Table of Contents


```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%
% CODE CHALLENGE 1 -
%
% The purpose of this challenge is to estimate atmospheric pressure in
% Boulder CO using a pressure model and measurements, and compare the
 two
% through error analysis and statistics.
%
% To complete the challenge, execute the following steps:
% 1) Load the given dataset
% 2) Extract altitude and pressure data
% 3) Determine standard deviation, variance, mean, and
%    standard error of the mean of the pressure data
% 4) Using information given about the instrument, find uncertainty
 associated
%    with altitude measurements
% 5) Use the model to predict pressure measurements at each altitude
 in the
%    data set, along with propagated uncertainty
% 6) Compare results, discuss, and print answers to the command
 window.
% Bonus) Repeat for larger measurement uncertainty in altitude
%
% NOTE: DO NOT change any variable names already present in the code.
%
% Upload your team's script to Canvas to complete the challenge.
%
% NAME YOUR FILE AS Challenge1_Sec{section number}_Group{group
 breakout #}.m
% ***Section numbers are 1 or 2***
% EX File Name: Challenge1_Sec1_Group15.m
%
%
% 1) Autumn Martinez
% 2) Thomas O'Connor
% 3) Siyang Liu
% 4)
% 5)
%
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%

% Housekeeping
clear all   % Clear all variables in workspace
close all   % Close all open figure windows
clc           % Clear the command window
```

1) Load data from given file

2) Extract just the altitude and station pressure data columns to meaningfully named variables

```
% Create a table which imports the data directly from the csv file for
% usability
boulderData = readtable("PressureInBoulder.csv")
% extract altitude and pressure data into individual arrays
AltitudeData = boulderData.Altitude_m_;
PressureData = boulderData.StationPressure_kPa_;
```

```
Warning: The DATETIME data was created using format 'MM/dd/uuuu HH:mm'
 but also
matched 'dd/MM/uuuu HH:mm'.
To avoid ambiguity, supply a datetime format using SETVAROPTS, e.g.
  opts = setvaropts(opts,varname,'InputFormat','MM/dd/uuuu HH:mm');
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.

boulderData =

  26×4 table

         Date           StationPressure_kPa_    Altitude_m_
 SeaLevelPressure_hPa_mBar_
    ________________    ____________________    ___________
 __________________________

    09/12/2019 10:01           84.302              1616.8
    851.5
    09/12/2019 10:01           84.302              1616.6
    851.5
    09/12/2019 10:01           84.301              1616.7
   851.49
    09/12/2019 10:01           84.301              1616.7
   851.49
```

```
 09/12/2019 10:01           84.301             1616.6
851.49
 09/12/2019 10:01           84.301             1616.6
851.49
 09/12/2019 10:01           84.301             1616.8
851.49
 09/12/2019 10:01           84.301             1616.6
851.49
 09/12/2019 10:01           84.303             1616.6
851.51
 09/12/2019 10:01           84.303             1616.7
851.51
 09/12/2019 10:01           84.303             1616.9
851.51
 09/12/2019 10:01           84.303             1616.6
851.51
 09/12/2019 10:01           84.303             1616.8
851.51
 09/12/2019 10:01           84.303             1616.6
851.51
 09/12/2019 10:01           84.303             1616.6
851.51
 09/12/2019 10:01           84.303             1616.7
851.51
 09/12/2019 10:01           84.303             1616.6
851.51
 09/12/2019 10:01           84.303             1616.6
851.51
 09/12/2019 10:01           84.303             1616.5
851.51
 09/12/2019 10:01           84.303             1616.6
851.51
 09/12/2019 10:01           84.303             1616.6
851.51
 09/12/2019 10:01           84.303             1616.7
851.51
 09/12/2019 10:01           84.303             1616.8
 851.5
 09/12/2019 10:01           84.303             1616.8
 851.5
 09/12/2019 10:01           84.303             1616.8
 851.5
 09/12/2019 10:01           84.298             1616.6
851.46
```

3) Determine Statistics and Error

the standard deviation, variance, mean, and standard error of the mean (sem) of the pressure data

```
% calculate each of the statistics using standard matlab functions
StdevPressure = std(PressureData)
```

```
VarPressure = var(PressureData)

MeanPressure = mean(PressureData)
% standard error of the mean is standard deviation of the dataset
 divided
% by the square root of the number of values in the dataset
Sem_Pressure = StdevPressure / sqrt(length(PressureData))
```

```
StdevPressure =

    0.0012


VarPressure =

   1.4020e-06


MeanPressure =

   84.3025


Sem_Pressure =

   2.3221e-04
```

4) Uncertainty

```
          The altitude measurements were taken using an instrument that displayed
          altitude to the nearest tenth of a meter.

%    What is the associated absolute uncertainty with these
 measurements?

AltitudeUncertainty = 0.1; % [m]
```

5) Pressure Predictions

```
          Using the altitude measurements and uncertainty, predict pressure with t
          First, propagate uncertainty BY HAND before calculating uncertainty for
          Then check: is it different for each calculation?

%               Model
%    P_est =   P_s * e^(-k*h)
%    Assume P_s is 101.7 ± 0.4 kPa and k is 1.2*10^(-4) [1/m]

P_s = 101.7;       % ± 0.4 [kPa]
k = 1.2*10^(-4);   % [1/m]

P_s_uncertainty = 0.4;
```

```
P_est = P_s * exp(-k*AltitudeData) % (vector of pressure estimates for
 each) (atmosphere pressure
% estimate)
% general method
P_sig = sqrt((exp(-k.*AltitudeData).*P_s_uncertainty).^2+(-
k.*P_s*exp(-k.*AltitudeData)*AltitudeUncertainty).^2) % (uncertainty
 using general rule)

% p_est and p_sig vary slightly


P_est =

   83.7647
   83.7667
   83.7662
   83.7657
   83.7667
   83.7667
   83.7647
   83.7667
   83.7667
   83.7662
   83.7637
   83.7667
   83.7652
   83.7667
   83.7667
   83.7657
   83.7667
   83.7667
   83.7672
   83.7667
   83.7667
   83.7662
   83.7642
   83.7647
   83.7647
   83.7667


P_sig =

    0.3295
    0.3295
    0.3295
    0.3295
    0.3295
    0.3295
    0.3295
    0.3295
    0.3295
    0.3295
```

```
0.3295
0.3295
0.3295
0.3295
0.3295
0.3295
0.3295
0.3295
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0.3295
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0.3295
0.3295
0.3295
```

6) Print Results

```
        Display the predicted pressure from the model with it's associated uncer
        the average pressure with the it's standard error of the mean from the d

results  = table(P_est,P_sig);
P_data = [num2str(MeanPressure) '  ±  ' num2str(Sem_Pressure) '
 kPa'];
disp(results);
disp(P_data);

% Disucss the accuracy of the model and whether or not you think the
% model agrees with the measurements

% disp('Model Discussion: (The difference between the top end of our
 model and the bottom end of the measured data is ~0.2078 kPa, which
 could be significant depending on the application of the model.
 In my opinion, the model is close enough to the measurement to be
 considered accurate.) ')
```

P_est	P_sig
83.765	0.32946
83.767	0.32947
83.766	0.32947
83.766	0.32946
83.767	0.32947
83.767	0.32947
83.765	0.32946
83.767	0.32947
83.767	0.32947
83.766	0.32947
83.764	0.32946
83.767	0.32947
83.765	0.32946

```
    83.767    0.32947
    83.767    0.32947
    83.766    0.32946
    83.767    0.32947
    83.767    0.32947
    83.767    0.32947
    83.767    0.32947
    83.767    0.32947
    83.766    0.32947
    83.764    0.32946
    83.765    0.32946
    83.765    0.32946
    83.767    0.32947

84.3025  ±  0.00023221   kPa
```

Bonus

Repeat steps 4-6, but assume the altitude measurements were taken on a lower precision instrument that only displayed altitude to nearest 10 meters
How does this change the results and comparison ?

```
% new altitude uncertainty
altitude_uncertainty_new = 10    % [m]
% changing the uncertainty in p_sig
p_sig_new = sqrt((exp(-k.*AltitudeData).*P_s_uncertainty).^2+(-
k.*P_s*exp(-k.*AltitudeData)*altitude_uncertainty_new).^2) %
 (uncertainty using general rule)

results  = table(P_est,p_sig_new);
P_data = [num2str(MeanPressure) '  ±  ' num2str(Sem_Pressure) '
 kPa'];
disp(results);
disp(P_data);

percent_change = mean((p_sig_new - P_sig)./P_sig .* 100)

% An increase in the error of the altitude measurement by a factor of
 100
% increases the error of pressure measurement by ~4.6 percent
```

```
altitude_uncertainty_new =

    10


p_sig_new =

    0.3445
    0.3445
    0.3445
    0.3445
```

```
0.3445
0.3445
0.3445
0.3445
0.3445
0.3445
0.3444
0.3445
0.3445
0.3445
0.3445
0.3445
0.3445
0.3445
0.3445
0.3445
0.3445
0.3445
0.3444
0.3445
0.3445
0.3445

P_est     p_sig_new
_______   __________

83.765     0.34445
83.767     0.34446
83.766     0.34446
83.766     0.34445
83.767     0.34446
83.767     0.34446
83.765     0.34445
83.767     0.34446
83.767     0.34446
83.766     0.34446
83.764     0.34445
83.767     0.34446
83.765     0.34445
83.767     0.34446
83.767     0.34446
83.766     0.34445
83.767     0.34446
83.767     0.34446
83.767     0.34446
83.767     0.34446
83.767     0.34446
83.766     0.34446
83.764     0.34445
83.765     0.34445
83.765     0.34445
83.767     0.34446

84.3025  ±  0.00023221   kPa
```

```
percent_change =

    4.5503
```

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