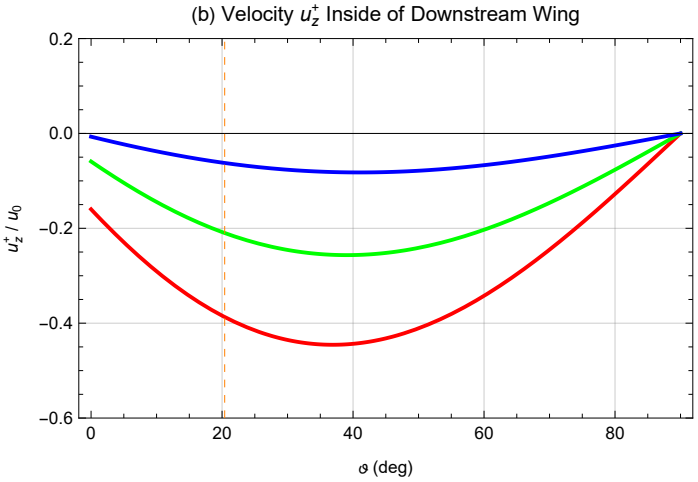
In[ ]:=
```
(*05/16/21*)
(*velocity u_z (constant) inside the norhern Alfven wing generated by a box-
 like ionospheric obstacle*)
B0 = 5.1369 * 10^-9;(*upstream magnetic field in Tesla*)
n0 = 0.11 * 10^6;(*upstream number density in 1/m^3*)
mp = 1.6726231 * 10^-27; (*proton mass*)
m = 7.5 * mp; (*upstream ion mass*)
mu0 = 4 * 3.14159265359 * 10^-7; (*magnetic permeability of vacuum*)
vA = B0/Sqrt[mu0 * n0 * m]; (*Alfven velocity*)
u0 = 43 * 10^3; (*magnitude of upstream flow velocity in m/s*)
MA = u0 / vA(*Alfvenic Mach number, Europa*)


uz[theta_, a_] = B0 * Cos[theta]/(Sqrt[mu0 * n0 * m] (1 + MA^2 + 2 MA Sin[theta])) *
    (Sqrt[(1 + MA^2 + 2 MA Sin[theta] - MA^2 a^2 (1 - Sin[theta] * Sin[theta]))] +
      MA * (a - 2) * Sin[theta] + MA^2 (a - 1) - 1);
ux[theta_, a_] = u0 - B0/(Sqrt[mu0 * n0 * m] (1 + MA^2 + 2 MA Sin[theta])) * ((Sin[theta] + MA) *
        Sqrt[(1 + MA^2 + 2 MA Sin[theta] - MA^2 a^2 (1 - Sin[theta] * Sin[theta]))] -
       MA * a * Cos[theta] * Cos[theta] - Sin[theta] * (1 + MA^2 + 2 MA Sin[theta]));
```

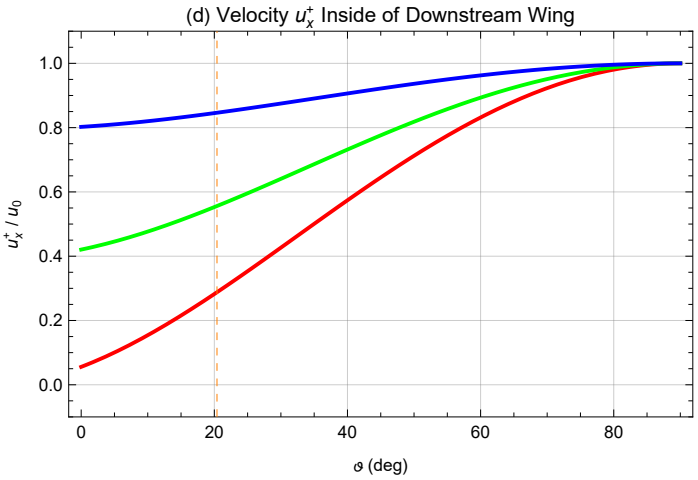
Out[ ]=
```
0.348577
```

In[ ]:=
```
Plot1 = Plot[
  {uz[theta * 2 π / 360, 0.0] / (u0), uz[theta * 2 π / 360, 0.4] / (u0), uz[theta * 2 π / 360, 0.8] / (u0)},
  {theta, 0, 90}, FrameLabel → {"ϑ (deg)", "u_z^+ / u_0"}, GridLines → Automatic,
  Frame → True, PlotLabel → "(b) Velocity u_z^+ Inside of Downstream Wing",
  PlotStyle → {{Red, Thick}, {Green, Thick}, {Blue, Thick}},
  (*PlotLegends →{"λ = 1.0","λ = 0.6","λ = 0.2"},*)
  PlotRange → {-0.6, 0.2}, Epilog → {Directive[Dashed, Orange],
    InfiniteLine[{{ArcSin[MA] * 360 / 2 π, -0.6}, {ArcSin[MA] * 360 / 2 π, 0.2}}]}]

Plot2 = Plot[{ux[theta * 2 π / 360, 0.0] / (u0), ux[theta * 2 π / 360, 0.4] / (u0),
   ux[theta * 2 π / 360, 0.8] / (u0)}, {theta, 0, 90},
  FrameLabel → {"ϑ (deg)", "u_x^+ / u_0"}, GridLines → Automatic, Frame → True,
  PlotLabel → "(d) Velocity u_x^+ Inside of Downstream Wing",
  PlotStyle → {{Red, Thick}, {Green, Thick}, {Blue, Thick}},
  (*PlotLegends →{"λ = 1.0","λ = 0.6","λ = 0.2"},*)
  PlotRange → {-0.1, 1.1}, Epilog → {Directive[Dashed, Orange],
    InfiniteLine[{{ArcSin[MA] * 360 / 2 π, -0.1}, {ArcSin[MA] * 360 / 2 π, 1.1}}]}]

Plot3 = Plot[{Abs[uz[theta * 2 π / 360, 0.0] / ux[theta * 2 π / 360, 0.0]],
   Abs[uz[theta * 2 π / 360, 0.4] / ux[theta * 2 π / 360, 0.4]],
   Abs[uz[theta * 2 π / 360, 0.8] / ux[theta * 2 π / 360, 0.8]]}, {theta, ArcSin[MA] * 360 / 2 π, 90},
  FrameLabel → {"ϑ (deg)", "|u_z^+ / u_x^+|"}, GridLines → Automatic, Frame → True,
  PlotLabel → "(f) Ratio |u_z^+ / u_x^+| Inside of Downstream Wing",
  PlotStyle → {{Red, Thick}, {Green, Thick}, {Blue, Thick}},
  (*PlotLegends →{"λ = 1.0","λ = 0.6","λ = 0.2"},*)PlotRange → {0, 2}]
```

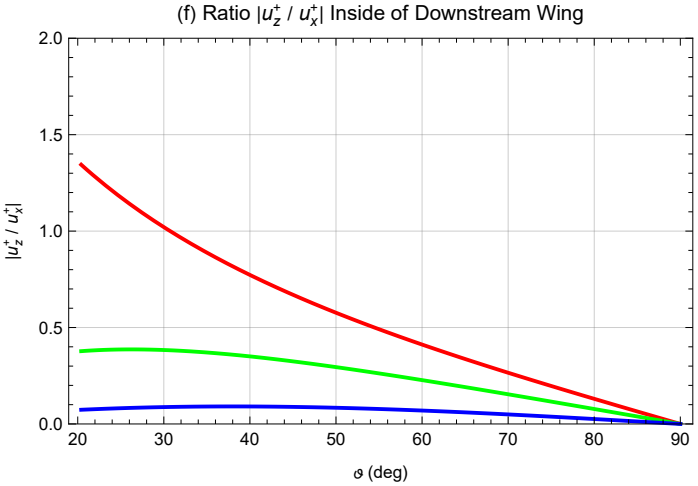
Out[ ]=


(b) Velocity u_z^+ Inside of Downstream Wing
u_z^+ / u_0
ϑ (deg)

Out[ ]=


(d) Velocity u_x^+ Inside of Downstream Wing
u_x^+ / u_0
ϑ (deg)

Out[ ]=


(f) Ratio $|u_z^+ / u_x^+|$ Inside of Downstream Wing
$|u_z^+ / u_x^+|$
ϑ (deg)

In[ ]:=
```
Export["figure3b_newNOLEGEND.pdf", Plot1]
Export["figure3d_newNOLEGEND.pdf", Plot2]
Export["figure3f_newNOLEGEND.pdf", Plot3]
```

Out[ ]= figure3b_newNOLEGEND.pdf

Out[ ]= figure3d_newNOLEGEND.pdf

Out[ ]= figure3f_newNOLEGEND.pdf

```
"figure3_uz_angleV3SOUTHlamS.pdf"
```