## Table of Contents



# homework 3

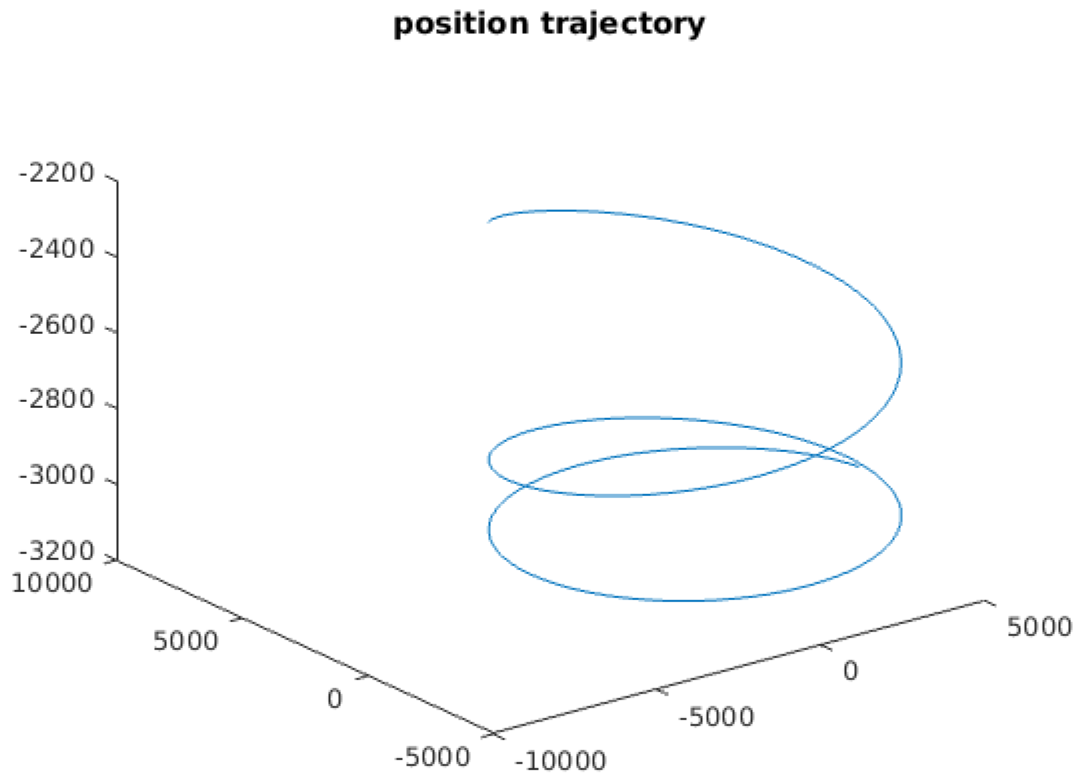
Bailey Waterman and Keshuai Xu

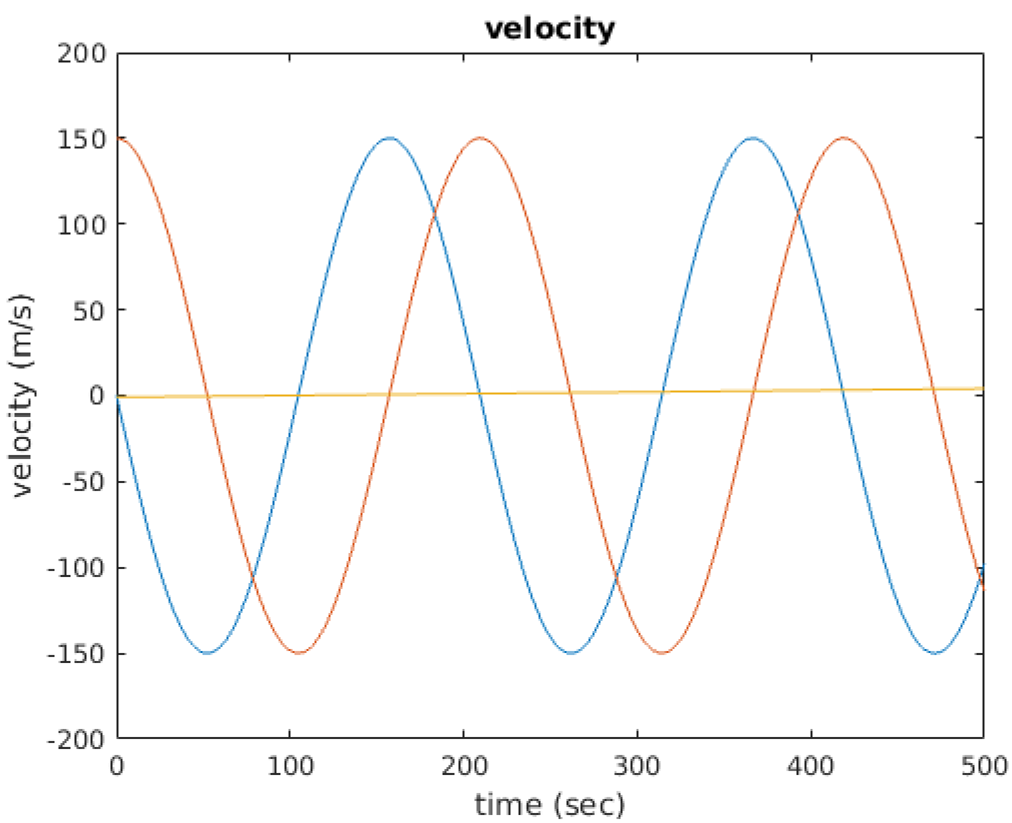
```
clear variables, clc, close all
```

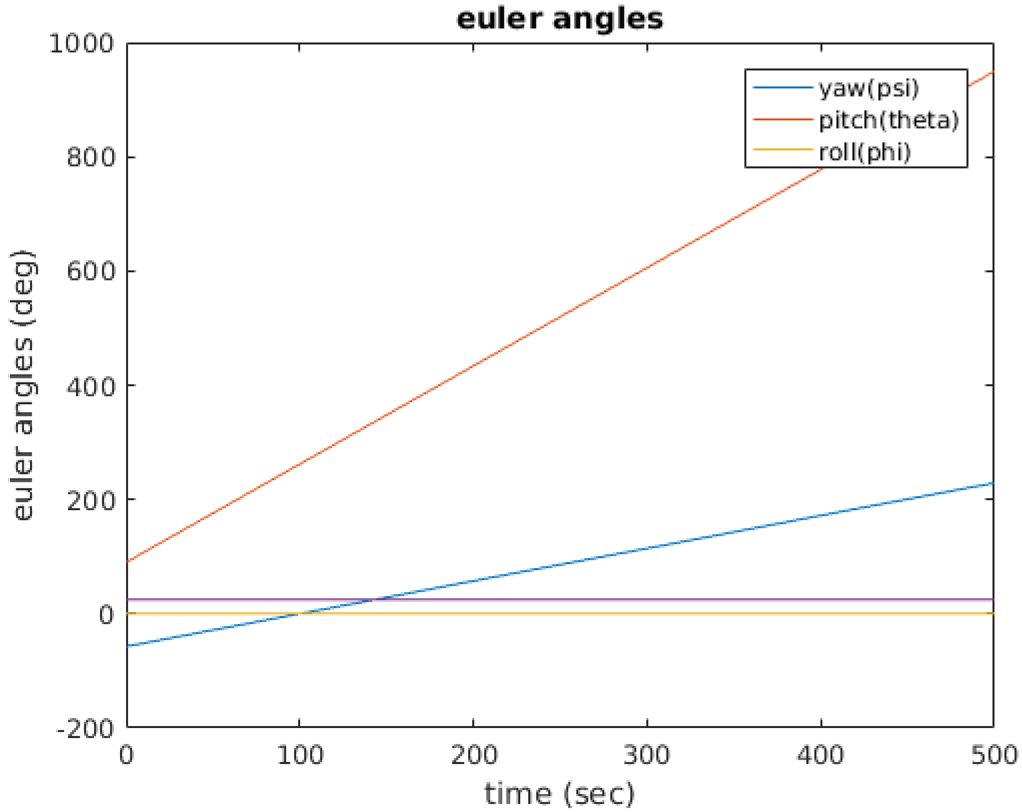
# Problem 4

```
%Create a function to write down the differnetial equations
function state_dot = ins_fun(t,state_xi, DATA)
%Time is always the first variable, state you're trying to integrate
 is
%second input

% need accel_meas_t from accel_meas
% need omega_iee from rate_gyros_meas
%pull out correct column
current_timestamp_col = find((t >= DATA.time_stamp), 1, 'last');
accel_meas_t = DATA.accel_readings(:, current_timestamp_col);
omega_iee = DATA.gyro_readings(:, current_timestamp_col);

grav_tt = [0; 0; 9.81];
omega_icc = [0, 0, 2*pi/86400]';

% posn_tt = state_xi(1:3);
vel_tt = state_xi(4:6);
yaw_321 = state_xi(7);
pitch_321 = state_xi(8);
roll_321 = state_xi(9);

mu_lat = deg2rad(42.271167);
mu_long = deg2rad(-71.807627);

% 3-2 rotation involving latitude and longitude
Rct = [cos(-(pi/2 + mu_lat)) 0 -sin(-(pi/2 + mu_lat));
        0 1 0;
        sin(-(pi/2 + mu_lat)) 0 cos(-(pi/2 + mu_lat))] * ...
      [cos(mu_long) sin(mu_long) 0;
      -sin(mu_long) cos(mu_long) 0;
      0 0 1];
```

```
Rte = ...
    [1 0 0;
    0 cos(roll_321) sin(roll_321);
    0 -sin(roll_321) cos(roll_321)] * ...
    [cos(pitch_321) 0 -sin(pitch_321);
    0 1 0;
    sin(pitch_321) 0 cos(pitch_321)] * ...
    [cos(yaw_321) sin(yaw_321) 0;
    -sin(yaw_321) cos(yaw_321) 0;
    0 0 1];

% Ret = inv(Rte); % 321 rotation involving yaw, pitch, and roll
Rce = Rte * Rct; % define correctly from the previous two

omega_itt = Rct * omega_icc;

H_321 = [-sin(pitch_321) 0 1;
    sin(roll_321)*cos(pitch_321) cos(roll_321) 0;
    cos(roll_321)*cos(pitch_321) -sin(roll_321) 0];

posn_dot = vel_tt;
vel_dot = Rte \ accel_meas_t + grav_tt - 2*cross(omega_itt, vel_tt);
angles_dot = H_321 \ (omega_iee - Rce*omega_icc);

state_dot = [posn_dot; vel_dot; angles_dot];



p4_data = load('hw3_p4.mat');
y0 = [p4_data.ptt_0; p4_data.vtt_0; p4_data.yaw_0; p4_data.ptc_0;
 p4_data.rol_0];
[t_sim, y_sim] = ode45(@(t,y) ins_fun(t,y,p4_data),
 p4_data.time_stamp, y0);

figure();
plot3(y_sim(:,1),y_sim(:,2),y_sim(:,3));
title('position trajectory')

figure();
plot(t_sim, y_sim(:,4:6));
xlabel('time (sec)');
ylabel ('velocity (m/s)');
title('velocity');

figure();
plot(t_sim, rad2deg(y_sim(:,6:9)));
xlabel('time (sec)');
ylabel ('euler angles (deg)');
title('euler angles');
legend ('yaw(psi)','pitch(theta)','roll(phi)')
```


position trajectory
-2200
-2400
-2600
-2800
-3000
-3200
10000
5000
0
-5000
-10000
-5000
0
5000


velocity
velocity (m/s)
time (sec)
200
150
100
50
0
-50
-100
-150
-200
0
100
200
300
400
500




# problem 6

```
p6_data = load ('hw3_p6.mat');

% We scaled the m to km to fix bad scaling

t0 = 288.16; % Kelvin
a1 = -6.5; % Kelvin/km.

% units in Kelvin, deg, km
R = sparse(diag([2 * ones(1500,1); 0.5 * ones(1500,1); 0.1 *
 ones(2000,1)].^2));

offset = [- t0 * ones(1500, 1); zeros(3500,1)];
scale = [ones(3000,1); 1e-3 * ones(2000,1)];
z = p6_data.measurements .* scale + offset;
C = sparse([a1 * ones(1500,1); ones(1500,1) * 180 / (pi * 1e1);
 ones(2000,1)]);

xi_hat = inv(C' * inv(R) * C ) * C' * inv(R) * z; % km
xi_hat_m = xi_hat * 1e3 % m
```

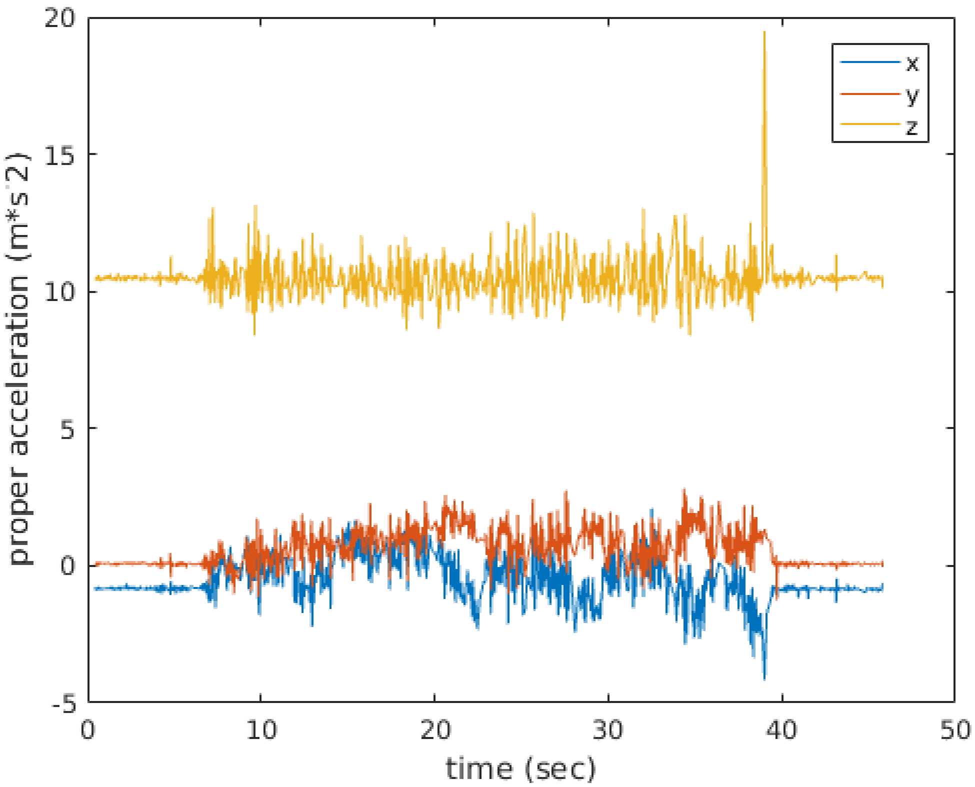
```
xi_hat_m =

  996.7334
```

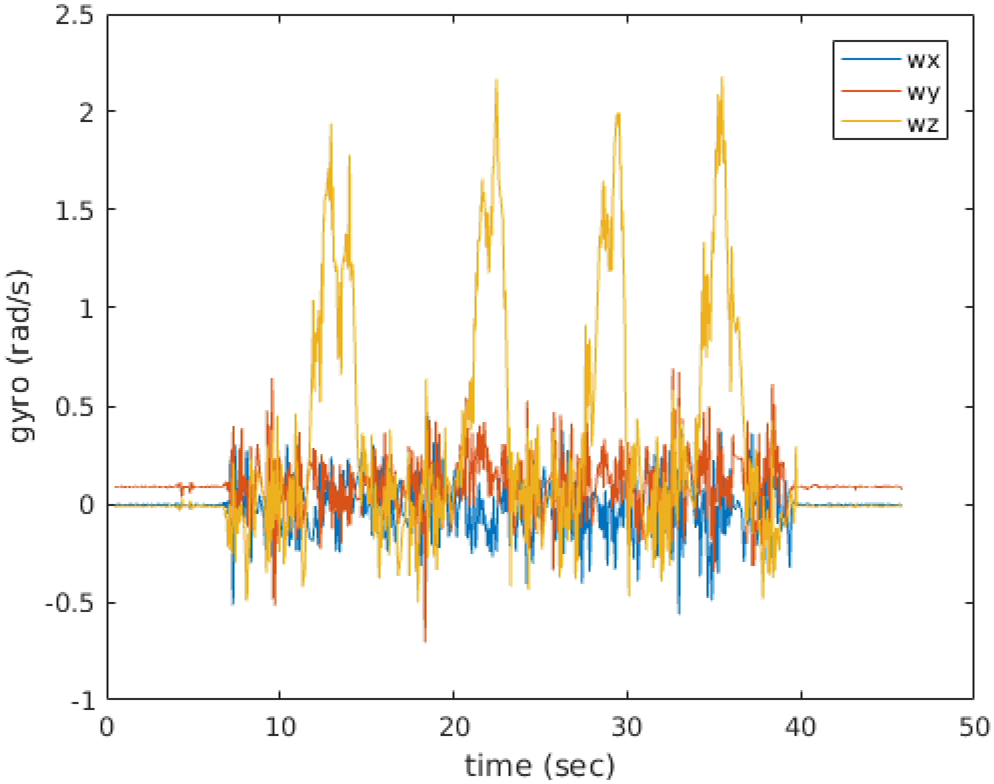
# problem 7

The trajectory is captured walking in a ~10 m hall way back and forth. at end of the straight segment I always turned around in z+ direction.

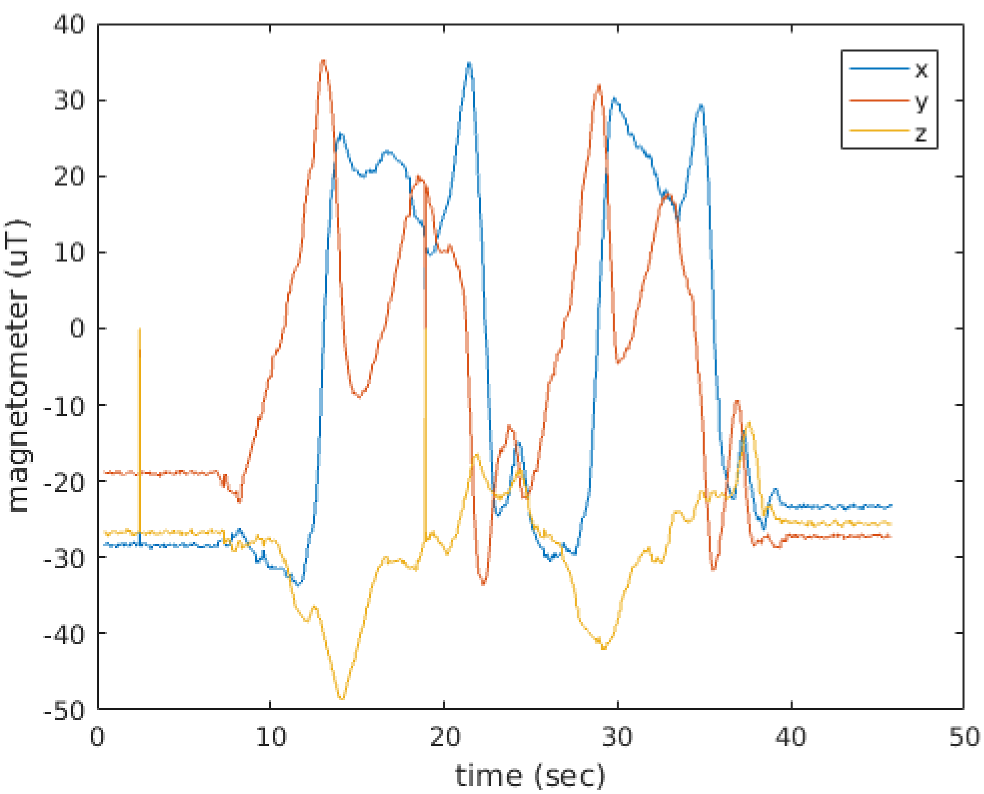
```
clear variables
close all
data = csvread('hw3q7_2.csv',1,0);
t = data(:, 1);

figure();
plot(t,data(:, 2:4));
xlabel('time (sec)');
ylabel ('proper acceleration (m*s^-2)');
legend ('x','y','z')

figure();
plot(t,data(:, 5:7));
xlabel('time (sec)');
ylabel ('gyro (rad/s)');
legend ('wx','wy','wz')

figure();
plot(t,data(:, 8:10));
xlabel('time (sec)');
ylabel ('magnetometer (uT)');
legend ('x','y','z')

figure();
plot(t,data(:, 11:13));
xlabel('time (sec)');
ylabel ('heading from tilt corrected magnetometer (deg)');
legend ('roll','pitch','yaw')

figure();
plot(t,0.01 * data(:, 14:15));
xlabel('time (sec)');
ylabel ('deg');
legend ('lat','long')

figure();
plot(t,data(:, 16));
xlabel('time (sec)');
ylabel ('altitude (cm)');

figure();
plot(t,data(:, 17));
xlabel('time (sec)');
ylabel ('speed (kt)');

figure();
```

```
plot(t,data(:, 18));
xlabel('time (sec)');
ylabel ('heading (deg)');
```

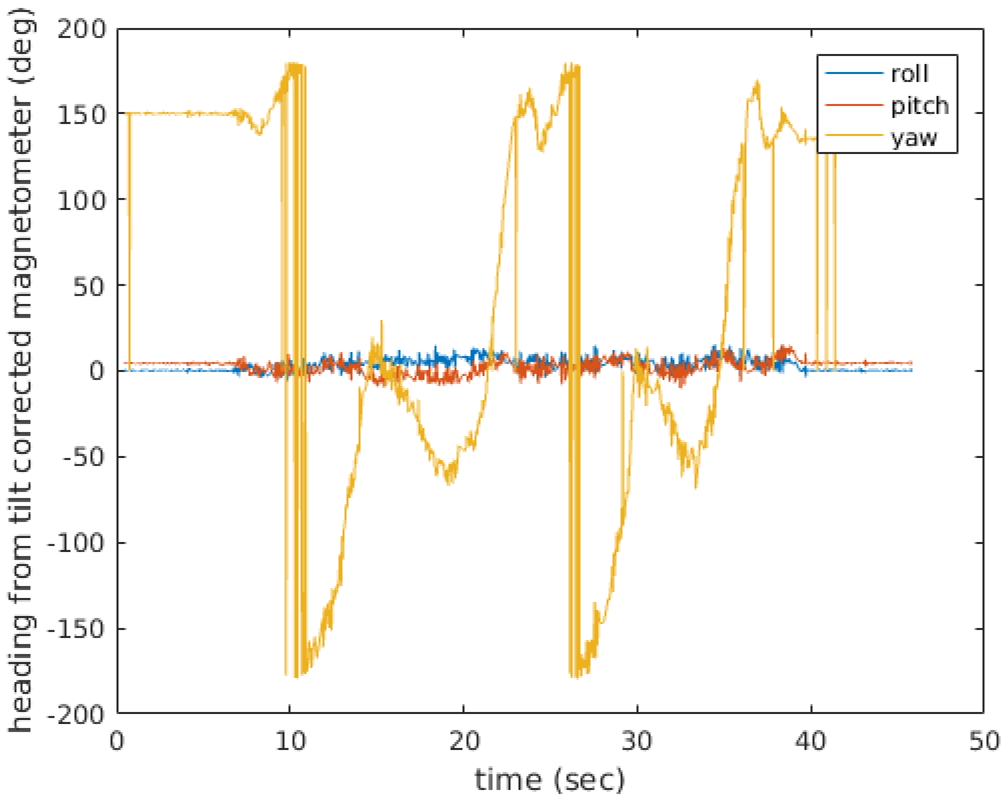


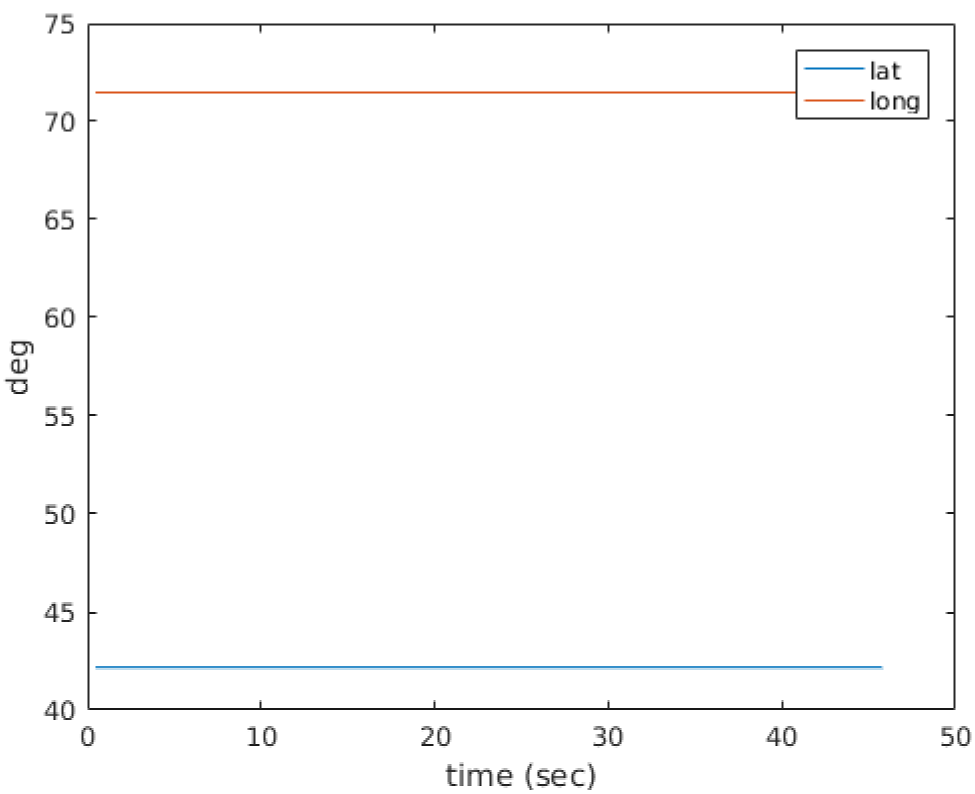


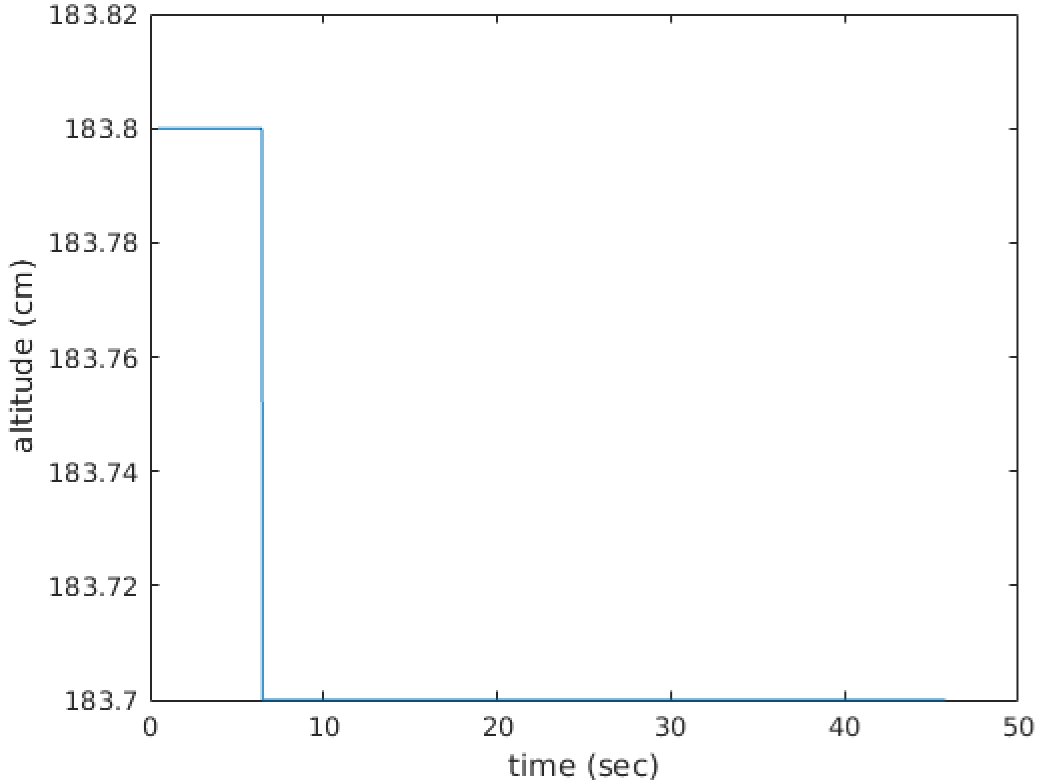
wx
wy
wz
gyro (rad/s)
time (sec)

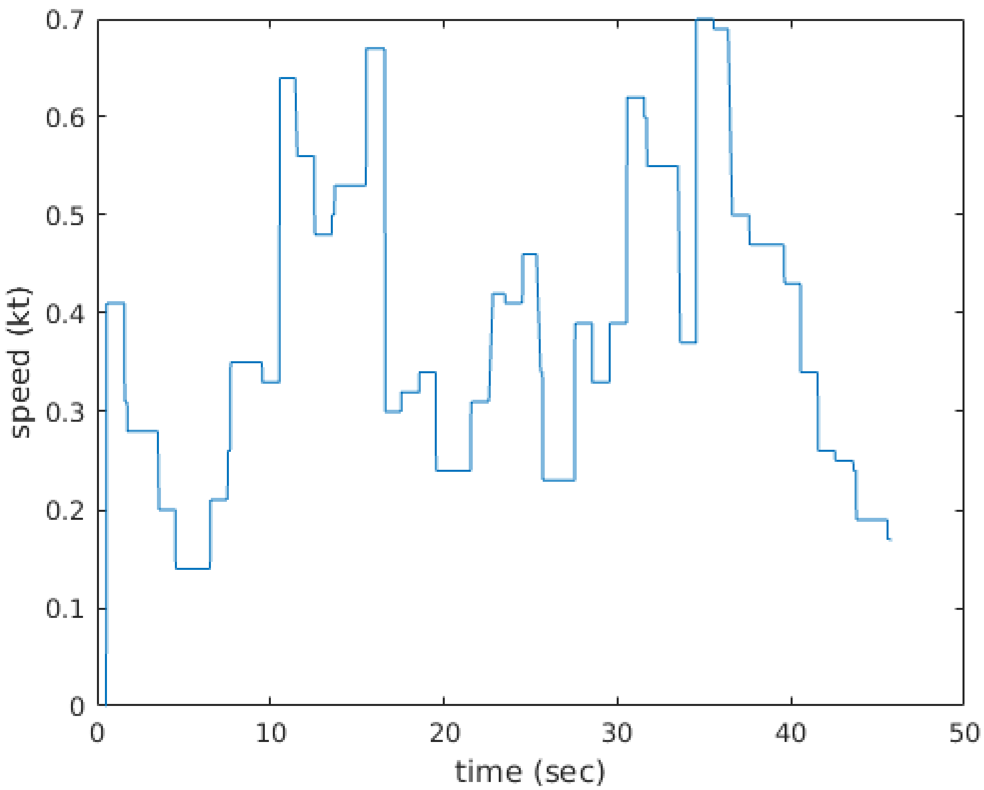



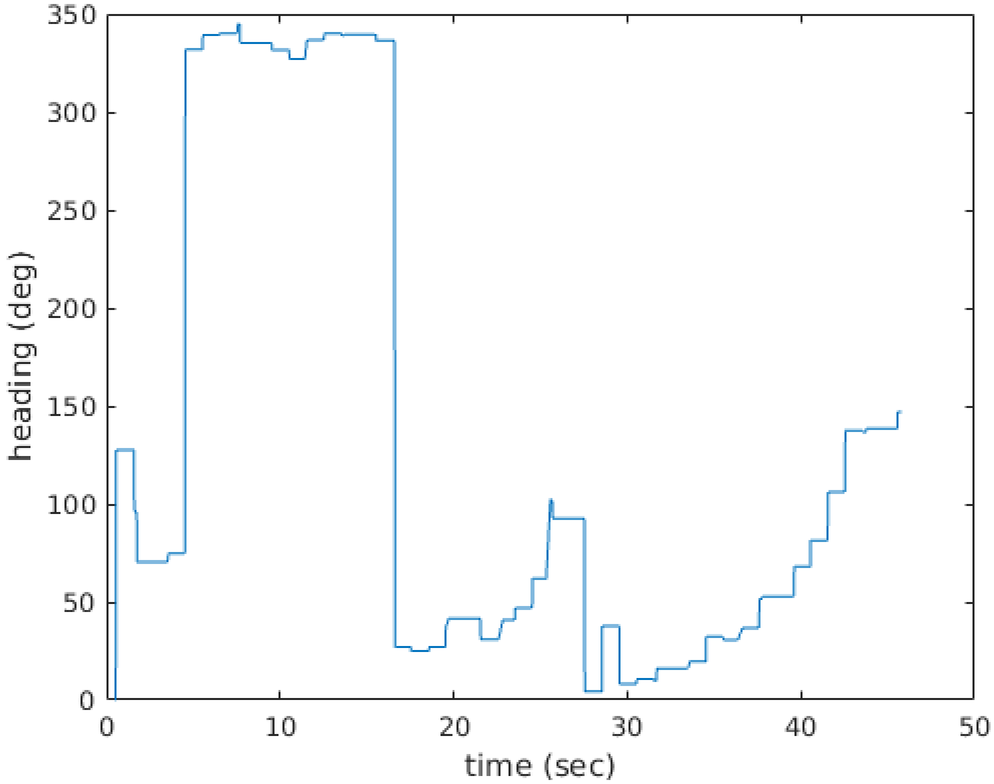
x
y
z
magnetometer (uT)
time (sec)


heading from tilt corrected magnetometer (deg)
time (sec)
roll
pitch
yaw


deg
time (sec)
lat
long


183.82
183.8
183.78
183.76
183.74
183.72
183.7
altitude (cm)
0
10
20
30
40
50
time (sec)


0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
speed (kt)
0
10
20
30
40
50
time (sec)

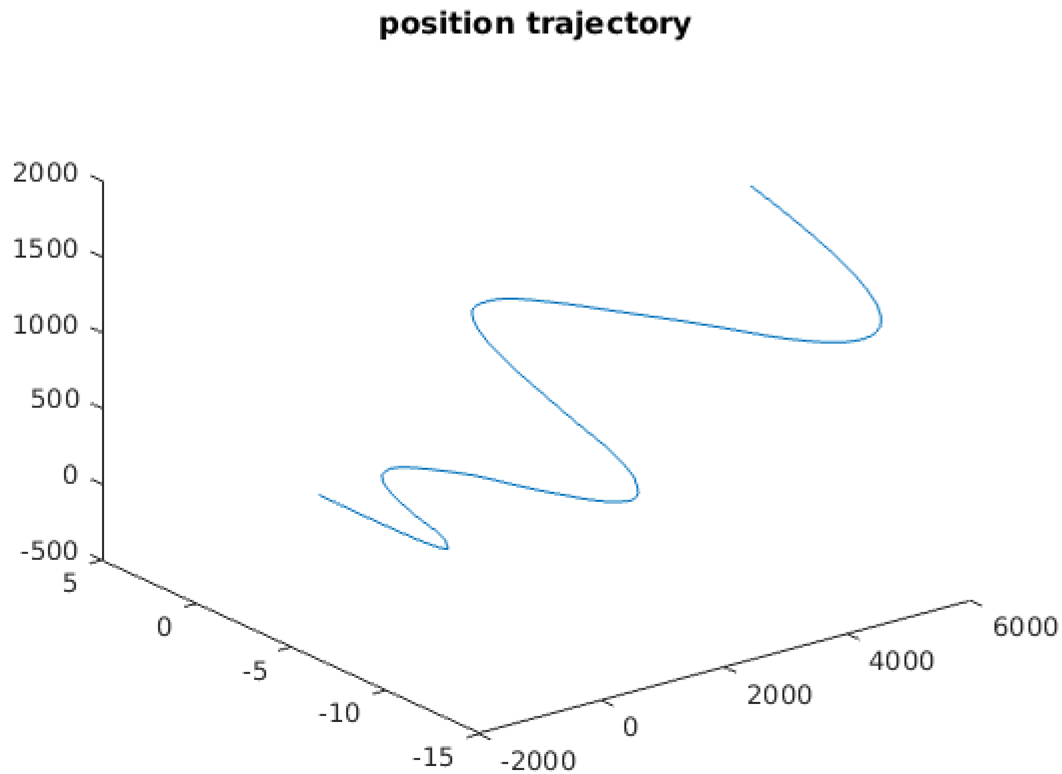


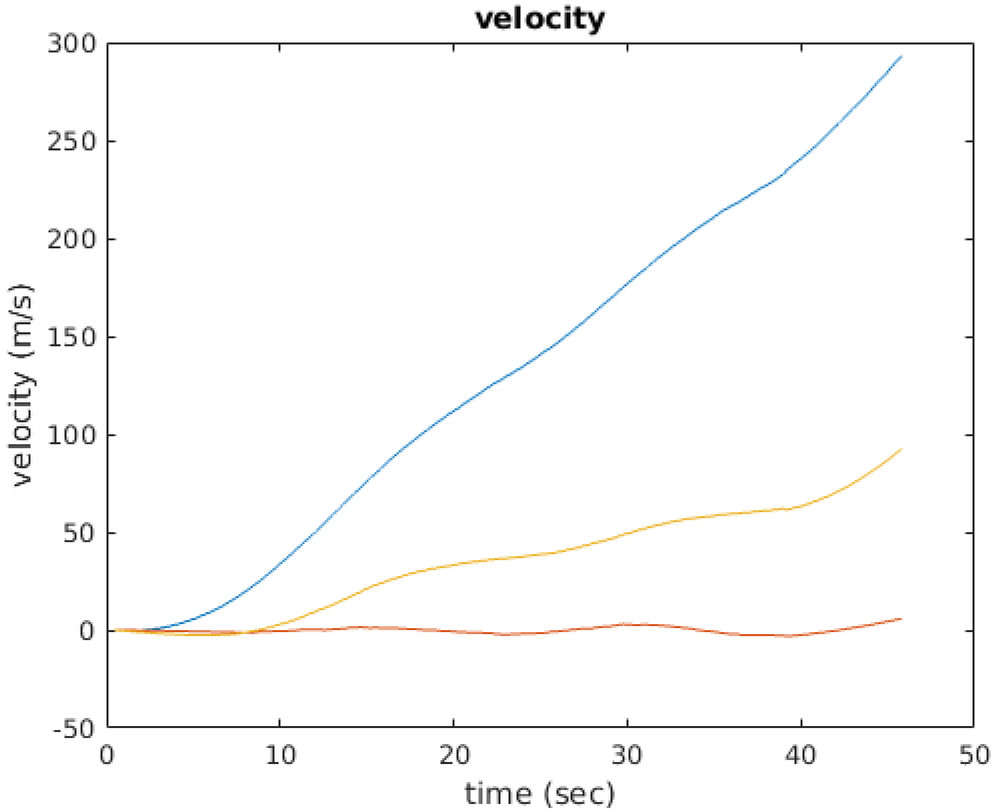

# problem 8

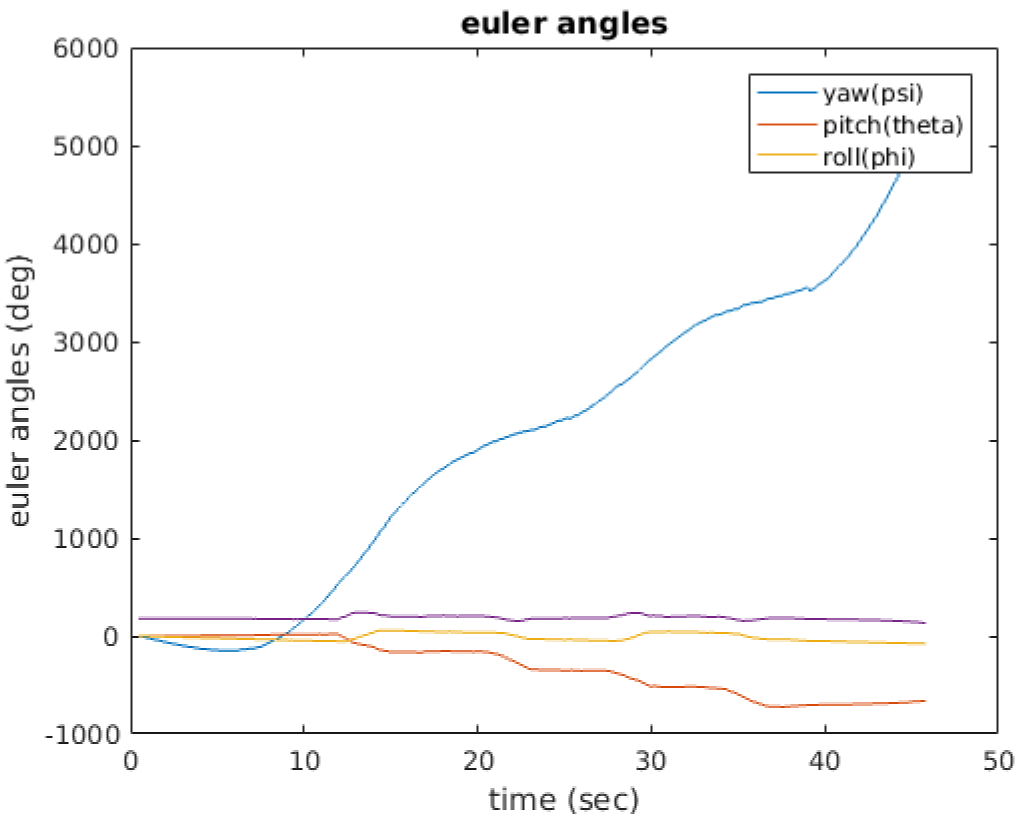
The calculated trajectory reflected the turning, but the acceleromter bias caused position and linear velocity drift. The gyro also exhibits bias.

```
y0 = [zeros(3,1);zeros(3,1); [0; 0; pi]];
p7_data.time_stamp = data(:, 1)';
p7_data.accel_readings = data(:, 2:4)';
p7_data.gyro_readings = data(:, 5:7)';
[t_sim, y_sim] = ode45(@(t,y) ins_fun(t,y,p7_data),
 p7_data.time_stamp, y0);

figure();
plot3(y_sim(:,1),y_sim(:,2),y_sim(:,3));
title('position trajectory')

figure();
plot(t_sim, y_sim(:,4:6));
xlabel('time (sec)');
ylabel ('velocity (m/s)');
title('velocity');

figure();
plot(t_sim, rad2deg(y_sim(:,6:9)));
xlabel('time (sec)');
ylabel ('euler angles (deg)');
```

```
title('euler angles');
legend ('yaw(psi)','pitch(theta)','roll(phi)')
```




velocity
velocity (m/s)
time (sec)
300
250
200
150
100
50
0
-50
0
10
20
30
40
50


euler angles
euler angles (deg)
time (sec)
yaw(psi)
pitch(theta)
roll(phi)
6000
5000
4000
3000
2000
1000
0
-1000
0
10
20
30
40
50

*Published with MATLAB® R2016a*