Calculating ω and v0 in Rotating Reference Frame (To Compare to ω and v0 Calculated in Non-Rotating)

In[∘]:=
```
ClearAll["Global`*"]
```

In[∘]:=
```
dataold = Import[FileNames["NIRF_puck_x_y.csv", NotebookDirectory[], 2][[1]]]
```

Out[∘]=
```
{{0, 30.217, -7.98}, {0.033, 27.387, -9.953},
 {0.067, 23.681, -11.683}, {0.1, 17.381, -13.721}, {0.133, 13.786, -14.267},
 {0.167, 11.272, -14.26}, {0.2, 7.834, -14.013}, {0.233, 4.384, -13.403},
 {0.267, 1.223, -12.424}, {0.3, -1.775, -11.013}, {0.333, -4.595, -9.281},
 {0.367, -7.054, -7.311}, {0.4, -9.136, -5.289}, {0.433, -10.928, -3.026},
 {0.467, -12.383, -0.552}, {0.5, -13.462, 2.025}, {0.533, -14.227, 4.704},
 {0.566, -14.796, 7.44}, {0.6, -15.04, 10.157}, {0.633, -14.925, 12.865},
 {0.666, -14.528, 15.589}, {0.7, -13.818, 18.278}, {0.733, -12.869, 20.794},
 {0.766, -11.77, 23.069}, {0.8, -10.61, 25.248}, {0.833, -9.098, 27.245},
 {0.866, -7.457, 29.057}, {0.901, -5.783, 30.702}, {0.933, -4.085, 32.284},
 {0.966, -2.23, 33.731}, {1, -0.29, 35.097}, {1.033, 1.865, 36.283},
 {1.066, 4.251, 37.259}, {1.1, 6.751, 38.038}, {1.133, 9.47, 38.584},
 {1.166, 12.024, 38.975}, {1.2, 14.934, 39.057}, {1.233, 17.698, 39.029},
 {1.266, 20.369, 38.757}, {1.3, 23.017, 38.344}, {1.333, 25.343, 37.864},
 {1.366, 27.733, 37.253}, {1.399, 30.192, 36.477}, {1.433, 32.48, 35.678},
 {1.466, 35.057, 34.622}, {1.499, 37.396, 33.53}, {1.533, 39.84, 32.3}}
```

In[∘]:=
```
data = Transpose[dataold];
```

Time Information in ti:

In[∘]:=
```
ti = data[[1, All]];
```

In[∘]:=
```
tfinal = ti[[-1]] + (ti[[-1]] * .03)
```

Out[∘]=
```
1.57899
```

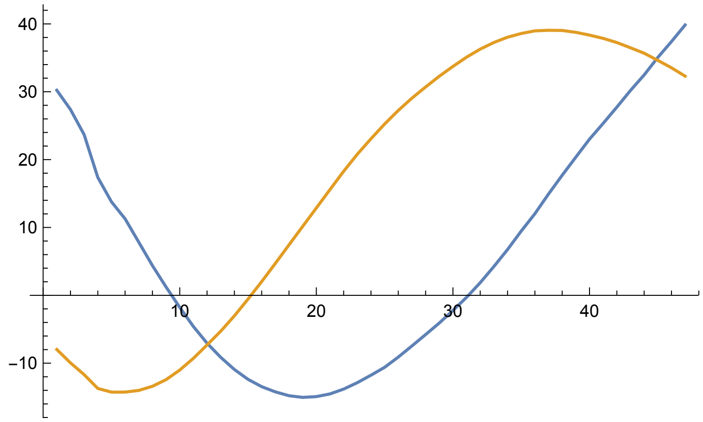
{x,y} coordinate information in ci:

In[∘]:=
```
ci = data[[2 ;;, All]];
```

In[∘]:=
```
sol = ParametricNDSolve[{xtheory''[t] == ω * (ω * xtheory[t]) + 2 * ω * ytheory'[t],
    ytheory''[t] == ω * (ω * ytheory[t]) - 2 * ω * xtheory'[t], xtheory[0] == x0,
    ytheory[0] == y0, xtheory'[0] == v0 * Cos[θ], ytheory'[0] == v0 * Sin[θ]},
   {xtheory, ytheory}, {t, 0, tfinal}, {ω, x0, y0, v0, θ}];
```

In[•]:=
```
ListLinePlot[ci]
```

Out[•]=



In[•]:=
```
transformedData = {ConstantArray[Range@Length[ci], Length[ti]] // Transpose,
    ConstantArray[ti, Length[ci]], ci}~Flatten~{{2, 3}, {1}};
```

Now the data is in following format: {dependent variable number (so like x=1 or y=2 or z=3), time (from ti), value}

This above assumed that originally it was like {t,x,y}

In[•]:=
```
NIRFraw = Import[FileNames["NIRF_puck_x_y.csv", NotebookDirectory[], 2][[1]]];
```

In[•]:=
```
xandy = {#[[2]], #[[3]]} & /@ NIRFraw;
```

In[•]:=
```
xandy[[1, 1]]
```

Out[•]=
```
30.217
```

In[•]:=
```
x0guess = xandy[[1, 1]]
```

Out[•]=
```
30.217
```

In[•]:=
```
y0guess = xandy[[1, 2]]
```

Out[•]=
```
-7.98
```

Next step is to use the guesses we got from analyzing motion in the non-rotating reference frame:

In[•]:=
```
sol = ParametricNDSolveValue[{xtheory''[t] == ω * (ω * xtheory[t]) + 2 * ω * ytheory'[t],
    ytheory''[t] == ω * (ω * ytheory[t]) - 2 * ω * xtheory'[t], xtheory[0] == x0,
    ytheory[0] == y0, xtheory'[0] == v0 * Cos[θ], ytheory'[0] == v0 * Sin[θ]},
   {xtheory, ytheory}, {t, 0, tfinal}, {ω, x0, y0, v0, θ}];
```

In[•]:=
```
model[ω_, x0_, y0_, v0_, θ_][i_, t_] := Through[sol[ω, x0, y0, v0, θ][t], List][[i]] /;
  And @@ NumericQ /@ {ω, x0, y0, v0, θ, i, t}
```

In[•]:=
```
fit = NonlinearModelFit[transformedData,
   model[ω, x0, y0, v0, θ][i, t], {ω, x0, y0, v0, θ}, {i, t}];
```

In[∘]:=
```
fit = NonlinearModelFit[transformedData, {model[ω, x0, y0, v0, θ][i, t],
    ω > 0, x0guess - 0.5 < x0 < x0guess + .5, y0guess - 0.5 < y0 < y0guess + .5},
   {{ω, 1.5}, {x0, 30}, {y0, -8}, {v0, 122}, {θ, -140 Degree}}, {i, t}];
```

In[∘]:=
```
fit["ParameterTable"]
```

FittedModel: The property values {ParameterTable} assume an unconstrained model. The results for these properties may not be valid, particularly if the fitted parameters are near a constraint boundary.

Out[∘]=

	Estimate	Standard Error	t-Statistic	P-Value
ω	1.7258	0.0702392	24.5703	$1.98951*10^{-41}$
x0	29.717	1.53958	19.3021	$1.4478*10^{-33}$
y0	−8.48	2.2489	−3.77073	0.000292506
v0	90.4996	3.47303	26.0578	$2.00065*10^{-43}$
θ	−2.55918	0.0849629	−30.1211	$1.84399*10^{-48}$

In[∘]:=
```
e = fit["ParameterTableEntries"]
```

FittedModel: The property values {ParameterTableEntries} assume an unconstrained model. The results for these properties may not be valid, particularly if the fitted parameters are near a constraint boundary.

Out[∘]= $\{\{1.7258, 0.0702392, 24.5703, 1.98951*10^{-41}\}, \{29.717, 1.53958, 19.3021, 1.4478*10^{-33}\}, \{-8.48, 2.2489, -3.77073, 0.000292506\}, \{90.4996, 3.47303, 26.0578, 2.00065*10^{-43}\}, \{-2.55918, 0.0849629, -30.1211, 1.84399*10^{-48}\}\}$

In[∘]:= `w1 = e[[1, 1]]`

Out[∘]= 1.7258

In[∘]:= `w2 = e[[1, 1]] + e[[1, 1]] .2`

Out[∘]= 2.07096

In[∘]:= `w3 = e[[1, 1]] - e[[1, 1]] .2`

Out[∘]= 1.38064

In[∘]:= `x0 = e[[2, 1]]`

Out[∘]= 29.717

In[∘]:= `y0 = e[[3, 1]]`

Out[∘]= -8.48

In[∘]:= `v0 = e[[4, 1]]`

Out[∘]= 90.4996

In[∘]:= `θ = e[[5, 1]]`

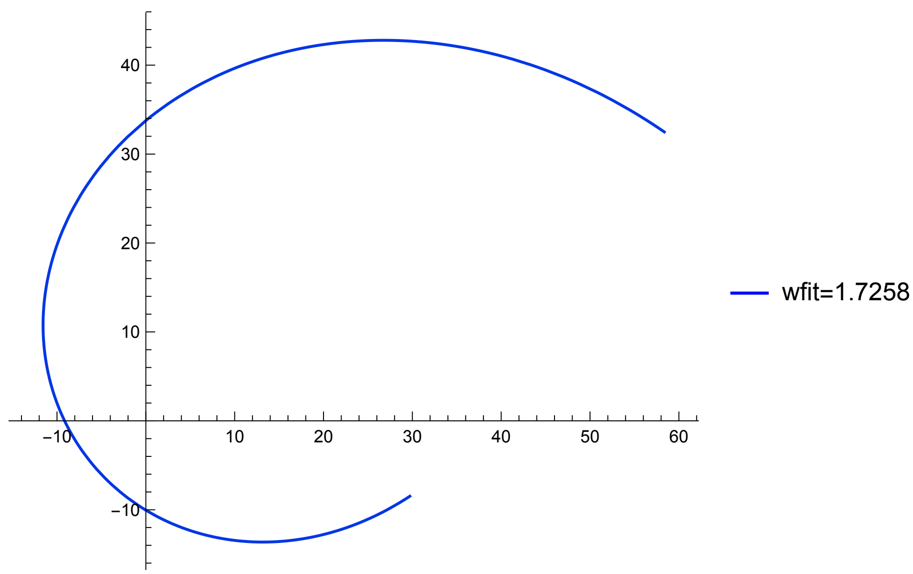
Out[∘]= -2.55918

In[∘]:=
```
s1 = NDSolve[{xtheory''[t] == ω * (ω * xtheory[t]) + 2 * ω * ytheory'[t],
    ytheory''[t] == ω * (ω * ytheory[t]) - 2 * ω * xtheory'[t], xtheory[0] == x0,
    ytheory[0] == y0, xtheory'[0] == v0 * Cos[θ], ytheory'[0] == v0 * Sin[θ]} /.
   {ω → w1}, {xtheory[t], ytheory[t]}, {t, 0, tfinal}]
```

Out[∘]=
```
{{xtheory[t] → InterpolatingFunction[ Domain: {{0., 1.58}} Output: scalar ][t],
  ytheory[t] → InterpolatingFunction[ Domain: {{0., 1.58}} Output: scalar ][t]}}
```

In[∘]:=
```
X1theory[t_] = xtheory[t] /. Flatten[s1];
Y1theory[t_] = ytheory[t] /. Flatten[s1];
```

In[∘]:=
```
pw1 = ParametricPlot[{X1theory[t], Y1theory[t]}, {t, 0, tfinal},
  PlotStyle → Directive[RGBColor[0., 0.21, 0.9], AbsoluteThickness[1.5]],
  PlotLegends → LineLegend[{Blue}, {"wfit=" <> ToString[w1]}]]
```

Out[∘]=


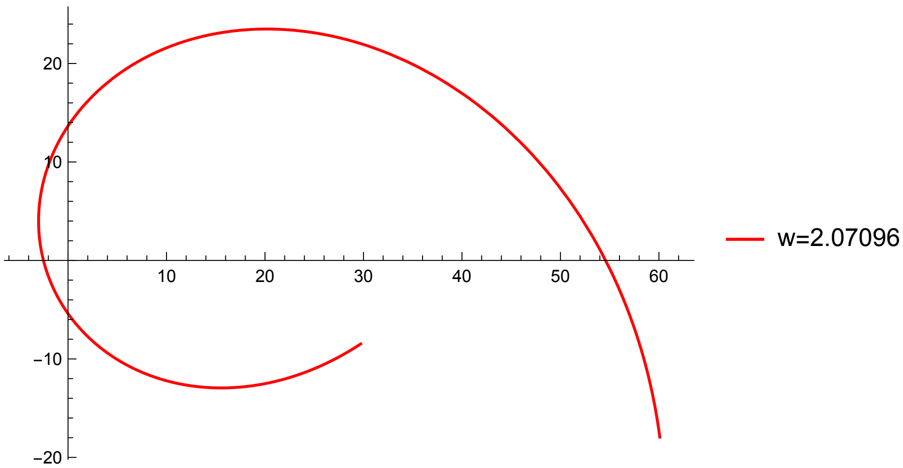
In[∘]:=
```
s2 = NDSolve[{xtheory''[t] == ω * (ω * xtheory[t]) + 2 * ω * ytheory'[t],
    ytheory''[t] == ω * (ω * ytheory[t]) - 2 * ω * xtheory'[t], xtheory[0] == x0,
    ytheory[0] == y0, xtheory'[0] == v0 * Cos[θ], ytheory'[0] == v0 * Sin[θ]} /.
   {ω → w2}, {xtheory[t], ytheory[t]}, {t, 0, tfinal}]
```

Out[∘]=
```
{{xtheory[t] → InterpolatingFunction[ Domain: {{0., 1.58}} Output: scalar ][t],
  ytheory[t] → InterpolatingFunction[ Domain: {{0., 1.58}} Output: scalar ][t]}}
```

In[•]:=
```
X2theory[t_] = xtheory[t] /. Flatten[s2];
Y2theory[t_] = ytheory[t] /. Flatten[s2];
```

In[•]:=
```
pw2 = ParametricPlot[{X2theory[t], Y2theory[t]},
  {t, 0, tfinal}, PlotStyle → Directive[Red, AbsoluteThickness[1.5]],
  PlotLegends → LineLegend[{Red}, {"w=" <> ToString[w2]}]]
```

Out[•]=



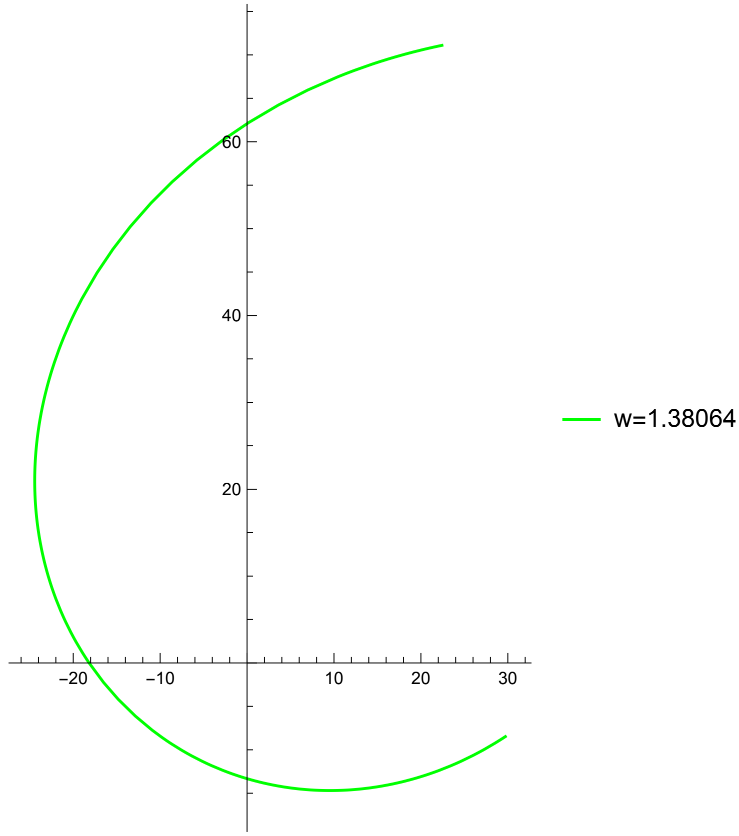
In[•]:=
```
s3 = NDSolve[{xtheory''[t] == ω * (ω * xtheory[t]) + 2 * ω * ytheory'[t],
    ytheory''[t] == ω * (ω * ytheory[t]) - 2 * ω * xtheory'[t], xtheory[0] == x0,
    ytheory[0] == y0, xtheory'[0] == v0 * Cos[θ], ytheory'[0] == v0 * Sin[θ]} /.
   {ω → w3}, {xtheory[t], ytheory[t]}, {t, 0, tfinal}]
```

Out[•]=
```
{{xtheory[t] → InterpolatingFunction[ Domain: {{0., 1.58}} Output: scalar ][t],
  ytheory[t] → InterpolatingFunction[ Domain: {{0., 1.58}} Output: scalar ][t]}}
```

In[•]:=
```
X3theory[t_] = xtheory[t] /. Flatten[s3];
Y3theory[t_] = ytheory[t] /. Flatten[s3];
```

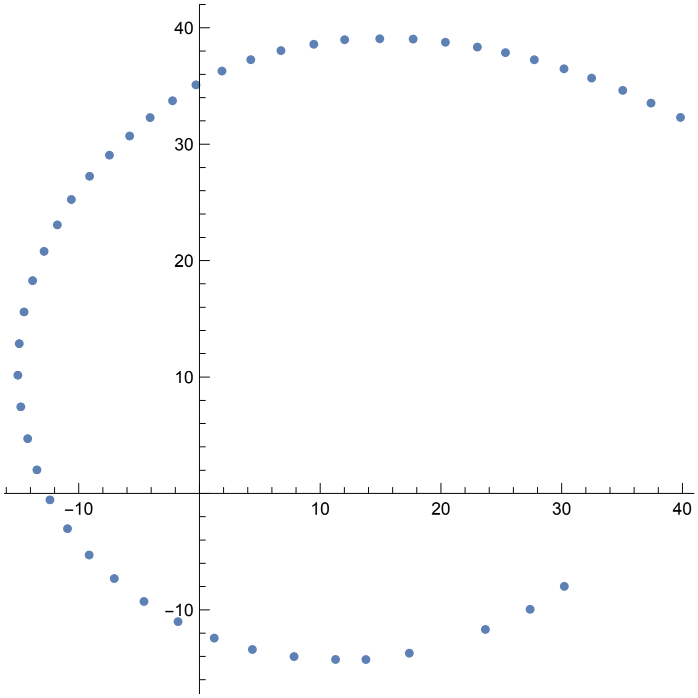
In[∘]:=
```
pw3 = ParametricPlot[{X3theory[t], Y3theory[t]},
  {t, 0, tfinal}, PlotStyle → Directive[Green, AbsoluteThickness[1.5]],
  PlotLegends → LineLegend[{Green}, {"w=" <> ToString[w3]}]]
```

Out[∘]=



In[∘]:=
```
p1 = ListPlot[xandy, AspectRatio → 1]
```

Out[∘]=



I'm not actually sure about the radius of this thing. it is $r = \frac{116}{2}$ cm

In[∘]:=
```
cir = Graphics[Circle[{0, 0}, 116 / 2]];
```

In[∘]:=
```
Show[p1, pw1, pw2, pw3, cir, PlotRange → {{-116 / 2, 116 / 2}, {-116 / 2, 116 / 2}},
 Frame → False, FrameTicks -> None, Ticks -> None, Axes → False]
```

Out[∘]=