PROBLEM 1

Table of Contents

```
clc; clear all; close all;
```

OPEN TABLES

```
data_table_acc_1_1   = readtable('Accelerometer_1_1.csv');
data_table_gyro_1_1  = readtable('Gyroscope_1_1.csv');
data_table_mag_1_1   = readtable('Magnetometer_1_1.csv');
```

```
g = 9.80328;
tru_acc_1  = [0;0;g];
tru_gyro_1 = [0;0;0];
tru_mag_1  = [-19.729; -4.9369; -47.6421];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
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property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_1_1   = data_table_acc_1_1{:,2};
acc_y_1_1   = data_table_acc_1_1{:,3};
acc_z_1_1   = data_table_acc_1_1{:,4};

mu_acc_x_1_1 = mean(acc_x_1_1);
sig2_acc_x_1_1 = var(acc_x_1_1);
```

```
mu_acc_y_1_1 =  mean(acc_y_1_1);
sig2_acc_y_1_1 = var(acc_y_1_1);

mu_acc_z_1_1 = mean(acc_z_1_1);
sig2_acc_z_1_1 = var(acc_z_1_1);

mu_acc_1_1      = [mu_acc_x_1_1; mu_acc_y_1_1; mu_acc_z_1_1];
bias_acc_1_1    = [mu_acc_x_1_1; mu_acc_y_1_1; mu_acc_z_1_1] - [0;0;g]
  ;% m/s/s
var_acc_1_1  = diag([sig2_acc_x_1_1 sig2_acc_y_1_1 sig2_acc_z_1_1]);
```

Gryroscopes

```
gyro_x_1_1 = data_table_gyro_1_1{:, 2};
gyro_y_1_1 = data_table_gyro_1_1{:, 3};
gyro_z_1_1 = data_table_gyro_1_1{:, 4};


mu_gyro_x_1_1 = mean(gyro_x_1_1);
sig2_gyro_x_1_1 = var(gyro_x_1_1);

mu_gyro_y_1_1 = mean(gyro_y_1_1);
sig2_gyro_y_1_1 = var(gyro_y_1_1);

mu_gyro_z_1_1 = mean(gyro_z_1_1);
sig2_gyro_z_1_1 = var(gyro_z_1_1);

mu_gyro_1_1     = [mu_gyro_x_1_1; mu_gyro_y_1_1; mu_gyro_z_1_1];
bias_gyro_1_1 = -[mu_gyro_x_1_1; mu_gyro_y_1_1; mu_gyro_z_1_1]    ;%
 rad/s
var_gyro_1_1 = diag([sig2_gyro_x_1_1 sig2_gyro_y_1_1
 sig2_gyro_z_1_1]);
```

Magnetometers

```
mag_x_1_1 = data_table_mag_1_1{:, 2};
mag_y_1_1 = data_table_mag_1_1{:, 3};
mag_z_1_1 = data_table_mag_1_1{:, 4};

mu_mag_x_1_1 = mean(mag_x_1_1);
sig2_mag_x_1_1 = var(mag_x_1_1);

mu_mag_y_1_1 = mean(mag_y_1_1);
sig2_mag_y_1_1 = var(mag_y_1_1);

mu_mag_z_1_1 = mean(mag_z_1_1);
sig2_mag_z_1_1 = var(mag_z_1_1);


mu_mag_1_1      = [mu_mag_x_1_1;mu_mag_y_1_1;mu_mag_z_1_1];
bias_mag_1_1 = [mu_mag_x_1_1;mu_mag_y_1_1;mu_mag_z_1_1] -
 [0;19.729;-47.6421] ;% muT
```

```
var_mag_1_1  = diag([sig2_mag_x_1_1 sig2_mag_y_1_1 sig2_mag_z_1_1]);

xlswrite('Data.xls',[mu_acc_1_1 tru_acc_1 bias_acc_1_1
 var_acc_1_1],'sheet1','E4');
xlswrite('Data.xls',[mu_gyro_1_1 tru_gyro_1 bias_gyro_1_1
 var_gyro_1_1],'sheet2','E4');
xlswrite('Data.xls',[mu_mag_1_1 tru_mag_1 bias_mag_1_1
 var_mag_1_1],'sheet3','E4');
```

OPEN TABLES

```
data_table_acc_1_2   = readtable('Accelerometer_1_2.csv');
data_table_gyro_1_2  = readtable('Gyroscope_1_2.csv');
data_table_mag_1_2   = readtable('Magnetometer_1_2.csv');


g = 9.80328;
tru_acc_1  = [0;0;g];
tru_gyro_1 = [0;0;0];
tru_mag_1  = [-19.729; -4.9369; -47.6421];
```

```
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modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_1_2   = data_table_acc_1_2{:,2};
acc_y_1_2   = data_table_acc_1_2{:,3};
```

```
acc_z_1_2   = data_table_acc_1_2{:,4};

mu_acc_x_1_2 = mean(acc_x_1_2);
sig2_acc_x_1_2 = var(acc_x_1_2);

mu_acc_y_1_2 =  mean(acc_y_1_2);
sig2_acc_y_1_2 = var(acc_y_1_2);

mu_acc_z_1_2 = mean(acc_z_1_2);
sig2_acc_z_1_2 = var(acc_z_1_2);

mu_acc_1_2      = [mu_acc_x_1_2; mu_acc_y_1_2; mu_acc_z_1_2];
bias_acc_1_2    = [mu_acc_x_1_2; mu_acc_y_1_2; mu_acc_z_1_2] - [0;0;g]
  ;% m/s/s
var_acc_1_2  = diag([sig2_acc_x_1_2 sig2_acc_y_1_2 sig2_acc_z_1_2]);
```

Gryroscopes

```
gyro_x_1_2 = data_table_gyro_1_2{:, 2};
gyro_y_1_2 = data_table_gyro_1_2{:, 3};
gyro_z_1_2 = data_table_gyro_1_2{:, 4};


mu_gyro_x_1_2 = mean(gyro_x_1_2);
sig2_gyro_x_1_2 = var(gyro_x_1_2);

mu_gyro_y_1_2 = mean(gyro_y_1_2);
sig2_gyro_y_1_2 = var(gyro_y_1_2);

mu_gyro_z_1_2 = mean(gyro_z_1_2);
sig2_gyro_z_1_2 = var(gyro_z_1_2);

mu_gyro_1_2     = [mu_gyro_x_1_2; mu_gyro_y_1_2; mu_gyro_z_1_2];
bias_gyro_1_2 = -[mu_gyro_x_1_2; mu_gyro_y_1_2; mu_gyro_z_1_2]    ;%
 rad/s
var_gyro_1_2 = diag([sig2_gyro_x_1_2 sig2_gyro_y_1_2
 sig2_gyro_z_1_2]);
```

Magnetometers

```
mag_x_1_2 = data_table_mag_1_2{:, 2};
mag_y_1_2 = data_table_mag_1_2{:, 3};
mag_z_1_2 = data_table_mag_1_2{:, 4};

mu_mag_x_1_2 = mean(mag_x_1_2);
sig2_mag_x_1_2 = var(mag_x_1_2);

mu_mag_y_1_2 = mean(mag_y_1_2);
sig2_mag_y_1_2 = var(mag_y_1_2);

mu_mag_z_1_2 = mean(mag_z_1_2);
sig2_mag_z_1_2 = var(mag_z_1_2);
```

```
mu_mag_1_2      = [mu_mag_x_1_2;mu_mag_y_1_2;mu_mag_z_1_2];
bias_mag_1_2 = [mu_mag_x_1_2;mu_mag_y_1_2;mu_mag_z_1_2] -
 [0;19.729;-47.6421] ;% muT
var_mag_1_2  = diag([sig2_mag_x_1_2 sig2_mag_y_1_2 sig2_mag_z_1_2]);

xlswrite('Data.xls',[mu_acc_1_2 tru_acc_1 bias_acc_1_2
 var_acc_1_2],'sheet1','E7');
xlswrite('Data.xls',[mu_gyro_1_2 tru_gyro_1 bias_gyro_1_2
 var_gyro_1_2],'sheet2','E7');
xlswrite('Data.xls',[mu_mag_1_2 tru_mag_1 bias_mag_1_2
 var_mag_1_2],'sheet3','E7');
```

OPEN TABLES

```
data_table_acc_1_3   = readtable('Accelerometer_1_3.csv');
data_table_gyro_1_3  = readtable('Gyroscope_1_3.csv');
data_table_mag_1_3   = readtable('Magnetometer_1_3.csv');


g = 9.80328;
tru_acc_1  = [0;0;g];
tru_gyro_1 = [0;0;0];
tru_mag_1  = [-19.729; -4.9369; -47.6421];
```

```
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the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_1_3   = data_table_acc_1_3{:,2};
acc_y_1_3   = data_table_acc_1_3{:,3};
acc_z_1_3   = data_table_acc_1_3{:,4};

mu_acc_x_1_3 = mean(acc_x_1_3);
sig2_acc_x_1_3 = var(acc_x_1_3);

mu_acc_y_1_3 =  mean(acc_y_1_3);
sig2_acc_y_1_3 = var(acc_y_1_3);

mu_acc_z_1_3 = mean(acc_z_1_3);
sig2_acc_z_1_3 = var(acc_z_1_3);

mu_acc_1_3      = [mu_acc_x_1_3; mu_acc_y_1_3; mu_acc_z_1_3];
bias_acc_1_3    = [mu_acc_x_1_3; mu_acc_y_1_3; mu_acc_z_1_3] - [0;0;g]
  ;% m/s/s
var_acc_1_3  = diag([sig2_acc_x_1_3 sig2_acc_y_1_3 sig2_acc_z_1_3]);
```

Gryroscopes

```
gyro_x_1_3 = data_table_gyro_1_3{:, 2};
gyro_y_1_3 = data_table_gyro_1_3{:, 3};
gyro_z_1_3 = data_table_gyro_1_3{:, 4};


mu_gyro_x_1_3 = mean(gyro_x_1_3);
sig2_gyro_x_1_3 = var(gyro_x_1_3);

mu_gyro_y_1_3 = mean(gyro_y_1_3);
sig2_gyro_y_1_3 = var(gyro_y_1_3);

mu_gyro_z_1_3 = mean(gyro_z_1_3);
sig2_gyro_z_1_3 = var(gyro_z_1_3);

mu_gyro_1_3     = [mu_gyro_x_1_3; mu_gyro_y_1_3; mu_gyro_z_1_3];
bias_gyro_1_3 = -[mu_gyro_x_1_3; mu_gyro_y_1_3; mu_gyro_z_1_3]    ;%
 rad/s
var_gyro_1_3 = diag([sig2_gyro_x_1_3 sig2_gyro_y_1_3
 sig2_gyro_z_1_3]);
```

Magnetometers

```
mag_x_1_3 = data_table_mag_1_3{:, 2};
mag_y_1_3 = data_table_mag_1_3{:, 3};
mag_z_1_3 = data_table_mag_1_3{:, 4};

mu_mag_x_1_3 = mean(mag_x_1_3);
sig2_mag_x_1_3 = var(mag_x_1_3);
```

```
mu_mag_y_1_3 = mean(mag_y_1_3);
sig2_mag_y_1_3 = var(mag_y_1_3);

mu_mag_z_1_3 = mean(mag_z_1_3);
sig2_mag_z_1_3 = var(mag_z_1_3);


mu_mag_1_3      = [mu_mag_x_1_3;mu_mag_y_1_3;mu_mag_z_1_3];
bias_mag_1_3 = [mu_mag_x_1_3;mu_mag_y_1_3;mu_mag_z_1_3] -
 [0;19.729;-47.6421] ;% muT
var_mag_1_3  = diag([sig2_mag_x_1_3 sig2_mag_y_1_3 sig2_mag_z_1_3]);

xlswrite('Data.xls',[mu_acc_1_3 tru_acc_1 bias_acc_1_3
 var_acc_1_3],'sheet1','E10');
xlswrite('Data.xls',[mu_gyro_1_3 tru_gyro_1 bias_gyro_1_3
 var_gyro_1_3],'sheet2','E10');
xlswrite('Data.xls',[mu_mag_1_3 tru_mag_1 bias_mag_1_3
 var_mag_1_3],'sheet3','E10');
```

OPEN TABLES

```
data_table_acc_1_4   = readtable('Accelerometer_1_4.csv');
data_table_gyro_1_4  = readtable('Gyroscope_1_4.csv');
data_table_mag_1_4   = readtable('Magnetometer_1_4.csv');


g = 9.80328;
tru_acc_1  = [0;0;g];
tru_gyro_1 = [0;0;0];
tru_mag_1  = [-19.729; -4.9369; -47.6421];
```

```
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for the table. The original column headers
```

```
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_1_4   = data_table_acc_1_4{:,2};
acc_y_1_4   = data_table_acc_1_4{:,3};
acc_z_1_4   = data_table_acc_1_4{:,4};

mu_acc_x_1_4 = mean(acc_x_1_4);
sig2_acc_x_1_4 = var(acc_x_1_4);

mu_acc_y_1_4 =  mean(acc_y_1_4);
sig2_acc_y_1_4 = var(acc_y_1_4);

mu_acc_z_1_4 = mean(acc_z_1_4);
sig2_acc_z_1_4 = var(acc_z_1_4);

mu_acc_1_4      = [mu_acc_x_1_4; mu_acc_y_1_4; mu_acc_z_1_4];
bias_acc_1_4    = [mu_acc_x_1_4; mu_acc_y_1_4; mu_acc_z_1_4] - [0;0;g]
  ;% m/s/s
var_acc_1_4  = diag([sig2_acc_x_1_4 sig2_acc_y_1_4 sig2_acc_z_1_4]);
```

Gryroscopes

```
gyro_x_1_4 = data_table_gyro_1_4{:, 2};
gyro_y_1_4 = data_table_gyro_1_4{:, 3};
gyro_z_1_4 = data_table_gyro_1_4{:, 4};


mu_gyro_x_1_4 = mean(gyro_x_1_4);
sig2_gyro_x_1_4 = var(gyro_x_1_4);

mu_gyro_y_1_4 = mean(gyro_y_1_4);
sig2_gyro_y_1_4 = var(gyro_y_1_4);

mu_gyro_z_1_4 = mean(gyro_z_1_4);
sig2_gyro_z_1_4 = var(gyro_z_1_4);

mu_gyro_1_4     = [mu_gyro_x_1_4; mu_gyro_y_1_4; mu_gyro_z_1_4];
bias_gyro_1_4 = -[mu_gyro_x_1_4; mu_gyro_y_1_4; mu_gyro_z_1_4]    ;%
 rad/s
var_gyro_1_4 = diag([sig2_gyro_x_1_4 sig2_gyro_y_1_4
 sig2_gyro_z_1_4]);
```

Magnetometers

```
mag_x_1_4 = data_table_mag_1_4{:, 2};
mag_y_1_4 = data_table_mag_1_4{:, 3};
```

```
mag_z_1_4 = data_table_mag_1_4{:, 4};

mu_mag_x_1_4 = mean(mag_x_1_4);
sig2_mag_x_1_4 = var(mag_x_1_4);

mu_mag_y_1_4 = mean(mag_y_1_4);
sig2_mag_y_1_4 = var(mag_y_1_4);

mu_mag_z_1_4 = mean(mag_z_1_4);
sig2_mag_z_1_4 = var(mag_z_1_4);


mu_mag_1_4      = [mu_mag_x_1_4;mu_mag_y_1_4;mu_mag_z_1_4];
bias_mag_1_4 = [mu_mag_x_1_4;mu_mag_y_1_4;mu_mag_z_1_4] -
 [0;19.729;-47.6421] ;% muT
var_mag_1_4  = diag([sig2_mag_x_1_4 sig2_mag_y_1_4 sig2_mag_z_1_4]);

xlswrite('Data.xls',[mu_acc_1_4 tru_acc_1 bias_acc_1_4
 var_acc_1_4],'sheet1','E13');
xlswrite('Data.xls',[mu_gyro_1_4 tru_gyro_1 bias_gyro_1_4
 var_gyro_1_4],'sheet2','E13');
xlswrite('Data.xls',[mu_mag_1_4 tru_mag_1 bias_mag_1_4
 var_mag_1_4],'sheet3','E13');
```

OPEN TABLES

```
data_table_acc_1_5   = readtable('Accelerometer_1_5.csv');
data_table_gyro_1_5  = readtable('Gyroscope_1_5.csv');
data_table_mag_1_5   = readtable('Magnetometer_1_5.csv');


g = 9.80328;
tru_acc_1  = [0;0;g];
tru_gyro_1 = [0;0;0];
tru_mag_1  = [-19.729; -4.9369; -47.6421];
```

```
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are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
```

```
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_1_5   = data_table_acc_1_5{:,2};
acc_y_1_5   = data_table_acc_1_5{:,3};
acc_z_1_5   = data_table_acc_1_5{:,4};

mu_acc_x_1_5 = mean(acc_x_1_5);
sig2_acc_x_1_5 = var(acc_x_1_5);

mu_acc_y_1_5 =  mean(acc_y_1_5);
sig2_acc_y_1_5 = var(acc_y_1_5);

mu_acc_z_1_5 = mean(acc_z_1_5);
sig2_acc_z_1_5 = var(acc_z_1_5);

mu_acc_1_5      = [mu_acc_x_1_5; mu_acc_y_1_5; mu_acc_z_1_5];
bias_acc_1_5    = [mu_acc_x_1_5; mu_acc_y_1_5; mu_acc_z_1_5] - [0;0;g]
  ;% m/s/s
var_acc_1_5  = diag([sig2_acc_x_1_5 sig2_acc_y_1_5 sig2_acc_z_1_5]);
```

Gryroscopes

```
gyro_x_1_5 = data_table_gyro_1_5{:, 2};
gyro_y_1_5 = data_table_gyro_1_5{:, 3};
gyro_z_1_5 = data_table_gyro_1_5{:, 4};


mu_gyro_x_1_5 = mean(gyro_x_1_5);
sig2_gyro_x_1_5 = var(gyro_x_1_5);

mu_gyro_y_1_5 = mean(gyro_y_1_5);
sig2_gyro_y_1_5 = var(gyro_y_1_5);

mu_gyro_z_1_5 = mean(gyro_z_1_5);
sig2_gyro_z_1_5 = var(gyro_z_1_5);

mu_gyro_1_5     = [mu_gyro_x_1_5; mu_gyro_y_1_5; mu_gyro_z_1_5];
bias_gyro_1_5 = -[mu_gyro_x_1_5; mu_gyro_y_1_5; mu_gyro_z_1_5]    ;%
 rad/s
var_gyro_1_5 = diag([sig2_gyro_x_1_5 sig2_gyro_y_1_5
 sig2_gyro_z_1_5]);
```

Magnetometers

```
mag_x_1_5 = data_table_mag_1_5{:, 2};
mag_y_1_5 = data_table_mag_1_5{:, 3};
mag_z_1_5 = data_table_mag_1_5{:, 4};

mu_mag_x_1_5 = mean(mag_x_1_5);
sig2_mag_x_1_5 = var(mag_x_1_5);

mu_mag_y_1_5 = mean(mag_y_1_5);
sig2_mag_y_1_5 = var(mag_y_1_5);

mu_mag_z_1_5 = mean(mag_z_1_5);
sig2_mag_z_1_5 = var(mag_z_1_5);


mu_mag_1_5      = [mu_mag_x_1_5;mu_mag_y_1_5;mu_mag_z_1_5];
bias_mag_1_5 = [mu_mag_x_1_5;mu_mag_y_1_5;mu_mag_z_1_5] -
 [0;19.729;-47.6421] ;% muT
var_mag_1_5  = diag([sig2_mag_x_1_5 sig2_mag_y_1_5 sig2_mag_z_1_5]);

xlswrite('Data.xls',[mu_acc_1_5 tru_acc_1 bias_acc_1_5
 var_acc_1_5],'sheet1','E16');
xlswrite('Data.xls',[mu_gyro_1_5 tru_gyro_1 bias_gyro_1_5
 var_gyro_1_5],'sheet2','E16');
xlswrite('Data.xls',[mu_mag_1_5 tru_mag_1 bias_mag_1_5
 var_mag_1_5],'sheet3','E16');
```

OPEN TABLES

```
data_table_acc_2_1   = readtable('Accelerometer_2_1.csv');
data_table_gyro_2_1  = readtable('Gyroscope_2_1.csv');
data_table_mag_2_1   = readtable('Magnetometer_2_1.csv');


g = 9.80328;
tru_acc_2  = [0;g;0];
tru_gyro_2 = [0;0;0];
tru_mag_2  = [-19.729;-47.6421;4.9369];

Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
```

```
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_2_1   = data_table_acc_2_1{:,2};
acc_y_2_1   = data_table_acc_2_1{:,3};
acc_z_2_1   = data_table_acc_2_1{:,4};

mu_acc_x_2_1 = mean(acc_x_2_1);
sig2_acc_x_2_1 = var(acc_x_2_1);

mu_acc_y_2_1 =  mean(acc_y_2_1);
sig2_acc_y_2_1 = var(acc_y_2_1);

mu_acc_z_2_1 = mean(acc_z_2_1);
sig2_acc_z_2_1 = var(acc_z_2_1);

mu_acc_2_1      = [mu_acc_x_2_1; mu_acc_y_2_1; mu_acc_z_2_1];
bias_acc_2_1    = [mu_acc_x_2_1; mu_acc_y_2_1; mu_acc_z_2_1] - [0;0;g]
  ;% m/s/s
var_acc_2_1  = diag([sig2_acc_x_2_1 sig2_acc_y_2_1 sig2_acc_z_2_1]);
```

Gryroscopes

```
gyro_x_2_1 = data_table_gyro_2_1{:, 2};
gyro_y_2_1 = data_table_gyro_2_1{:, 3};
gyro_z_2_1 = data_table_gyro_2_1{:, 4};


mu_gyro_x_2_1 = mean(gyro_x_2_1);
sig2_gyro_x_2_1 = var(gyro_x_2_1);

mu_gyro_y_2_1 = mean(gyro_y_2_1);
sig2_gyro_y_2_1 = var(gyro_y_2_1);

mu_gyro_z_2_1 = mean(gyro_z_2_1);
sig2_gyro_z_2_1 = var(gyro_z_2_1);
```

```
mu_gyro_2_1     = [mu_gyro_x_2_1; mu_gyro_y_2_1; mu_gyro_z_2_1];
bias_gyro_2_1 = -[mu_gyro_x_2_1; mu_gyro_y_2_1; mu_gyro_z_2_1]    ;%
 rad/s
var_gyro_2_1 = diag([sig2_gyro_x_2_1 sig2_gyro_y_2_1
 sig2_gyro_z_2_1]);
```

Magnetometers

```
mag_x_2_1 = data_table_mag_2_1{:, 2};
mag_y_2_1 = data_table_mag_2_1{:, 3};
mag_z_2_1 = data_table_mag_2_1{:, 4};

mu_mag_x_2_1 = mean(mag_x_2_1);
sig2_mag_x_2_1 = var(mag_x_2_1);

mu_mag_y_2_1 = mean(mag_y_2_1);
sig2_mag_y_2_1 = var(mag_y_2_1);

mu_mag_z_2_1 = mean(mag_z_2_1);
sig2_mag_z_2_1 = var(mag_z_2_1);


mu_mag_2_1      = [mu_mag_x_2_1;mu_mag_y_2_1;mu_mag_z_2_1];
bias_mag_2_1 = [mu_mag_x_2_1;mu_mag_y_2_1;mu_mag_z_2_1] -
 [0;19.729;-47.6421] ;% muT
var_mag_2_1  = diag([sig2_mag_x_2_1 sig2_mag_y_2_1 sig2_mag_z_2_1]);

xlswrite('Data.xls',[mu_acc_2_1 tru_acc_2 bias_acc_2_1
 var_acc_2_1],'sheet1','E19');
xlswrite('Data.xls',[mu_gyro_2_1 tru_gyro_2 bias_gyro_2_1
 var_gyro_2_1],'sheet2','E19');
xlswrite('Data.xls',[mu_mag_2_1 tru_mag_2 bias_mag_2_1
 var_mag_2_1],'sheet3','E19');
```

OPEN TABLES

```
data_table_acc_2_2   = readtable('Accelerometer_2_2.csv');
data_table_gyro_2_2  = readtable('Gyroscope_2_2.csv');
data_table_mag_2_2   = readtable('Magnetometer_2_2.csv');


g = 9.80328;
tru_acc_2  = [0;g;0];
tru_gyro_2 = [0;0;0];
tru_mag_2  = [-19.729;-47.6421;4.9369];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
```

```
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_2_2   = data_table_acc_2_2{:,2};
acc_y_2_2   = data_table_acc_2_2{:,3};
acc_z_2_2   = data_table_acc_2_2{:,4};

mu_acc_x_2_2 = mean(acc_x_2_2);
sig2_acc_x_2_2 = var(acc_x_2_2);

mu_acc_y_2_2 =  mean(acc_y_2_2);
sig2_acc_y_2_2 = var(acc_y_2_2);

mu_acc_z_2_2 = mean(acc_z_2_2);
sig2_acc_z_2_2 = var(acc_z_2_2);

mu_acc_2_2      = [mu_acc_x_2_2; mu_acc_y_2_2; mu_acc_z_2_2];
bias_acc_2_2    = [mu_acc_x_2_2; mu_acc_y_2_2; mu_acc_z_2_2] - [0;0;g]
  ;% m/s/s
var_acc_2_2  = diag([sig2_acc_x_2_2 sig2_acc_y_2_2 sig2_acc_z_2_2]);
```

Gryroscopes

```
gyro_x_2_2 = data_table_gyro_2_2{:, 2};
gyro_y_2_2 = data_table_gyro_2_2{:, 3};
gyro_z_2_2 = data_table_gyro_2_2{:, 4};


mu_gyro_x_2_2 = mean(gyro_x_2_2);
sig2_gyro_x_2_2 = var(gyro_x_2_2);

mu_gyro_y_2_2 = mean(gyro_y_2_2);
```

```
sig2_gyro_y_2_2 = var(gyro_y_2_2);

mu_gyro_z_2_2 = mean(gyro_z_2_2);
sig2_gyro_z_2_2 = var(gyro_z_2_2);

mu_gyro_2_2     = [mu_gyro_x_2_2; mu_gyro_y_2_2; mu_gyro_z_2_2];
bias_gyro_2_2 = -[mu_gyro_x_2_2; mu_gyro_y_2_2; mu_gyro_z_2_2]    ;%
 rad/s
var_gyro_2_2 = diag([sig2_gyro_x_2_2 sig2_gyro_y_2_2
 sig2_gyro_z_2_2]);
```

Magnetometers

```
mag_x_2_2 = data_table_mag_2_2{:, 2};
mag_y_2_2 = data_table_mag_2_2{:, 3};
mag_z_2_2 = data_table_mag_2_2{:, 4};

mu_mag_x_2_2 = mean(mag_x_2_2);
sig2_mag_x_2_2 = var(mag_x_2_2);

mu_mag_y_2_2 = mean(mag_y_2_2);
sig2_mag_y_2_2 = var(mag_y_2_2);

mu_mag_z_2_2 = mean(mag_z_2_2);
sig2_mag_z_2_2 = var(mag_z_2_2);


mu_mag_2_2      = [mu_mag_x_2_2;mu_mag_y_2_2;mu_mag_z_2_2];
bias_mag_2_2 = [mu_mag_x_2_2;mu_mag_y_2_2;mu_mag_z_2_2] -
 [0;19.729;-47.6421] ;% muT
var_mag_2_2  = diag([sig2_mag_x_2_2 sig2_mag_y_2_2 sig2_mag_z_2_2]);

xlswrite('Data.xls',[mu_acc_2_2 tru_acc_2 bias_acc_2_2
 var_acc_2_2],'sheet1','E22');
xlswrite('Data.xls',[mu_gyro_2_2 tru_gyro_2 bias_gyro_2_2
 var_gyro_2_2],'sheet2','E22');
xlswrite('Data.xls',[mu_mag_2_2 tru_mag_2 bias_mag_2_2
 var_mag_2_2],'sheet3','E22');
```

OPEN TABLES

```
data_table_acc_2_3   = readtable('Accelerometer_2_3.csv');
data_table_gyro_2_3  = readtable('Gyroscope_2_3.csv');
data_table_mag_2_3   = readtable('Magnetometer_2_3.csv');


g = 9.80328;
tru_acc_2  = [0;g;0];
tru_gyro_2 = [0;0;0];
tru_mag_2  = [-19.729;-47.6421;4.9369];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
```

```
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_2_3   = data_table_acc_2_3{:,2};
acc_y_2_3   = data_table_acc_2_3{:,3};
acc_z_2_3   = data_table_acc_2_3{:,4};

mu_acc_x_2_3 = mean(acc_x_2_3);
sig2_acc_x_2_3 = var(acc_x_2_3);

mu_acc_y_2_3 =  mean(acc_y_2_3);
sig2_acc_y_2_3 = var(acc_y_2_3);

mu_acc_z_2_3 = mean(acc_z_2_3);
sig2_acc_z_2_3 = var(acc_z_2_3);

mu_acc_2_3      = [mu_acc_x_2_3; mu_acc_y_2_3; mu_acc_z_2_3];
bias_acc_2_3    = [mu_acc_x_2_3; mu_acc_y_2_3; mu_acc_z_2_3] - [0;0;g]
  ;% m/s/s
var_acc_2_3  = diag([sig2_acc_x_2_3 sig2_acc_y_2_3 sig2_acc_z_2_3]);
```

Gryroscopes

```
gyro_x_2_3 = data_table_gyro_2_3{:, 2};
gyro_y_2_3 = data_table_gyro_2_3{:, 3};
gyro_z_2_3 = data_table_gyro_2_3{:, 4};
```

```
mu_gyro_x_2_3 = mean(gyro_x_2_3);
sig2_gyro_x_2_3 = var(gyro_x_2_3);

mu_gyro_y_2_3 = mean(gyro_y_2_3);
sig2_gyro_y_2_3 = var(gyro_y_2_3);

mu_gyro_z_2_3 = mean(gyro_z_2_3);
sig2_gyro_z_2_3 = var(gyro_z_2_3);

mu_gyro_2_3     = [mu_gyro_x_2_3; mu_gyro_y_2_3; mu_gyro_z_2_3];
bias_gyro_2_3 = -[mu_gyro_x_2_3; mu_gyro_y_2_3; mu_gyro_z_2_3]    ;%
 rad/s
var_gyro_2_3 = diag([sig2_gyro_x_2_3 sig2_gyro_y_2_3
 sig2_gyro_z_2_3]);
```

Magnetometers

```
mag_x_2_3 = data_table_mag_2_3{:, 2};
mag_y_2_3 = data_table_mag_2_3{:, 3};
mag_z_2_3 = data_table_mag_2_3{:, 4};

mu_mag_x_2_3 = mean(mag_x_2_3);
sig2_mag_x_2_3 = var(mag_x_2_3);

mu_mag_y_2_3 = mean(mag_y_2_3);
sig2_mag_y_2_3 = var(mag_y_2_3);

mu_mag_z_2_3 = mean(mag_z_2_3);
sig2_mag_z_2_3 = var(mag_z_2_3);


mu_mag_2_3      = [mu_mag_x_2_3;mu_mag_y_2_3;mu_mag_z_2_3];
bias_mag_2_3 = [mu_mag_x_2_3;mu_mag_y_2_3;mu_mag_z_2_3] -
 [0;19.729;-47.6421] ;% muT
var_mag_2_3  = diag([sig2_mag_x_2_3 sig2_mag_y_2_3 sig2_mag_z_2_3]);

xlswrite('Data.xls',[mu_acc_2_3 tru_acc_2 bias_acc_2_3
 var_acc_2_3],'sheet1','E25');
xlswrite('Data.xls',[mu_gyro_2_3 tru_gyro_2 bias_gyro_2_3
 var_gyro_2_3],'sheet2','E25');
xlswrite('Data.xls',[mu_mag_2_3 tru_mag_2 bias_mag_2_3
 var_mag_2_3],'sheet3','E25');
```

OPEN TABLES

```
data_table_acc_2_4   = readtable('Accelerometer_2_4.csv');
data_table_gyro_2_4  = readtable('Gyroscope_2_4.csv');
data_table_mag_2_4   = readtable('Magnetometer_2_4.csv');


g = 9.80328;
tru_acc_2  = [0;g;0];
tru_gyro_2 = [0;0;0];
```

```
tru_mag_2  = [-19.729;-47.6421;4.9369];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
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are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_2_4   = data_table_acc_2_4{:,2};
acc_y_2_4   = data_table_acc_2_4{:,3};
acc_z_2_4   = data_table_acc_2_4{:,4};

mu_acc_x_2_4 = mean(acc_x_2_4);
sig2_acc_x_2_4 = var(acc_x_2_4);

mu_acc_y_2_4 =  mean(acc_y_2_4);
sig2_acc_y_2_4 = var(acc_y_2_4);

mu_acc_z_2_4 = mean(acc_z_2_4);
sig2_acc_z_2_4 = var(acc_z_2_4);

mu_acc_2_4      = [mu_acc_x_2_4; mu_acc_y_2_4; mu_acc_z_2_4];
bias_acc_2_4    = [mu_acc_x_2_4; mu_acc_y_2_4; mu_acc_z_2_4] - [0;0;g]
  ;% m/s/s
var_acc_2_4  = diag([sig2_acc_x_2_4 sig2_acc_y_2_4 sig2_acc_z_2_4]);
```

Gyroscopes

```
gyro_x_2_4 = data_table_gyro_2_4{:, 2};
```

```
gyro_y_2_4 = data_table_gyro_2_4{:, 3};
gyro_z_2_4 = data_table_gyro_2_4{:, 4};


mu_gyro_x_2_4 = mean(gyro_x_2_4);
sig2_gyro_x_2_4 = var(gyro_x_2_4);

mu_gyro_y_2_4 = mean(gyro_y_2_4);
sig2_gyro_y_2_4 = var(gyro_y_2_4);

mu_gyro_z_2_4 = mean(gyro_z_2_4);
sig2_gyro_z_2_4 = var(gyro_z_2_4);

mu_gyro_2_4     = [mu_gyro_x_2_4; mu_gyro_y_2_4; mu_gyro_z_2_4];
bias_gyro_2_4 = -[mu_gyro_x_2_4; mu_gyro_y_2_4; mu_gyro_z_2_4]    ;%
 rad/s
var_gyro_2_4 = diag([sig2_gyro_x_2_4 sig2_gyro_y_2_4
 sig2_gyro_z_2_4]);
```

Magnetometers

```
mag_x_2_4 = data_table_mag_2_4{:, 2};
mag_y_2_4 = data_table_mag_2_4{:, 3};
mag_z_2_4 = data_table_mag_2_4{:, 4};

mu_mag_x_2_4 = mean(mag_x_2_4);
sig2_mag_x_2_4 = var(mag_x_2_4);

mu_mag_y_2_4 = mean(mag_y_2_4);
sig2_mag_y_2_4 = var(mag_y_2_4);

mu_mag_z_2_4 = mean(mag_z_2_4);
sig2_mag_z_2_4 = var(mag_z_2_4);


mu_mag_2_4      = [mu_mag_x_2_4;mu_mag_y_2_4;mu_mag_z_2_4];
bias_mag_2_4 = [mu_mag_x_2_4;mu_mag_y_2_4;mu_mag_z_2_4] -
 [0;19.729;-47.6421] ;% muT
var_mag_2_4  = diag([sig2_mag_x_2_4 sig2_mag_y_2_4 sig2_mag_z_2_4]);

xlswrite('Data.xls',[mu_acc_2_4 tru_acc_2 bias_acc_2_4
 var_acc_2_4],'sheet1','E28');
xlswrite('Data.xls',[mu_gyro_2_4 tru_gyro_2 bias_gyro_2_4
 var_gyro_2_4],'sheet2','E28');
xlswrite('Data.xls',[mu_mag_2_4 tru_mag_2 bias_mag_2_4
 var_mag_2_4],'sheet3','E28');
```

OPEN TABLES

```
data_table_acc_2_5   = readtable('Accelerometer_2_5.csv');
data_table_gyro_2_5  = readtable('Gyroscope_2_5.csv');
data_table_mag_2_5   = readtable('Magnetometer_2_5.csv');
```

```
g = 9.80328;
tru_acc_2  = [0;g;0];
tru_gyro_2 = [0;0;0];
tru_mag_2  = [-19.729;-47.6421;4.9369];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_2_5   = data_table_acc_2_5{:,2};
acc_y_2_5   = data_table_acc_2_5{:,3};
acc_z_2_5   = data_table_acc_2_5{:,4};

mu_acc_x_2_5 = mean(acc_x_2_5);
sig2_acc_x_2_5 = var(acc_x_2_5);

mu_acc_y_2_5 =  mean(acc_y_2_5);
sig2_acc_y_2_5 = var(acc_y_2_5);

mu_acc_z_2_5 = mean(acc_z_2_5);
sig2_acc_z_2_5 = var(acc_z_2_5);

mu_acc_2_5      = [mu_acc_x_2_5; mu_acc_y_2_5; mu_acc_z_2_5];
bias_acc_2_5    = [mu_acc_x_2_5; mu_acc_y_2_5; mu_acc_z_2_5] - [0;0;g]
  ;% m/s/s
```

```
var_acc_2_5  = diag([sig2_acc_x_2_5 sig2_acc_y_2_5 sig2_acc_z_2_5]);
```

Gryroscopes

```
gyro_x_2_5 = data_table_gyro_2_5{:, 2};
gyro_y_2_5 = data_table_gyro_2_5{:, 3};
gyro_z_2_5 = data_table_gyro_2_5{:, 4};


mu_gyro_x_2_5 = mean(gyro_x_2_5);
sig2_gyro_x_2_5 = var(gyro_x_2_5);

mu_gyro_y_2_5 = mean(gyro_y_2_5);
sig2_gyro_y_2_5 = var(gyro_y_2_5);

mu_gyro_z_2_5 = mean(gyro_z_2_5);
sig2_gyro_z_2_5 = var(gyro_z_2_5);

mu_gyro_2_5     = [mu_gyro_x_2_5; mu_gyro_y_2_5; mu_gyro_z_2_5];
bias_gyro_2_5 = -[mu_gyro_x_2_5; mu_gyro_y_2_5; mu_gyro_z_2_5]    ;%
 rad/s
var_gyro_2_5 = diag([sig2_gyro_x_2_5 sig2_gyro_y_2_5
 sig2_gyro_z_2_5]);
```

Magnetometers

```
mag_x_2_5 = data_table_mag_2_5{:, 2};
mag_y_2_5 = data_table_mag_2_5{:, 3};
mag_z_2_5 = data_table_mag_2_5{:, 4};

mu_mag_x_2_5 = mean(mag_x_2_5);
sig2_mag_x_2_5 = var(mag_x_2_5);

mu_mag_y_2_5 = mean(mag_y_2_5);
sig2_mag_y_2_5 = var(mag_y_2_5);

mu_mag_z_2_5 = mean(mag_z_2_5);
sig2_mag_z_2_5 = var(mag_z_2_5);


mu_mag_2_5      = [mu_mag_x_2_5;mu_mag_y_2_5;mu_mag_z_2_5];
bias_mag_2_5 = [mu_mag_x_2_5;mu_mag_y_2_5;mu_mag_z_2_5] -
 [0;19.729;-47.6421] ;% muT
var_mag_2_5  = diag([sig2_mag_x_2_5 sig2_mag_y_2_5 sig2_mag_z_2_5]);

xlswrite('Data.xls',[mu_acc_2_5 tru_acc_2 bias_acc_2_5
 var_acc_2_5],'sheet1','E31');
xlswrite('Data.xls',[mu_gyro_2_5 tru_gyro_2 bias_gyro_2_5
 var_gyro_2_5],'sheet2','E31');
xlswrite('Data.xls',[mu_mag_2_5 tru_mag_2 bias_mag_2_5
 var_mag_2_5],'sheet3','E31');

clc
```

OPEN TABLES

```
data_table_acc_3_1   = readtable('Accelerometer_3_1.csv');
data_table_gyro_3_1  = readtable('Gyroscope_3_1.csv');
data_table_mag_3_1   = readtable('Magnetometer_3_1.csv');


g = 9.80328;
tru_acc_3  = [g;0;0];
tru_gyro_3 = [0;0;0];
tru_mag_3  = [-47.6421;19.729;4.9369];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_3_1   = data_table_acc_3_1{:,2};
acc_y_3_1   = data_table_acc_3_1{:,3};
acc_z_3_1   = data_table_acc_3_1{:,4};

mu_acc_x_3_1 = mean(acc_x_3_1);
sig2_acc_x_3_1 = var(acc_x_3_1);

mu_acc_y_3_1 =  mean(acc_y_3_1);
sig2_acc_y_3_1 = var(acc_y_3_1);

mu_acc_z_3_1 = mean(acc_z_3_1);
```

```
sig2_acc_z_3_1 = var(acc_z_3_1);

mu_acc_3_1      = [mu_acc_x_3_1; mu_acc_y_3_1; mu_acc_z_3_1];
bias_acc_3_1    = [mu_acc_x_3_1; mu_acc_y_3_1; mu_acc_z_3_1] - [0;0;g]
  ;% m/s/s
var_acc_3_1  = diag([sig2_acc_x_3_1 sig2_acc_y_3_1 sig2_acc_z_3_1]);
```

Gryroscopes

```
gyro_x_3_1 = data_table_gyro_3_1{:, 2};
gyro_y_3_1 = data_table_gyro_3_1{:, 3};
gyro_z_3_1 = data_table_gyro_3_1{:, 4};


mu_gyro_x_3_1 = mean(gyro_x_3_1);
sig2_gyro_x_3_1 = var(gyro_x_3_1);

mu_gyro_y_3_1 = mean(gyro_y_3_1);
sig2_gyro_y_3_1 = var(gyro_y_3_1);

mu_gyro_z_3_1 = mean(gyro_z_3_1);
sig2_gyro_z_3_1 = var(gyro_z_3_1);

mu_gyro_3_1     = [mu_gyro_x_3_1; mu_gyro_y_3_1; mu_gyro_z_3_1];
bias_gyro_3_1 = -[mu_gyro_x_3_1; mu_gyro_y_3_1; mu_gyro_z_3_1]    ;%
 rad/s
var_gyro_3_1 = diag([sig2_gyro_x_3_1 sig2_gyro_y_3_1
 sig2_gyro_z_3_1]);
```

Magnetometers

```
mag_x_3_1 = data_table_mag_3_1{:, 2};
mag_y_3_1 = data_table_mag_3_1{:, 3};
mag_z_3_1 = data_table_mag_3_1{:, 4};

mu_mag_x_3_1 = mean(mag_x_3_1);
sig2_mag_x_3_1 = var(mag_x_3_1);

mu_mag_y_3_1 = mean(mag_y_3_1);
sig2_mag_y_3_1 = var(mag_y_3_1);

mu_mag_z_3_1 = mean(mag_z_3_1);
sig2_mag_z_3_1 = var(mag_z_3_1);


mu_mag_3_1      = [mu_mag_x_3_1;mu_mag_y_3_1;mu_mag_z_3_1];
bias_mag_3_1 = [mu_mag_x_3_1;mu_mag_y_3_1;mu_mag_z_3_1] -
 [0;19.729;-47.6421] ;% muT
var_mag_3_1  = diag([sig2_mag_x_3_1 sig2_mag_y_3_1 sig2_mag_z_3_1]);

xlswrite('Data.xls',[mu_acc_3_1 tru_acc_3 bias_acc_3_1
 var_acc_3_1],'sheet1','E34');
```

```
xlswrite('Data.xls',[mu_gyro_3_1 tru_gyro_3 bias_gyro_3_1
 var_gyro_3_1],'sheet2','E34');
xlswrite('Data.xls',[mu_mag_3_1 tru_mag_3 bias_mag_3_1
 var_mag_3_1],'sheet3','E34');
```

OPEN TABLES

```
data_table_acc_3_2   = readtable('Accelerometer_3_2.csv');
data_table_gyro_3_2  = readtable('Gyroscope_3_2.csv');
data_table_mag_3_2   = readtable('Magnetometer_3_2.csv');
```

```
g = 9.80328;
tru_acc_3  = [g;0;0];
tru_gyro_3 = [0;0;0];
tru_mag_3  = [-47.6421;19.729;4.9369];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_3_2   = data_table_acc_3_2{:,2};
acc_y_3_2   = data_table_acc_3_2{:,3};
acc_z_3_2   = data_table_acc_3_2{:,4};

mu_acc_x_3_2 = mean(acc_x_3_2);
sig2_acc_x_3_2 = var(acc_x_3_2);
```

```
mu_acc_y_3_2 =  mean(acc_y_3_2);
sig2_acc_y_3_2 = var(acc_y_3_2);

mu_acc_z_3_2 = mean(acc_z_3_2);
sig2_acc_z_3_2 = var(acc_z_3_2);

mu_acc_3_2      = [mu_acc_x_3_2; mu_acc_y_3_2; mu_acc_z_3_2];
bias_acc_3_2    = [mu_acc_x_3_2; mu_acc_y_3_2; mu_acc_z_3_2] - [0;0;g]
  ;% m/s/s
var_acc_3_2  = diag([sig2_acc_x_3_2 sig2_acc_y_3_2 sig2_acc_z_3_2]);
```

Gryroscopes

```
gyro_x_3_2 = data_table_gyro_3_2{:, 2};
gyro_y_3_2 = data_table_gyro_3_2{:, 3};
gyro_z_3_2 = data_table_gyro_3_2{:, 4};


mu_gyro_x_3_2 = mean(gyro_x_3_2);
sig2_gyro_x_3_2 = var(gyro_x_3_2);

mu_gyro_y_3_2 = mean(gyro_y_3_2);
sig2_gyro_y_3_2 = var(gyro_y_3_2);

mu_gyro_z_3_2 = mean(gyro_z_3_2);
sig2_gyro_z_3_2 = var(gyro_z_3_2);

mu_gyro_3_2     = [mu_gyro_x_3_2; mu_gyro_y_3_2; mu_gyro_z_3_2];
bias_gyro_3_2 = -[mu_gyro_x_3_2; mu_gyro_y_3_2; mu_gyro_z_3_2]    ;%
 rad/s
var_gyro_3_2 = diag([sig2_gyro_x_3_2 sig2_gyro_y_3_2
 sig2_gyro_z_3_2]);
```

Magnetometers

```
mag_x_3_2 = data_table_mag_3_2{:, 2};
mag_y_3_2 = data_table_mag_3_2{:, 3};
mag_z_3_2 = data_table_mag_3_2{:, 4};

mu_mag_x_3_2 = mean(mag_x_3_2);
sig2_mag_x_3_2 = var(mag_x_3_2);

mu_mag_y_3_2 = mean(mag_y_3_2);
sig2_mag_y_3_2 = var(mag_y_3_2);

mu_mag_z_3_2 = mean(mag_z_3_2);
sig2_mag_z_3_2 = var(mag_z_3_2);


mu_mag_3_2      = [mu_mag_x_3_2;mu_mag_y_3_2;mu_mag_z_3_2];
bias_mag_3_2 = [mu_mag_x_3_2;mu_mag_y_3_2;mu_mag_z_3_2] -
 [0;19.729;-47.6421] ;% muT
```

```
var_mag_3_2  = diag([sig2_mag_x_3_2 sig2_mag_y_3_2 sig2_mag_z_3_2]);

xlswrite('Data.xls',[mu_acc_3_2 tru_acc_3 bias_acc_3_2
 var_acc_3_2],'sheet1','E37');
xlswrite('Data.xls',[mu_gyro_3_2 tru_gyro_3 bias_gyro_3_2
 var_gyro_3_2],'sheet2','E37');
xlswrite('Data.xls',[mu_mag_3_2 tru_mag_3 bias_mag_3_2
 var_mag_3_2],'sheet3','E37');
```

OPEN TABLES

```
data_table_acc_3_3   = readtable('Accelerometer_3_3.csv');
data_table_gyro_3_3  = readtable('Gyroscope_3_3.csv');
data_table_mag_3_3   = readtable('Magnetometer_3_3.csv');


g = 9.80328;
tru_acc_3  = [g;0;0];
tru_gyro_3 = [0;0;0];
tru_mag_3  = [-47.6421;19.729;4.9369];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_3_3   = data_table_acc_3_3{:,2};
acc_y_3_3   = data_table_acc_3_3{:,3};
```

```
acc_z_3_3   = data_table_acc_3_3{:,4};

mu_acc_x_3_3 = mean(acc_x_3_3);
sig2_acc_x_3_3 = var(acc_x_3_3);

mu_acc_y_3_3 =  mean(acc_y_3_3);
sig2_acc_y_3_3 = var(acc_y_3_3);

mu_acc_z_3_3 = mean(acc_z_3_3);
sig2_acc_z_3_3 = var(acc_z_3_3);

mu_acc_3_3      = [mu_acc_x_3_3; mu_acc_y_3_3; mu_acc_z_3_3];
bias_acc_3_3    = [mu_acc_x_3_3; mu_acc_y_3_3; mu_acc_z_3_3] - [0;0;g]
  ;% m/s/s
var_acc_3_3  = diag([sig2_acc_x_3_3 sig2_acc_y_3_3 sig2_acc_z_3_3]);
```

Gryroscopes

```
gyro_x_3_3 = data_table_gyro_3_3{:, 2};
gyro_y_3_3 = data_table_gyro_3_3{:, 3};
gyro_z_3_3 = data_table_gyro_3_3{:, 4};


mu_gyro_x_3_3 = mean(gyro_x_3_3);
sig2_gyro_x_3_3 = var(gyro_x_3_3);

mu_gyro_y_3_3 = mean(gyro_y_3_3);
sig2_gyro_y_3_3 = var(gyro_y_3_3);

mu_gyro_z_3_3 = mean(gyro_z_3_3);
sig2_gyro_z_3_3 = var(gyro_z_3_3);

mu_gyro_3_3     = [mu_gyro_x_3_3; mu_gyro_y_3_3; mu_gyro_z_3_3];
bias_gyro_3_3 = -[mu_gyro_x_3_3; mu_gyro_y_3_3; mu_gyro_z_3_3]    ;%
 rad/s
var_gyro_3_3 = diag([sig2_gyro_x_3_3 sig2_gyro_y_3_3
 sig2_gyro_z_3_3]);
```

Magnetometers

```
mag_x_3_3 = data_table_mag_3_3{:, 2};
mag_y_3_3 = data_table_mag_3_3{:, 3};
mag_z_3_3 = data_table_mag_3_3{:, 4};

mu_mag_x_3_3 = mean(mag_x_3_3);
sig2_mag_x_3_3 = var(mag_x_3_3);

mu_mag_y_3_3 = mean(mag_y_3_3);
sig2_mag_y_3_3 = var(mag_y_3_3);

mu_mag_z_3_3 = mean(mag_z_3_3);
sig2_mag_z_3_3 = var(mag_z_3_3);
```

```
mu_mag_3_3      = [mu_mag_x_3_3;mu_mag_y_3_3;mu_mag_z_3_3];
bias_mag_3_3 = [mu_mag_x_3_3;mu_mag_y_3_3;mu_mag_z_3_3] -
 [0;19.729;-47.6421] ;% muT
var_mag_3_3  = diag([sig2_mag_x_3_3 sig2_mag_y_3_3 sig2_mag_z_3_3]);

xlswrite('Data.xls',[mu_acc_3_3 tru_acc_3 bias_acc_3_3
 var_acc_3_3],'sheet1','E40');
xlswrite('Data.xls',[mu_gyro_3_3 tru_gyro_3 bias_gyro_3_3
 var_gyro_3_3],'sheet2','E40');
xlswrite('Data.xls',[mu_mag_3_3 tru_mag_3 bias_mag_3_3
 var_mag_3_3],'sheet3','E40');
```

OPEN TABLES

```
data_table_acc_3_4   = readtable('Accelerometer_3_4.csv');
data_table_gyro_3_4  = readtable('Gyroscope_3_4.csv');
data_table_mag_3_4   = readtable('Magnetometer_3_4.csv');


g = 9.80328;
tru_acc_3  = [g;0;0];
tru_gyro_3 = [0;0;0];
tru_mag_3  = [-47.6421;19.729;4.9369];

Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_3_4   = data_table_acc_3_4{:,2};
acc_y_3_4   = data_table_acc_3_4{:,3};
acc_z_3_4   = data_table_acc_3_4{:,4};

mu_acc_x_3_4 = mean(acc_x_3_4);
sig2_acc_x_3_4 = var(acc_x_3_4);

mu_acc_y_3_4 =  mean(acc_y_3_4);
sig2_acc_y_3_4 = var(acc_y_3_4);

mu_acc_z_3_4 = mean(acc_z_3_4);
sig2_acc_z_3_4 = var(acc_z_3_4);

mu_acc_3_4      = [mu_acc_x_3_4; mu_acc_y_3_4; mu_acc_z_3_4];
bias_acc_3_4    = [mu_acc_x_3_4; mu_acc_y_3_4; mu_acc_z_3_4] - [0;0;g]
  ;% m/s/s
var_acc_3_4  = diag([sig2_acc_x_3_4 sig2_acc_y_3_4 sig2_acc_z_3_4]);
```

Gryroscopes

```
gyro_x_3_4 = data_table_gyro_3_4{:, 2};
gyro_y_3_4 = data_table_gyro_3_4{:, 3};
gyro_z_3_4 = data_table_gyro_3_4{:, 4};


mu_gyro_x_3_4 = mean(gyro_x_3_4);
sig2_gyro_x_3_4 = var(gyro_x_3_4);

mu_gyro_y_3_4 = mean(gyro_y_3_4);
sig2_gyro_y_3_4 = var(gyro_y_3_4);

mu_gyro_z_3_4 = mean(gyro_z_3_4);
sig2_gyro_z_3_4 = var(gyro_z_3_4);

mu_gyro_3_4     = [mu_gyro_x_3_4; mu_gyro_y_3_4; mu_gyro_z_3_4];
bias_gyro_3_4 = -[mu_gyro_x_3_4; mu_gyro_y_3_4; mu_gyro_z_3_4]    ;%
 rad/s
var_gyro_3_4 = diag([sig2_gyro_x_3_4 sig2_gyro_y_3_4
 sig2_gyro_z_3_4]);
```

Magnetometers

```
mag_x_3_4 = data_table_mag_3_4{:, 2};
mag_y_3_4 = data_table_mag_3_4{:, 3};
mag_z_3_4 = data_table_mag_3_4{:, 4};

mu_mag_x_3_4 = mean(mag_x_3_4);
sig2_mag_x_3_4 = var(mag_x_3_4);
```

```
mu_mag_y_3_4 = mean(mag_y_3_4);
sig2_mag_y_3_4 = var(mag_y_3_4);

mu_mag_z_3_4 = mean(mag_z_3_4);
sig2_mag_z_3_4 = var(mag_z_3_4);


mu_mag_3_4      = [mu_mag_x_3_4;mu_mag_y_3_4;mu_mag_z_3_4];
bias_mag_3_4 = [mu_mag_x_3_4;mu_mag_y_3_4;mu_mag_z_3_4] -
 [0;19.729;-47.6421] ;% muT
var_mag_3_4  = diag([sig2_mag_x_3_4 sig2_mag_y_3_4 sig2_mag_z_3_4]);

xlswrite('Data.xls',[mu_acc_3_4 tru_acc_3 bias_acc_3_4
 var_acc_3_4],'sheet1','E43');
xlswrite('Data.xls',[mu_gyro_3_4 tru_gyro_3 bias_gyro_3_4
 var_gyro_3_4],'sheet2','E43');
xlswrite('Data.xls',[mu_mag_3_4 tru_mag_3 bias_mag_3_4
 var_mag_3_4],'sheet3','E43');
```

OPEN TABLES

```
data_table_acc_3_5   = readtable('Accelerometer_3_5.csv');
data_table_gyro_3_5  = readtable('Gyroscope_3_5.csv');
data_table_mag_3_5   = readtable('Magnetometer_3_5.csv');


g = 9.80328;
tru_acc_3  = [g;0;0];
tru_gyro_3 = [0;0;0];
tru_mag_3  = [-47.6421;19.729;4.9369];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
```

```
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_3_5   = data_table_acc_3_5{:,2};
acc_y_3_5   = data_table_acc_3_5{:,3};
acc_z_3_5   = data_table_acc_3_5{:,4};

mu_acc_x_3_5 = mean(acc_x_3_5);
sig2_acc_x_3_5 = var(acc_x_3_5);

mu_acc_y_3_5 =  mean(acc_y_3_5);
sig2_acc_y_3_5 = var(acc_y_3_5);

mu_acc_z_3_5 = mean(acc_z_3_5);
sig2_acc_z_3_5 = var(acc_z_3_5);

mu_acc_3_5      = [mu_acc_x_3_5; mu_acc_y_3_5; mu_acc_z_3_5];
bias_acc_3_5    = [mu_acc_x_3_5; mu_acc_y_3_5; mu_acc_z_3_5] - [0;0;g]
  ;% m/s/s
var_acc_3_5  = diag([sig2_acc_x_3_5 sig2_acc_y_3_5 sig2_acc_z_3_5]);
```

Gryroscopes

```
gyro_x_3_5 = data_table_gyro_3_5{:, 2};
gyro_y_3_5 = data_table_gyro_3_5{:, 3};
gyro_z_3_5 = data_table_gyro_3_5{:, 4};


mu_gyro_x_3_5 = mean(gyro_x_3_5);
sig2_gyro_x_3_5 = var(gyro_x_3_5);

mu_gyro_y_3_5 = mean(gyro_y_3_5);
sig2_gyro_y_3_5 = var(gyro_y_3_5);

mu_gyro_z_3_5 = mean(gyro_z_3_5);
sig2_gyro_z_3_5 = var(gyro_z_3_5);

mu_gyro_3_5     = [mu_gyro_x_3_5; mu_gyro_y_3_5; mu_gyro_z_3_5];
bias_gyro_3_5 = -[mu_gyro_x_3_5; mu_gyro_y_3_5; mu_gyro_z_3_5]    ;%
 rad/s
var_gyro_3_5 = diag([sig2_gyro_x_3_5 sig2_gyro_y_3_5
 sig2_gyro_z_3_5]);
```

Magnetometers

```
mag_x_3_5 = data_table_mag_3_5{:, 2};
mag_y_3_5 = data_table_mag_3_5{:, 3};
```

```
mag_z_3_5 = data_table_mag_3_5{:, 4};

mu_mag_x_3_5 = mean(mag_x_3_5);
sig2_mag_x_3_5 = var(mag_x_3_5);

mu_mag_y_3_5 = mean(mag_y_3_5);
sig2_mag_y_3_5 = var(mag_y_3_5);

mu_mag_z_3_5 = mean(mag_z_3_5);
sig2_mag_z_3_5 = var(mag_z_3_5);


mu_mag_3_5      = [mu_mag_x_3_5;mu_mag_y_3_5;mu_mag_z_3_5];
bias_mag_3_5 = [mu_mag_x_3_5;mu_mag_y_3_5;mu_mag_z_3_5] -
 [0;19.729;-47.6421] ;% muT
var_mag_3_5  = diag([sig2_mag_x_3_5 sig2_mag_y_3_5 sig2_mag_z_3_5]);

xlswrite('Data.xls',[mu_acc_3_5 tru_acc_3 bias_acc_3_5
 var_acc_3_5],'sheet1','E46');
xlswrite('Data.xls',[mu_gyro_3_5 tru_gyro_3 bias_gyro_3_5
 var_gyro_3_5],'sheet2','E46');
xlswrite('Data.xls',[mu_mag_3_5 tru_mag_3 bias_mag_3_5
 var_mag_3_5],'sheet3','E46');
```

OPEN TABLES

```
data_table_acc_4_1   = readtable('Accelerometer_4_1.csv');
data_table_gyro_4_1  = readtable('Gyroscope_4_1.csv');
data_table_mag_4_1   = readtable('Magnetometer_4_1.csv');


g = 9.80328;
tru_acc_4  = [0;0;g];
tru_gyro_4 = [0;0;0];
tru_mag_4  = [19.729;0;-47.6421];

Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
```

```
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_4_1   = data_table_acc_4_1{:,2};
acc_y_4_1   = data_table_acc_4_1{:,3};
acc_z_4_1   = data_table_acc_4_1{:,4};

mu_acc_x_4_1 = mean(acc_x_4_1);
sig2_acc_x_4_1 = var(acc_x_4_1);

mu_acc_y_4_1 =  mean(acc_y_4_1);
sig2_acc_y_4_1 = var(acc_y_4_1);

mu_acc_z_4_1 = mean(acc_z_4_1);
sig2_acc_z_4_1 = var(acc_z_4_1);

mu_acc_4_1      = [mu_acc_x_4_1; mu_acc_y_4_1; mu_acc_z_4_1];
bias_acc_4_1    = [mu_acc_x_4_1; mu_acc_y_4_1; mu_acc_z_4_1] - [0;0;g]
  ;% m/s/s
var_acc_4_1  = diag([sig2_acc_x_4_1 sig2_acc_y_4_1 sig2_acc_z_4_1]);
```

Gryroscopes

```
gyro_x_4_1 = data_table_gyro_4_1{:, 2};
gyro_y_4_1 = data_table_gyro_4_1{:, 3};
gyro_z_4_1 = data_table_gyro_4_1{:, 4};


mu_gyro_x_4_1 = mean(gyro_x_4_1);
sig2_gyro_x_4_1 = var(gyro_x_4_1);

mu_gyro_y_4_1 = mean(gyro_y_4_1);
sig2_gyro_y_4_1 = var(gyro_y_4_1);

mu_gyro_z_4_1 = mean(gyro_z_4_1);
sig2_gyro_z_4_1 = var(gyro_z_4_1);

mu_gyro_4_1     = [mu_gyro_x_4_1; mu_gyro_y_4_1; mu_gyro_z_4_1];
bias_gyro_4_1 = -[mu_gyro_x_4_1; mu_gyro_y_4_1; mu_gyro_z_4_1]    ;%
 rad/s
var_gyro_4_1 = diag([sig2_gyro_x_4_1 sig2_gyro_y_4_1
 sig2_gyro_z_4_1]);
```

Magnetometers

```
mag_x_4_1 = data_table_mag_4_1{:, 2};
mag_y_4_1 = data_table_mag_4_1{:, 3};
mag_z_4_1 = data_table_mag_4_1{:, 4};

mu_mag_x_4_1 = mean(mag_x_4_1);
sig2_mag_x_4_1 = var(mag_x_4_1);

mu_mag_y_4_1 = mean(mag_y_4_1);
sig2_mag_y_4_1 = var(mag_y_4_1);

mu_mag_z_4_1 = mean(mag_z_4_1);
sig2_mag_z_4_1 = var(mag_z_4_1);


mu_mag_4_1      = [mu_mag_x_4_1;mu_mag_y_4_1;mu_mag_z_4_1];
bias_mag_4_1 = [mu_mag_x_4_1;mu_mag_y_4_1;mu_mag_z_4_1] -
 [0;19.729;-47.6421] ;% muT
var_mag_4_1  = diag([sig2_mag_x_4_1 sig2_mag_y_4_1 sig2_mag_z_4_1]);

xlswrite('Data.xls',[mu_acc_4_1 tru_acc_4 bias_acc_4_1
 var_acc_4_1],'sheet1','E49');
xlswrite('Data.xls',[mu_gyro_4_1 tru_gyro_4 bias_gyro_4_1
 var_gyro_4_1],'sheet2','E49');
xlswrite('Data.xls',[mu_mag_4_1 tru_mag_4 bias_mag_4_1
 var_mag_4_1],'sheet3','E49');
```

OPEN TABLES

```
data_table_acc_4_2   = readtable('Accelerometer_4_2.csv');
data_table_gyro_4_2  = readtable('Gyroscope_4_2.csv');
data_table_mag_4_2   = readtable('Magnetometer_4_2.csv');


g = 9.80328;
tru_acc_4  = [0;0;g];
tru_gyro_4 = [0;0;0];
tru_mag_4  = [19.729;0;-47.6421];

Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
```

```
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_4_2   = data_table_acc_4_2{:,2};
acc_y_4_2   = data_table_acc_4_2{:,3};
acc_z_4_2   = data_table_acc_4_2{:,4};

mu_acc_x_4_2 = mean(acc_x_4_2);
sig2_acc_x_4_2 = var(acc_x_4_2);

mu_acc_y_4_2 =  mean(acc_y_4_2);
sig2_acc_y_4_2 = var(acc_y_4_2);

mu_acc_z_4_2 = mean(acc_z_4_2);
sig2_acc_z_4_2 = var(acc_z_4_2);

mu_acc_4_2      = [mu_acc_x_4_2; mu_acc_y_4_2; mu_acc_z_4_2];
bias_acc_4_2    = [mu_acc_x_4_2; mu_acc_y_4_2; mu_acc_z_4_2] - [0;0;g]
  ;% m/s/s
var_acc_4_2  = diag([sig2_acc_x_4_2 sig2_acc_y_4_2 sig2_acc_z_4_2]);
```

Gryroscopes

```
gyro_x_4_2 = data_table_gyro_4_2{:, 2};
gyro_y_4_2 = data_table_gyro_4_2{:, 3};
gyro_z_4_2 = data_table_gyro_4_2{:, 4};


mu_gyro_x_4_2 = mean(gyro_x_4_2);
sig2_gyro_x_4_2 = var(gyro_x_4_2);

mu_gyro_y_4_2 = mean(gyro_y_4_2);
sig2_gyro_y_4_2 = var(gyro_y_4_2);

mu_gyro_z_4_2 = mean(gyro_z_4_2);
sig2_gyro_z_4_2 = var(gyro_z_4_2);
```

```
mu_gyro_4_2     = [mu_gyro_x_4_2; mu_gyro_y_4_2; mu_gyro_z_4_2];
bias_gyro_4_2 = -[mu_gyro_x_4_2; mu_gyro_y_4_2; mu_gyro_z_4_2]    ;%
 rad/s
var_gyro_4_2 = diag([sig2_gyro_x_4_2 sig2_gyro_y_4_2
 sig2_gyro_z_4_2]);
```

Magnetometers

```
mag_x_4_2 = data_table_mag_4_2{:, 2};
mag_y_4_2 = data_table_mag_4_2{:, 3};
mag_z_4_2 = data_table_mag_4_2{:, 4};

mu_mag_x_4_2 = mean(mag_x_4_2);
sig2_mag_x_4_2 = var(mag_x_4_2);

mu_mag_y_4_2 = mean(mag_y_4_2);
sig2_mag_y_4_2 = var(mag_y_4_2);

mu_mag_z_4_2 = mean(mag_z_4_2);
sig2_mag_z_4_2 = var(mag_z_4_2);


mu_mag_4_2      = [mu_mag_x_4_2;mu_mag_y_4_2;mu_mag_z_4_2];
bias_mag_4_2 = [mu_mag_x_4_2;mu_mag_y_4_2;mu_mag_z_4_2] -
 [0;19.729;-47.6421] ;% muT
var_mag_4_2  = diag([sig2_mag_x_4_2 sig2_mag_y_4_2 sig2_mag_z_4_2]);

xlswrite('Data.xls',[mu_acc_4_2 tru_acc_4 bias_acc_4_2
 var_acc_4_2],'sheet1','E52');
xlswrite('Data.xls',[mu_gyro_4_2 tru_gyro_4 bias_gyro_4_2
 var_gyro_4_2],'sheet2','E52');
xlswrite('Data.xls',[mu_mag_4_2 tru_mag_4 bias_mag_4_2
 var_mag_4_2],'sheet3','E52');
```

OPEN TABLES

```
data_table_acc_4_3   = readtable('Accelerometer_4_3.csv');
data_table_gyro_4_3  = readtable('Gyroscope_4_3.csv');
data_table_mag_4_3   = readtable('Magnetometer_4_3.csv');


g = 9.80328;
tru_acc_4  = [0;0;g];
tru_gyro_4 = [0;0;0];
tru_mag_4  = [19.729;0;-47.6421];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
```

```
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_4_3   = data_table_acc_4_3{:,2};
acc_y_4_3   = data_table_acc_4_3{:,3};
acc_z_4_3   = data_table_acc_4_3{:,4};

mu_acc_x_4_3 = mean(acc_x_4_3);
sig2_acc_x_4_3 = var(acc_x_4_3);

mu_acc_y_4_3 =  mean(acc_y_4_3);
sig2_acc_y_4_3 = var(acc_y_4_3);

mu_acc_z_4_3 = mean(acc_z_4_3);
sig2_acc_z_4_3 = var(acc_z_4_3);

mu_acc_4_3      = [mu_acc_x_4_3; mu_acc_y_4_3; mu_acc_z_4_3];
bias_acc_4_3    = [mu_acc_x_4_3; mu_acc_y_4_3; mu_acc_z_4_3] - [0;0;g]
  ;% m/s/s
var_acc_4_3  = diag([sig2_acc_x_4_3 sig2_acc_y_4_3 sig2_acc_z_4_3]);
```

Gryroscopes

```
gyro_x_4_3 = data_table_gyro_4_3{:, 2};
gyro_y_4_3 = data_table_gyro_4_3{:, 3};
gyro_z_4_3 = data_table_gyro_4_3{:, 4};


mu_gyro_x_4_3 = mean(gyro_x_4_3);
sig2_gyro_x_4_3 = var(gyro_x_4_3);

mu_gyro_y_4_3 = mean(gyro_y_4_3);
```

```
sig2_gyro_y_4_3 = var(gyro_y_4_3);

mu_gyro_z_4_3 = mean(gyro_z_4_3);
sig2_gyro_z_4_3 = var(gyro_z_4_3);

mu_gyro_4_3     = [mu_gyro_x_4_3; mu_gyro_y_4_3; mu_gyro_z_4_3];
bias_gyro_4_3 = -[mu_gyro_x_4_3; mu_gyro_y_4_3; mu_gyro_z_4_3]    ;%
 rad/s
var_gyro_4_3 = diag([sig2_gyro_x_4_3 sig2_gyro_y_4_3
 sig2_gyro_z_4_3]);
```

Magnetometers

```
mag_x_4_3 = data_table_mag_4_3{:, 2};
mag_y_4_3 = data_table_mag_4_3{:, 3};
mag_z_4_3 = data_table_mag_4_3{:, 4};

mu_mag_x_4_3 = mean(mag_x_4_3);
sig2_mag_x_4_3 = var(mag_x_4_3);

mu_mag_y_4_3 = mean(mag_y_4_3);
sig2_mag_y_4_3 = var(mag_y_4_3);

mu_mag_z_4_3 = mean(mag_z_4_3);
sig2_mag_z_4_3 = var(mag_z_4_3);


mu_mag_4_3      = [mu_mag_x_4_3;mu_mag_y_4_3;mu_mag_z_4_3];
bias_mag_4_3 = [mu_mag_x_4_3;mu_mag_y_4_3;mu_mag_z_4_3] -
 [0;19.729;-47.6421] ;% muT
var_mag_4_3  = diag([sig2_mag_x_4_3 sig2_mag_y_4_3 sig2_mag_z_4_3]);

xlswrite('Data.xls',[mu_acc_4_3 tru_acc_4 bias_acc_4_3
 var_acc_4_3],'sheet1','E55');
xlswrite('Data.xls',[mu_gyro_4_3 tru_gyro_4 bias_gyro_4_3
 var_gyro_4_3],'sheet2','E55');
xlswrite('Data.xls',[mu_mag_4_3 tru_mag_4 bias_mag_4_3
 var_mag_4_3],'sheet3','E55');
```

OPEN TABLES

```
data_table_acc_4_4   = readtable('Accelerometer_4_4.csv');
data_table_gyro_4_4  = readtable('Gyroscope_4_4.csv');
data_table_mag_4_4   = readtable('Magnetometer_4_4.csv');


g = 9.80328;
tru_acc_4  = [0;0;g];
tru_gyro_4 = [0;0;0];
tru_mag_4  = [19.729;0;-47.6421];
```

Warning: Column headers from the file were
modified to make them valid MATLAB

```
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_4_4   = data_table_acc_4_4{:,2};
acc_y_4_4   = data_table_acc_4_4{:,3};
acc_z_4_4   = data_table_acc_4_4{:,4};

mu_acc_x_4_4 = mean(acc_x_4_4);
sig2_acc_x_4_4 = var(acc_x_4_4);

mu_acc_y_4_4 =  mean(acc_y_4_4);
sig2_acc_y_4_4 = var(acc_y_4_4);

mu_acc_z_4_4 = mean(acc_z_4_4);
sig2_acc_z_4_4 = var(acc_z_4_4);

mu_acc_4_4      = [mu_acc_x_4_4; mu_acc_y_4_4; mu_acc_z_4_4];
bias_acc_4_4    = [mu_acc_x_4_4; mu_acc_y_4_4; mu_acc_z_4_4] - [0;0;g]
  ;% m/s/s
var_acc_4_4  = diag([sig2_acc_x_4_4 sig2_acc_y_4_4 sig2_acc_z_4_4]);
```

Gryroscopes

```
gyro_x_4_4 = data_table_gyro_4_4{:, 2};
gyro_y_4_4 = data_table_gyro_4_4{:, 3};
gyro_z_4_4 = data_table_gyro_4_4{:, 4};
```

```
mu_gyro_x_4_4 = mean(gyro_x_4_4);
sig2_gyro_x_4_4 = var(gyro_x_4_4);

mu_gyro_y_4_4 = mean(gyro_y_4_4);
sig2_gyro_y_4_4 = var(gyro_y_4_4);

mu_gyro_z_4_4 = mean(gyro_z_4_4);
sig2_gyro_z_4_4 = var(gyro_z_4_4);

mu_gyro_4_4     = [mu_gyro_x_4_4; mu_gyro_y_4_4; mu_gyro_z_4_4];
bias_gyro_4_4 = -[mu_gyro_x_4_4; mu_gyro_y_4_4; mu_gyro_z_4_4]    ;%
 rad/s
var_gyro_4_4 = diag([sig2_gyro_x_4_4 sig2_gyro_y_4_4
 sig2_gyro_z_4_4]);
```

Magnetometers

```
mag_x_4_4 = data_table_mag_4_4{:, 2};
mag_y_4_4 = data_table_mag_4_4{:, 3};
mag_z_4_4 = data_table_mag_4_4{:, 4};

mu_mag_x_4_4 = mean(mag_x_4_4);
sig2_mag_x_4_4 = var(mag_x_4_4);

mu_mag_y_4_4 = mean(mag_y_4_4);
sig2_mag_y_4_4 = var(mag_y_4_4);

mu_mag_z_4_4 = mean(mag_z_4_4);
sig2_mag_z_4_4 = var(mag_z_4_4);


mu_mag_4_4      = [mu_mag_x_4_4;mu_mag_y_4_4;mu_mag_z_4_4];
bias_mag_4_4 = [mu_mag_x_4_4;mu_mag_y_4_4;mu_mag_z_4_4] -
 [0;19.729;-47.6421] ;% muT
var_mag_4_4  = diag([sig2_mag_x_4_4 sig2_mag_y_4_4 sig2_mag_z_4_4]);

xlswrite('Data.xls',[mu_acc_4_4 tru_acc_4 bias_acc_4_4
 var_acc_4_4],'sheet1','E58');
xlswrite('Data.xls',[mu_gyro_4_4 tru_gyro_4 bias_gyro_4_4
 var_gyro_4_4],'sheet2','E58');
xlswrite('Data.xls',[mu_mag_4_4 tru_mag_4 bias_mag_4_4
 var_mag_4_4],'sheet3','E58');
```

OPEN TABLES

```
data_table_acc_4_5   = readtable('Accelerometer_4_5.csv');
data_table_gyro_4_5  = readtable('Gyroscope_4_5.csv');
data_table_mag_4_5   = readtable('Magnetometer_4_5.csv');


g = 9.80328;
tru_acc_4  = [0;0;g];
tru_gyro_4 = [0;0;0];
```

```
tru_mag_4  = [19.729;0;-47.6421];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
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property.
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Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_4_5   = data_table_acc_4_5{:,2};
acc_y_4_5   = data_table_acc_4_5{:,3};
acc_z_4_5   = data_table_acc_4_5{:,4};

mu_acc_x_4_5 = mean(acc_x_4_5);
sig2_acc_x_4_5 = var(acc_x_4_5);

mu_acc_y_4_5 =  mean(acc_y_4_5);
sig2_acc_y_4_5 = var(acc_y_4_5);

mu_acc_z_4_5 = mean(acc_z_4_5);
sig2_acc_z_4_5 = var(acc_z_4_5);

mu_acc_4_5      = [mu_acc_x_4_5; mu_acc_y_4_5; mu_acc_z_4_5];
bias_acc_4_5    = [mu_acc_x_4_5; mu_acc_y_4_5; mu_acc_z_4_5] - [0;0;g]
  ;% m/s/s
var_acc_4_5  = diag([sig2_acc_x_4_5 sig2_acc_y_4_5 sig2_acc_z_4_5]);
```

Gyroscopes

```
gyro_x_4_5 = data_table_gyro_4_5{:, 2};
```

```
gyro_y_4_5 = data_table_gyro_4_5{:, 3};
gyro_z_4_5 = data_table_gyro_4_5{:, 4};


mu_gyro_x_4_5 = mean(gyro_x_4_5);
sig2_gyro_x_4_5 = var(gyro_x_4_5);

mu_gyro_y_4_5 = mean(gyro_y_4_5);
sig2_gyro_y_4_5 = var(gyro_y_4_5);

mu_gyro_z_4_5 = mean(gyro_z_4_5);
sig2_gyro_z_4_5 = var(gyro_z_4_5);

mu_gyro_4_5     = [mu_gyro_x_4_5; mu_gyro_y_4_5; mu_gyro_z_4_5];
bias_gyro_4_5 = -[mu_gyro_x_4_5; mu_gyro_y_4_5; mu_gyro_z_4_5]    ;%
 rad/s
var_gyro_4_5 = diag([sig2_gyro_x_4_5 sig2_gyro_y_4_5
 sig2_gyro_z_4_5]);
```

Magnetometers

```
mag_x_4_5 = data_table_mag_4_5{:, 2};
mag_y_4_5 = data_table_mag_4_5{:, 3};
mag_z_4_5 = data_table_mag_4_5{:, 4};

mu_mag_x_4_5 = mean(mag_x_4_5);
sig2_mag_x_4_5 = var(mag_x_4_5);

mu_mag_y_4_5 = mean(mag_y_4_5);
sig2_mag_y_4_5 = var(mag_y_4_5);

mu_mag_z_4_5 = mean(mag_z_4_5);
sig2_mag_z_4_5 = var(mag_z_4_5);


mu_mag_4_5      = [mu_mag_x_4_5;mu_mag_y_4_5;mu_mag_z_4_5];
bias_mag_4_5 = [mu_mag_x_4_5;mu_mag_y_4_5;mu_mag_z_4_5] -
 [0;19.729;-47.6421] ;% muT
var_mag_4_5  = diag([sig2_mag_x_4_5 sig2_mag_y_4_5 sig2_mag_z_4_5]);

xlswrite('Data.xls',[mu_acc_4_5 tru_acc_4 bias_acc_4_5
 var_acc_4_5],'sheet1','E61');
xlswrite('Data.xls',[mu_gyro_4_5 tru_gyro_4 bias_gyro_4_5
 var_gyro_4_5],'sheet2','E61');
xlswrite('Data.xls',[mu_mag_4_5 tru_mag_4 bias_mag_4_5
 var_mag_4_5],'sheet3','E61');
```

OPEN TABLES

```
data_table_acc_5_1   = readtable('Accelerometer_5_1.csv');
data_table_gyro_5_1  = readtable('Gyroscope_5_1.csv');
data_table_mag_5_1   = readtable('Magnetometer_5_1.csv');
```

```
g = 9.80328;
tru_acc_5  = [0;0;g];
tru_gyro_5 = [0;0;0];
tru_mag_5  = [0;19.729;-47.6421];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_5_1   = data_table_acc_5_1{:,2};
acc_y_5_1   = data_table_acc_5_1{:,3};
acc_z_5_1   = data_table_acc_5_1{:,4};

mu_acc_x_5_1 = mean(acc_x_5_1);
sig2_acc_x_5_1 = var(acc_x_5_1);

mu_acc_y_5_1 =  mean(acc_y_5_1);
sig2_acc_y_5_1 = var(acc_y_5_1);

mu_acc_z_5_1 = mean(acc_z_5_1);
sig2_acc_z_5_1 = var(acc_z_5_1);

mu_acc_5_1      = [mu_acc_x_5_1; mu_acc_y_5_1; mu_acc_z_5_1];
bias_acc_5_1    = [mu_acc_x_5_1; mu_acc_y_5_1; mu_acc_z_5_1] - [0;0;g]
  ;% m/s/s
var_acc_5_1  = diag([sig2_acc_x_5_1 sig2_acc_y_5_1 sig2_acc_z_5_1]);
```

Gryroscopes

```
gyro_x_5_1 = data_table_gyro_5_1{:, 2};
gyro_y_5_1 = data_table_gyro_5_1{:, 3};
gyro_z_5_1 = data_table_gyro_5_1{:, 4};


mu_gyro_x_5_1 = mean(gyro_x_5_1);
sig2_gyro_x_5_1 = var(gyro_x_5_1);

mu_gyro_y_5_1 = mean(gyro_y_5_1);
sig2_gyro_y_5_1 = var(gyro_y_5_1);

mu_gyro_z_5_1 = mean(gyro_z_5_1);
sig2_gyro_z_5_1 = var(gyro_z_5_1);

mu_gyro_5_1     = [mu_gyro_x_5_1; mu_gyro_y_5_1; mu_gyro_z_5_1];
bias_gyro_5_1 = -[mu_gyro_x_5_1; mu_gyro_y_5_1; mu_gyro_z_5_1]    ;%
 rad/s
var_gyro_5_1 = diag([sig2_gyro_x_5_1 sig2_gyro_y_5_1
 sig2_gyro_z_5_1]);
```

Magnetometers

```
mag_x_5_1 = data_table_mag_5_1{:, 2};
mag_y_5_1 = data_table_mag_5_1{:, 3};
mag_z_5_1 = data_table_mag_5_1{:, 4};

mu_mag_x_5_1 = mean(mag_x_5_1);
sig2_mag_x_5_1 = var(mag_x_5_1);

mu_mag_y_5_1 = mean(mag_y_5_1);
sig2_mag_y_5_1 = var(mag_y_5_1);

mu_mag_z_5_1 = mean(mag_z_5_1);
sig2_mag_z_5_1 = var(mag_z_5_1);


mu_mag_5_1      = [mu_mag_x_5_1;mu_mag_y_5_1;mu_mag_z_5_1];
bias_mag_5_1 = [mu_mag_x_5_1;mu_mag_y_5_1;mu_mag_z_5_1] -
 [0;19.729;-47.6421] ;% muT
var_mag_5_1  = diag([sig2_mag_x_5_1 sig2_mag_y_5_1 sig2_mag_z_5_1]);

xlswrite('Data.xls',[mu_acc_5_1 tru_acc_5 bias_acc_5_1
 var_acc_5_1],'sheet1','E64');
xlswrite('Data.xls',[mu_gyro_5_1 tru_gyro_5 bias_gyro_5_1
 var_gyro_5_1],'sheet2','E64');
xlswrite('Data.xls',[mu_mag_5_1 tru_mag_5 bias_mag_5_1
 var_mag_5_1],'sheet3','E64');
```

OPEN TABLES

```
data_table_acc_5_2   = readtable('Accelerometer_5_2.csv');
data_table_gyro_5_2  = readtable('Gyroscope_5_2.csv');
data_table_mag_5_2   = readtable('Magnetometer_5_2.csv');
```

```
g = 9.80328;
tru_acc_5  = [0;0;g];
tru_gyro_5 = [0;0;0];
tru_mag_5  = [0;19.729;-47.6421];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
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variable names.
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modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_5_2   = data_table_acc_5_2{:,2};
acc_y_5_2   = data_table_acc_5_2{:,3};
acc_z_5_2   = data_table_acc_5_2{:,4};

mu_acc_x_5_2 = mean(acc_x_5_2);
sig2_acc_x_5_2 = var(acc_x_5_2);

mu_acc_y_5_2 =  mean(acc_y_5_2);
sig2_acc_y_5_2 = var(acc_y_5_2);
```

```
mu_acc_z_5_2 = mean(acc_z_5_2);
sig2_acc_z_5_2 = var(acc_z_5_2);

mu_acc_5_2      = [mu_acc_x_5_2; mu_acc_y_5_2; mu_acc_z_5_2];
bias_acc_5_2    = [mu_acc_x_5_2; mu_acc_y_5_2; mu_acc_z_5_2] - [0;0;g]
  ;% m/s/s
var_acc_5_2  = diag([sig2_acc_x_5_2 sig2_acc_y_5_2 sig2_acc_z_5_2]);
```

Gryroscopes

```
gyro_x_5_2 = data_table_gyro_5_2{:, 2};
gyro_y_5_2 = data_table_gyro_5_2{:, 3};
gyro_z_5_2 = data_table_gyro_5_2{:, 4};


mu_gyro_x_5_2 = mean(gyro_x_5_2);
sig2_gyro_x_5_2 = var(gyro_x_5_2);

mu_gyro_y_5_2 = mean(gyro_y_5_2);
sig2_gyro_y_5_2 = var(gyro_y_5_2);

mu_gyro_z_5_2 = mean(gyro_z_5_2);
sig2_gyro_z_5_2 = var(gyro_z_5_2);

mu_gyro_5_2     = [mu_gyro_x_5_2; mu_gyro_y_5_2; mu_gyro_z_5_2];
bias_gyro_5_2 = -[mu_gyro_x_5_2; mu_gyro_y_5_2; mu_gyro_z_5_2]    ;%
 rad/s
var_gyro_5_2 = diag([sig2_gyro_x_5_2 sig2_gyro_y_5_2
 sig2_gyro_z_5_2]);
```

Magnetometers

```
mag_x_5_2 = data_table_mag_5_2{:, 2};
mag_y_5_2 = data_table_mag_5_2{:, 3};
mag_z_5_2 = data_table_mag_5_2{:, 4};

mu_mag_x_5_2 = mean(mag_x_5_2);
sig2_mag_x_5_2 = var(mag_x_5_2);

mu_mag_y_5_2 = mean(mag_y_5_2);
sig2_mag_y_5_2 = var(mag_y_5_2);

mu_mag_z_5_2 = mean(mag_z_5_2);
sig2_mag_z_5_2 = var(mag_z_5_2);


mu_mag_5_2      = [mu_mag_x_5_2;mu_mag_y_5_2;mu_mag_z_5_2];
bias_mag_5_2 = [mu_mag_x_5_2;mu_mag_y_5_2;mu_mag_z_5_2] -
 [0;19.729;-47.6421] ;% muT
var_mag_5_2  = diag([sig2_mag_x_5_2 sig2_mag_y_5_2 sig2_mag_z_5_2]);

xlswrite('Data.xls',[mu_acc_5_2 tru_acc_5 bias_acc_5_2
 var_acc_5_2],'sheet1','E67');
```

```
xlswrite('Data.xls',[mu_gyro_5_2 tru_gyro_5 bias_gyro_5_2
 var_gyro_5_2],'sheet2','E67');
xlswrite('Data.xls',[mu_mag_5_2 tru_mag_5 bias_mag_5_2
 var_mag_5_2],'sheet3','E67');
```

OPEN TABLES

```
data_table_acc_5_3   = readtable('Accelerometer_5_3.csv');
data_table_gyro_5_3  = readtable('Gyroscope_5_3.csv');
data_table_mag_5_3   = readtable('Magnetometer_5_3.csv');
```

```
g = 9.80328;
tru_acc_5  = [0;0;g];
tru_gyro_5 = [0;0;0];
tru_mag_5  = [0;19.729;-47.6421];
```

```
Warning: Column headers from the file were
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are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_5_3   = data_table_acc_5_3{:,2};
acc_y_5_3   = data_table_acc_5_3{:,3};
acc_z_5_3   = data_table_acc_5_3{:,4};

mu_acc_x_5_3 = mean(acc_x_5_3);
sig2_acc_x_5_3 = var(acc_x_5_3);
```

```
mu_acc_y_5_3 =  mean(acc_y_5_3);
sig2_acc_y_5_3 = var(acc_y_5_3);

mu_acc_z_5_3 = mean(acc_z_5_3);
sig2_acc_z_5_3 = var(acc_z_5_3);

mu_acc_5_3      = [mu_acc_x_5_3; mu_acc_y_5_3; mu_acc_z_5_3];
bias_acc_5_3    = [mu_acc_x_5_3; mu_acc_y_5_3; mu_acc_z_5_3] - [0;0;g]
  ;% m/s/s
var_acc_5_3  = diag([sig2_acc_x_5_3 sig2_acc_y_5_3 sig2_acc_z_5_3]);
```

Gryroscopes

```
gyro_x_5_3 = data_table_gyro_5_3{:, 2};
gyro_y_5_3 = data_table_gyro_5_3{:, 3};
gyro_z_5_3 = data_table_gyro_5_3{:, 4};


mu_gyro_x_5_3 = mean(gyro_x_5_3);
sig2_gyro_x_5_3 = var(gyro_x_5_3);

mu_gyro_y_5_3 = mean(gyro_y_5_3);
sig2_gyro_y_5_3 = var(gyro_y_5_3);

mu_gyro_z_5_3 = mean(gyro_z_5_3);
sig2_gyro_z_5_3 = var(gyro_z_5_3);

mu_gyro_5_3     = [mu_gyro_x_5_3; mu_gyro_y_5_3; mu_gyro_z_5_3];
bias_gyro_5_3 = -[mu_gyro_x_5_3; mu_gyro_y_5_3; mu_gyro_z_5_3]    ;%
 rad/s
var_gyro_5_3 = diag([sig2_gyro_x_5_3 sig2_gyro_y_5_3
 sig2_gyro_z_5_3]);
```

Magnetometers

```
mag_x_5_3 = data_table_mag_5_3{:, 2};
mag_y_5_3 = data_table_mag_5_3{:, 3};
mag_z_5_3 = data_table_mag_5_3{:, 4};

mu_mag_x_5_3 = mean(mag_x_5_3);
sig2_mag_x_5_3 = var(mag_x_5_3);

mu_mag_y_5_3 = mean(mag_y_5_3);
sig2_mag_y_5_3 = var(mag_y_5_3);

mu_mag_z_5_3 = mean(mag_z_5_3);
sig2_mag_z_5_3 = var(mag_z_5_3);


mu_mag_5_3      = [mu_mag_x_5_3;mu_mag_y_5_3;mu_mag_z_5_3];
bias_mag_5_3 = [mu_mag_x_5_3;mu_mag_y_5_3;mu_mag_z_5_3] -
 [0;19.729;-47.6421] ;% muT
```

```
var_mag_5_3  = diag([sig2_mag_x_5_3 sig2_mag_y_5_3 sig2_mag_z_5_3]);

xlswrite('Data.xls',[mu_acc_5_3 tru_acc_5 bias_acc_5_3
 var_acc_5_3],'sheet1','E70');
xlswrite('Data.xls',[mu_gyro_5_3 tru_gyro_5 bias_gyro_5_3
 var_gyro_5_3],'sheet2','E70');
xlswrite('Data.xls',[mu_mag_5_3 tru_mag_5 bias_mag_5_3
 var_mag_5_3],'sheet3','E70');
```

OPEN TABLES

```
data_table_acc_5_4   = readtable('Accelerometer_5_4.csv');
data_table_gyro_5_4  = readtable('Gyroscope_5_4.csv');
data_table_mag_5_4   = readtable('Magnetometer_5_4.csv');


g = 9.80328;
tru_acc_5  = [0;0;g];
tru_gyro_5 = [0;0;0];
tru_mag_5  = [0;19.729;-47.6421];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
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variable names.
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property.
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variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_5_4   = data_table_acc_5_4{:,2};
acc_y_5_4   = data_table_acc_5_4{:,3};
```

```
acc_z_5_4   = data_table_acc_5_4{:,4};

mu_acc_x_5_4 = mean(acc_x_5_4);
sig2_acc_x_5_4 = var(acc_x_5_4);

mu_acc_y_5_4 =  mean(acc_y_5_4);
sig2_acc_y_5_4 = var(acc_y_5_4);

mu_acc_z_5_4 = mean(acc_z_5_4);
sig2_acc_z_5_4 = var(acc_z_5_4);

mu_acc_5_4      = [mu_acc_x_5_4; mu_acc_y_5_4; mu_acc_z_5_4];
bias_acc_5_4    = [mu_acc_x_5_4; mu_acc_y_5_4; mu_acc_z_5_4] - [0;0;g]
  ;% m/s/s
var_acc_5_4  = diag([sig2_acc_x_5_4 sig2_acc_y_5_4 sig2_acc_z_5_4]);
```

Gryroscopes

```
gyro_x_5_4 = data_table_gyro_5_4{:, 2};
gyro_y_5_4 = data_table_gyro_5_4{:, 3};
gyro_z_5_4 = data_table_gyro_5_4{:, 4};


mu_gyro_x_5_4 = mean(gyro_x_5_4);
sig2_gyro_x_5_4 = var(gyro_x_5_4);

mu_gyro_y_5_4 = mean(gyro_y_5_4);
sig2_gyro_y_5_4 = var(gyro_y_5_4);

mu_gyro_z_5_4 = mean(gyro_z_5_4);
sig2_gyro_z_5_4 = var(gyro_z_5_4);

mu_gyro_5_4     = [mu_gyro_x_5_4; mu_gyro_y_5_4; mu_gyro_z_5_4];
bias_gyro_5_4 = -[mu_gyro_x_5_4; mu_gyro_y_5_4; mu_gyro_z_5_4]    ;%
 rad/s
var_gyro_5_4 = diag([sig2_gyro_x_5_4 sig2_gyro_y_5_4
 sig2_gyro_z_5_4]);
```

Magnetometers

```
mag_x_5_4 = data_table_mag_5_4{:, 2};
mag_y_5_4 = data_table_mag_5_4{:, 3};
mag_z_5_4 = data_table_mag_5_4{:, 4};

mu_mag_x_5_4 = mean(mag_x_5_4);
sig2_mag_x_5_4 = var(mag_x_5_4);

mu_mag_y_5_4 = mean(mag_y_5_4);
sig2_mag_y_5_4 = var(mag_y_5_4);

mu_mag_z_5_4 = mean(mag_z_5_4);
sig2_mag_z_5_4 = var(mag_z_5_4);
```

```
mu_mag_5_4      = [mu_mag_x_5_4;mu_mag_y_5_4;mu_mag_z_5_4];
bias_mag_5_4 = [mu_mag_x_5_4;mu_mag_y_5_4;mu_mag_z_5_4] -
 [0;19.729;-47.6421] ;% muT
var_mag_5_4  = diag([sig2_mag_x_5_4 sig2_mag_y_5_4 sig2_mag_z_5_4]);

xlswrite('Data.xls',[mu_acc_5_4 tru_acc_5 bias_acc_5_4
 var_acc_5_4],'sheet1','E73');
xlswrite('Data.xls',[mu_gyro_5_4 tru_gyro_5 bias_gyro_5_4
 var_gyro_5_4],'sheet2','E73');
xlswrite('Data.xls',[mu_mag_5_4 tru_mag_5 bias_mag_5_4
 var_mag_5_4],'sheet3','E73');
```

OPEN TABLES

```
data_table_acc_5_5   = readtable('Accelerometer_5_5.csv');
data_table_gyro_5_5  = readtable('Gyroscope_5_5.csv');
data_table_mag_5_5   = readtable('Magnetometer_5_5.csv');


g = 9.80328;
tru_acc_5  = [0;0;g];
tru_gyro_5 = [0;0;0];
tru_mag_5  = [0;19.729;-47.6421];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
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property.
Set 'PreserveVariableNames' to true to use
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identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Accelerometers

```
acc_x_5_5   = data_table_acc_5_5{:,2};
acc_y_5_5   = data_table_acc_5_5{:,3};
acc_z_5_5   = data_table_acc_5_5{:,4};

mu_acc_x_5_5 = mean(acc_x_5_5);
sig2_acc_x_5_5 = var(acc_x_5_5);

mu_acc_y_5_5 =  mean(acc_y_5_5);
sig2_acc_y_5_5 = var(acc_y_5_5);

mu_acc_z_5_5 = mean(acc_z_5_5);
sig2_acc_z_5_5 = var(acc_z_5_5);

mu_acc_5_5      = [mu_acc_x_5_5; mu_acc_y_5_5; mu_acc_z_5_5];
bias_acc_5_5    = [mu_acc_x_5_5; mu_acc_y_5_5; mu_acc_z_5_5] - [0;0;g]
  ;% m/s/s
var_acc_5_5  = diag([sig2_acc_x_5_5 sig2_acc_y_5_5 sig2_acc_z_5_5]);
```

Gryroscopes

```
gyro_x_5_5 = data_table_gyro_5_5{:, 2};
gyro_y_5_5 = data_table_gyro_5_5{:, 3};
gyro_z_5_5 = data_table_gyro_5_5{:, 4};


mu_gyro_x_5_5 = mean(gyro_x_5_5);
sig2_gyro_x_5_5 = var(gyro_x_5_5);

mu_gyro_y_5_5 = mean(gyro_y_5_5);
sig2_gyro_y_5_5 = var(gyro_y_5_5);

mu_gyro_z_5_5 = mean(gyro_z_5_5);
sig2_gyro_z_5_5 = var(gyro_z_5_5);

mu_gyro_5_5     = [mu_gyro_x_5_5; mu_gyro_y_5_5; mu_gyro_z_5_5];
bias_gyro_5_5 = -[mu_gyro_x_5_5; mu_gyro_y_5_5; mu_gyro_z_5_5]    ;%
 rad/s
var_gyro_5_5 = diag([sig2_gyro_x_5_5 sig2_gyro_y_5_5
 sig2_gyro_z_5_5]);
```

Magnetometers

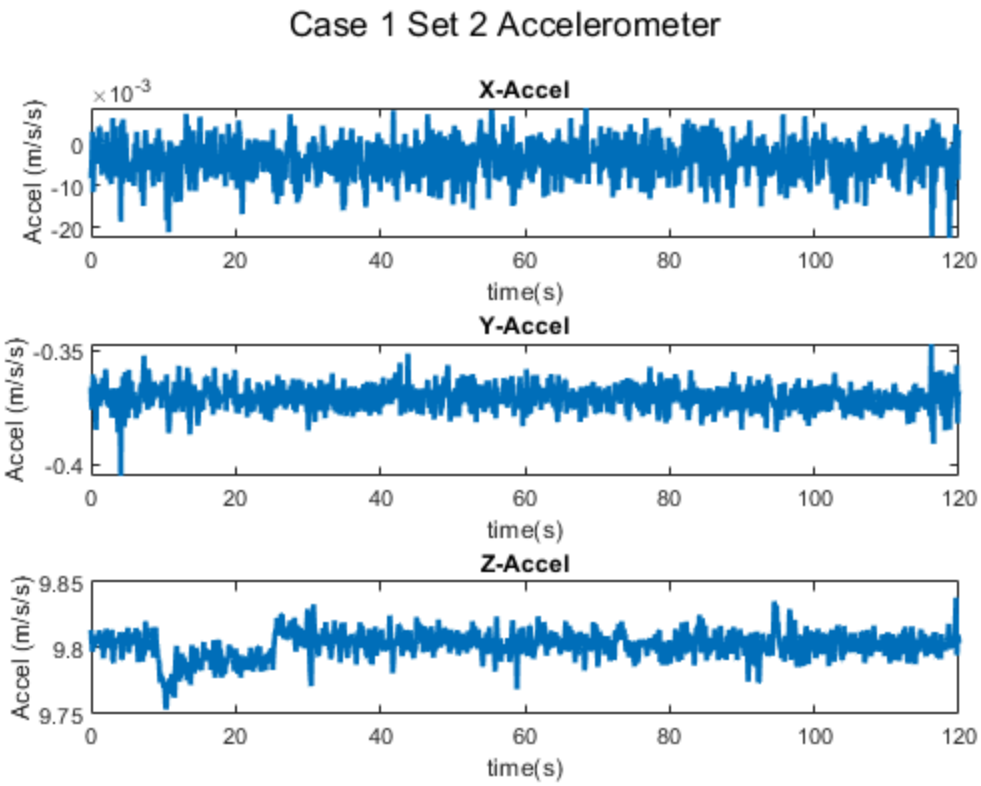
```
mag_x_5_5 = data_table_mag_5_5{:, 2};
mag_y_5_5 = data_table_mag_5_5{:, 3};
mag_z_5_5 = data_table_mag_5_5{:, 4};

mu_mag_x_5_5 = mean(mag_x_5_5);
sig2_mag_x_5_5 = var(mag_x_5_5);

mu_mag_y_5_5 = mean(mag_y_5_5);
```

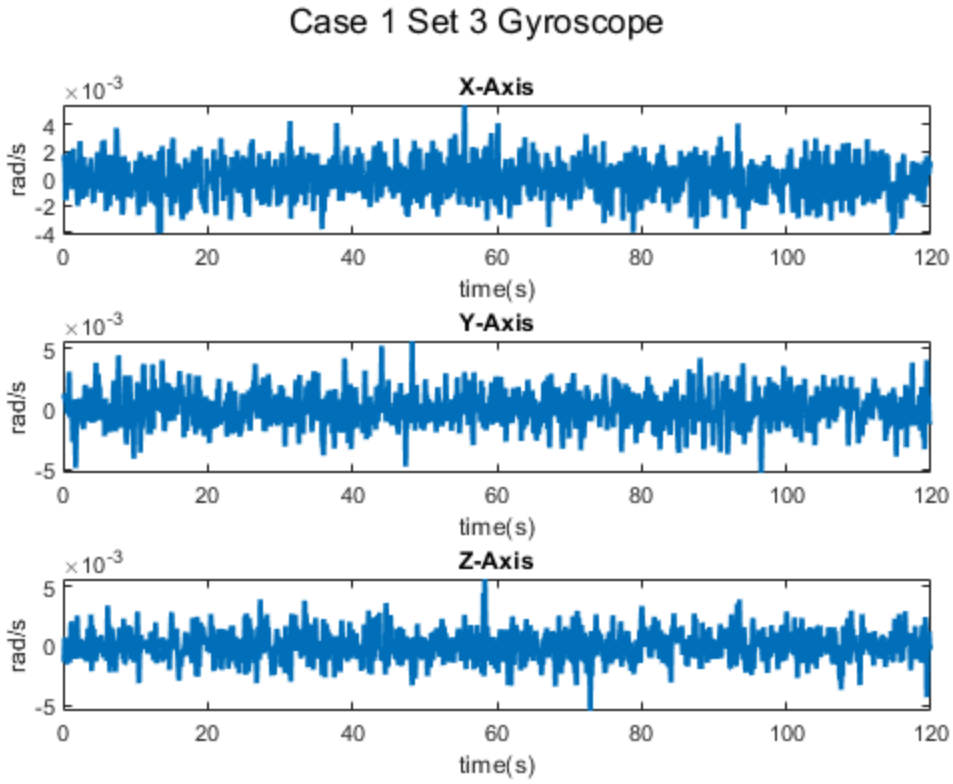
```
sig2_mag_y_5_5 = var(mag_y_5_5);

mu_mag_z_5_5 = mean(mag_z_5_5);
sig2_mag_z_5_5 = var(mag_z_5_5);


mu_mag_5_5      = [mu_mag_x_5_5;mu_mag_y_5_5;mu_mag_z_5_5];
bias_mag_5_5 = [mu_mag_x_5_5;mu_mag_y_5_5;mu_mag_z_5_5] -
 [0;19.729;-47.6421] ;% muT
var_mag_5_5  = diag([sig2_mag_x_5_5 sig2_mag_y_5_5 sig2_mag_z_5_5]);

xlswrite('Data.xls',[mu_acc_5_5 tru_acc_5 bias_acc_5_5
 var_acc_5_5],'sheet1','E76');
xlswrite('Data.xls',[mu_gyro_5_5 tru_gyro_5 bias_gyro_5_5
 var_gyro_5_5],'sheet2','E76');
xlswrite('Data.xls',[mu_mag_5_5 tru_mag_5 bias_mag_5_5
 var_mag_5_5],'sheet3','E76');
clc
```

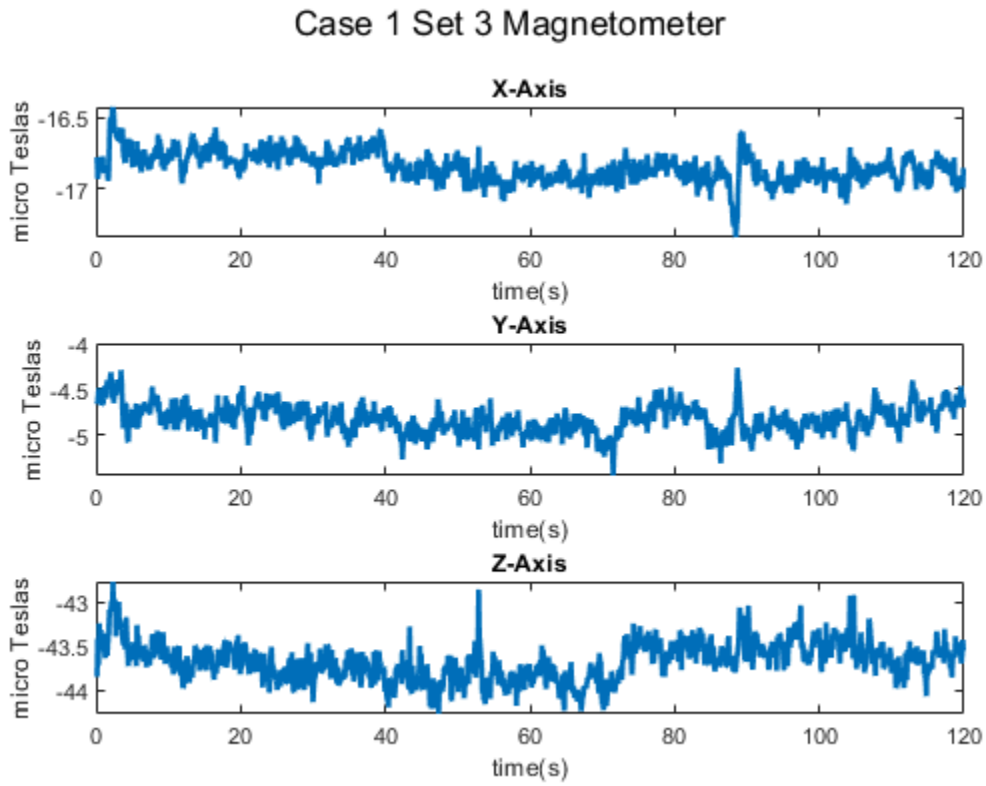
PLOTS

```
figure(1)
sgtitle('Case 1 Set 2 Accelerometer')

subplot(311)
plot(data_table_acc_1_2{:,1},acc_x_1_2,'Linewidth',2)
xlabel('time(s)');ylabel('Accel (m/s/s)'); title('X-Accel')
hold on

subplot(312)
plot(data_table_acc_1_2{:,1},acc_y_1_2,'Linewidth',2)
xlabel('time(s)');ylabel('Accel (m/s/s)'); title('Y-Accel')
hold on

subplot(313)
plot(data_table_acc_1_2{:,1},acc_z_1_2,'Linewidth',2)
xlabel('time(s)');ylabel('Accel (m/s/s)'); title('Z-Accel')
hold off

figure(2)
sgtitle('Case 1 Set 3 Gyroscope')

subplot(311)
plot(data_table_gyro_1_3{:,1},gyro_x_1_3,'Linewidth',2)
xlabel('time(s)');ylabel('rad/s'); title('X-Axis')
hold on

subplot(312)
plot(data_table_gyro_1_3{:,1},gyro_y_1_3,'Linewidth',2)
xlabel('time(s)');ylabel('rad/s'); title('Y-Axis')
hold on

subplot(313)
```

```
plot(data_table_gyro_1_3{:,1},gyro_z_1_3,'Linewidth',2)
xlabel('time(s)');ylabel('rad/s'); title('Z-Axis')
hold off

figure(3)
sgtitle('Case 1 Set 3 Magnetometer')

subplot(311)
plot(data_table_mag_1_3{:,1},mag_x_1_3,'Linewidth',2)
xlabel('time(s)');ylabel('micro Teslas'); title('X-Axis')
hold on

subplot(312)
plot(data_table_mag_1_3{:,1},mag_y_1_3,'Linewidth',2)
xlabel('time(s)');ylabel('micro Teslas'); title('Y-Axis')
hold on

subplot(313)
plot(data_table_mag_1_3{:,1},mag_z_1_3,'Linewidth',2)
xlabel('time(s)');ylabel('micro Teslas'); title('Z-Axis')
hold off
```




Case 1 Set 3 Gyroscope
X-Axis
×10^-3
rad/s
4
2
0
-2
-4
0
20
40
60
80
100
120
time(s)
Y-Axis
×10^-3
rad/s
5
0
-5
time(s)
Z-Axis
×10^-3
rad/s
5
0
-5
time(s)


Case 1 Set 3 Magnetometer
X-Axis
micro Teslas
-16.5
-17
time(s)
Y-Axis
micro Teslas
-4
-4.5
-5
time(s)
Z-Axis
micro Teslas
-43
-43.5
-44
time(s)

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PROBLEM 2

```
clear variables; close all; clc

data_table_mag = readtable('Magnetometer_Prob_2.csv');
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Magnetometers

```
bias_mag =[-12.11214937;
           -19.67616054;
            22.73696197];
var_mag = [0.467656955 0          0;
           0         0.744016854  0;
           0         0          0.463154807];


mag_x = data_table_mag{:, 2};
mag_y = data_table_mag{:, 3};
mag_z = data_table_mag{:, 4};

mag_x_wo_bias = mag_x - bias_mag(1);
mag_y_wo_bias = mag_y - bias_mag(2);
mag_z_wo_bias = mag_z - bias_mag(3);

magnetic_heading_data = -atan2( mag_y_wo_bias, mag_x_wo_bias );
declination    = -14.07*pi/180;
% Declination  for Worcester, MA found using World Magnetic Model
% https://www.ngdc.noaa.gov/geomag/calculators/
magcalc.shtml#declination

true_heading_data = declination + magnetic_heading_data;
true_heading_mu  = mean(true_heading_data)
disp('rad')
true_heading_var = var(true_heading_data)
disp('rad')


fprintf('The heading is %f deg +/- %f deg\n', ...
 true_heading_mu*180/pi, 3*sqrt(true_heading_var)*180/pi);

Validity = ['This heading is accurate given the orientation of the
 device '...
```

```
    'and that the positive x axis faced west'];
disp(Validity)
```

```
true_heading_mu =

   -1.4815

rad

true_heading_var =

   1.3227e-05

rad
The heading is -84.881480 deg +/- 0.625142 deg
This heading is accurate given the orientation of the device and that
 the positive x axis faced west
```

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PROBLEM 3

Table of Contents


```
clear variables; close all; clc

data_table_acc = readtable('Accelerometer_pitch_roll_head.csv');
data_table_mag = readtable('Magnetometer_pitch_roll_head.csv');
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Biases

```
bias_mag = [-12.11214937;
            -19.67616054;
            22.73696197];
bias_acc = [1.948244375;
            1.926002907;
            -3.760826138];
```

Local gravitational acceleration

```
g = 9.80333; % m/s/s
```

Accelerometers

```
acc_x = data_table_acc{:, 2};
acc_y = data_table_acc{:, 3};
acc_z = data_table_acc{:, 4};
```

Magnetometers

```
mag_xb = data_table_mag{:, 2};
mag_yb = data_table_mag{:, 3};
mag_zb = data_table_mag{:, 4};
```

Remove bias

```
acc_x_wo_bias = acc_x - bias_acc(1);
acc_y_wo_bias = acc_y - bias_acc(2);
acc_z_wo_bias = acc_z - bias_acc(3);

mag_xb_wo_bias = mag_xb - bias_mag(1);
mag_yb_wo_bias = mag_yb - bias_mag(2);
mag_zb_wo_bias = mag_zb - bias_mag(3);
```

Pitch and Roll

```
roll_data = atan( acc_y_wo_bias ./ acc_z_wo_bias );
pitch_data = asin( acc_x_wo_bias / g );

roll_mu  = mean( roll_data )
disp('rad')
pitch_mu = mean( pitch_data )
disp('rad')

roll_var = var(roll_data)
disp('rad')
pitch_var = var(pitch_data)
disp('rad')

fprintf('The roll angle is %f deg +/- %f deg\n', ...
 roll_mu*180/pi, 3*sqrt(roll_var)*180/pi);


fprintf('The pitch angle is %f deg +/- %f deg\n', ...
 pitch_mu*180/pi, 3*sqrt(pitch_var)*180/pi);


roll_mu =

    0.0210

rad
```

```
pitch_mu =

   -0.2017

rad

roll_var =

   2.6802e-07

rad

pitch_var =

   3.2389e-07

rad
The roll angle is 1.203306 deg +/- 0.088988 deg
The pitch angle is -11.556843 deg +/- 0.097824 deg
```

Heading

```
tmp1 = [...
 cos(pitch_mu) sin(pitch_mu)*sin(roll_mu)
 sin(pitch_mu)*cos(roll_mu); ...
 0 cos(roll_mu) -sin(roll_mu); ...
 -sin(pitch_mu) cos(pitch_mu)*sin(roll_mu) cos(pitch_mu)*cos(roll_mu)]
 * ...
 [mag_xb_wo_bias'; mag_yb_wo_bias'; mag_zb_wo_bias'];

mag_x_wo_bias = tmp1(1,:)';
mag_y_wo_bias = tmp1(2,:)';

magnetic_heading_data = -atan2( mag_y_wo_bias, mag_x_wo_bias );
declination    = -14.07*pi/180;
% Declination  for Worcester, MA found using World Magnetic Model
% https://www.ngdc.noaa.gov/geomag/calculators/
magcalc.shtml#declination

true_heading_data = declination + magnetic_heading_data;
true_heading_mu  = mean(true_heading_data)
disp('rad')
true_heading_var = var(true_heading_data)
disp('rad')

fprintf('The heading is %f deg +/- %f deg\n', ...
 true_heading_mu*180/pi, 3*sqrt(true_heading_var)*180/pi);

disp('This is a valid result as the device orientation matched the
 calculated values')


true_heading_mu =
```

```
   -1.2314

rad

true_heading_var =

   1.1804e-04

rad
The heading is -70.552140 deg +/- 1.867522 deg
This is a valid result as the device orientation matched the
 calculated values
```

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Table of Contents

PROBLEM 4

```
clear variables; close all; clc
```

Data Fetch

```
data_table_acc = readtable('Accelerometer_Att_est.csv');

data_table_gyro = readtable('Gyroscope_Att_est.csv');

data_table_mag = readtable('Magnetometer_Att_est.csv');

% CORRECT VALUES FOR THESE BIASES AND VARIANCES AS COMPUTED IN
 EXPERIMENT 1
bias_acc = [1.948244;
               1.926003;
               -3.76083]; % biases in accelerometer x,y,z

bias_mag = [-12.11214937;
               -19.67616054;
               22.73696197]; % biases in magnetometer x,y,z

bias_gyro = [0.00001194560806;
               -0.00000912316961;
               -0.00000169621783]; % biases in gyro x,y,z

var_acc  = [4.94; 5.23; 13.5]*10^-5;
var_gyro = [2.1; 2.6; 4.9]*10^-6;
var_mag     = [0.467657;0.744017;0.463155];
%================================================================================

Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
```

```
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Local gravitational acceleration

```
g = 9.80333; % m/s/s
```

Accelerometers

```
time_stamps_acc = data_table_acc{:, 1};
acc_x = data_table_acc{:, 2};
acc_y = data_table_acc{:, 3};
acc_z = data_table_acc{:, 4};
```

Rate gyros

```
time_stamps_gyro = data_table_gyro{:, 1};
gyro_x = data_table_gyro{:, 2};
gyro_y = data_table_gyro{:, 3};
gyro_z = data_table_gyro{:, 4};
```

Magnetometers

```
time_stamps_mag  = data_table_mag{:, 1};
mag_xb = data_table_mag{:, 2};
mag_yb = data_table_mag{:, 3};
mag_zb = data_table_mag{:, 4};
```

Remove bias

```
acc_x_wo_bias = acc_x - bias_acc(1);
acc_y_wo_bias = acc_y - bias_acc(2);
acc_z_wo_bias = acc_z - bias_acc(3);
```

```
gyro_x_wo_bias= gyro_x - bias_gyro(1);
gyro_y_wo_bias= gyro_y - bias_gyro(2);
gyro_z_wo_bias= gyro_z - bias_gyro(3);

mag_xb_wo_bias = mag_xb - bias_mag(1);
mag_yb_wo_bias = mag_yb - bias_mag(2);
mag_zb_wo_bias = mag_zb - bias_mag(3);
```

Initial Pitch, Roll, and Yaw

```
initial_few_pts = 5;
roll_data = atan( acc_y_wo_bias(1:initial_few_pts) ./
 acc_z_wo_bias(1:initial_few_pts) );
pitch_data = asin( acc_x_wo_bias(1:initial_few_pts) / g );

initial_roll = mean( roll_data )
disp('rad')
initial_pitch = mean( pitch_data )
disp('rad')


tmp1 = [...
 cos(initial_pitch) sin(initial_pitch)*sin(initial_roll)
 sin(initial_pitch)*cos(initial_roll); ...
 0 cos(initial_roll) -sin(initial_roll); ...
 -sin(initial_pitch) cos(initial_pitch)*sin(initial_roll)
 cos(initial_pitch)*cos(initial_roll)] * ...
 [mag_xb_wo_bias(1:initial_few_pts)'; ...
 mag_yb_wo_bias(1:initial_few_pts)';
 mag_zb_wo_bias(1:initial_few_pts)'];

mag_x_wo_bias = tmp1(1,:)';
mag_y_wo_bias = tmp1(2,:)';

magnetic_heading_data = -atan2( mag_y_wo_bias, mag_x_wo_bias );
declination    = -14.07*pi/180;
% Declination  for Worcester, MA found using World Magnetic Model
% https://www.ngdc.noaa.gov/geomag/calculators/
magcalc.shtml#declination

true_heading_data = declination + magnetic_heading_data;
initial_yaw  = mean(true_heading_data)
disp('rad')


initial_roll =

    0.0248

rad

initial_pitch =
```

```
   -0.1978

rad

initial_yaw =

   -1.2761

rad
```

Final Pitch, Roll, Yaw

```
Final_few_pts = (1185:1194);
roll_data_f = atan( acc_y_wo_bias(Final_few_pts) ./
 acc_z_wo_bias(Final_few_pts) );
pitch_data_f = asin( acc_x_wo_bias(Final_few_pts) / g );

final_roll = mean( roll_data_f )
disp('rad')
final_pitch = mean( pitch_data_f )
disp('rad')

tmp2 = [...
 cos(final_pitch) sin(final_pitch)*sin(final_roll)
 sin(final_pitch)*cos(final_roll); ...
 0 cos(final_roll) -sin(final_roll); ...
 -sin(final_pitch) cos(final_pitch)*sin(final_roll)
 cos(final_pitch)*cos(final_roll)] * ...
 [mag_xb_wo_bias(Final_few_pts)'; ...
 mag_yb_wo_bias(Final_few_pts)'; mag_zb_wo_bias(Final_few_pts)'];

mag_x_wo_bias_f = tmp2(1,:)';
mag_y_wo_bias_f = tmp2(2,:)';

magnetic_heading_data_f = -atan2( mag_y_wo_bias_f, mag_x_wo_bias_f );
declination    = -14.07*pi/180;
% Declination  for Worcester, MA found using World Magnetic Model
% https://www.ngdc.noaa.gov/geomag/calculators/
magcalc.shtml#declination

true_heading_data_f = declination + magnetic_heading_data_f;
final_yaw  = mean(true_heading_data_f)
disp('rad')


final_roll =

   -0.1675

rad

final_pitch =
```

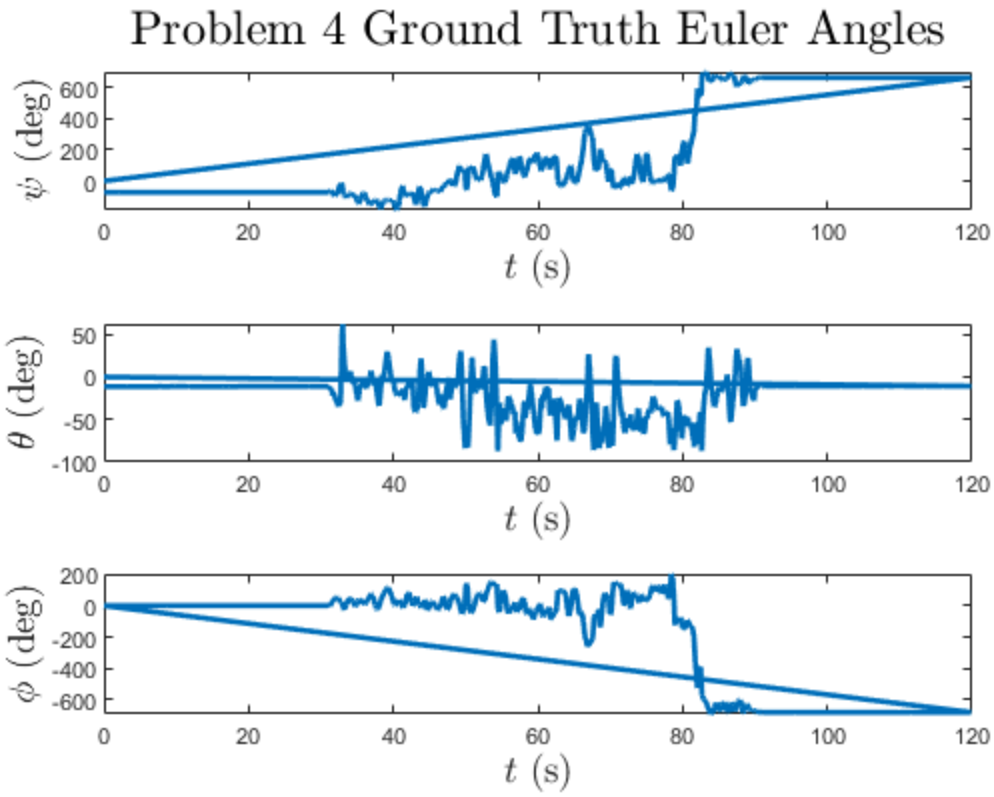
```
   -0.2021

rad

final_yaw =

   -1.6215

rad
```

RK4 Integration

```
dt = 0.001;

t = max([time_stamps_acc(1), time_stamps_mag(1),
 time_stamps_gyro(1)]);
x_t = [initial_yaw; initial_pitch; initial_roll];

tfinal = min([time_stamps_acc(end), time_stamps_mag(end),
 time_stamps_gyro(end)]);

n_time_pts = round( tfinal /dt );
t_ground_truth_store = zeros(1, n_time_pts);
x_ground_truth_store = zeros(3, n_time_pts);
t_ground_truth_store(1, 1) = t;
x_ground_truth_store(:, 1) = x_t;

column_number = 1;
while (t < tfinal)
 col_gyro = find(time_stamps_gyro <= t, 1, 'last');
%  col_acc = find(time_stamp_acc <= t, 1, 'last');
%  col_mag = find(time_stamp_mag <= t, 1, 'last');

 u_t = [gyro_x_wo_bias(col_gyro); gyro_y_wo_bias(col_gyro);
 gyro_z_wo_bias(col_gyro)];

 k1  = dt*attitude_kinematics_asg3(x_t, u_t);
 k2  = dt*attitude_kinematics_asg3((x_t + 0.5*k1), u_t);
 k3  = dt*attitude_kinematics_asg3((x_t + 0.5*k2), u_t);
 k4  = dt*attitude_kinematics_asg3((x_t + k3),  u_t);
 x_tplusdt = x_t + (1/6)*k1 + (1/3)*k2 + (1/3)*k3 + (1/6)*k4;

 column_number = column_number + 1;
 t = t + dt;  % New time
 x_t = x_tplusdt; % x_t is the state at time t

 t_ground_truth_store(1, column_number) = t;
 x_ground_truth_store(:, column_number) = x_t;

end

figure;
```

```
subplot(311)
plot(t_ground_truth_store(1, :), x_ground_truth_store(1, :)*180/
pi, 'LineWidth', 2);
ylabel('$\psi$ (deg)', 'Interpreter', 'latex', 'FontSize', 14)
xlabel('$t$ (s)', 'Interpreter', 'latex', 'FontSize', 14)
title('Problem 4 Ground Truth Euler
 Angles', 'Interpreter', 'latex', 'FontSize', 18)

subplot(312)
plot(t_ground_truth_store(1, :), x_ground_truth_store(2, :)*180/
pi, 'LineWidth', 2);
ylabel('$\theta$ (deg)', 'Interpreter', 'latex', 'FontSize', 14)
xlabel('$t$ (s)', 'Interpreter', 'latex', 'FontSize', 14)

subplot(313)
plot(t_ground_truth_store(1, :), x_ground_truth_store(3, :)*180/
pi, 'LineWidth', 2);
ylabel('$\phi$ (deg)', 'Interpreter', 'latex', 'FontSize', 14)
xlabel('$t$ (s)', 'Interpreter', 'latex', 'FontSize', 14)


disp('The result gathered is a valid result as it matches the devices
 orientation. It is')
disp('consistent with results gathered in step 4 with the only
 inconsistancy being the large')
disp('angle measurments due to full rotations during movement')

function x_dot = attitude_kinematics_asg3(x_, u_)
 theta_ = x_(2);
 phi_ = x_(3);

 x_dot = [-sin(theta_) 0 1; ...
    sin(phi_)*cos(theta_) cos(phi_) 0; ...
    cos(phi_)*cos(theta_) -sin(phi_) 0] \ u_;
end
```

```
The result gathered is a valid result as it matches the devices
 orientation. It is
consistent with results gathered in step 4 with the only inconsistancy
 being the large
angle measurments due to full rotations during movement
```



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PROBLEM 4

```
clear variables; close all; clc

data_table_mag = readtable('Magnetometer_Att_est.csv');

time_stamps_mag = data_table_mag{1:20, 1};
mag_x = data_table_mag{1:20, 2};
mag_y = data_table_mag{1:20, 3};
mag_z = data_table_mag{1:20, 4};

time_stamps = 0:0.1:60;
n_t  = numel(time_stamps);
omega_b = zeros(3, n_t);

n_pieces = 6;
for m1 = 0:(n_pieces-1)
 omega_b(:, (m1*100 + 1):((m1+1)*100)) = kron( ...
  ((-15 + 30*rand(3,1))*pi/180), ones(1, 100));
end

plot(time_stamps, omega_b*180/pi)

data_table_sheet1 = table( ...
 time_stamps', omega_b(1,: )', omega_b(2,: )',
 omega_b(3,: )', 'VariableNames', ...
 {'Time (s)'; 'Gyroscope x (rad/s)'; 'Gyroscope y (rad/s)'; 'Gyroscope
 z (rad/s)'});

data_table_sheet2 = table( ...
 time_stamps_mag, mag_x, mag_y, mag_z, 'VariableNames', ...
 {'Time (s)'; 'Magnetic field x (mu T)'; 'Magnetic field y (mu
 T)'; 'Magnetic field z (mu T)'});

writetable(data_table_sheet1, 'data_exp4.xls', 'Sheet', 1)
writetable(data_table_sheet2, 'data_exp4.xls', 'Sheet', 2)

Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

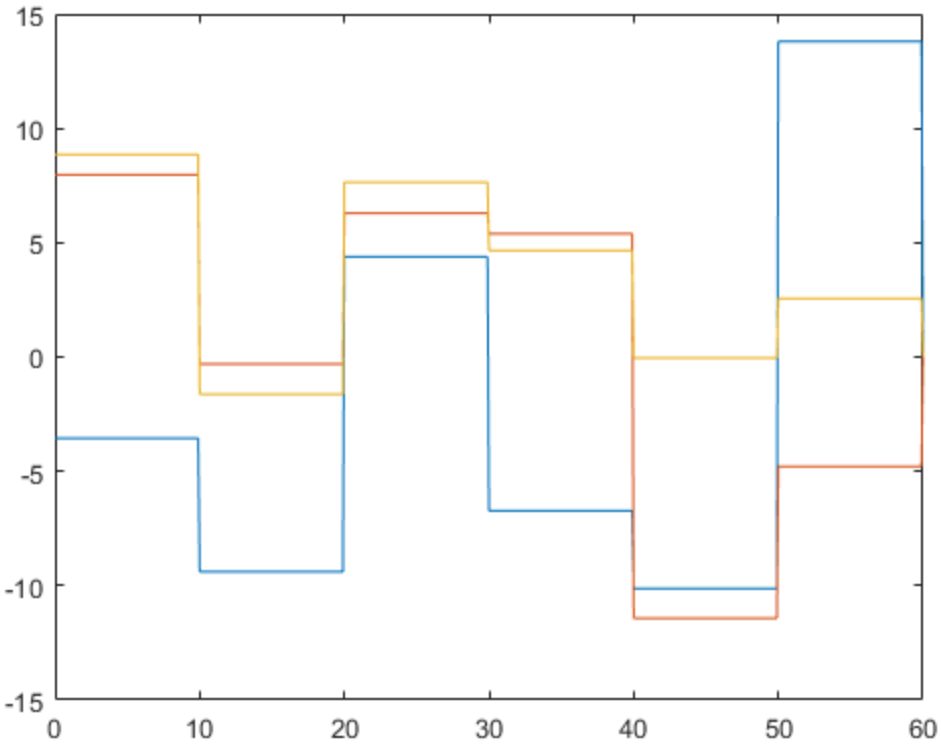

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Table of Contents

PROBLEM 5

```
clear variables; close all; clc


data_table_acc = readtable('Accelerometer_Att_EKF.csv');

data_table_gyro = readtable('Gyroscope_Att_EKF.csv');

data_table_mag = readtable('Magnetometer_Att_EKF.csv');
%==========================================================================

% CORRECT VALUES FOR THESE BIASES AND VARIANCES AS COMPUTED IN
 EXPERIMENT 1
bias_acc = [1.948244;
               1.926003;
               -3.76083]; % biases in accelerometer x,y,z

bias_mag = [-12.11214937;
               -19.67616054;
               22.73696197]; % biases in magnetometer x,y,z

bias_gyro = [0.00001194560806;
               -0.00000912316961;
               -0.00000169621783]; % biases in gyro x,y,z
var_acc  = [4.94; 5.23; 13.5]*10^-5;
var_gyro = [2.1; 2.6; 4.9]*10^-6;
var_mag     = [0.467657;0.744017;0.463155];


var_mag_heading = 1.3227*10^-5;

Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
```

```
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Local gravitational acceleration

```
g = 9.80333; % m/s/s
```

Accelerometers

```
time_stamps_acc = data_table_acc{:, 1};
acc_x = data_table_acc{:, 2};
acc_y = data_table_acc{:, 3};
acc_z = data_table_acc{:, 4};
```

Rate gyros

```
time_stamps_gyro = data_table_gyro{:, 1};
gyro_x = data_table_gyro{:, 2};
gyro_y = data_table_gyro{:, 3};
gyro_z = data_table_gyro{:, 4};
```

Magnetometers

```
time_stamps_mag  = data_table_mag{:, 1};
mag_xb = data_table_mag{:, 2};
mag_yb = data_table_mag{:, 3};
mag_zb = data_table_mag{:, 4};
```

Remove bias

```
acc_x_wo_bias = acc_x - bias_acc(1);
```

```
acc_y_wo_bias = acc_y - bias_acc(2);
acc_z_wo_bias = acc_z - bias_acc(3);

gyro_x_wo_bias= gyro_x - bias_gyro(1);
gyro_y_wo_bias= gyro_y - bias_gyro(2);
gyro_z_wo_bias= gyro_z - bias_gyro(3);

mag_xb_wo_bias = mag_xb - bias_mag(1);
mag_yb_wo_bias = mag_yb - bias_mag(2);
mag_zb_wo_bias = mag_zb - bias_mag(3);
```

Initial Pitch, Roll, and Yaw

```
initial_few_pts = 5;
roll_data = atan( acc_y_wo_bias(1:initial_few_pts) ./
 acc_z_wo_bias(1:initial_few_pts) );
pitch_data = asin( acc_x_wo_bias(1:initial_few_pts) / g );

initial_roll = mean( roll_data )
disp('rad')
initial_pitch = mean( pitch_data )
disp('rad')

tmp1 = [...
 cos(initial_pitch) sin(initial_pitch)*sin(initial_roll)
 sin(initial_pitch)*cos(initial_roll); ...
 0 cos(initial_roll) -sin(initial_roll); ...
 -sin(initial_pitch) cos(initial_pitch)*sin(initial_roll)
 cos(initial_pitch)*cos(initial_roll)] * ...
 [mag_xb_wo_bias(1:initial_few_pts)'; ...
 mag_yb_wo_bias(1:initial_few_pts)';
 mag_zb_wo_bias(1:initial_few_pts)'];

mag_x_wo_bias = tmp1(1,:)';
mag_y_wo_bias = tmp1(2,:)';

magnetic_heading_data = -atan2( mag_y_wo_bias, mag_x_wo_bias );
declination    = -14.07*pi/180;
% Declination  for Worcester, MA found using World Magnetic Model
% https://www.ngdc.noaa.gov/geomag/calculators/
magcalc.shtml#declination

true_heading_data = declination + magnetic_heading_data;
initial_yaw  = mean(true_heading_data)
disp('rad')
```

```
initial_roll =

   -0.0704

rad
```

```
initial_pitch =

   -0.2026

rad

initial_yaw =

   -1.4858

rad
```

Final Pitch, Roll, Yaw

```
Final_few_pts = (670:679);
roll_data_f = atan( acc_y_wo_bias(Final_few_pts) ./
 acc_z_wo_bias(Final_few_pts) );
pitch_data_f = asin( acc_x_wo_bias(Final_few_pts) / g );

final_roll = mean( roll_data_f )
disp('rad')
final_pitch = mean( pitch_data_f )
disp('rad')

tmp2 = [...
 cos(final_pitch) sin(final_pitch)*sin(final_roll)
 sin(final_pitch)*cos(final_roll); ...
 0 cos(final_roll) -sin(final_roll); ...
 -sin(final_pitch) cos(final_pitch)*sin(final_roll)
 cos(final_pitch)*cos(final_roll)] * ...
 [mag_xb_wo_bias(Final_few_pts)'; ...
 mag_yb_wo_bias(Final_few_pts)'; mag_zb_wo_bias(Final_few_pts)'];

mag_x_wo_bias_f = tmp2(1,:)';
mag_y_wo_bias_f = tmp2(2,:)';

magnetic_heading_data_f = -atan2( mag_y_wo_bias_f, mag_x_wo_bias_f );
declination    = -14.07*pi/180;
% Declination  for Worcester, MA found using World Magnetic Model
% https://www.ngdc.noaa.gov/geomag/calculators/
magcalc.shtml#declination

true_heading_data_f = declination + magnetic_heading_data_f;
final_yaw      = mean(true_heading_data_f)
disp('rad')


final_roll =

   -0.1627

rad
```

```
final_pitch =

   -0.2027

rad

final_yaw =

   -2.0483

rad
```

EKF

```
Q = diag(var_gyro);
R = diag([var_acc; var_mag_heading]);

dt = 0.01;
m1 = 1;
t = max([time_stamps_acc(1), time_stamps_mag(1),
 time_stamps_gyro(1)]);
tfinal  = min([time_stamps_acc(end), time_stamps_mag(end),
 time_stamps_gyro(end)]);
n_time_pts = round( tfinal /dt );

V = 0;

xhat = [initial_yaw; initial_pitch; initial_roll];
P  = diag([var_mag_heading var_acc(1) var_acc(2)]);

time_stamps_store = zeros(1, n_time_pts);
xhat_store   = zeros(3, n_time_pts);
P_store    = zeros(9, n_time_pts);
P_trace_store  = zeros(1, n_time_pts);

xhat_store(:, 1) = xhat;
P_trace_store(:, 1) = trace(P);
P_store(:, 1)  = reshape(P, 9, 1);


while (t < tfinal)

 col_gyro = find(time_stamps_gyro <= t, 1, 'last');
 col_acc = find(time_stamps_acc <= t, 1, 'last');
 col_mag = find(time_stamps_mag <= t, 1, 'last');
 t = t + dt;

 u = [gyro_x_wo_bias(col_gyro); gyro_y_wo_bias(col_gyro);
 gyro_z_wo_bias(col_gyro)];

 psi_hat  = xhat(1);
 theta_hat = xhat(2);
 phi_hat  = xhat(3);
```

```
A = [[0;0;0] ...
 [ 0  sin(phi_hat)*tan(theta_hat)*sec(theta_hat)
sin(phi_hat)*tan(theta_hat)*sec(theta_hat); ...
  0  0            0;...
  0  sin(phi_hat)*sec(theta_hat)^2
cos(phi_hat)*sec(theta_hat)^2 ]*u ...
 [ 0 cos(phi_hat)*sec(theta_hat)  -sin(phi_hat)*sec(theta_hat); ...
  0 -sin(phi_hat)     -cos(phi_hat); ...
  0 cos(phi_hat)*tan(theta_hat)  sin(phi_hat)*tan(theta_hat)]*u];
B2 = [...
 0 sin(phi_hat)*sec(theta_hat)  cos(phi_hat)*sec(theta_hat); ...
 0 cos(phi_hat)     -sin(phi_hat); ...
 1 sin(phi_hat)*tan(theta_hat)  cos(phi_hat)*tan(theta_hat);];
C = [[0;0;0;1] ...
 [V*[0 cos(theta_hat) 0; -cos(theta_hat) 0 -sin(theta_hat); 0
sin(theta_hat) 0]*u + ...
 g*[cos(theta_hat); sin(theta_hat)*sin(phi_hat);
sin(theta_hat)*cos(phi_hat)]; 0] ...
 g*[0; -cos(theta_hat)*cos(phi_hat); cos(theta_hat)*sin(phi_hat);
0]];

F = eye(3) + A*dt;
G2 = B2*dt;

tmp1 = [...
 cos(theta_hat) sin(theta_hat)*sin(phi_hat)
sin(theta_hat)*cos(phi_hat); ...
 0 cos(phi_hat) -sin(phi_hat); ...
 -sin(theta_hat) cos(theta_hat)*sin(phi_hat)
cos(theta_hat)*cos(phi_hat)] * ...
 [mag_xb_wo_bias(col_mag); mag_yb_wo_bias(col_mag);
mag_zb_wo_bias(col_mag)];

mag_x_wo_bias = tmp1(1);
mag_y_wo_bias = tmp1(2);

magnetic_heading_data = -atan2( mag_y_wo_bias, mag_x_wo_bias );
magnetometer_yaw = declination + magnetic_heading_data;

x_minus = xhat + attitude_kinematics_asg3(xhat, u)*dt;
P_minus = F*P*F' + G2*Q*G2';

L  = (P_minus * C') / (C * P_minus * C' + R );
z  = [acc_x_wo_bias(col_acc); ...
 acc_y_wo_bias(col_acc); acc_z_wo_bias(col_acc); ...
 magnetometer_yaw];
xhat = x_minus + L*(z - attitude_measurement_asg3(xhat, u, V));
P  = (eye(3) - L*C)*P_minus;

time_stamps_store(m1 + 1) = t;
xhat_store(:, m1+1) = xhat;
P_store(:, m1+1) = reshape(P, 9, 1);
P_trace_store(:, m1+1) = trace(P);
```

```
 m1 = m1 + 1;
end



figure;
subplot(311)
plot(time_stamps_store(1:m1), xhat_store(1, 1:m1)*180/pi, 'LineWidth',
 2);
ylabel('$\psi$ (deg)', 'Interpreter', 'latex', 'FontSize', 14)
xlabel('$t$ (s)', 'Interpreter', 'latex', 'FontSize', 14)
title('Problem 5 Ground Truth Euler
 Angles', 'Interpreter', 'latex', 'FontSize', 18)

subplot(312)
plot(time_stamps_store(1:m1), xhat_store(2, 1:m1)*180/pi, 'LineWidth',
 2);
ylabel('$\theta$ (deg)', 'Interpreter', 'latex', 'FontSize', 14)
xlabel('$t$ (s)', 'Interpreter', 'latex', 'FontSize', 14)

subplot(313)
plot(time_stamps_store(1:m1), xhat_store(3, 1:m1)*180/pi, 'LineWidth',
 2);
ylabel('$\phi$ (deg)', 'Interpreter', 'latex', 'FontSize', 14)
xlabel('$t$ (s)', 'Interpreter', 'latex', 'FontSize', 14)

figure;
plot(time_stamps_store(1:m1), P_trace_store(1:m1), 'LineWidth', 2);
title('Problem 5 $\mathrm{tr}
(P)$', 'Interpreter', 'latex', 'FontSize', 18)

disp('The resultant angles correctly discribe the devices movement and
 match ')
disp('those found in step 3.')
```

Function definitions

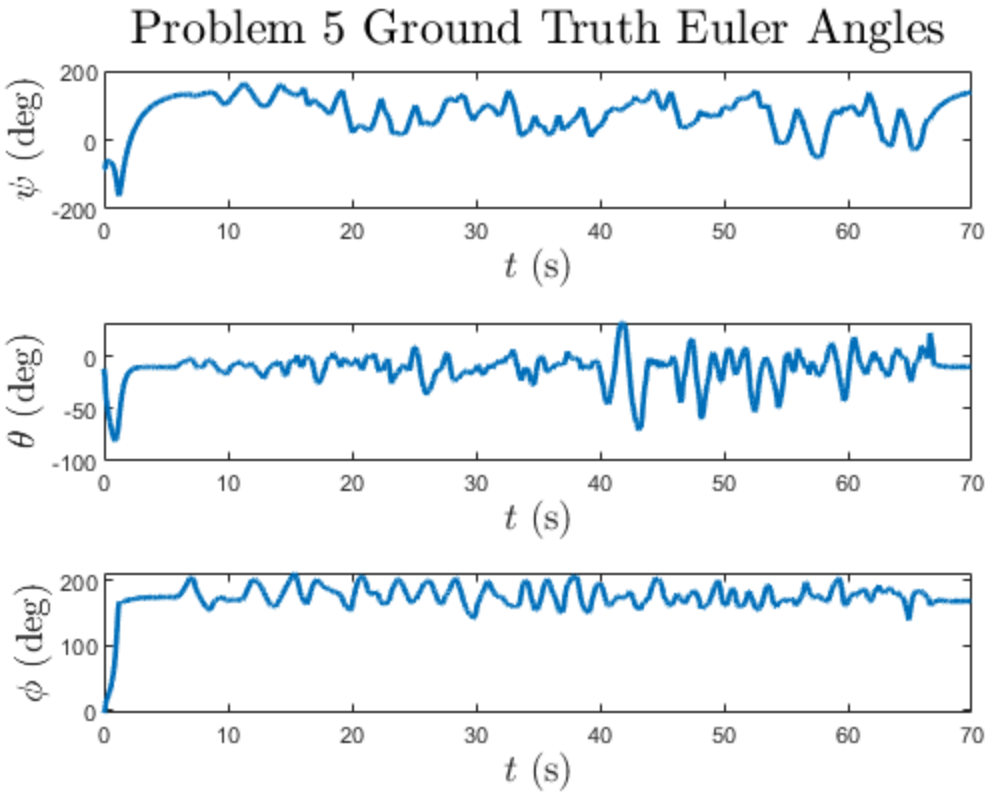
```
function x_dot = attitude_kinematics_asg3(x_, u_)
 theta_ = x_(2);
 phi_ = x_(3);

 x_dot = [-sin(theta_) 0 1; ...
    sin(phi_)*cos(theta_) cos(phi_) 0; ...
    cos(phi_)*cos(theta_) -sin(phi_) 0] \ u_;
end

function z_ = attitude_measurement_asg3(x_, u_, V)
 psi_ = x_(1);
 theta_ = x_(2);
 phi_ = x_(3);
 z_  = [ V*[...
  0 sin(theta_) 0; -sin(theta_) 0 cos(theta_); 0 -cos(theta_) 0]*u_
 + ...
```

```
  9.81*[sin(theta_); -cos(theta_)*sin(phi_); -cos(theta_)*cos(phi_)];
 psi_];
end
```

The resultant angles correctly discribe the devices movement and match
those found in step 3.



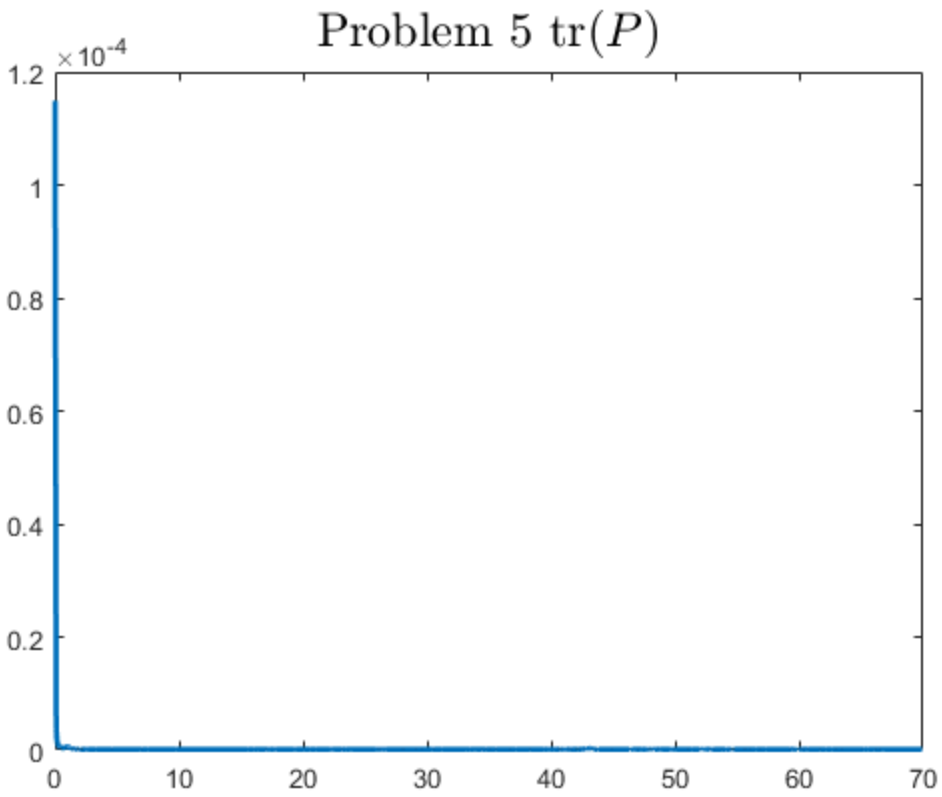


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Table of Contents

PROBLEM 5

```
clear variables; close all; clc

data_table_acc = readtable('Accelerometer_Att_EKF');
data_table_gyro = readtable('Gyroscope_att_EKF');
data_table_mag = readtable('Magnetometer_Att_EKF');

clc

% CORRECT VALUES FOR THESE BIASES AND VARIANCES AS COMPUTED IN
 EXPERIMENT 1
bias_acc = [1.948244;
               1.926003;
               -3.76083]; % biases in accelerometer x,y,z


bias_mag = [-12.11214937;
               -19.67616054;
               22.73696197]; % biases in magnetometer x,y,z

bias_gyro = [0.00001194560806;
               -0.00000912316961;
               -0.00000169621783]; % biases in gyro x,y,z
var_acc  = [4.94; 5.23; 13.5]*10^-5;
var_gyro = [2.1; 2.6; 4.9]*10^-6;
var_mag     = [0.467657;0.744017;0.463155];
```

```
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
```

```
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Local gravitational acceleration

```
g = 9.80333; % m/s/s
```

Accelerometers

```
acc_x = data_table_acc{:, 2};
acc_y = data_table_acc{:, 3};
acc_z = data_table_acc{:, 4};
```

Rate gyros

```
gyro_x = data_table_gyro{:, 2};
gyro_y = data_table_gyro{:, 3};
gyro_z = data_table_gyro{:, 4};
```

Magnetometers

```
mag_xb = data_table_mag{:, 2};
mag_yb = data_table_mag{:, 3};
mag_zb = data_table_mag{:, 4};
```

Remove bias

```
acc_x_wo_bias = acc_x - bias_acc(1);
acc_y_wo_bias = acc_y - bias_acc(2);
acc_z_wo_bias = acc_z - bias_acc(3);

mag_xb_wo_bias = mag_xb - bias_mag(1);
mag_yb_wo_bias = mag_yb - bias_mag(2);
mag_zb_wo_bias = mag_zb - bias_mag(3);
```

Pitch and Roll

```
roll_data = atan( acc_y_wo_bias ./ acc_z_wo_bias );
```

```
pitch_data = asin( acc_x_wo_bias / g );

roll_mu  = mean( roll_data );
pitch_mu = mean( pitch_data );

roll_var = var(roll_data);
pitch_var = var(pitch_data);


time_stamps_mag = data_table_mag{1:20, 1};
mag_x = data_table_mag{1:20, 2};
mag_y = data_table_mag{1:20, 3};
mag_z = data_table_mag{1:20, 4};

time_stamps = 0:0.1:60;
n_t  = numel(time_stamps);
omega_b = zeros(3, n_t);

n_pieces = 6;
for m1 = 0:(n_pieces-1)
 omega_b(:, (m1*100 + 1):((m1+1)*100)) = kron( ...
  ((-15 + 30*rand(3,1))*pi/180), ones(1, 100));
end

plot(time_stamps, omega_b*180/pi)

data_table_sheet1 = table( ...
 time_stamps', omega_b(1,: )', omega_b(2,: )',
 omega_b(3,: )', 'VariableNames', ...
 {'Time (s)'; 'Gyroscope x (rad/s)'; 'Gyroscope y (rad/s)'; 'Gyroscope
 z (rad/s)'});

data_table_sheet2 = table( ...
 time_stamps_mag, mag_x, mag_y, mag_z, 'VariableNames', ...
 {'Time (s)'; 'Magnetic field x (mu T)'; 'Magnetic field y (mu
 T)'; 'Magnetic field z (mu T)'});

writetable(data_table_sheet1, 'data_exp4_sample.xls', 'Sheet', 1)
writetable(data_table_sheet2, 'data_exp4_sample.xls', 'Sheet', 2)


function euler_dot = euler321_kinematics( t, euler_angles, omega_b_ )

 phi   = euler_angles(1);
 theta = euler_angles(2);

 Hinv_321 = (1 / cos(theta) ) * [cos(theta), sin(phi)*sin(theta),
 cos(phi)*sin(theta); ...
  0, cos(phi)*cos(theta), -sin(phi)*cos(theta);
  0, sin(phi), cos(phi)];

 euler_dot = Hinv_321 * rate_gyro_readings;
```

```
end
```

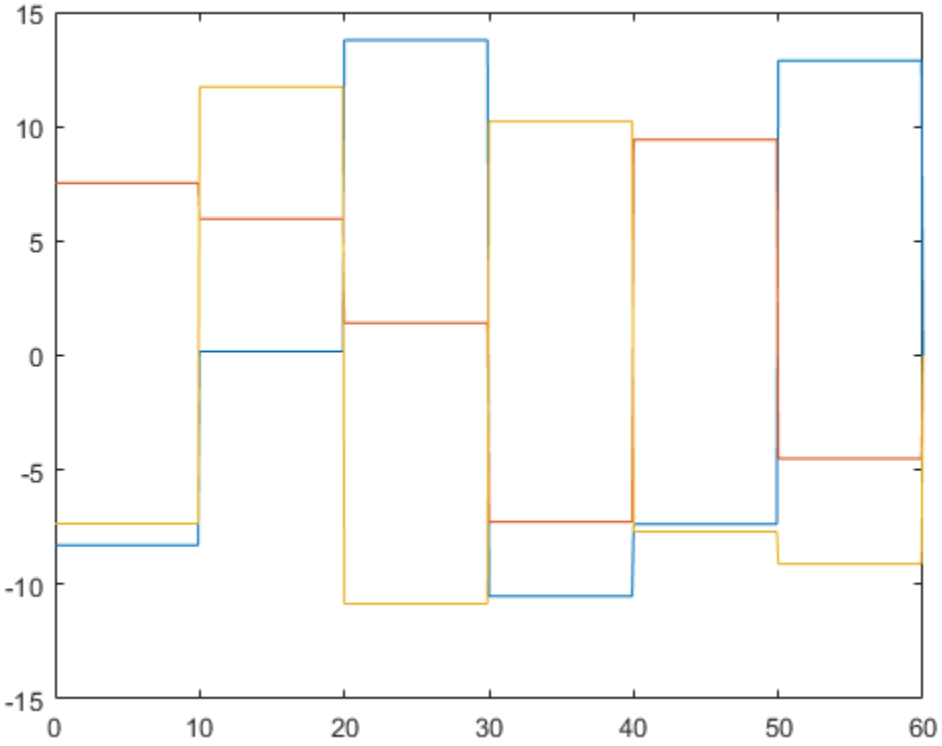

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Table of Contents

PROBLEM 6

```
clear variables; close all; clc


data_table_acc = readtable('Accelerometer_exp6.csv');


data_table_gyro = readtable('Gyroscope_exp6');


data_table_gps = readtable('Location_exp6');


data_table_mag = readtable('Magnetomerter_exp6');
%==========================================================================

% CORRECT VALUES FOR THESE BIASES AND VARIANCES AS COMPUTED IN
 EXPERIMENT 1
bias_acc = [1.948244;
               1.926003;
               -3.76083]; % biases in accelerometer x,y,z

bias_mag = [-12.11214937;
               -19.67616054;
               22.73696197]; % biases in magnetometer x,y,z

bias_gyro = [0.00001194560806;
               -0.00000912316961;
               -0.00000169621783]; % biases in gyro x,y,z
var_acc  = [4.94; 5.23; 13.5]*10^-5;
var_gyro = [2.1; 2.6; 4.9]*10^-6;
var_mag     = [0.467657;0.744017;0.463155];

var_mag_heading = 1.3227*10^-5;

Warning: Column headers from the file were
modified to make them valid MATLAB
```

```
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
Warning: Column headers from the file were
modified to make them valid MATLAB
identifiers before creating variable names
for the table. The original column headers
are saved in the VariableDescriptions
property.
Set 'PreserveVariableNames' to true to use
the original column headers as table
variable names.
```

Local gravitational acceleration

```
g = 9.80333; % m/s/s
```

Accelerometers

```
time_stamps_acc = data_table_acc{:, 1};
acc_x = data_table_acc{:, 2};
acc_y = data_table_acc{:, 3};
acc_z = data_table_acc{:, 4};
```

Rate gyros

```
time_stamps_gyro = data_table_gyro{:, 1};
gyro_x = data_table_gyro{:, 2};
gyro_y = data_table_gyro{:, 3};
gyro_z = data_table_gyro{:, 4};
```

Magnetometers

```
time_stamps_mag  = data_table_mag{:, 1};
mag_xb = data_table_mag{:, 2};
mag_yb = data_table_mag{:, 3};
mag_zb = data_table_mag{:, 4};
```

Remove bias

```
acc_x_wo_bias = acc_x - bias_acc(1);
acc_y_wo_bias = acc_y - bias_acc(2);
acc_z_wo_bias = acc_z - bias_acc(3);

gyro_x_wo_bias= gyro_x - bias_gyro(1);
gyro_y_wo_bias= gyro_y - bias_gyro(2);
gyro_z_wo_bias= gyro_z - bias_gyro(3);

mag_xb_wo_bias = mag_xb - bias_mag(1);
mag_yb_wo_bias = mag_yb - bias_mag(2);
mag_zb_wo_bias = mag_zb - bias_mag(3);
```

Initial Pitch, Roll, and Yaw

```
initial_few_pts = 5;
roll_data = atan( acc_y_wo_bias(1:initial_few_pts) ./
 acc_z_wo_bias(1:initial_few_pts) );
pitch_data = asin( acc_x_wo_bias(1:initial_few_pts) / g );

initial_roll = mean( roll_data )
initial_pitch = mean( pitch_data )

tmp1 = [...
 cos(initial_pitch) sin(initial_pitch)*sin(initial_roll)
 sin(initial_pitch)*cos(initial_roll); ...
 0 cos(initial_roll) -sin(initial_roll); ...
 -sin(initial_pitch) cos(initial_pitch)*sin(initial_roll)
 cos(initial_pitch)*cos(initial_roll)] * ...
 [mag_xb_wo_bias(1:initial_few_pts)'; ...
 mag_yb_wo_bias(1:initial_few_pts)';
 mag_zb_wo_bias(1:initial_few_pts)'];

mag_x_wo_bias = tmp1(1,:)';
mag_y_wo_bias = tmp1(2,:)';

magnetic_heading_data = -atan2( mag_y_wo_bias, mag_x_wo_bias );
declination    = -14.07*pi/180;
% Declination  for Worcester, MA found using World Magnetic Model
% https://www.ngdc.noaa.gov/geomag/calculators/
magcalc.shtml#declination

true_heading_data = declination + magnetic_heading_data;
initial_yaw  = mean(true_heading_data)
```

```
initial_roll =

   -0.0303


initial_pitch =

   -0.1781


initial_yaw =

   -0.3886
```

Final Pitch, Roll, Yaw

```
Final_few_pts = (670:679);
roll_data_f = atan( acc_y_wo_bias(Final_few_pts) ./
 acc_z_wo_bias(Final_few_pts) );
pitch_data_f = asin( acc_x_wo_bias(Final_few_pts) / g );

final_roll = mean( roll_data_f )
final_pitch = mean( pitch_data_f )

tmp2 = [...
 cos(final_pitch) sin(final_pitch)*sin(final_roll)
 sin(final_pitch)*cos(final_roll); ...
 0 cos(final_roll) -sin(final_roll); ...
 -sin(final_pitch) cos(final_pitch)*sin(final_roll)
 cos(final_pitch)*cos(final_roll)] * ...
 [mag_xb_wo_bias(Final_few_pts)'; ...
 mag_yb_wo_bias(Final_few_pts)'; mag_zb_wo_bias(Final_few_pts)'];

mag_x_wo_bias_f = tmp2(1,:)';
mag_y_wo_bias_f = tmp2(2,:)';

magnetic_heading_data_f = -atan2( mag_y_wo_bias_f, mag_x_wo_bias_f );
declination    = -14.07*pi/180;
% Declination  for Worcester, MA found using World Magnetic Model
% https://www.ngdc.noaa.gov/geomag/calculators/
magcalc.shtml#declination

true_heading_data_f = declination + magnetic_heading_data_f;
final_yaw  = mean(true_heading_data_f)


final_roll =

   -0.0889
```

```
final_pitch =

   -0.1922


final_yaw =

   -0.0673
```

EKF

```
Q = diag(var_gyro);
R = diag([var_acc; var_mag_heading]);

dt = 0.01;
m1 = 1;
t = max([time_stamps_acc(1), time_stamps_mag(1),
 time_stamps_gyro(1)]);
tfinal  = min([time_stamps_acc(end), time_stamps_mag(end),
 time_stamps_gyro(end)]);
n_time_pts = round( tfinal /dt );


initial_few_points = 10;
final_few_points = 10;
gps_lat_init  = mean( data_table_gps{1:initial_few_points, 2} );
gps_long_init  = mean( data_table_gps{1:initial_few_points, 3} );
gps_lat_final  = mean( data_table_gps{(end-final_few_points):end,
 2} );
gps_long_final  = mean( data_table_gps{(end-final_few_points):end,
 3} );

pos_fin = lla2flat([gps_lat_final gps_long_final 0], ...
 [gps_lat_init gps_long_init], 0, 0);
displacement_gps = norm(pos_fin);
V_loc = displacement_gps / (data_table_gps{end, 1} - data_table_gps{1,
 1});
V_gps = mean( data_table_gps{(data_table_gps{:, 6} > 0), 5} );
V = (V_gps + V_loc)/2;

xhat = [initial_yaw; initial_pitch; initial_roll];
P  = diag([var_mag_heading var_acc(1) var_acc(2)]);

time_stamps_store = zeros(1, n_time_pts);
xhat_store   = zeros(3, n_time_pts);
P_store    = zeros(9, n_time_pts);
P_trace_store  = zeros(1, n_time_pts);

xhat_store(:, 1) = xhat;
P_trace_store(:, 1) = trace(P);
P_store(:, 1)  = reshape(P, 9, 1);
```

```
while (t < tfinal)

 col_gyro = find(time_stamps_gyro <= t, 1, 'last');
 col_acc = find(time_stamps_acc <= t, 1, 'last');
 col_mag = find(time_stamps_mag <= t, 1, 'last');
 t = t + dt;

 u = [gyro_x_wo_bias(col_gyro); gyro_y_wo_bias(col_gyro);
 gyro_z_wo_bias(col_gyro)];

 psi_hat  = xhat(1);
 theta_hat = xhat(2);
 phi_hat  = xhat(3);
 A = [[0;0;0] ...
  [ 0  sin(phi_hat)*tan(theta_hat)*sec(theta_hat)
 sin(phi_hat)*tan(theta_hat)*sec(theta_hat); ...
   0  0            0;...
   0  sin(phi_hat)*sec(theta_hat)^2
 cos(phi_hat)*sec(theta_hat)^2 ]*u ...
  [ 0 cos(phi_hat)*sec(theta_hat)  -sin(phi_hat)*sec(theta_hat); ...
   0 -sin(phi_hat)     -cos(phi_hat); ...
   0 cos(phi_hat)*tan(theta_hat)  sin(phi_hat)*tan(theta_hat)]*u];
 B2 = [...
  0 sin(phi_hat)*sec(theta_hat)  cos(phi_hat)*sec(theta_hat); ...
  0 cos(phi_hat)     -sin(phi_hat); ...
  1 sin(phi_hat)*tan(theta_hat)  cos(phi_hat)*tan(theta_hat);];
 C = [[0;0;0;1] ...
  [V*[0 cos(theta_hat) 0; -cos(theta_hat) 0 -sin(theta_hat); 0
 sin(theta_hat) 0]*u + ...
  g*[cos(theta_hat); sin(theta_hat)*sin(phi_hat);
 sin(theta_hat)*cos(phi_hat)]; 0] ...
  g*[0; -cos(theta_hat)*cos(phi_hat); cos(theta_hat)*sin(phi_hat);
 0]];

 F = eye(3) + A*dt;
 G2 = B2*dt;

 tmp1 = [...
  cos(theta_hat) sin(theta_hat)*sin(phi_hat)
 sin(theta_hat)*cos(phi_hat); ...
  0 cos(phi_hat) -sin(phi_hat); ...
  -sin(theta_hat) cos(theta_hat)*sin(phi_hat)
 cos(theta_hat)*cos(phi_hat)] * ...
  [mag_xb_wo_bias(col_mag); mag_yb_wo_bias(col_mag);
 mag_zb_wo_bias(col_mag)];

 mag_x_wo_bias = tmp1(1);
 mag_y_wo_bias = tmp1(2);

 magnetic_heading_data = -atan2( mag_y_wo_bias, mag_x_wo_bias );
 magnetometer_yaw = declination + magnetic_heading_data;

 x_minus = xhat + attitude_kinematics_asg3(xhat, u)*dt;
```

```
 P_minus = F*P*F' + G2*Q*G2';

 L  = (P_minus * C') / (C * P_minus * C' + R );
 z  = [acc_x_wo_bias(col_acc); ...
  acc_y_wo_bias(col_acc); acc_z_wo_bias(col_acc); ...
  magnetometer_yaw];
 xhat = x_minus + L*(z - attitude_measurement_asg3(xhat, u, V));
 P  = (eye(3) - L*C)*P_minus;

 time_stamps_store(m1 + 1) = t;
 xhat_store(:, m1+1) = xhat;
 P_store(:, m1+1) = reshape(P, 9, 1);
 P_trace_store(:, m1+1) = trace(P);

 m1 = m1 + 1;
end



figure;
subplot(311)
plot(time_stamps_store(1:m1), xhat_store(1, 1:m1)*180/pi, 'LineWidth',
 2);
ylabel('$\psi$ (deg)', 'Interpreter', 'latex', 'FontSize', 14)
xlabel('$t$ (s)', 'Interpreter', 'latex', 'FontSize', 14)
title('Problem 6 Ground Truth Euler
 Angles', 'Interpreter', 'latex', 'FontSize', 18)

subplot(312)
plot(time_stamps_store(1:m1), xhat_store(2, 1:m1)*180/pi, 'LineWidth',
 2);
ylabel('$\theta$ (deg)', 'Interpreter', 'latex', 'FontSize', 14)
xlabel('$t$ (s)', 'Interpreter', 'latex', 'FontSize', 14)

subplot(313)
plot(time_stamps_store(1:m1), xhat_store(3, 1:m1)*180/pi, 'LineWidth',
 2);
ylabel('$\phi$ (deg)', 'Interpreter', 'latex', 'FontSize', 14)
xlabel('$t$ (s)', 'Interpreter', 'latex', 'FontSize', 14)

figure;
plot(time_stamps_store(1:m1), P_trace_store(1:m1), 'LineWidth', 2);
title('Problem 6 $\mathrm{tr}
(P)$', 'Interpreter', 'latex', 'FontSize', 18)


disp('The resultant angles correctly discribe the devices movement and
 match ')
disp('those found in step 3.')
```

Function definitions

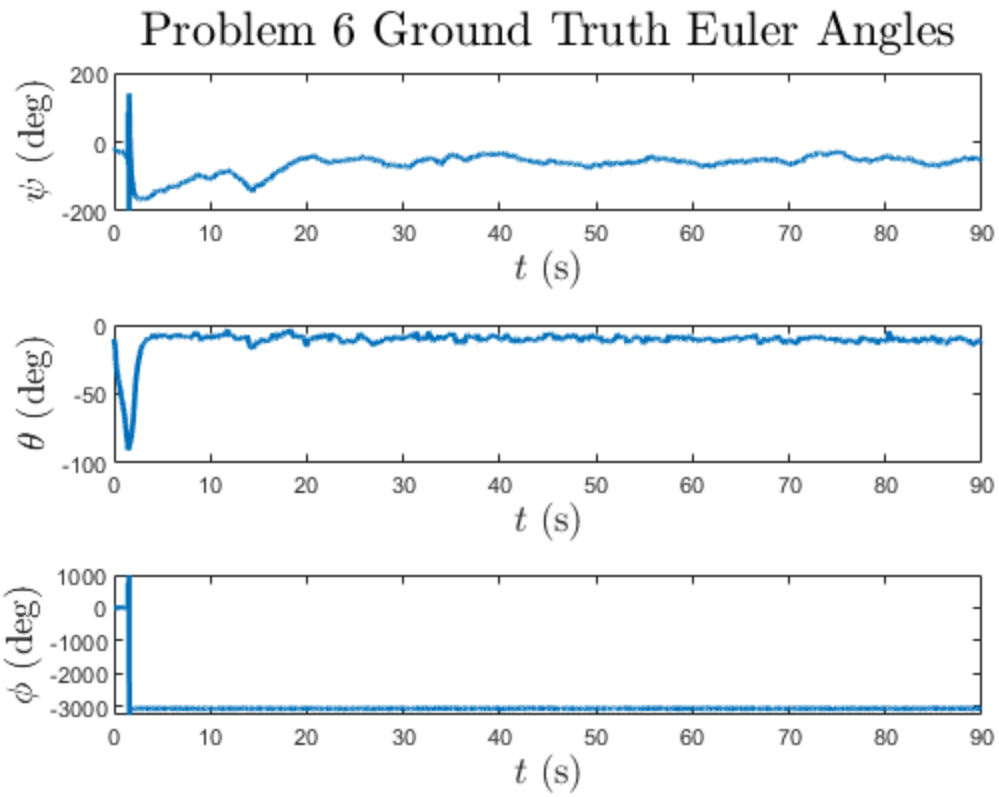
```
function x_dot = attitude_kinematics_asg3(x_, u_)
```

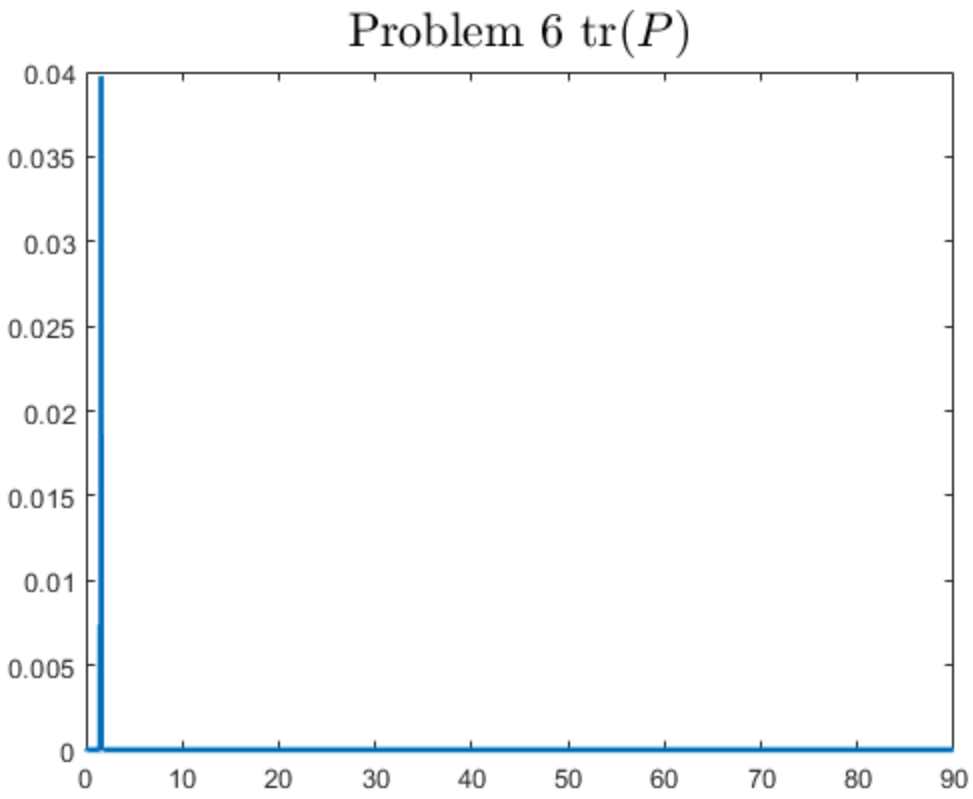
```
 theta_ = x_(2);
 phi_ = x_(3);

 x_dot = [-sin(theta_) 0 1; ...
    sin(phi_)*cos(theta_) cos(phi_) 0; ...
    cos(phi_)*cos(theta_) -sin(phi_) 0] \ u_;
end

function z_ = attitude_measurement_asg3(x_, u_, V)
 psi_ = x_(1);
 theta_ = x_(2);
 phi_ = x_(3);
 z_  = [ V*[...
  0 sin(theta_) 0; -sin(theta_) 0 cos(theta_); 0 -cos(theta_) 0]*u_
 + ...
  9.81*[sin(theta_); -cos(theta_)*sin(phi_); -cos(theta_)*cos(phi_)];
 psi_];
end
```

The resultant angles correctly discribe the devices movement and match
those found in step 3.





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