y_10degree^2/b_10degree^2)] - Δa_10degree == -Tan[6 °] y_10degree +
      x0forWireMiddles[number] && ϕ > .01 && ϕ < 30, ϕ]}, {number, 13, 18}]]
```

Out[1688]=
```
{{{4.75099}}, {{11.7028}}, {{15.2855}}, {{18.0175}}, {{20.2921}}, {{22.2662}}}
```

In[1689]:=
```
Degree10LineLeft = -1 Degree10LineLeft
```

Out[1689]=
```
{{{-4.75099}}, {{-11.7028}}, {{-15.2855}},
 {{-18.0175}}, {{-20.2921}}, {{-22.2662}}}
```

In[1690]:=
```
Degree10LineLeft = Prepend[Degree10LineLeft, {{0}}]
```

Out[1690]=
```
{{{0}}, {{-4.75099}}, {{-11.7028}},
 {{-15.2855}}, {{-18.0175}}, {{-20.2921}}, {{-22.2662}}}
```

In[1691]:=
```
Degree10Line = Union[Degree10LineLeft, Degree10LineRight]
```

Out[1691]=
```
{{{-22.2662}}, {{-20.2921}}, {{-18.0175}}, {{-15.2855}}, {{-11.7028}},
 {{-4.75099}}, {{0}}, {{0.045343}}, {{7.07936}}, {{10.7465}},
 {{13.5653}}, {{15.9292}}, {{17.9949}}, {{19.8442}}, {{21.5257}}}
```

In[1692]:=
```
TableOfValues10a =
  Prepend[Replace[Degree10Line, {x_List} :→ x, {0, -1}], {"ϕ(degrees)"}];
```

We can add the number of successive crossings

In[1420]:=
```
TableOfValues10b = MapThread[Prepend,
   {TableOfValues10a, {"Crossing", -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8}}];
```

In[1421]:=
```
n
```

Out[1421]=
```
18.0724
```

In[1693]:=
```
TableOfValues10c = MapThread[Append, {TableOfValues10a,
    {"Wire Number", 13, 14, 15, 16, 17, 18, 18.07235, 18, 17, 16, 15, 14, 13, 12, 11}}];
```

In[1423]:=
```
Table10degree = Labeled[Grid[TableOfValues10b, Frame → All],
  "Crossing Number as a function of ϕ", Top]
```

Out[1423]=

Crossing Number as a function of ϕ

Crossing	ϕ(degrees)
-6	-22.2662
-5	-20.2921
-4	-18.0175
-3	-15.2855
-2	-11.7028
-1	-4.75099
0	0
1	0.045343
2	7.07936
3	10.7465
4	13.5653
5	15.9292
6	17.9949
7	19.8442
8	21.5257

In[1424]:=
```
Table10degreeWire = Labeled[Grid[TableOfValues10c, Frame → All],
  "Midpoint Wire Number as a function of ϕ", Top]
```

Midpoint Wire Number as a function of ϕ

Out[1424]=

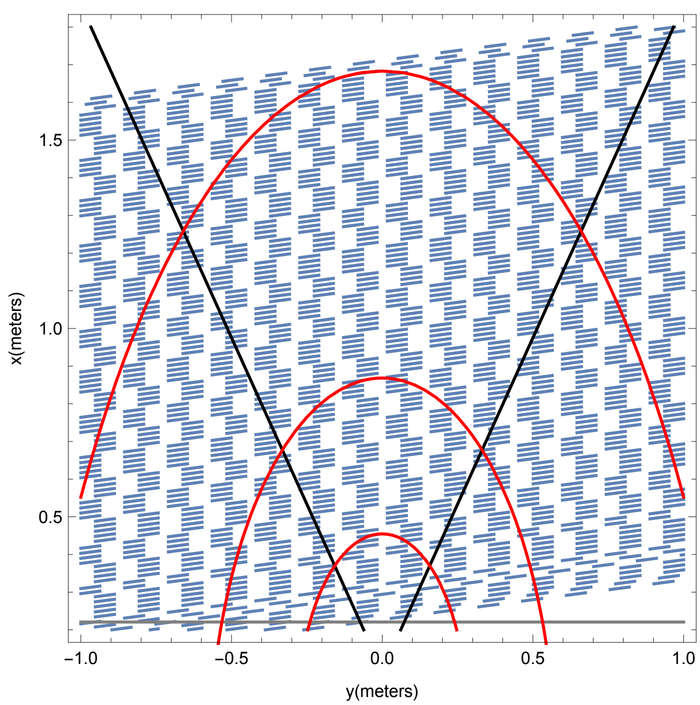
ϕ(degrees)	Wire Number
-22.2662	13
-20.2921	14
-18.0175	15
-15.2855	16
-11.7028	17
-4.75099	18
0	18.0724
0.045343	18
7.07936	17
10.7465	16
13.5653	15
15.9292	14
17.9949	13
19.8442	12
21.5257	11

We can examine the ellipses for θ=20°, 30°, and 40° in the DC plane as they cross the wires

In[1119]:=
```
θ
```
Out[1119]= 10

In[1120]:=
```
Show[Table[
  ContourPlot[xWire[number2] == Tan[6 °] yWire[number2] + x0forWireMiddles[number2],
   {yWire[number2], -1, 1}, {xWire[number2], .2, 1.8},
   FrameLabel → {"y(meters)", "x(meters)"},
   ContourStyle → {Dashing[Large]}], {number2, 1, 112}]
 , bottom, right, left, ellipse10, ellipse20, ellipse40]
```

Out[1120]=



In[1121]:=

We can find the angle ϕ where the elliptical xy path for θ=40° crosses the midway point in between wires. This corresponds to hits at a constant θ occurring on different wires. The elliptical path hits the right and left wall at ϕ = ±24.9252 and will not cross additional wires lower than 78 in the 1st quadrant. On the left hand side, the limit is lower since the slope of this plane is positive.

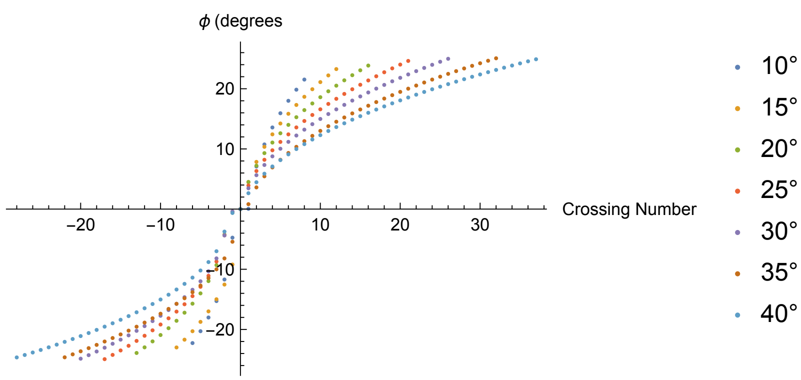
In[1122]:=

Using the points where the elliptical path cross wires measured in ϕ degrees

In[1425]:=
```
CrossingData10 = Drop[TableOfValues10b, 1];
CrossingData15 = Drop[TableOfValues15b, 1];
CrossingData20 = Drop[TableOfValues20b, 1];
CrossingData25 = Drop[TableOfValues25b, 1];
CrossingData30 = Drop[TableOfValues30b, 1];
CrossingData35 = Drop[TableOfValues35b, 1];
CrossingData40 = Drop[TableOfValues40b, 1];
```

In[1130]:=
```
ListPlot[{CrossingData10, CrossingData15, CrossingData20,
  CrossingData25, CrossingData30, CrossingData35, CrossingData40},
 AxesLabel → {"Crossing Number", "ϕ (degrees"},
 PlotLegends → {"10°", "15°", "20°", "25°", "30°", "35°", "40°"}]
```

Out[1130]=



In[1694]:=
```
WireData10 = Drop[TableOfValues10c, 1]
WireData125 = Drop[TableOfValues125c, 1]
WireData15 = Drop[TableOfValues15c, 1];
WireData175 = Drop[TableOfValues175c, 1]
WireData20 = Drop[TableOfValues20c, 1];
WireData25 = Drop[TableOfValues25c, 1];
WireData30 = Drop[TableOfValues30c, 1];
WireData35 = Drop[TableOfValues35c, 1];
WireData40 = Drop[TableOfValues40c, 1];
```

Out[1694]= {{-22.2662, 13}, {-20.2921, 14}, {-18.0175, 15}, {-15.2855, 16}, {-11.7028, 17}, {-4.75099, 18}, {0, 18.0724}, {0.045343, 18}, {7.07936, 17}, {10.7465, 16}, {13.5653, 15}, {15.9292, 14}, {17.9949, 13}, {19.8442, 12}, {21.5257, 11}}

Out[1695]= Drop[TableOfValues125c, 1]

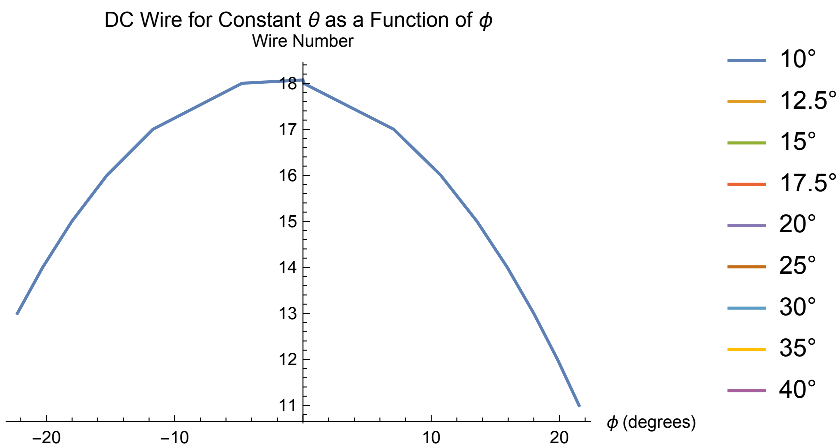
Out[1697]= Drop[TableOfValues175c, 1]

In[1703]:= WireData10

Out[1703]= {{-22.2662, 13}, {-20.2921, 14}, {-18.0175, 15}, {-15.2855, 16}, {-11.7028, 17}, {-4.75099, 18}, {0, 18.0724}, {0.045343, 18}, {7.07936, 17}, {10.7465, 16}, {13.5653, 15}, {15.9292, 14}, {17.9949, 13}, {19.8442, 12}, {21.5257, 11}}

In[1704]:=
```
ListLinePlot[{WireData10, WireData125, WireData15, WireData175,
  WireData20, WireData25, WireData30, WireData35, WireData40},
 AxesLabel → {"ϕ (degrees)", "Wire Number"},
 PlotLabel → "DC Wire for Constant θ as a Function of ϕ",
 PlotLegends → {"10°", "12.5°", "15°", "17.5°", "20°", "25°", "30°", "35°", "40°"}]
```

Out[1704]=



We can find an equation that gives the wire midpoint crossing as a function of ϕ

In[1141]:= ClearAll[A125, a125, b125]

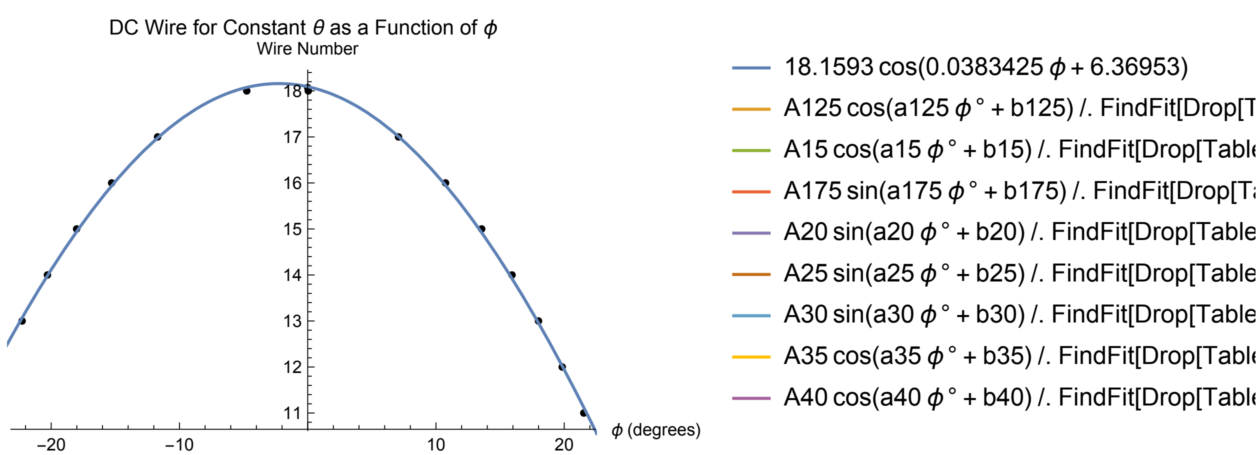
In[1705]:=
```
Fit10form1 = A10 Cos[a10 ϕ ° + b10]
Fit125form1 = A125 Cos[a125 ϕ ° + b125]
Fit15form1 = A15 Cos[a15 ϕ ° + b15];
Fit175form1 = A175 Sin[a175 ϕ ° + b175]
Fit20form1 = A20 Sin[a20 ϕ ° + b20];
Fit25form1 = A25 Sin[a25 ϕ ° + b25];
Fit30form1 = A30 Sin[a30 ϕ ° + b30];
Fit35form1 = A35 Cos[a35 ϕ ° + b35]
Fit40form1 = A40 Cos[a40 ϕ ° + b40];
```

Out[1705]= A10 Cos[b10 + a10 ° ϕ]

Out[1706]= A125 Cos[b125 + a125 ° ϕ]

```
Out[1708]= A175 Sin[b175 + a175 ° ϕ]

Out[1712]= A35 Cos[b35 + a35 ° ϕ]

In[1714]:= Fit10degree1 = FindFit[WireData10, {Fit10form1}, {A10, a10, b10}, ϕ]
           Fit125degree1 = FindFit[WireData125, {Fit125form1}, {A125, a125, b125}, ϕ]
           Fit15degree1 = FindFit[WireData15, {Fit15form1}, {A15, a15, b15}, ϕ];
           Fit175degree1 = FindFit[WireData175, {Fit175form1}, {A175, a175, b175}, ϕ]
           Fit20degree1 = FindFit[WireData20, {Fit20form1}, {A20, a20, b20}, ϕ];
           Fit25degree1 = FindFit[WireData25, {Fit25form1}, {A25, a25, b25}, ϕ];
           Fit30degree1 = FindFit[WireData30, {Fit30form1}, {A30, a30, b30}, ϕ];
           Fit35degree1 = FindFit[WireData35, {Fit35form1}, {A35, a35, b35}, ϕ]
           Fit40degree1 = FindFit[WireData40, {Fit40form1}, {A40, a40, b40}, ϕ];

Out[1714]= {A10 → 18.1593, a10 → -2.19687, b10 → -6.36953}

Out[1715]= FindFit[Drop[TableOfValues125c, 1], {A125 Cos[b125 + a125 ° ϕ]}, {A125, a125, b125}, ϕ]

Out[1717]= FindFit[Drop[TableOfValues175c, 1], {A175 Sin[b175 + a175 ° ϕ]}, {A175, a175, b175}, ϕ]

Out[1721]= FindFit[Drop[TableOfValues35c, 1], {A35 Cos[b35 + a35 ° ϕ]}, {A35, a35, b35}, ϕ]

In[1723]:= Show[ListPlot[{WireData10, WireData125, WireData15, WireData175,
              WireData20, WireData25, WireData30, WireData35, WireData40},
             PlotStyle → Black, AxesLabel → {"ϕ (degrees)", "Wire Number"},
             PlotLabel → "DC Wire for Constant θ as a Function of ϕ"],
            Plot[{Fit10form1 /. Fit10degree1, Fit125form1 /. Fit125degree1,
              Fit15form1 /. Fit15degree1, Fit175form1 /. Fit175degree1, Fit20form1 /.
               Fit20degree1, Fit25form1 /. Fit25degree1, Fit30form1 /. Fit30degree1,
              Fit35form1 /. Fit35degree1, Fit40form1 /. Fit40degree1}, {ϕ, -25, 25},
             PlotLegends → {Fit10form1 /. Fit10degree1, Fit125form1 /. Fit125degree1,
               Fit15form1 /. Fit15degree1, Fit175form1 /. Fit175degree1,
               Fit20form1 /. Fit20degree1, Fit25form1 /. Fit25degree1, Fit30form1 /.
                Fit30degree1, Fit35form1 /. Fit35degree1, Fit40form1 /. Fit40degree1}]]
```

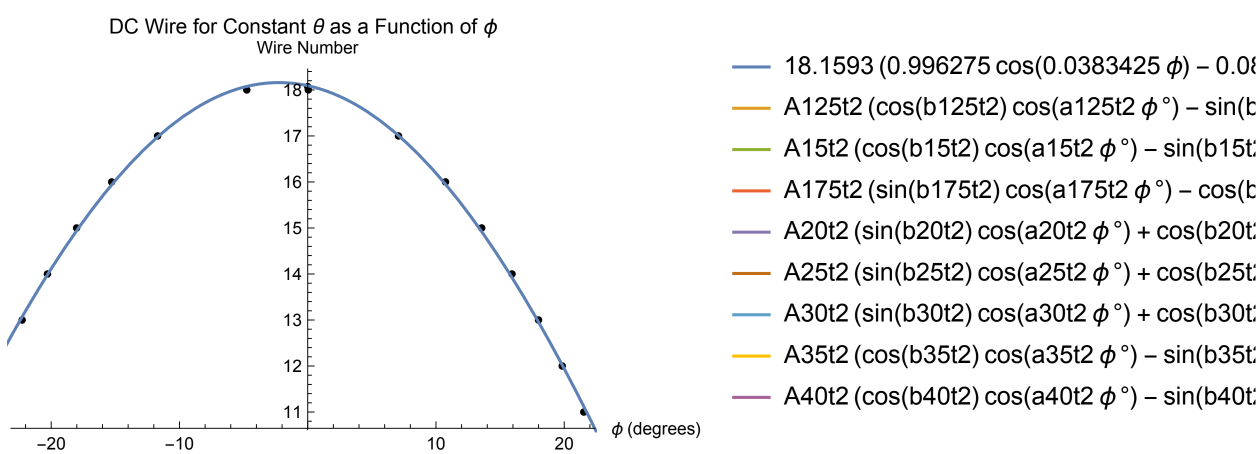
Out[1723]=



We can trig identities to rewrite the fit

In[1724]:=
```
Fit10form2 = A10t2 (Cos[a10t2 ϕ °] Cos[ b10t2] - Sin[a10t2 ϕ °] Sin[ b10t2]);
Fit125form2 = A125t2 (Cos[a125t2 ϕ ° ] Cos[b125t2] - Sin[a125t2 ϕ ° ] Sin[b125t2]);
Fit15form2 = A15t2 (Cos[a15t2 ϕ ° ] Cos[b15t2] - Sin[a15t2 ϕ ° ] Sin[b15t2]);
Fit175form2 = A175t2 (Cos[a175t2 ϕ ° ] Sin[b175t2] - Sin[a175t2 ϕ ° ] Cos[b175t2]);
Fit20form2 = A20t2 (Sin[b20t2] Cos[a20t2 ϕ ° ] + Cos[b20t2] Sin[a20t2 ϕ ° ]);
Fit25form2 = A25t2 (Sin[a25t2 ϕ °] Cos [b25t2] + Cos[a25t2 ϕ °] Sin [b25t2]);
Fit30form2 = A30t2 (Sin[a30t2 ϕ ° ] Cos[b30t2] + Cos[a30t2 ϕ ° ] Sin[b30t2]);
Fit35form2 = A35t2 (Cos[a35t2 ϕ ° ] Cos[b35t2] - Sin[a35t2 ϕ ° ] Sin[b35t2]);
Fit40form2 = A40t2 ( Cos[a40t2 ϕ ° ] Cos[b40t2] - Sin[a40t2 ϕ ° ] Sin[b40t2]);
Fit10degree2 = FindFit[WireData10, {Fit10form2}, {A10t2, a10t2, b10t2}, ϕ];
Fit125degree2 = FindFit[WireData125, {Fit125form2}, {A125t2, a125t2, b125t2}, ϕ];
Fit15degree2 = FindFit[WireData15, {Fit15form2}, {A15t2, a15t2, b15t2}, ϕ];
Fit175degree2 = FindFit[WireData175, {Fit175form2}, {A175t2, a175t2, b175t2}, ϕ];
Fit20degree2 = FindFit[WireData20, {Fit20form2}, {A20t2, a20t2, b20t2}, ϕ];
Fit25degree2 = FindFit[WireData25, {Fit25form2}, {A25t2, a25t2, b25t2}, ϕ];
Fit30degree2 = FindFit[WireData30, {Fit30form2}, {A30t2, a30t2, b30t2}, ϕ];
Fit35degree2 = FindFit[WireData35, {Fit35form2}, {A35t2, a35t2, b35t2}, ϕ];
Fit40degree2 = FindFit[WireData40, {Fit40form2}, {A40t2, a40t2, b40t2}, ϕ];
Show[ListPlot[{WireData10, WireData125, WireData15, WireData175,
    WireData20, WireData25, WireData30, WireData35, WireData40},
   PlotStyle → Black, AxesLabel → {"ϕ (degrees)", "Wire Number"},
   PlotLabel → "DC Wire for Constant θ as a Function of ϕ"],
  Plot[{Fit10form2 /. Fit10degree2, Fit125form2 /. Fit125degree2,
    Fit15form2 /. Fit15degree2, Fit175form2 /. Fit175degree2, Fit20form2 /.
     Fit20degree2, Fit25form2 /. Fit25degree2, Fit30form2 /. Fit30degree2,
    Fit35form2 /. Fit35degree2, Fit40form2 /. Fit40degree2}, {ϕ, -25, 25},
   PlotLegends → {Fit10form2 /. Fit10degree2, Fit125form2 /. Fit125degree2,
     Fit15form2 /. Fit15degree2, Fit175form2 /. Fit175degree2,
     Fit20form2 /. Fit20degree2, Fit25form2 /. Fit25degree2, Fit30form2 /.
      Fit30degree2, Fit35form2 /. Fit35degree2, Fit40form2 /. Fit40degree2}]]
```

Out[1742]=



At ϕ=0, the condition of $n = \frac{-957}{\tan\theta° + 2.14437} + 430.626$ should be met

In[1180]:=
```
ϕ = 0;
```

In[1181]:=
```
18.15925945940476` (0.9962747171551987` Cos[0.038342535819113815` ϕ] -
   0.08623623343658383` Sin[0.038342535819113815` ϕ])
```

Out[1181]= 18.0916

In[1182]:=
```
Sin[0]
```

Out[1182]= 0

In[1743]:=
```
f[θforϕat0_] := -957.412 / (Tan[θforϕat0 °] + 2.14437) + 430.626
```

In[1744]:=
```
f[10]
```

Out[1744]= 18.0724

In[1185]:=
```
18.15925945940476` / 18.072354281152116`
```

Out[1185]= 1.00481

If we write the coefficient as a multiple of the function for θ at ϕ=0

=18.072354281152116`*1.004808735868092`*(0.9962747171551987` Cos[0.038342535819113815` ϕ] - 0.08623623343658383` Sin[0.038342535819113815` ϕ])

=18.072354281152116`*(1.004808735868092`*0.9962747171551987` Cos[0.038342535819113815` ϕ] - 1.004808735868092`*0.08623623343658383` Sin[0.038342535819113815` ϕ])

In[1186]:=

In[1187]:=
```
ClearAll[ϕ]
```

In[1188]:=
```
18.072354281152116` *
 (1.004808735868092` * 0.9962747171551987` Cos[0.038342535819113815` ϕ] -
   1.004808735868092` * 0.08623623343658383` Sin[0.038342535819113815` ϕ])
```

Out[1188]= 18.0724 (1.00107 Cos[0.0383425 ϕ] - 0.0866509 Sin[0.0383425 ϕ])

We can also use the trig identities for
$\sin\left(\frac{\pi}{2} - \theta\right) = \cos(\theta)$ and $\cos\left(\frac{\pi}{2} - \theta\right) = \sin(\theta)$ to match the forms of the fit equations.

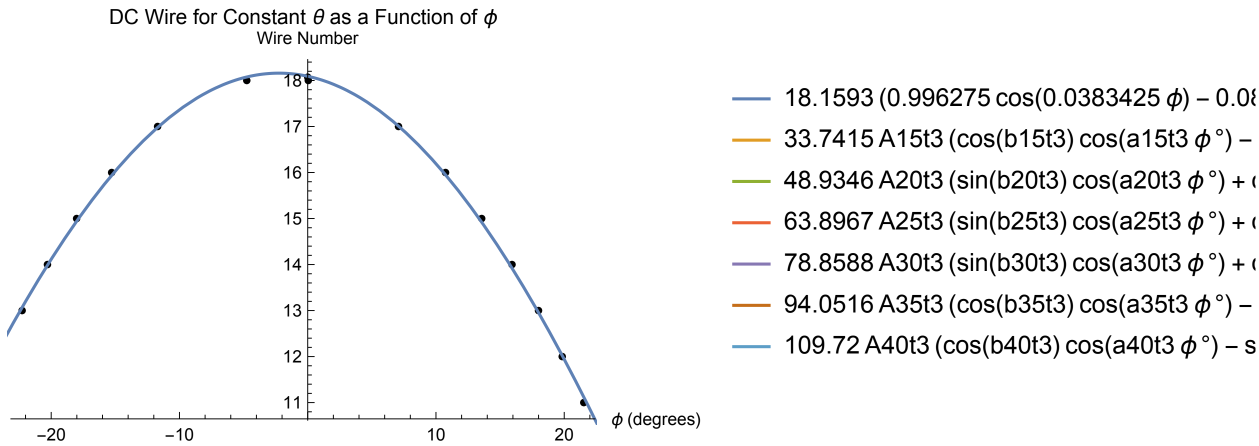
Fit20form3 =f[20]A20t3(Cos[90°-b20t3]Cos[a20t3 ϕ °]+Sin[90°-b20t3]Sin[a20t3 ϕ °]);
=f[20]A20t3((Cos[90°]Cos[b20t3]+Sin[[90°]Cos[b20t3])Cos[a20t3 ϕ °]+(Sin[90°]Cos[b20t3]-Cos[90°]Cos[b20t3])Sin[a20t3 ϕ °]);
=f[20]A20t3(Cos[b20t3]Cos[a20t3 ϕ °]+Cos[b20t3]Sin[a20t3 ϕ °]);

Fit25form3=f[25] A25t3(Sin[a25t3 ϕ °]Sin [90°-b25t3]+Cos[a25t3 ϕ °]Cos [90°-b25t3]);

Fit30form3=f[30] A30t3(Sin[a30t3 ϕ °]Sin[90°-b30t3]+Cos[a30t3 ϕ °]Cos[90°-b30t3]);

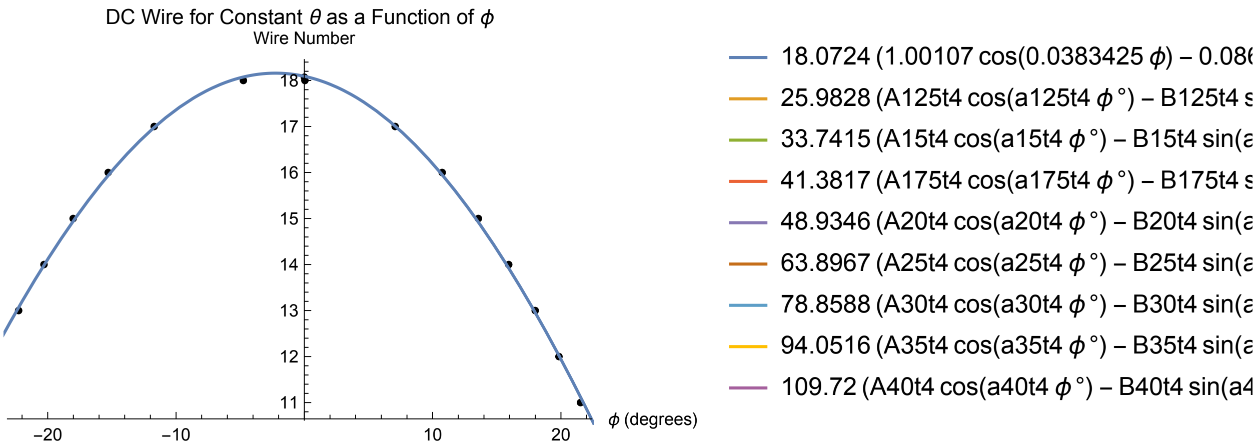
In[1745]:=
```
Fit10form3 = f[10] A10t3 (Cos[a10t3 ϕ °] Cos[ b10t3] - Sin[a10t3 ϕ °] Sin[ b10t3]);
Fit125form3 =
  f[12.5] A125t3 (Cos[a125t3 ϕ ° ] Cos[b125t3] - Sin[a125t3 ϕ ° ] Sin[b125t3]);
Fit15form3 = f[15] A15t3 (Cos[a15t3 ϕ ° ] Cos[b15t3] - Sin[a15t3 ϕ ° ] Sin[b15t3]);
Fit175form3 =
  f[17.5] A175t3 (Cos[a175t3 ϕ ° ] Cos[b175t3] - Sin[a175t3 ϕ ° ] Sin[b175t3]);
Fit20form3 = f[20] A20t3
   (Cos[90 ° - b20t3] Cos[a20t3 ϕ ° ] + Sin[90 ° - b20t3] Sin[a20t3 ϕ ° ]);
Fit25form3 = f[25] A25t3 (Sin[a25t3 ϕ °] Sin [90 ° - b25t3] +
     Cos[a25t3 ϕ °] Cos [90 ° - b25t3]);
Fit30form3 = f[30] A30t3 (Sin[a30t3 ϕ ° ] Sin[90 ° - b30t3] +
     Cos[a30t3 ϕ ° ] Cos[90 ° - b30t3]);
Fit35form3 = f[35] A35t3 (Cos[a35t3 ϕ ° ] Cos[b35t3] - Sin[a35t3 ϕ ° ] Sin[b35t3]);
Fit40form3 = f[40] A40t3 ( Cos[a40t3 ϕ ° ] Cos[b40t3] - Sin[a40t3 ϕ ° ] Sin[b40t3]);
Fit10degree3 = FindFit[WireData10, {Fit10form3}, {A10t3, a10t3, b10t3}, ϕ];
Fit15degree3 = FindFit[WireData15, {Fit15form3}, {A15t3, a15t3, b15t3}, ϕ];
Fit20degree3 = FindFit[WireData20, {Fit20form3}, {A20t3, a20t3, b20t3}, ϕ];
Fit25degree3 = FindFit[WireData25, {Fit25form3}, {A25t3, a25t3, b25t3}, ϕ];
Fit30degree3 = FindFit[WireData30, {Fit30form3}, {A30t3, a30t3, b30t3}, ϕ];
Fit35degree3 = FindFit[WireData35, {Fit35form3}, {A35t3, a35t3, b35t3}, ϕ];
Fit40degree3 = FindFit[WireData40, {Fit40form3}, {A40t3, a40t3, b40t3}, ϕ];
Show[ListPlot[{WireData10, WireData15,
    WireData20, WireData25, WireData30, WireData35, WireData40},
  PlotStyle → Black, AxesLabel → {"ϕ (degrees)", "Wire Number"},
  PlotLabel → "DC Wire for Constant θ as a Function of ϕ"],
 Plot[{Fit10form3 /. Fit10degree3, Fit15form3 /. Fit15degree3, Fit20form3 /.
     Fit20degree3, Fit25form3 /. Fit25degree3, Fit30form3 /. Fit30degree3,
    Fit35form3 /. Fit35degree3, Fit40form3 /. Fit40degree3}, {ϕ, -25, 25},
  PlotLegends → {Fit10form3 /. Fit10degree3, Fit15form3 /. Fit15degree3,
    Fit20form3 /. Fit20degree3, Fit25form3 /. Fit25degree3, Fit30form3 /.
     Fit30degree3, Fit35form3 /. Fit35degree3, Fit40form3 /. Fit40degree3}]]
```

Out[1761]=


DC Wire for Constant θ as a Function of ϕ
Wire Number
18
17
16
15
14
13
12
11
–20
–10
10
20
ϕ (degrees)
18.1593 (0.996275 cos(0.0383425 ϕ) – 0.08
33.7415 A15t3 (cos(b15t3) cos(a15t3 ϕ °) –
48.9346 A20t3 (sin(b20t3) cos(a20t3 ϕ °) + (
63.8967 A25t3 (sin(b25t3) cos(a25t3 ϕ °) + (
78.8588 A30t3 (sin(b30t3) cos(a30t3 ϕ °) + (
94.0516 A35t3 (cos(b35t3) cos(a35t3 ϕ °) –
109.72 A40t3 (cos(b40t3) cos(a40t3 ϕ °) – s

In[1762]:=
```
Fit10form4 = f[10] (A10t4 Cos[a10t4 ϕ °] - B10t4 Sin[a10t4 ϕ °]);
Fit125form4 = f[12.5] (A125t4 Cos[a125t4 ϕ °] - B125t4 Sin[a125t4 ϕ °]);
Fit15form4 = f[15] (A15t4 Cos[a15t4 ϕ °] - B15t4 Sin[a15t4 ϕ °]);
Fit175form4 = f[17.5] (A175t4 Cos[a175t4 ϕ °] - B175t4 Sin[a175t4 ϕ °]);
Fit15form4 = f[15] (A15t4 Cos[a15t4 ϕ °] - B15t4 Sin[a15t4 ϕ °]);
Fit20form4 = f[20] (A20t4 Cos[a20t4 ϕ °] - B20t4 Sin[a20t4 ϕ °]);
Fit25form4 = f[25] (A25t4 Cos[a25t4 ϕ °] - B25t4 Sin[a25t4 ϕ °]);
Fit30form4 = f[30] (A30t4 Cos[a30t4 ϕ °] - B30t4 Sin[a30t4 ϕ °]);
Fit35form4 = f[35] (A35t4 Cos[a35t4 ϕ °] - B35t4 Sin[a35t4 ϕ °]);
Fit40form4 = f[40] (A40t4 Cos[a40t4 ϕ °] - B40t4 Sin[a40t4 ϕ °]);
Fit10degree4 = FindFit[WireData10, {Fit10form4}, {A10t4, a10t4, B10t4}, ϕ];
Fit125degree4 = FindFit[WireData125, {Fit125form4}, {A125t4, a125t4, B125t4}, ϕ];
Fit15degree4 = FindFit[WireData15, {Fit15form4}, {A15t4, a15t4, B15t4}, ϕ];
Fit175degree4 = FindFit[WireData175, {Fit175form4}, {A175t4, a175t4, B175t4}, ϕ];
Fit15degree4 = FindFit[WireData15, {Fit15form4}, {A15t4, a15t4, B15t4}, ϕ];
Fit20degree4 = FindFit[WireData20, {Fit20form4}, {A20t4, a20t4, B20t4}, ϕ];
Fit25degree4 = FindFit[WireData25, {Fit25form4}, {A25t4, a25t4, B25t4}, ϕ];
Fit30degree4 = FindFit[WireData30, {Fit30form4}, {A30t4, a30t4, B30t4}, ϕ];
Fit35degree4 = FindFit[WireData35, {Fit35form4}, {A35t4, a35t4, B35t4}, ϕ];
Fit40degree4 = FindFit[WireData40, {Fit40form4}, {A40t4, a40t4, B40t4}, ϕ];
Show[ListPlot[{WireData10, WireData125, WireData15, WireData175,
    WireData20, WireData25, WireData30, WireData35, WireData40},
   PlotStyle → Black, AxesLabel → {"ϕ (degrees)", "Wire Number"},
   PlotLabel → "DC Wire for Constant θ as a Function of ϕ"],
  Plot[{Fit10form4 /. Fit10degree4, Fit125form4 /. Fit125degree4,
    Fit15form4 /. Fit15degree4, Fit175form4 /. Fit175degree4, Fit20form4 /.
     Fit20degree4, Fit25form4 /. Fit25degree4, Fit30form4 /. Fit30degree4,
    Fit35form4 /. Fit35degree4, Fit40form4 /. Fit40degree4}, {ϕ, -25, 25},
   PlotLegends → {Fit10form4 /. Fit10degree4, Fit125form4 /. Fit125degree4,
     Fit15form4 /. Fit15degree4, Fit175form4 /. Fit175degree4,
     Fit20form4 /. Fit20degree4, Fit25form4 /. Fit25degree4, Fit30form4 /.
      Fit30degree4, Fit35form4 /. Fit35degree4, Fit40form4 /. Fit40degree4}]]
```

Out[1782]=



In[1783]:=
```
Acoeff10 = A10t4 /. FindFit[WireData10, {Fit10form4}, {A10t4, a10t4, B10t4}, ϕ]
Acoeff125 =
  A125t4 /. FindFit[WireData125, {Fit125form4}, {A125t4, a125t4, B125t4}, ϕ];
Acoeff15 = A15t4 /. FindFit[WireData15, {Fit15form4}, {A15t4, a15t4, B15t4}, ϕ];
Acoeff175 =
  A175t4 /. FindFit[WireData175, {Fit175form4}, {A175t4, a175t4, B175t4}, ϕ];
Acoeff20 = A20t4 /. FindFit[WireData20, {Fit20form4}, {A20t4, a20t4, B20t4}, ϕ];
Acoeff25 = A25t4 /. FindFit[WireData25, {Fit25form4}, {A25t4, a25t4, B25t4}, ϕ];
Acoeff30 = A30t4 /. FindFit[WireData30, {Fit30form4}, {A30t4, a30t4, B30t4}, ϕ];
Acoeff35 = A35t4 /. FindFit[WireData35, {Fit35form4}, {A35t4, a35t4, B35t4}, ϕ];
Acoeff40 = A40t4 /. FindFit[WireData40, {Fit40form4}, {A40t4, a40t4, B40t4}, ϕ];
```

Out[1783]= 1.00107

In[1236]:=
```
Coeff1 = List[{Acoeff10}, {Acoeff125}, {Acoeff15}, {Acoeff175},
  {Acoeff20}, {Acoeff25}, {Acoeff30}, {Acoeff35}, {Acoeff40}]
```

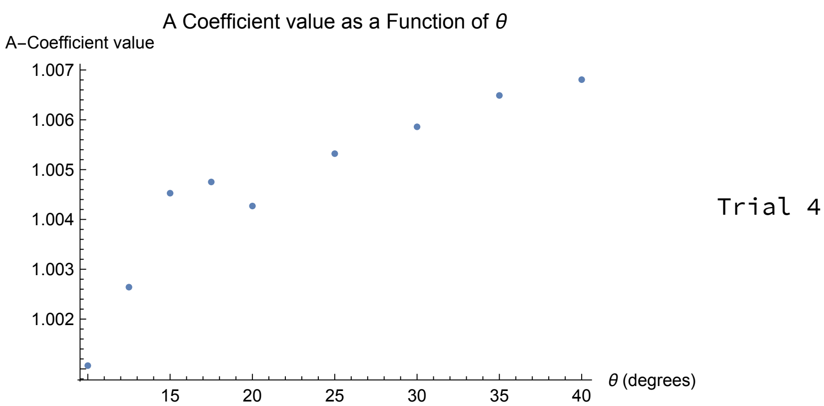
Out[1236]=
```
{{1.00107}, {1.00264}, {1.00453}, {1.00475},
 {1.00427}, {1.00532}, {1.00586}, {1.00649}, {1.00681}}
```

In[1237]:=
```
Coeff1 = MapThread[Prepend, {Coeff1, {10, 12.5, 15, 17.5, 20, 25, 30, 35, 40}}]
```

Out[1237]=
```
{{10, 1.00107}, {12.5, 1.00264}, {15, 1.00453}, {17.5, 1.00475},
 {20, 1.00427}, {25, 1.00532}, {30, 1.00586}, {35, 1.00649}, {40, 1.00681}}
```

In[1238]:=
```
ListPlot[{Coeff1}, AxesLabel → {"θ (degrees)", "A-Coefficient value"},
 PlotLabel → "A Coefficient value as a Function of θ", PlotLegends → "Trial 4"]
```

Out[1238]=



Need to add more data points

In[1239]:=
```
ClearAll[θ];
```