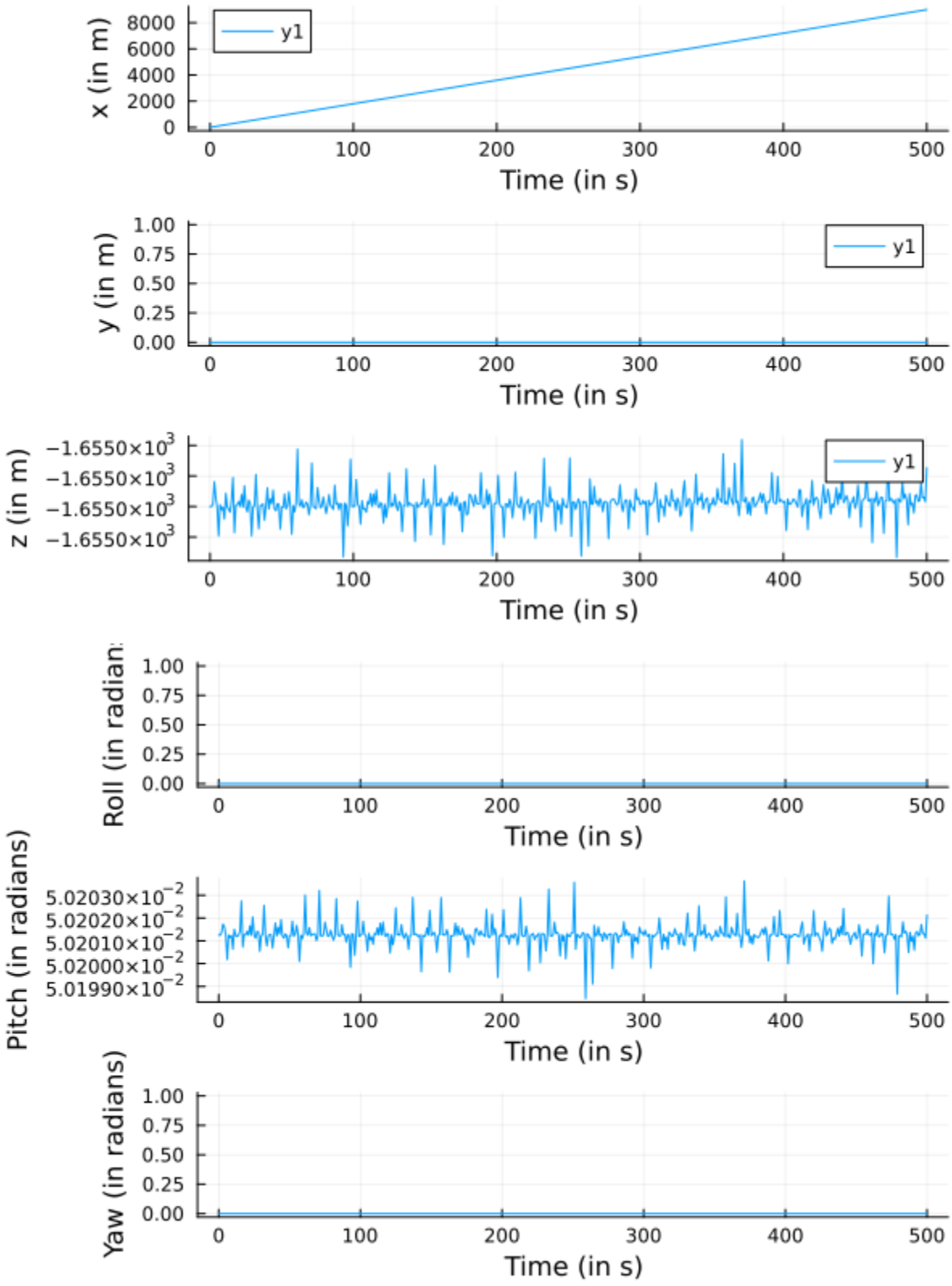
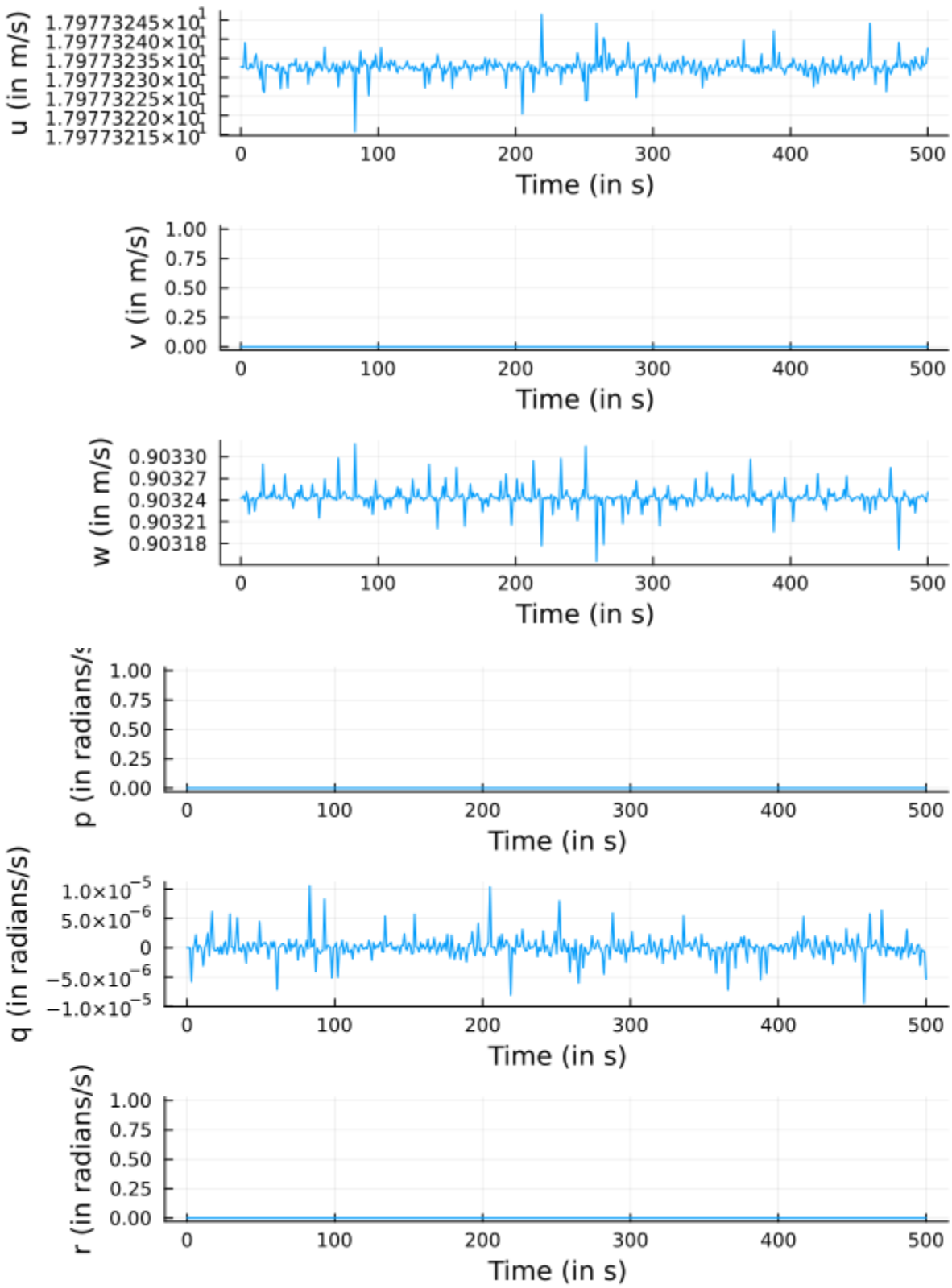
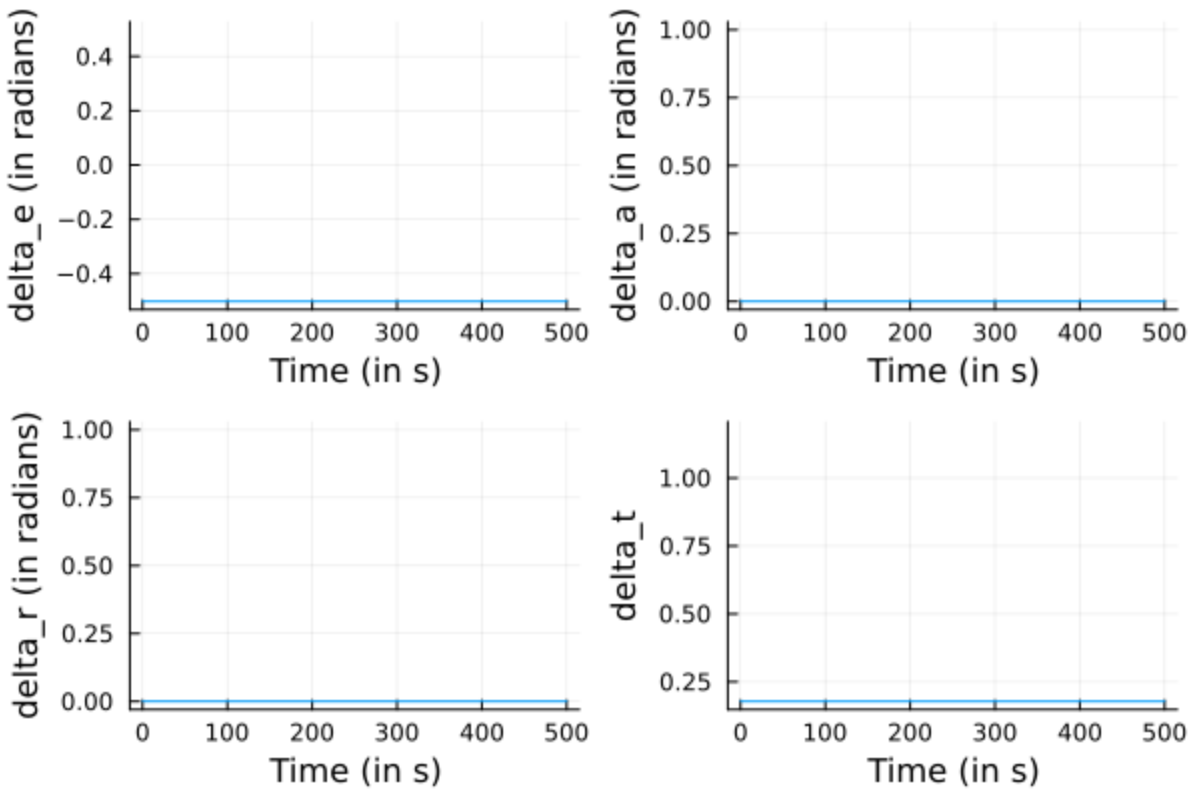
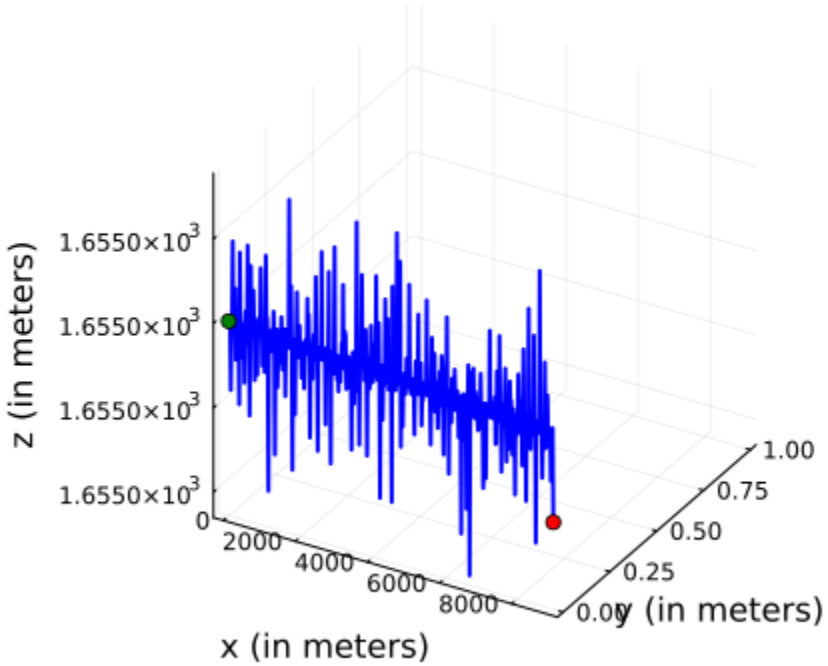
Problem 3.1


x (in m)
8000
6000
4000
2000
0
y1
0
100
200
300
400
500
Time (in s)
y (in m)
1.00
0.75
0.50
0.25
0.00
y1
0
100
200
300
400
500
Time (in s)
z (in m)
−1.6550×10^3
−1.6550×10^3
−1.6550×10^3
−1.6550×10^3
y1
0
100
200
300
400
500
Time (in s)
Roll (in radian
1.00
0.75
0.50
0.25
0.00
0
100
200
300
400
500
Time (in s)
Pitch (in radians)
5.02030×10^−2
5.02020×10^−2
5.02010×10^−2
5.02000×10^−2
5.01990×10^−2
0
100
200
300
400
500
Time (in s)
Yaw (in radians)
1.00
0.75
0.50
0.25
0.00
0
100
200
300
400
500
Time (in s)


u (in m/s)
1.79773245×10^1
1.79773240×10^1
1.79773235×10^1
1.79773230×10^1
1.79773225×10^1
1.79773220×10^1
1.79773215×10^1
0
100
200
300
400
500
Time (in s)
v (in m/s)
1.00
0.75
0.50
0.25
0.00
0
100
200
300
400
500
Time (in s)
w (in m/s)
0.90330
0.90327
0.90324
0.90321
0.90318
0
100
200
300
400
500
Time (in s)
p (in radians/s
1.00
0.75
0.50
0.25
0.00
0
100
200
300
400
500
Time (in s)
q (in radians/s)
1.0×10^−5
5.0×10^−6
0
−5.0×10^−6
−1.0×10^−5
0
100
200
300
400
500
Time (in s)
r (in radians/s)
1.00
0.75
0.50
0.25
0.00
0
100
200
300
400
500
Time (in s)


delta_e (in radians)
0.4
0.2
0.0
−0.2
−0.4
0
100
200
300
400
500
Time (in s)
delta_a (in radians)
1.00
0.75
0.50
0.25
0.00
Time (in s)
delta_r (in radians)
Time (in s)
delta_t
Time (in s)


z (in meters)
1.6550×10^3
1.6550×10^3
1.6550×10^3
1.6550×10^3
0
2000
4000
6000
8000
x (in meters)
1.00
0.75
0.50
0.25
0.00
y (in meters)

Starting (Trim) State:

0.0
0.0
-1655.0
0.0
0.050201252250689686
0.0
17.977323271478497
0.0
0.9032430419093346
0.0
0.0
0.0

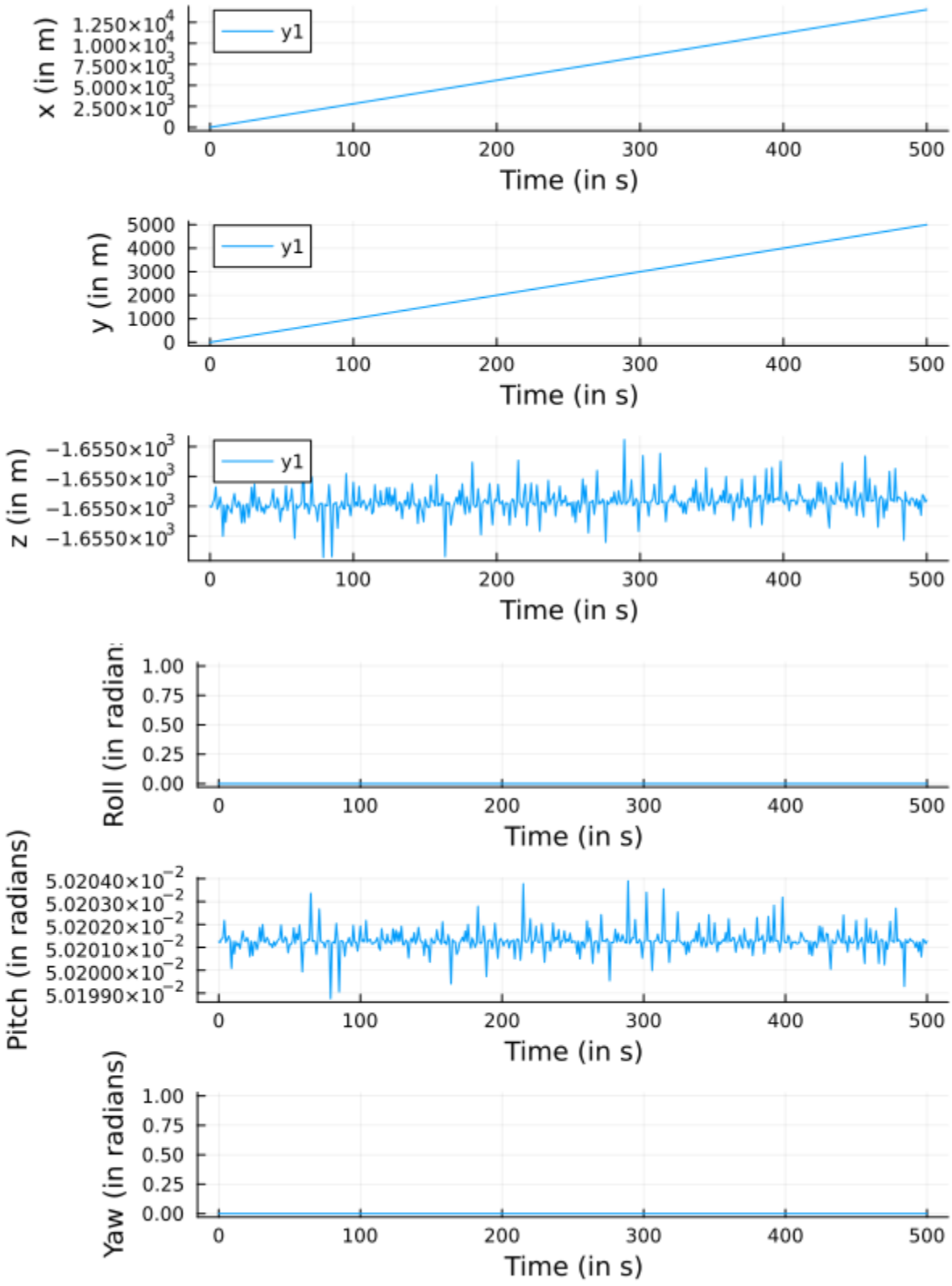
Trim Controls:

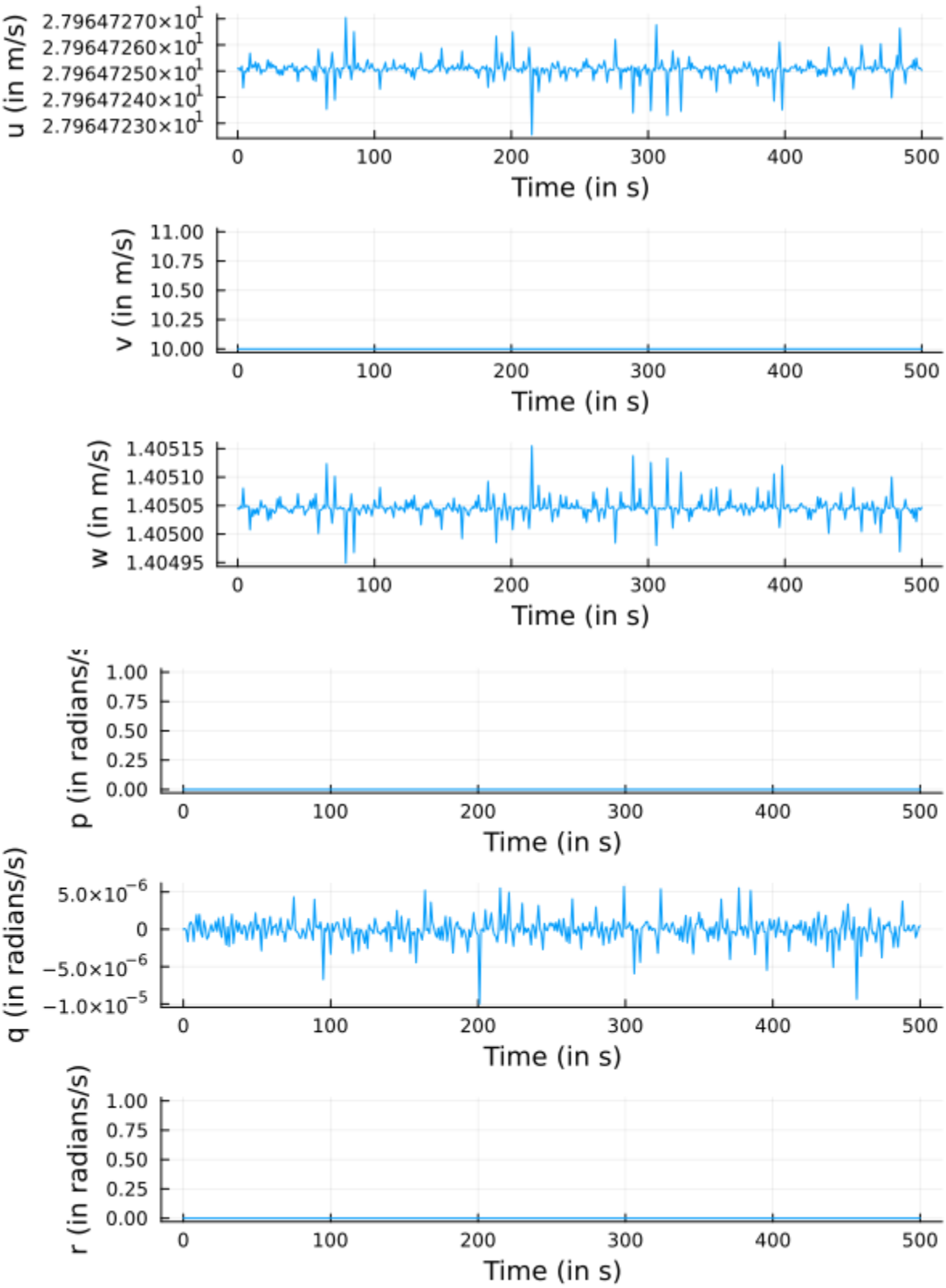
-0.5021558030179929
0.0
0.0
0.17764553656958398

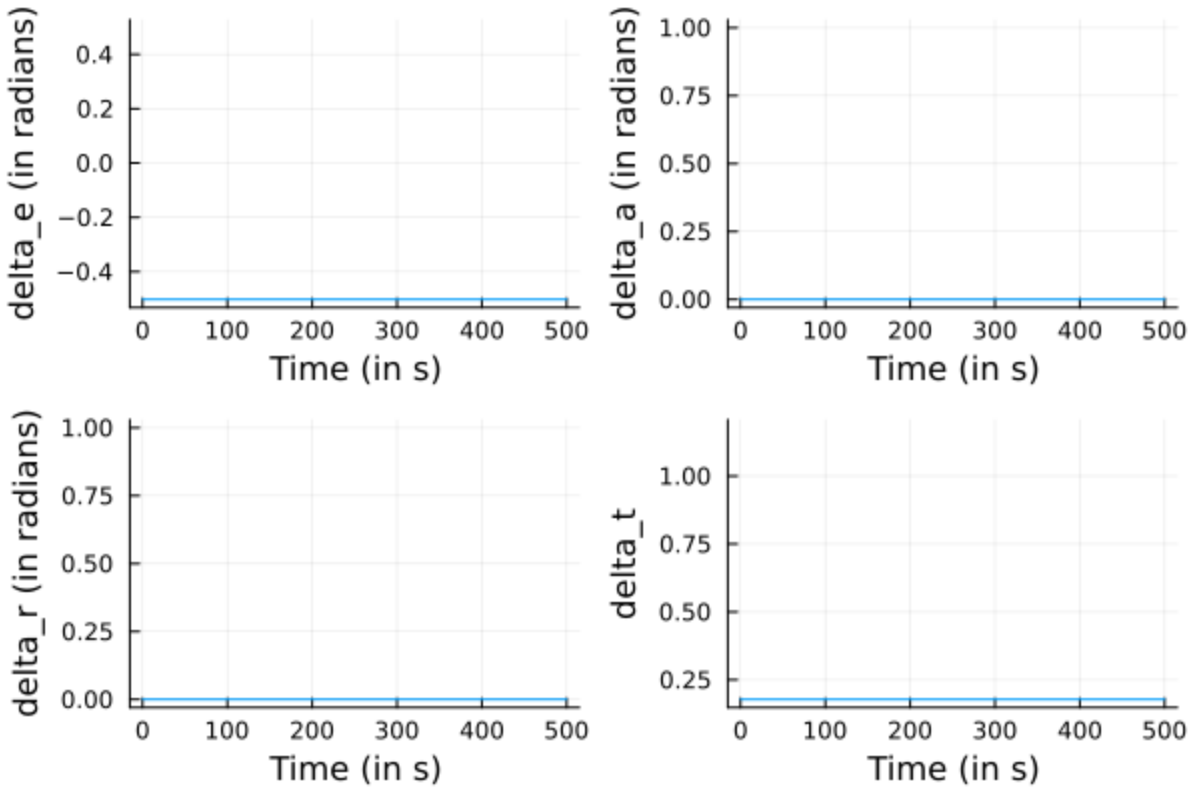
Trim Variables:

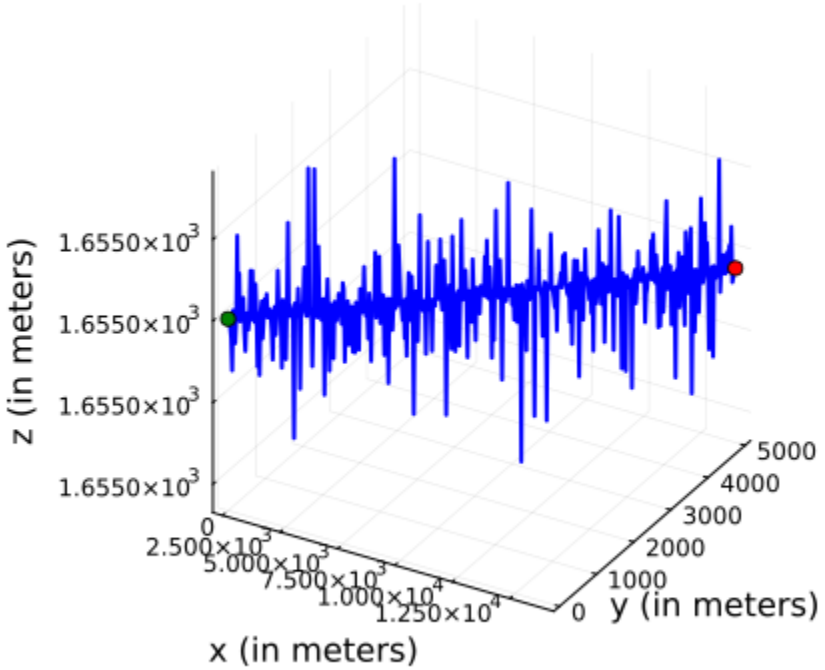
0.050201252250689686
-0.5021558030179929
0.17764553656958398

Problem 3.2


x (in m)
1.250×10^4
1.000×10^4
7.500×10^3
5.000×10^3
2.500×10^3
0
y1
0
100
200
300
400
500
Time (in s)
y (in m)
5000
4000
3000
2000
1000
0
y1
Time (in s)
z (in m)
−1.6550×10^3
−1.6550×10^3
−1.6550×10^3
−1.6550×10^3
y1
Time (in s)
Roll (in radian
1.00
0.75
0.50
0.25
0.00
Time (in s)
Pitch (in radians)
5.02040×10^−2
5.02030×10^−2
5.02020×10^−2
5.02010×10^−2
5.02000×10^−2
5.01990×10^−2
Time (in s)
Yaw (in radians)
1.00
0.75
0.50
0.25
0.00
Time (in s)


u (in m/s)
2.79647270×10^1
2.79647260×10^1
2.79647250×10^1
2.79647240×10^1
2.79647230×10^1
0
100
200
300
400
500
Time (in s)
v (in m/s)
11.00
10.75
10.50
10.25
10.00
0
100
200
300
400
500
Time (in s)
w (in m/s)
1.40515
1.40510
1.40505
1.40500
1.40495
0
100
200
300
400
500
Time (in s)
p (in radians/s
1.00
0.75
0.50
0.25
0.00
0
100
200
300
400
500
Time (in s)
q (in radians/s)
5.0×10^−6
0
−5.0×10^−6
−1.0×10^−5
0
100
200
300
400
500
Time (in s)
r (in radians/s)
1.00
0.75
0.50
0.25
0.00
0
100
200
300
400
500
Time (in s)


delta_e (in radians)
0.4
0.2
0.0
−0.2
−0.4
0
100
200
300
400
500
Time (in s)
delta_a (in radians)
1.00
0.75
0.50
0.25
0.00
Time (in s)
delta_r (in radians)
Time (in s)
delta_t
Time (in s)


z (in meters)
1.6550×10^3
1.6550×10^3
1.6550×10^3
1.6550×10^3
0
2.500×10^3
5.000×10^3
7.500×10^3
1.000×10^4
1.250×10^4
x (in meters)
0
1000
2000
3000
4000
5000
y (in meters)

Starting (Trim) State:

```
     0.0
     0.0
 -1655.0
     0.0
     0.050201252250689686
     0.0
    27.964725088966553
    10.0
     1.405044731858965
     0.0
     0.0
     0.0
```

Trim Controls:

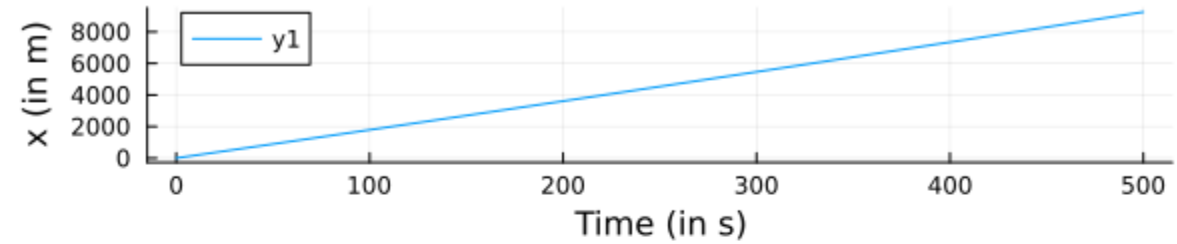
```
 -0.5021558030179929
  0.0
  0.0
  0.17764553656958398
```

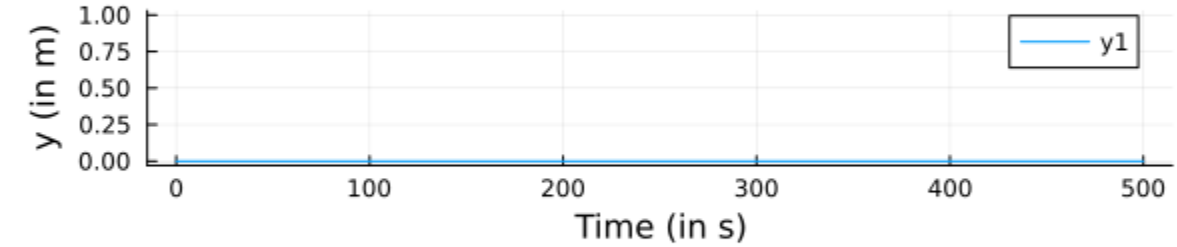
Trim Variables:

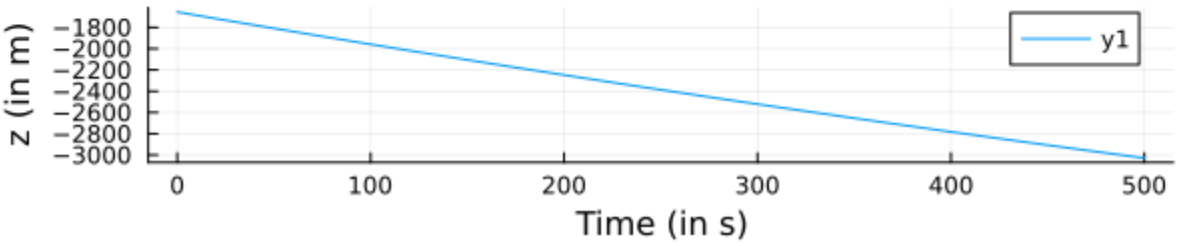
```
  0.050201252250689686
 -0.5021558030179929
  0.17764553656958398
```

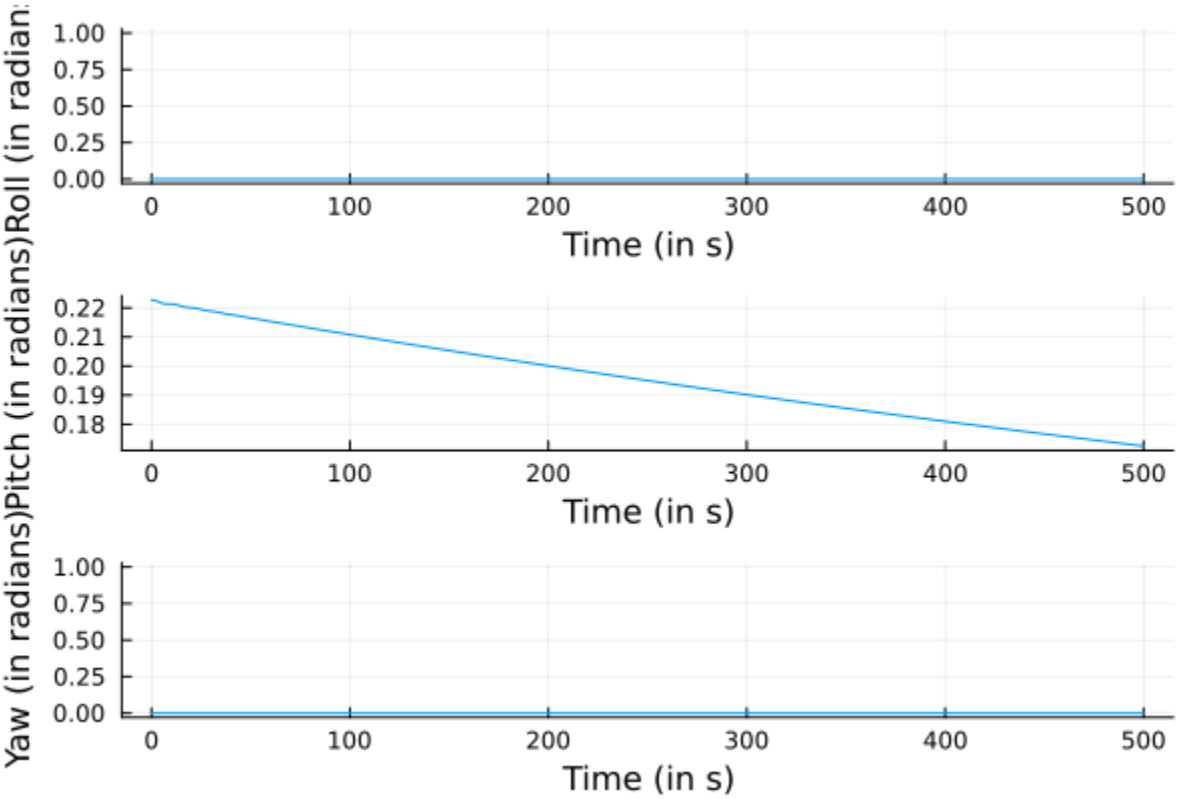
The velocity component in the start state is augmented with the inertial wind velocity expressed in the body frame to get the inertial aircraft velocity in the body frame. This is done because the trim condition is computed using the air-relative velocity vector, not the inertial aircraft velocity.

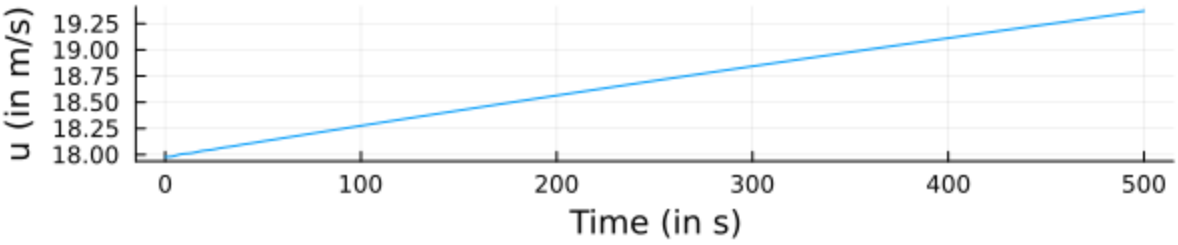
Problem 3.3

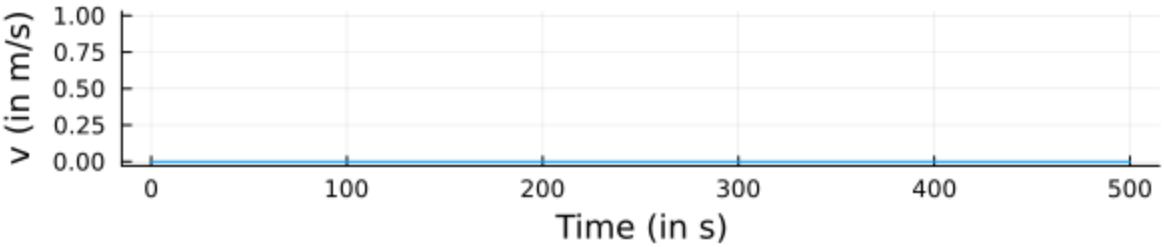

x (in m)
8000
6000
4000
2000
0
y1
0
100
200
300
400
500
Time (in s)

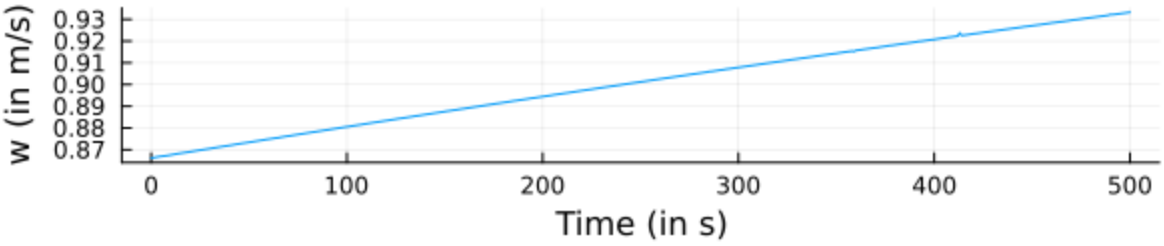

y (in m)
1.00
0.75
0.50
0.25
0.00
y1
0
100
200
300
400
500
Time (in s)

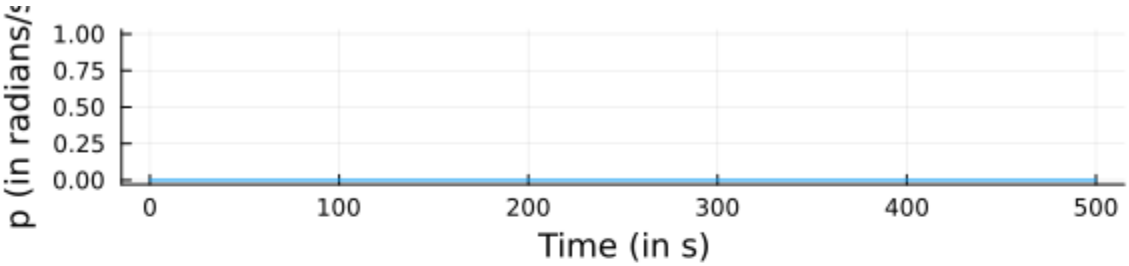

z (in m)
−1800
−2000
−2200
−2400
−2600
−2800
−3000
y1
0
100
200
300
400
500
Time (in s)

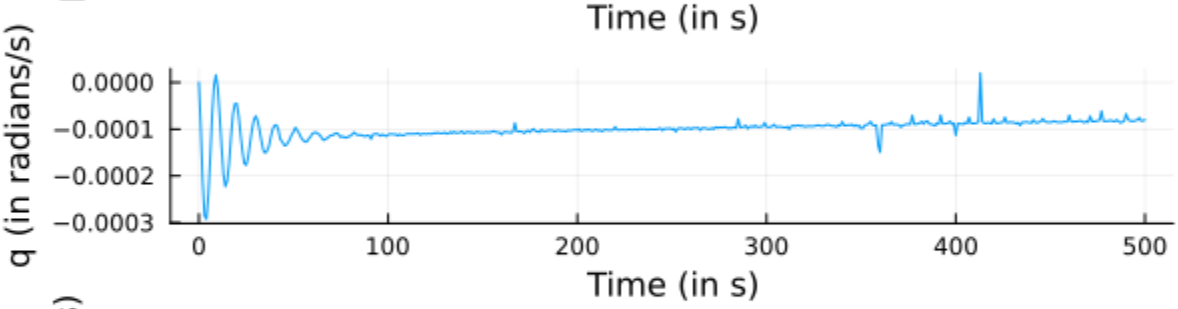

Roll (in radian
Pitch (in radians)
Yaw (in radians)
1.00
0.75
0.50
0.25
0.00
0.22
0.21
0.20
0.19
0.18
0
100
200
300
400
500
Time (in s)

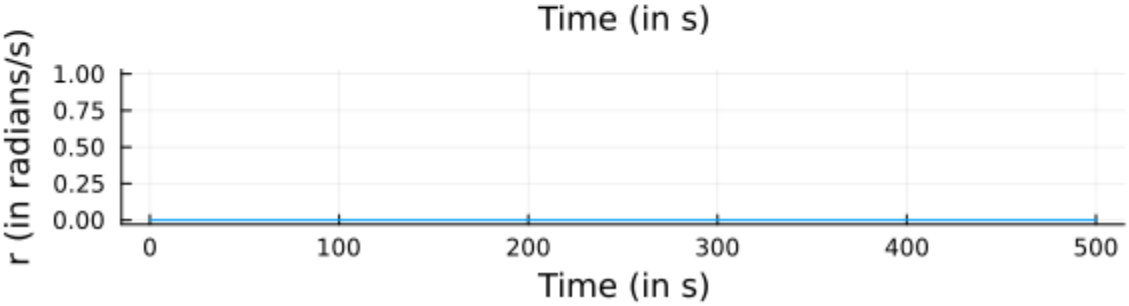

u (in m/s)
19.25
19.00
18.75
18.50
18.25
18.00
0
100
200
300
400
500
Time (in s)

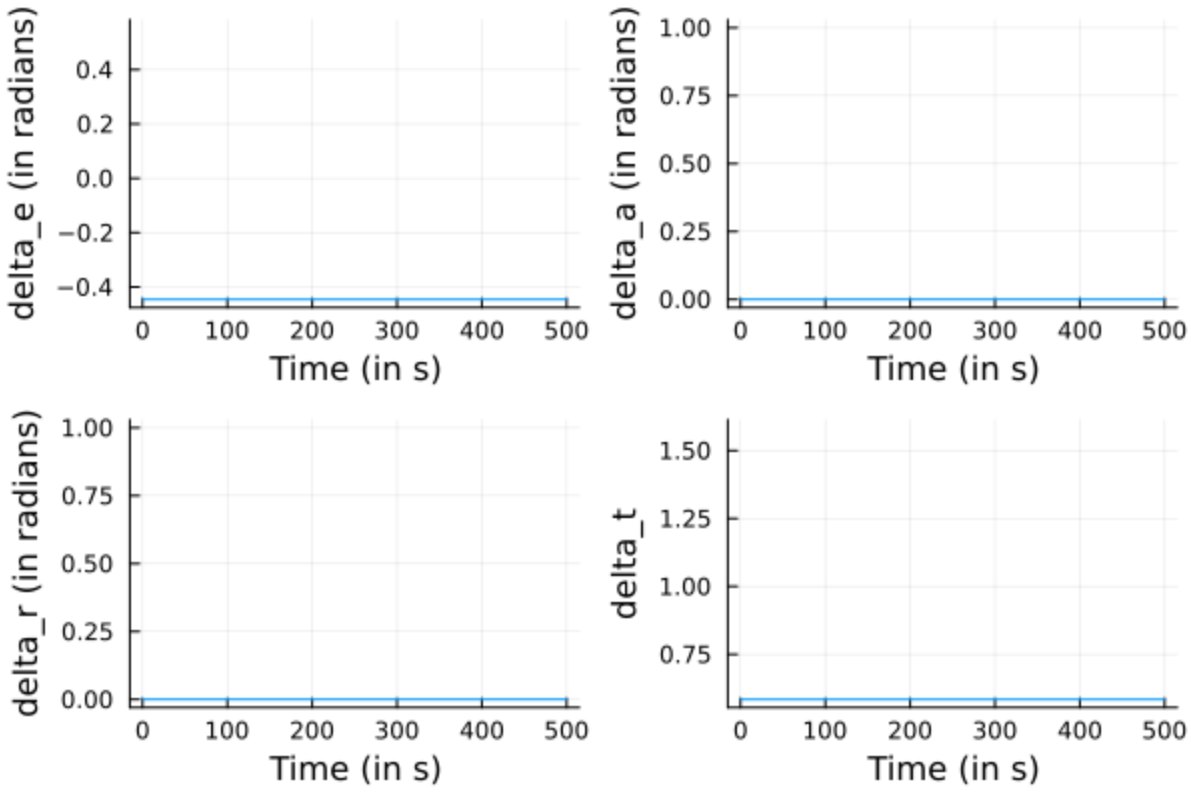

v (in m/s)
1.00
0.75
0.50
0.25
0.00
0
100
200
300
400
500
Time (in s)

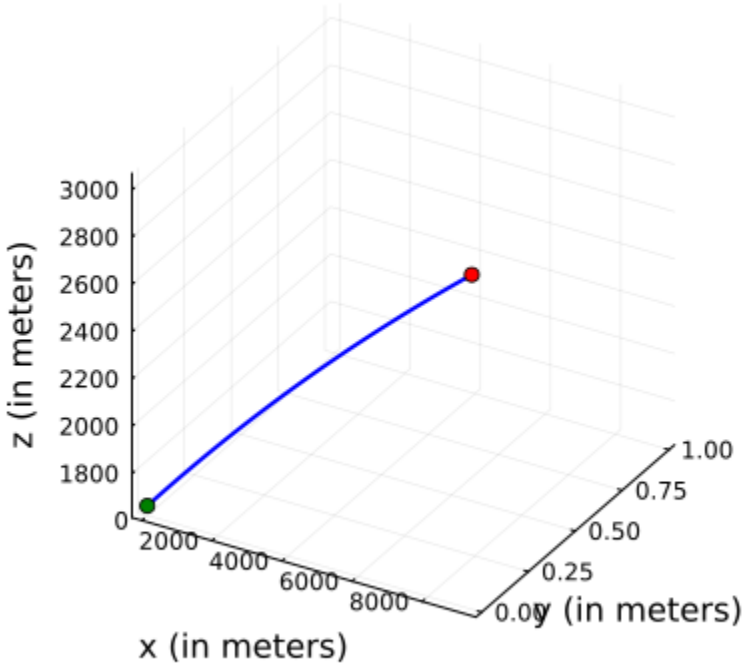

w (in m/s)
0.93
0.92
0.91
0.90
0.89
0.88
0.87
0
100
200
300
400
500
Time (in s)


p (in radians/s
1.00
0.75
0.50
0.25
0.00
0
100
200
300
400
500
Time (in s)


q (in radians/s)
0.0000
−0.0001
−0.0002
−0.0003
0
100
200
300
400
500
Time (in s)


r (in radians/s)
1.00
0.75
0.50
0.25
0.00
0
100
200
300
400
500
Time (in s)


delta_e (in radians)
0.4
0.2
0.0
−0.2
−0.4
0
100
200
300
400
500
Time (in s)
delta_a (in radians)
1.00
0.75
0.50
0.25
0.00
Time (in s)
delta_r (in radians)
Time (in s)
delta_t
1.50
1.25
1.00
0.75
Time (in s)


z (in meters)
3000
2800
2600
2400
2200
2000
1800
0
2000
4000
6000
8000
x (in meters)
1.00
0.75
0.50
0.25
0.00
y (in meters)

Starting (Trim) State:

```
    0.0
    0.0
-1655.0
    0.0
    0.2226670348482986
    0.0
   17.979151993077068
    0.0
    0.8660794477603566
    0.0
    0.0
    0.0
```

Trim Controls:

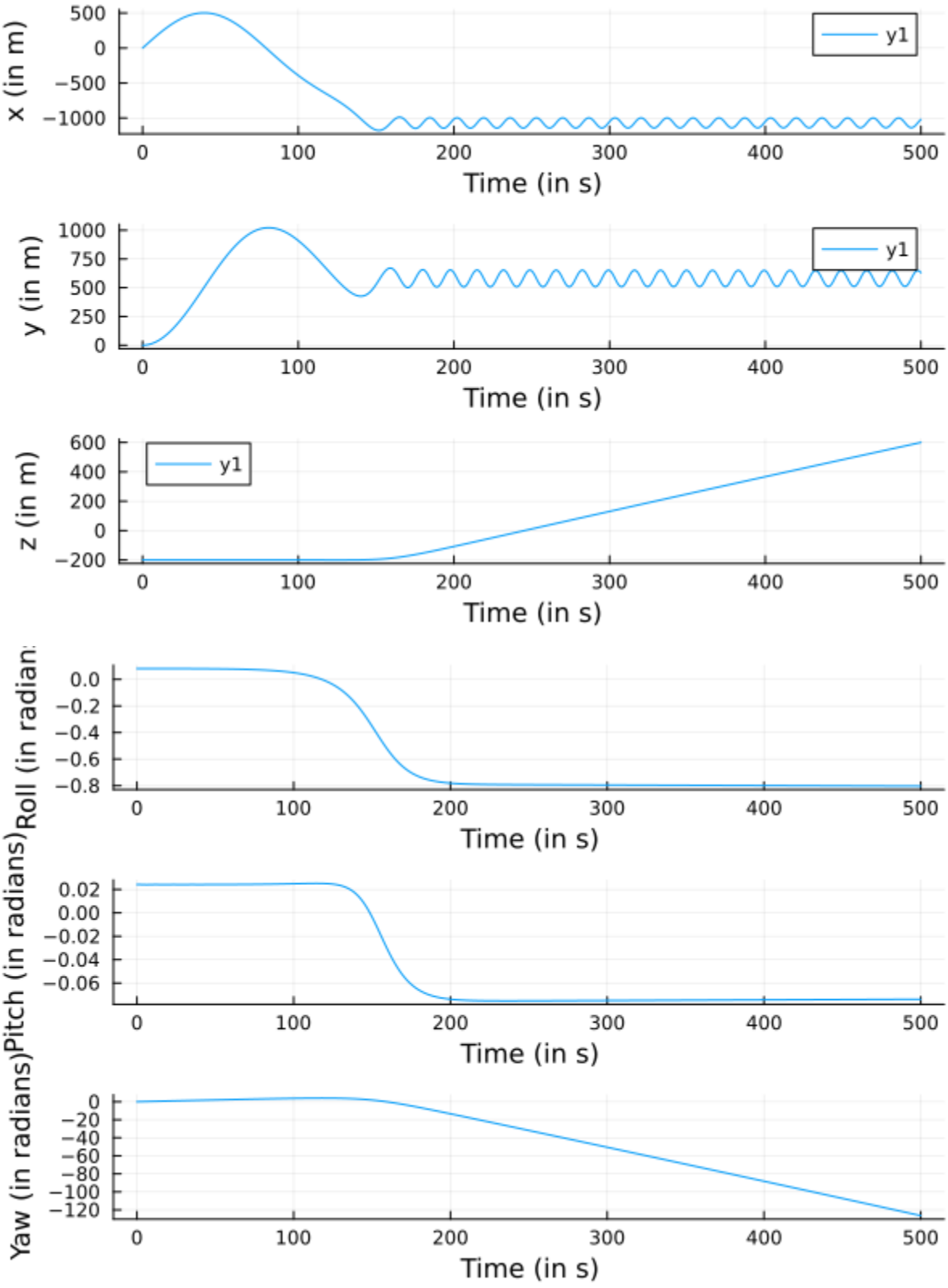
```
-0.44586027498230835
 0.0
 0.0
 0.5838151089543826
```

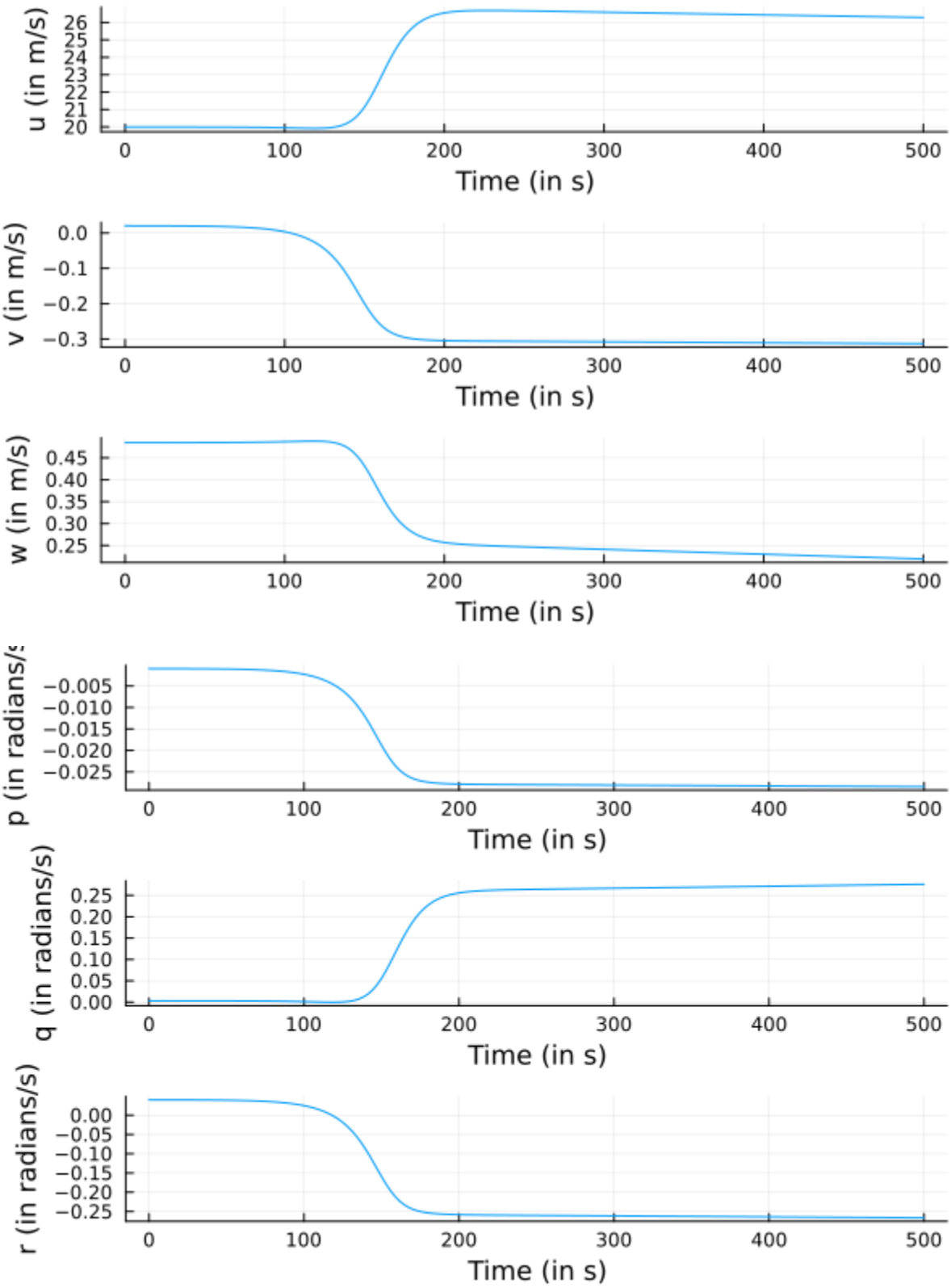
Trim Variables:

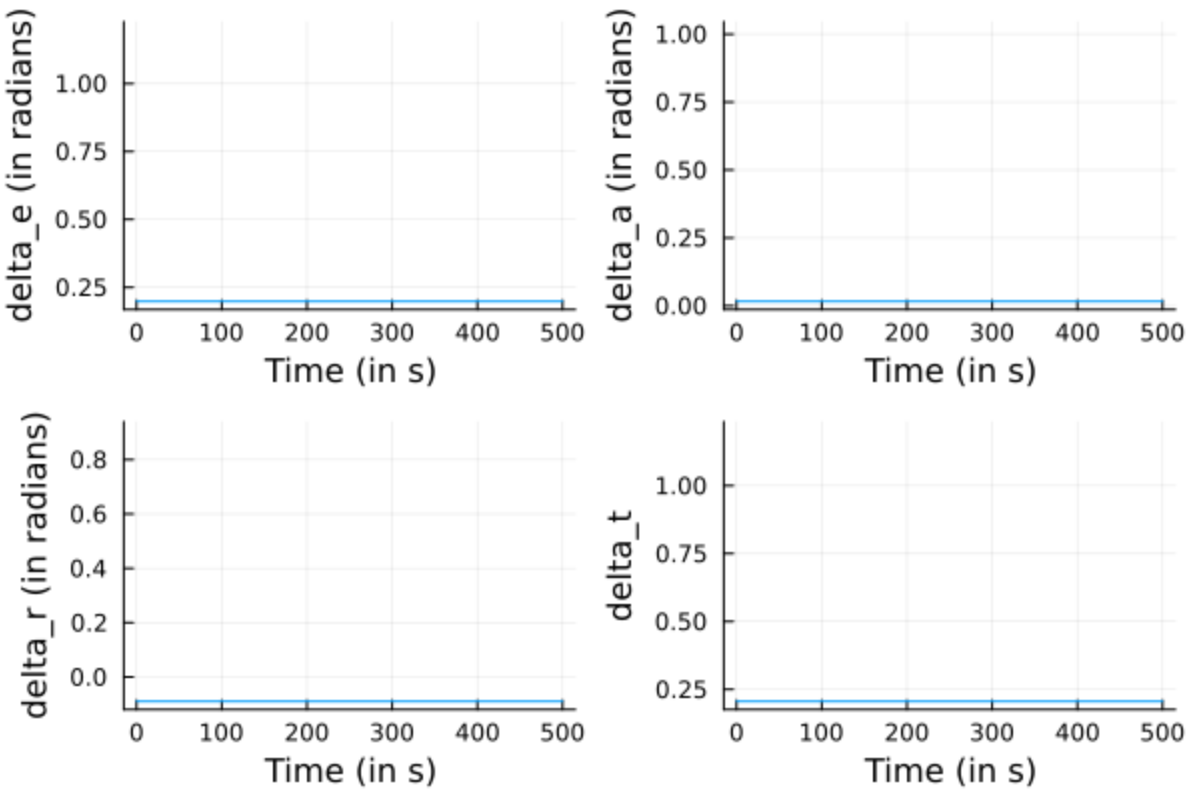
```
 0.048134109648865664
-0.44586027498230835
 0.5838151089543826
```

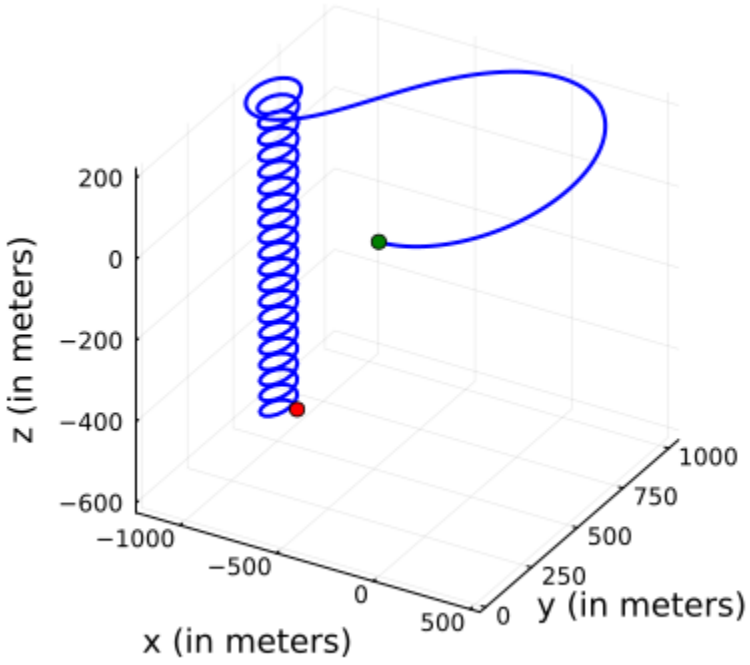
The aircraft initially flies upward, but as it gains height, the density changes and the aircraft is no longer in trim for the given control inputs. Consequently, the pitch starts to decrease, and the aircraft will eventually settle into a new straight, wing-level, horizontal flight condition.

Problem 3.4


x (in m)
500
0
−500
−1000
y1
0
100
200
300
400
500
Time (in s)
y (in m)
1000
750
500
250
0
y1
Time (in s)
z (in m)
600
400
200
0
−200
y1
Time (in s)
Roll (in radian
0.0
−0.2
−0.4
−0.6
−0.8
Time (in s)
Pitch (in radians)
0.02
0.00
−0.02
−0.04
−0.06
Time (in s)
Yaw (in radians)
0
−20
−40
−60
−80
−100
−120
Time (in s)


u (in m/s)
26
25
24
23
22
21
20
0
100
200
300
400
500
Time (in s)
v (in m/s)
0.0
−0.1
−0.2
−0.3
0
100
200
300
400
500
Time (in s)
w (in m/s)
0.45
0.40
0.35
0.30
0.25
0
100
200
300
400
500
Time (in s)
p (in radians/s
−0.005
−0.010
−0.015
−0.020
−0.025
0
100
200
300
400
500
Time (in s)
q (in radians/s)
0.25
0.20
0.15
0.10
0.05
0.00
0
100
200
300
400
500
Time (in s)
r (in radians/s)
0.00
−0.05
−0.10
−0.15
−0.20
−0.25
0
100
200
300
400
500
Time (in s)


delta_e (in radians)
1.00
0.75
0.50
0.25
0
100
200
300
400
500
Time (in s)
delta_a (in radians)
1.00
0.75
0.50
0.25
0.00
0
100
200
300
400
500
Time (in s)
delta_r (in radians)
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
500
Time (in s)
delta_t
1.00
0.75
0.50
0.25
0
100
200
300
400
500
Time (in s)


z (in meters)
200
0
−200
−400
−600
−1000
−500
0
500
x (in meters)
0
250
500
750
1000
y (in meters)

Starting (Trim) State:

```
    0.0
    0.0
 -200.0
    0.08139317666496125
    0.02423488776132034
    0.0
   19.994116848132784
    0.020143935528348887
    0.48465006455598303
   -0.0009693006207633428
    0.003251178482991965
    0.03985586901296117
```

Trim Controls:

```
  0.19813076930125995
  0.016071727204618393
 -0.08999161995556897
  0.2057215557228874
```

Trim Variables:

```
  0.02423488776132034
  0.19813076930125995
  0.2057215557228874
  0.08139317666496125
  0.001007196946708536
  0.016071727204618393
 -0.08999161995556897
```

The aircraft initially enters a banked turn to achieve the desired radius, but since the lateral mode is unstable, it transitions into a spiral mode.