MATLAB Exploration #3 for MATH 1554

For each MATLAB assignment, follow the step-by-step formatting guidelines we provided. You will be graded on completeness, following directions, proper usage of comments, and overall readability of your code and published .pdf submission. We recommend `format bank`

For Week 11: MATLAB #3 - This exploration asks you to fill in the missing parts of the code below. Copy the code into a MATLAB window and fill in the missing portions. Alternately, you can download a .txt file of the MATLAB code here.
`https://sbarone7.math.gatech.edu/exploration_least_squares_MATLAB_code.txt`

A completed submission that can be used for reference is here.
`https://sbarone7.math.gatech.edu/exploration_least_squares_complete.pdf`
WARNING: do not **copy** from the completed submission, but if you are stuck you can use the pdf as a *guide only*.

The parts that the student needs to fill in are:

1. Part 1, in the second model, the design matrix A which is the coefficient matrix of the system $Ax = b$ when you plug in the data points into the model given.
2. Part 1, in the third model, which the student selects the model to use, the model name and the general formula for the model.
3. Part 1, in the third model, the design matrix for the model.
4. Part 1, in the third model, you may need to change the number of variables depending on how many terms your model has.
5. Part 1, in the third model, the MATLAB formula for the function which will be plotted. NOTE: MATLAB requires the use of `.*` and `.^` for multiplication and exponents in order to avoid errors, see for example this MathWorks post.
6. **Answer the questions** at the end of Part 1.
7. Part 2, the student should provide a data set with at least 6 data points.
8. Part 2, the model needs the same things as the third model of Part 1. Namely, the student fills in the name of the model, the general formula, the design matrix, may need to change number of variables, and the MATLAB formula for the function to be plotted.
9. Part 2, as a last step, the student needs to modify the x-values range if the data the student creates includes x-values outside the range $0 \leq x \leq 8$ (which is the range of the first data set).

MATLAB code begins on the next page.

```
clc
format shortG

%% Part 1: first data set
% data is given by an mx2 matrix with x-values in column 1
% and y-values in column 2
data1=[ 1 8 ; 2 6 ; 4 5 ; 5 7 ; 8 16 ];
% extracts the x-values in column 1
x=data1(:,1);
% extracts the y-values in column 2
y=data1(:,2);


%% first model: linear y=a0+a1*x
% constructs the design matrix which is the coefficient matrix of the system
% Ax=b obtained from plugging in data points into the model
A=[1 x(1) ;
   1 x(2) ;
   1 x(3) ;
   1 x(4) ;
   1 x(5) ]
% b vector is just the y-values
b=y;
% gets xhat least squares solution using fact that A has linearly
% independent columns so A^T*A is invertible - note A' is MATLAB transpose
xhat=inv(A'*A)*A'*b;
% extracts alpha and beta values from the xhat vector
a0=xhat(1);
a1=xhat(2);
% defines the function for plotting
% WARNING: you must use .* for 'times' and .^ for 'exponent' or else
% MATLAB will give an error code
f1=@(x) a0+a1.*x;
% compute the least squares error ||A*xhat-b||
errorLine=sqrt((A*xhat-b)'*(A*xhat-b))
% draws figure
```

```
figure(1)
fplot(f1,[0 8])
hold on
plot(x,y,'.','markersize',28)
hold off


%% second model: full quadratic y=a0+a1*x+a2*x^2
% [STUDENT FILL IN:] student should construct the design matrix which
% is the coefficient matrix of the system Ax=b obtained from plugging
% in data points into the model y=a0+a1*x+a2*x^2
A=[ '_fill_in_matrix_here_'




       ]
% copy-pasted/modified code from part 1
b=y;
xhat=inv(A'*A)*A'*b;
a0=xhat(1);
a1=xhat(2);
a2=xhat(3);
% defines the function for plotting
% WARNING: you must use .* for 'times' and .^ for 'exponent' or else
% MATLAB will give an error code
f2=@(x) a0+a1.*x+a2.*x.^2;
% least squares error ||A*xhat-b||
errorQuad=sqrt((A*xhat-b)'*(A*xhat-b))
% draws figure
figure(2)
fplot(f2,[0 8])
hold on
plot(x,y,'.','markersize',28)
hold off
```

```
%% third model: [STUDENT FILL IN:] _model_name_here_ _model_here_
% [STUDENT FILL IN:] student shout construct the design matrix which
% is the coefficient matrix of the system Ax=b obtained from plugging
% in data points into the model
A=[ '_fill_in_matrix_here_'



       ]
b=y;
xhat=inv(A'*A)*A'*b;
% [STUDENT FILL IN:] you may need to add/delete variables depending on how
% many terms your model has, e.g. three terms needs up to a2=xhat(3)
a0=xhat(1);
a1=xhat(2);
a2=xhat(3);
% [STUDENT FILL IN:] define the function for plotting
% WARNING: you must use .* for 'times' and .^ for 'exponent' or else
% MATLAB will give an error code
f3=@(x) '_fill_in_model_here_' ;
% least squares error is ||A*xhat-b||
errorStudentModelforData1=sqrt((A*xhat-b)'*(A*xhat-b))
% draws figure
figure(3)
fplot(f3,[0 8])
hold on
plot(x,y,'.','markersize',28)
hold off

%% answer questions: [STUDENT FILL IN:] answer questions as comments
% Q1: which model has the best error (smallest error value)?
% Ans1:
% Q2: what does the value of the error ||A*hat-b|| represent geometrically?
% Ans2:

%% Part 2: student created data set must have at least 6 data points
```

```
% [STUDENT FILL IN:] create a data2 matrix where the data is
% given by an mx2 matrix with m>5 (at least 6 data points)
% with x-values in column 1
% and y-values in column 2
data2=[ '_fill_in_data_here' ];
% extracts the x-values in column 1
x=data2(:,1);
% extracts the y-values in column 2
y=data2(:,2);

%% fourth model: [STUDENT FILL IN:]  _model_name_here_ _model_here_
% [STUDENT FILL IN:] student should construct the design matrix which
% is the coefficient matrix of the system Ax=b obtained from plugging
% in data points into the model
A=[ '_fill_in_matrix_here_'




        ]
b=y;
xhat=inv(A'*A)*A'*b;
% [STUDENT FILL IN:] you may need to add/delete variables depending on how
% many terms your model has
a0=xhat(1);
a1=xhat(2);
a2=xhat(3);
% [STUDENT FILL IN:] define the function for plotting
% WARNING: you must use .* for 'times' and .^ for 'exponent' or else
% MATLAB will give an error code
f4=@(x) '_fill_in_model_here_' ;
% least squares error is ||A*xhat-b||
errorStudentModelforData2=sqrt((A*xhat-b)'*(A*xhat-b))
% draws figure
% [STUDENT FILL IN:] You may need to modify the range of the fplot second
% argument [0 8] if your x-values go outside the range 0 <= x <= 8
```

```
figure(4)
fplot(f4,[0 8])
hold on
plot(x,y,'.','markersize',28)
hold off
```