# Example Runs

## Problem 1: Verifying using the same orbit

Initial orbit:

a = 20000;
e = 0.4335;
i = 30.19;
raan = 44.6;
w = 30.71;
u = 350.8;

Final orbit:

v = [-3.3125 -4.1966 -0.38529];
r = [-14600 2500 7000];
a =20000;
e=0.4335;
i=30.19;
raan=44.6;
w=30.71;
u=91.1225;

Time of flight = 3600 sec

This is the same orbit but at different true anomalies.

We solved by freeing dvx, dvy, dvz and the time of flight. Then we expect that the impulse will be almost zero.

| | 1 |
|---|---|
| 1 | -2.2802e-06 |
| 2 | -6.4820e-06 |
| 3 | -1.7537e-06 |
| 4 | 3.6007e+03 |

Converged after 12 iterations at tolerance = 1e-5

Answer is:

dv=[-2.2802e-6, -6.4820e-6, -1.7537e-6), tof=3.6007e03

## Problem 2: Rendezvous

The problem was based on constructing a transfer orbit between earth and a near earth object. Our free variables were 6. We assumed in this test case that we had 2 impulse maneuvers: dvx1, dvy1, dvz1, dvx2, dvy2, dvz2. Our initial guesses were as follows:

```
dvx1 = 2; dvy1 =2; dvz1 = 2;dvx2 = 2; dvy2 = 2; dvz2 = 2;
```

And here are the first three iterations of the Jacobian matrix

6x6 double

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 2.6705 | 1.5995 | -0.2259 | 1.0000 | 0 | 0 |
| 2 | 5.0211 | 2.1763 | -0.3667 | 0 | 1.0000 | 0 |
| 3 | -0.4373 | -0.2358 | -0.6167 | 0 | 0 | 1.0000 |
| 4 | 1.7750e+07 | 2.9408e+06 | -7.1371e+05 | 0 | 0 | 0 |
| 5 | 7.7133e+06 | 7.4515e+06 | -5.1792e+05 | 0 | 0 | 0 |
| 6 | -1.0081e+06 | -3.3527e+05 | 3.9059e+06 | 0 | 0 | 0 |
| 7 | | | | | | |

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 1.2346 | 0.5341 | -0.0277 | 1.0000 | 0 | 0 |
| 2 | 1.0621 | 1.6629 | -0.0501 | 0 | 1.0000 | 0 |
| 3 | -0.0405 | -0.0421 | 0.2661 | 0 | 0 | 1.0000 |
| 4 | 1.1801e+07 | 2.8643e+06 | -1.7150e+05 | 0 | 0 | 0 |
| 5 | 4.6433e+06 | 9.8797e+06 | -1.8754e+05 | 0 | 0 | 0 |
| 6 | -2.1466e+05 | -1.6046e+05 | 5.0636e+06 | 0 | 0 | 0 |
| 7 | | | | | | |
| 8 | | | | | | |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1 | 0.9564 | 0.4521 | -0.0217 | 1.0000 | 0 | 0 | |
| 2 | 1.5698 | 2.2659 | -0.0663 | 0 | 1.0000 | 0 | |
| 3 | -0.0442 | -0.0523 | -0.0556 | 0 | 0 | 1.0000 | |
| 4 | 1.1896e+07 | 3.4367e+06 | -1.7164e+05 | 0 | 0 | 0 | |
| 5 | 7.0727e+06 | 1.1537e+07 | -2.4650e+05 | 0 | 0 | 0 | |
| 6 | -2.4456e+05 | -2.0097e+05 | 3.6594e+06 | 0 | 0 | 0 | |
| 7 | | | | | | | |

The convergence critereon (1e-5) was met after seven iterations. Our boundary conditions were the vx, vy, vz, rx, ry, and rz of the initial earth orbit.

```
rinit=[-1.25732e08 7.77318e07 -2734.18];
vinit=[-16.1558 -25.4399 0.000561496];
```

And after the seven iterations, our 2 delta v vectors were as follows:

| |
|---|
| 15.4895 |
| -20.8443 |
| 0.8771 |
| -14.9935 |
| 14.4833 |
| 0.1648 |

with the order of vx1 vy1 vz1 vx2 vy2 vz2

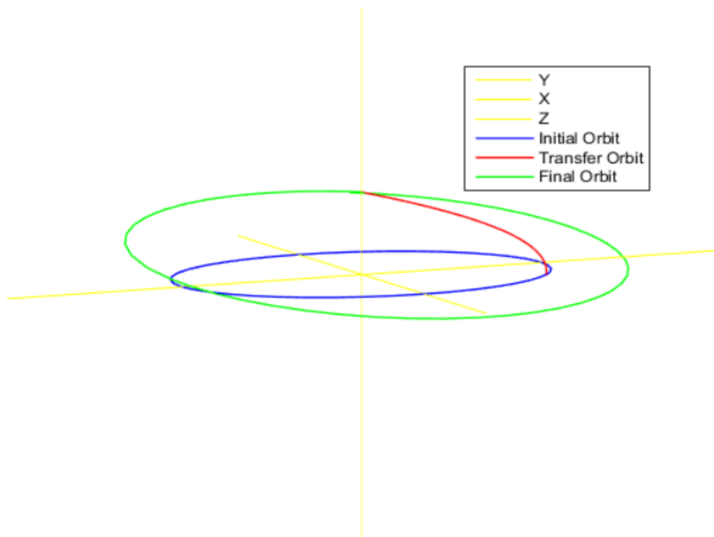
Our final velocity vector:

1x3 double

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 17.3569 | -4.6072 | 0.1484 | |
| 2 | | | | |

The plot between the initial and final orbits:

After convergence:




Its iterations:


## Hohmann Transfer

### FIRST TRIAL:

Initial: Vo = [0,7.7258,0]; Ro = [6678,0,0];

TOF = 3579;

Boundary conditions:

- Rmag = 9378
- e=0

*following dvs are in VUW frame

Given fixed dvs:

- flight path angle 1 = dihedral angle 1 = dihedral angle 2 =0
- flight path angle 2=pi

Guesses:

- dv1 = 0.2
- dv2=0

Convergence tolerance = 1e-4

Perturbation = 1e-3

- After 1 iteration:

```
G =

     1


Jaco =

   1.0e+03 *

    3.7860         0
    0.0003    0.0002
```

- After 2 iterations:

```
G =

     2


Jaco =

   1.0e+03 *

    5.5689         0
   -0.0001   -0.0003
```

- After 3 iterations:

```
G =

     3


Jaco =

   1.0e+03 *

    5.4036         0
   -0.0002   -0.0003
```

- After 4 iterations:

```
G =

     4


Jaco =

   1.0e+03 *

    5.4008         0
    0.0003   -0.0003
```

- After 5 iterations:

```
G =

     5


Jaco =

   1.0e+03 *

    5.4008         0
    0.0003   -0.0002
```

Convergence happens after 5 iterations.

Result:

- rmag=9.378e03
- e=8e-05

BC final (result): [vmag rmag e i a energy]

| | | | | | |
|---|---|---|---|---|---|
| 6.5192 | 9.3780e+03 | 8.0961e-05 | 0 | 9.3773e+03 | -21.2534 |

And it can be verified from our original BCs of rmag = 93780 and eccentricity = 0.

## SECOND TRIAL:

We changed the BCs to Vmag and energy, from the vector seen in the previous figure. Our BCs were as follows and initial guesses were as follows:

```
BCus = [6.5192, -21.2534];
x0 = [0.2 0 0 0 pi 0 3579];
```

Our order of the initial guesses ad the constraints the user should put are as follows: dv1 flight path angle 1, dihedral angle 1, dv2 ,flight path angle 2, dihedral angle 2, tof.

As our previous trial we freed the dv1 and dv2 and iterated with the initial guesses of 0.2 and zero in the previous figure. (xo vector)

The jacobian of the iterations were as follows: (left to right iterations 1 to 4)

```
Jaco =

   -2.8632   -1.0000
    7.9001   -7.2863
```

```
Jaco =

   -2.7212   -1.0000
    6.9613   -6.4672
```

```
Jaco =

   -2.7109   -1.0000
    6.7965   -6.5195
```

```
Jaco =

   -2.7111   -1.0000
    6.7968   -6.5195
```

The solution of the dv1 and dv2 was:

xp

2x1 double

| | 1 |
|---|---|
| 1 | 0.6502 |
| 2 | -0.5731 |
| 3 | |

And the final solution vector converged to:

1x6 double

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1 | 6.5192 | 9.3781e+03 | 8.8183e-05 | 0 | 9.3773e+03 | -21.2534 | |
| 2 | | | | | | | |
| 3 | | | | | | | |

## THIRD TRIAL:

In our third trial we decided to change the free variables to Dv1 and time of flight. Our xo and user BCs (rmag and e) were as follows:

```
BCus = [9.378e+3, 0];
x0 = [0.2 0 0 -5.733996e-01 pi 0 2500];
```

Our free variables, as mentioned earlier, ar the Dv1 with an initial guess of 0.2 and tof woth an initial guess of 2500.

Our solution converged after 6 iterarations to :

xp

2x1 double

| | 1 |
|---|---|
| 1 | 0.6502 |
| 2 | 3.5791e+03 |
| 3 | |

The Dv1 corresponds to the first term and the tof corresponds to the second term. As can be seen, the tof and Dv1 converged to the correct solutions that were found and defined in the previous two trials.

The final answerr vector was:

1x6 double

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 6.5195 | 9.3780e+03 | 1.2559e-05 | 0 | 9.3781e+03 | -21.2517 |
| 2 | | | | | | |

In all the previous trials, the solution converged to the same graph. Here are the graphs of the iterations and the final answer.