```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% 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")
```

```
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_
1	09/12/20...	84.3025	1.6168e+03	851.5000
2	09/12/20...	84.3025	1.6166e+03	851.5000
3	09/12/20...	84.3013	1.6167e+03	851.4880
4	09/12/20...	84.3013	1.6167e+03	851.4880
5	09/12/20...	84.3014	1.6166e+03	851.4880
6	09/12/20...	84.3014	1.6166e+03	851.4880
7	09/12/20...	84.3014	1.6168e+03	851.4880
8	09/12/20...	84.3014	1.6166e+03	851.4880
9	09/12/20...	84.3032	1.6166e+03	851.5070
10	09/12/20...	84.3032	1.6167e+03	851.5070
11	09/12/20...	84.3032	1.6169e+03	851.5070
12	09/12/20...	84.3032	1.6166e+03	851.5070
13	09/12/20...	84.3032	1.6168e+03	851.5070
14	09/12/20...	84.3033	1.6166e+03	851.5080
15	09/12/20...	84.3033	1.6166e+03	851.5080
16	09/12/20...	84.3033	1.6167e+03	851.5080
17	09/12/20...	84.3033	1.6166e+03	851.5080
18	09/12/20...	84.3032	1.6166e+03	851.5070
19	09/12/20...	84.3032	1.6165e+03	851.5070
20	09/12/20...	84.3032	1.6166e+03	851.5070
21	09/12/20...	84.3032	1.6166e+03	851.5070
22	09/12/20...	84.3032	1.6167e+03	851.5070
23	09/12/20...	84.3030	1.6168e+03	851.5050
24	09/12/20...	84.3030	1.6168e+03	851.5050
25	09/12/20...	84.3026	1.6168e+03	851.5010
26	09/12/20...	84.2981	1.6166e+03	851.4550

```
% extract altitude and pressure data into individual arrays
AltitudeData = boulderData.Altitude_m_;
PressureData = boulderData.StationPressure_kPa_;
```

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)
```

```
StdevPressure = 0.0012
```

```
VarPressure = var(PressureData)
```

```
VarPressure = 1.4020e-06
```

```
MeanPressure = mean(PressureData)
```

```
MeanPressure = 84.3025
```

```
% 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))
```

```
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 the follwing model:
First, propagate uncertainty BY HAND before calculating uncertainty for each value.
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 pressu
```

```
P_est = 26×1
   83.7647
   83.7667
   83.7662
   83.7657
   83.7667
   83.7667
   83.7647
   83.7667
```

```
    83.7667
    83.7662
      ⋮
```

```
% estimate)
% general method
P_sig = sqrt((exp(-k.*AltitudeData).*P_s_uncertainty).^2+(-k.*P_s*exp(-k.*AltitudeData)*Altitud
```

```
P_sig = 26×1
    0.3295
    0.3295
    0.3295
    0.3295
    0.3295
    0.3295
    0.3295
    0.3295
    0.3295
    0.3295
      ⋮
```

```

% p_est and p_sig vary slightly
```

6) Print Results

```
Display the predicted pressure from the model with it's associated uncertainty and
the average pressure with the it's standard error of the mean from the data.
```

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

```
    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
```

```
disp(P_data);
```

```
84.3025  ±  0.00023221   kPa
```

```
% 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 o
```

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]
```

```
altitude_uncertainty_new = 10
```

```
% changing the uncertainty in p_sig
p_sig_new = sqrt((exp(-k.*AltitudeData).*P_s_uncertainty).^2+(-k.*P_s*exp(-k.*AltitudeData)*alt
```

```
p_sig_new = 26×1
    0.3445
    0.3445
    0.3445
    0.3445
    0.3445
    0.3445
    0.3445
    0.3445
    0.3445
    0.3445
      ⋮
```

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

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
```

```
disp(P_data);
```

```
84.3025  ±  0.00023221   kPa
```

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

```
percent_change = 4.5503
```

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