Calculating v0 average and ω average in Non-Rotating Reference Frame (To Compare to ω calculated in Rotating, and to supply initial guess values to rotating reference frame nonlinear model fitting)

```
In[•]:= ClearAll["Global`*"]
```

Call in data from tracker.

```
In[•]:= IRFraw = Import[FileNames["IRF_puck_x_y.csv", NotebookDirectory[], 2][[1]]]
```

```
Out[•]= {{0, 4.56, 6.894}, {0.017, 4.879, 5.091}, {0.033, 5.091, 3.076}, {0.05, 5.091, 1.061},
  {0.1, 5.091, -6.257}, {0.117, 5.091, -8.591}, {0.133, 5.409, -10.818},
  {0.15, 5.303, -13.151}, {0.167, 5.409, -14.954}, {0.183, 5.409, -17.075},
  {0.2, 5.515, -19.408}, {0.217, 5.727, -21.211}, {0.233, 6.045, -23.014},
  {0.25, 6.045, -25.135}, {0.267, 6.363, -27.15}, {0.283, 6.363, -28.741},
  {0.3, 6.682, -30.969}, {0.317, 6.682, -32.771}, {0.333, 7.106, -34.574},
  {0.35, 7.318, -36.483}, {0.367, 7.212, -38.286}, {0.383, 7.954, -39.877},
  {0.4, 8.166, -41.68}, {0.417, 8.485, -43.377}, {0.433, 8.803, -45.18},
  {0.45, 9.651, -47.089}, {0.467, 9.757, -48.892}, {0.483, 9.969, -50.801}}
```

```
In[•]:= t1 = IRFraw[[3, 1]]
```

```
Out[•]= 0.033
```

```
In[•]:= t2 = IRFraw[[Length[IRFraw] - 2, 1]]
```

```
Out[•]= 0.45
```

```
In[•]:= IRFx = {#[[1]], #[[2]]} & /@ IRFraw
```

```
Out[•]= {{0, 4.56}, {0.017, 4.879}, {0.033, 5.091}, {0.05, 5.091}, {0.1, 5.091},
  {0.117, 5.091}, {0.133, 5.409}, {0.15, 5.303}, {0.167, 5.409},
  {0.183, 5.409}, {0.2, 5.515}, {0.217, 5.727}, {0.233, 6.045}, {0.25, 6.045},
  {0.267, 6.363}, {0.283, 6.363}, {0.3, 6.682}, {0.317, 6.682}, {0.333, 7.106},
  {0.35, 7.318}, {0.367, 7.212}, {0.383, 7.954}, {0.4, 8.166}, {0.417, 8.485},
  {0.433, 8.803}, {0.45, 9.651}, {0.467, 9.757}, {0.483, 9.969}}
```

```
In[•]:= IRFy = {#[[1]], #[[3]]} & /@ IRFraw
```

```
Out[•]= {{0, 6.894}, {0.017, 5.091}, {0.033, 3.076}, {0.05, 1.061},
  {0.1, -6.257}, {0.117, -8.591}, {0.133, -10.818}, {0.15, -13.151},
  {0.167, -14.954}, {0.183, -17.075}, {0.2, -19.408}, {0.217, -21.211},
  {0.233, -23.014}, {0.25, -25.135}, {0.267, -27.15}, {0.283, -28.741},
  {0.3, -30.969}, {0.317, -32.771}, {0.333, -34.574}, {0.35, -36.483},
  {0.367, -38.286}, {0.383, -39.877}, {0.4, -41.68}, {0.417, -43.377},
  {0.433, -45.18}, {0.45, -47.089}, {0.467, -48.892}, {0.483, -50.801}}
```

In[]:=
```
x[t_] = Interpolation[IRFx][t]
```

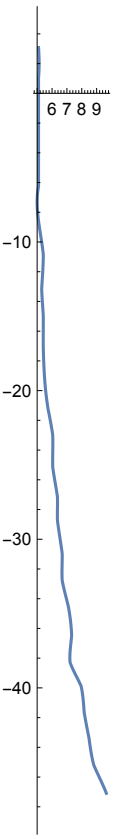
Out[]=
```
InterpolatingFunction[ ⊞ Domain: {{0., 0.483}}
                       Output: scalar ][t]
```

In[]:=
```
y[t_] = Interpolation[IRFy][t]
```

Out[]=
```
InterpolatingFunction[ ⊞ Domain: {{0., 0.483}}
                       Output: scalar ][t]
```

In[]:=
```
ParametricPlot[{x[t], y[t]}, {t, t1, t2}]
```

Out[]=



In[]:=
```
dx[t_] = D[x[t], t]
```

Out[]=
```
InterpolatingFunction[ ⊞ Domain: {{0., 0.483}}
                       Output: scalar ][t]
```

In[]:=
```
dy[t_] = D[y[t], t]
```

Out[]=
```
InterpolatingFunction[ ⊞ Domain: {{0., 0.483}}
                       Output: scalar ][t]
```

In[]:=
```
ds[t_] = √(dx[t]^2 + dy[t]^2)
```

Out[]=
```
√(InterpolatingFunction[ ⊞ Domain: {{0., 0.483}} Output: scalar ][t]^2 +
    InterpolatingFunction[ ⊞ Domain: {{0., 0.483}} Output: scalar ][t]^2)
```

In[]:=
```
v0ave = 1/(t2 - t1) NIntegrate[ds[t], {t, t1, t2}]
```

Out[]=
```
121.788
```

In[]:=
```
v0ave // Framed(*cm/s*)
```

Out[]=
```
121.788
```

Calculating ω average from the position of the tape on table

In[]:=
```
ωraw = Import[FileNames["IRF_tape_x_y.csv", NotebookDirectory[], 2][[1]]]
```

Out[]=
```
{{0, -41.786, -18.666}, {0.017, -40.882, -20.534}, {0.033, -39.861, -22.326},
 {0.05, -38.859, -24.127}, {0.067, -37.672, -25.823}, {0.083, -36.454, -27.528},
 {0.1, -35.112, -29.108}, {0.117, -33.745, -30.724}, {0.133, -32.242, -32.231},
 {0.15, -30.669, -33.681}, {0.167, -29.05, -35.014}, {0.183, -27.413, -36.295},
 {0.2, -25.669, -37.554}, {0.217, -23.891, -38.657}, {0.233, -22.051, -39.734},
 {0.25, -20.177, -40.729}, {0.267, -18.237, -41.596}, {0.283, -16.223, -42.397},
 {0.3, -14.179, -43.045}, {0.317, -12.16, -43.69}, {0.333, -10.079, -44.208},
 {0.35, -7.957, -44.602}, {0.367, -5.828, -44.906}, {0.383, -3.709, -45.015},
 {0.4, -1.573, -45.116}, {0.417, 0.52, -45.124}, {0.433, 2.627, -44.996},
 {0.45, 4.417, -44.567}, {0.467, 6.739, -44.112}, {0.483, 8.74, -44.083}}
```

In[]:=
```
t1 = ωraw[[3, 1]]
```

Out[]=
```
0.033
```

In[]:=
```
t2 = ωraw[[Length[ωraw] - 2, 1]]
```

Out[]=
```
0.45
```

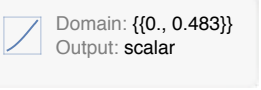
In[•]:=
```
xtapelist = {#[[1]], #[[2]]} & /@ ωraw
```

Out[•]=
```
{{0, -41.786}, {0.017, -40.882}, {0.033, -39.861}, {0.05, -38.859},
 {0.067, -37.672}, {0.083, -36.454}, {0.1, -35.112}, {0.117, -33.745},
 {0.133, -32.242}, {0.15, -30.669}, {0.167, -29.05}, {0.183, -27.413},
 {0.2, -25.669}, {0.217, -23.891}, {0.233, -22.051}, {0.25, -20.177},
 {0.267, -18.237}, {0.283, -16.223}, {0.3, -14.179}, {0.317, -12.16},
 {0.333, -10.079}, {0.35, -7.957}, {0.367, -5.828}, {0.383, -3.709}, {0.4, -1.573},
 {0.417, 0.52}, {0.433, 2.627}, {0.45, 4.417}, {0.467, 6.739}, {0.483, 8.74}}
```

In[•]:=
```
ytapelist = {#[[1]], #[[3]]} & /@ ωraw
```

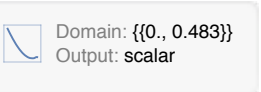
Out[•]=
```
{{0, -18.666}, {0.017, -20.534}, {0.033, -22.326},
 {0.05, -24.127}, {0.067, -25.823}, {0.083, -27.528},
 {0.1, -29.108}, {0.117, -30.724}, {0.133, -32.231}, {0.15, -33.681},
 {0.167, -35.014}, {0.183, -36.295}, {0.2, -37.554}, {0.217, -38.657},
 {0.233, -39.734}, {0.25, -40.729}, {0.267, -41.596}, {0.283, -42.397},
 {0.3, -43.045}, {0.317, -43.69}, {0.333, -44.208}, {0.35, -44.602},
 {0.367, -44.906}, {0.383, -45.015}, {0.4, -45.116}, {0.417, -45.124},
 {0.433, -44.996}, {0.45, -44.567}, {0.467, -44.112}, {0.483, -44.083}}
```

In[•]:=
```
xtape[t_] = Interpolation[xtapelist][t]
```

Out[•]=
```
InterpolatingFunction[ 

][t]
```

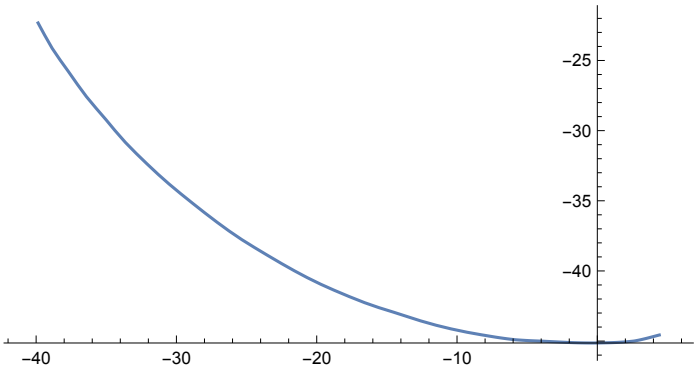
In[•]:=
```
ytape[t_] = Interpolation[ytapelist][t]
```

Out[•]=
```
InterpolatingFunction[ 

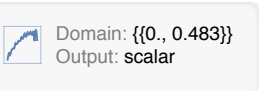
][t]
```

In[•]:=
```
ParametricPlot[{xtape[t], ytape[t]}, {t, t1, t2}]
```

Out[•]=



In[•]:=
```
dxtape[t_] = D[xtape[t], t]
```

Out[•]=
```
InterpolatingFunction[ 

][t]
```

In[]:=
```
dytape[t_] = D[ytape[t], t]
```

Out[]=
```
InterpolatingFunction[ ⟨Domain: {{0., 0.483}} Output: scalar⟩ ][t]
```

In[]:=
```
dstape[t_] = Sqrt[dxtape[t]^2 + dytape[t]^2]
```

Out[]=
```
Sqrt[ InterpolatingFunction[ ⟨Domain: {{0., 0.483}} Output: scalar⟩ ][t]^2 +
      InterpolatingFunction[ ⟨Domain: {{0., 0.483}} Output: scalar⟩ ][t]^2 ]
```

In[]:=
```
rtape[t_] = Sqrt[xtape[t]^2 + ytape[t]^2]
```

Out[]=
```
Sqrt[ InterpolatingFunction[ ⟨Domain: {{0., 0.483}} Output: scalar⟩ ][t]^2 +
      InterpolatingFunction[ ⟨Domain: {{0., 0.483}} Output: scalar⟩ ][t]^2 ]
```

In[]:=
```
omega[t_] = dstape[t] / rtape[t]
```

Out[]=
```
( Sqrt[ InterpolatingFunction[ ⟨Domain: {{0., 0.483}} Output: scalar⟩ ][t]^2 +
        InterpolatingFunction[ ⟨Domain: {{0., 0.483}} Output: scalar⟩ ][t]^2 ] ) /
( Sqrt[ InterpolatingFunction[ ⟨Domain: {{0., 0.483}} Output: scalar⟩ ][t]^2 +
        InterpolatingFunction[ ⟨Domain: {{0., 0.483}} Output: scalar⟩ ][t]^2 ] )
```

In[]:=
```
wave = 1/(t2 - t1) NIntegrate[omega[t], {t, t1, t2}]
```

Out[]=
```
2.7813
```

In[]:=
```
wave // Framed(*rad/s*)
```

Out[]=
```
2.7813
```