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%%MATLAB EXPLORATION 12
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```

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])
```

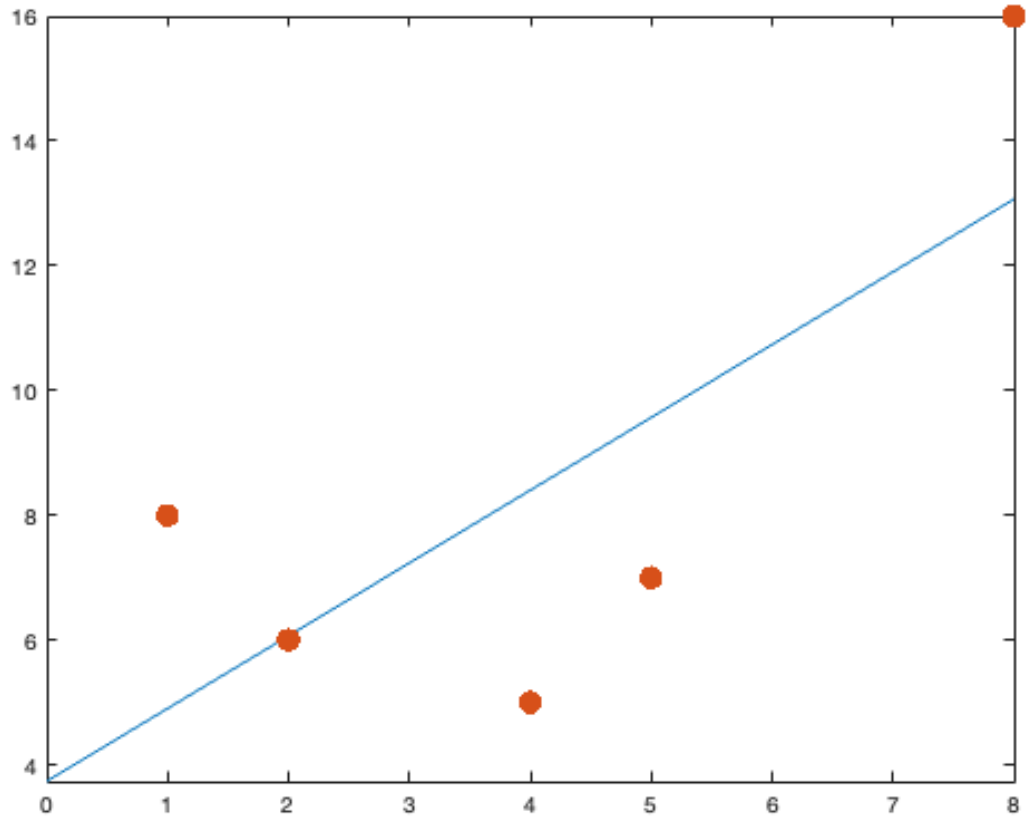
```
hold on
plot(x,y,'.','markersize',28)
hold off
```

```
A =

     1     1
     1     2
     1     4
     1     5
     1     8
```

```
errorLine =

    6.0305
```



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

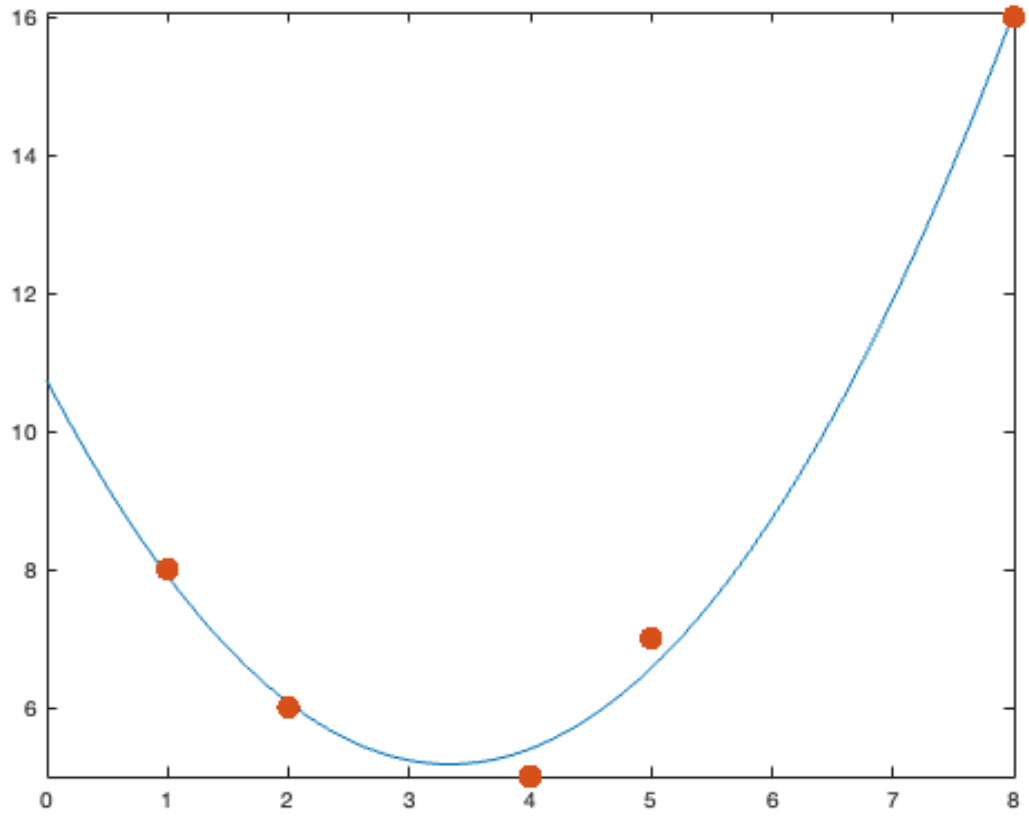
```
A=[ 1 x(1) x(1)^2;
    1 x(2) x(2)^2;
    1 x(3) x(3)^2;
    1 x(4) x(4)^2;
    1 x(5) x(5)^2]
% copy-pasted/modified code from part 1
b=y;
xhat=inv(A'*A)*A'*b;
a0=xhat(1);
a1=xhat(2);
a2=xhat(3);
% defines the function for plotting
% WARNING: you must use .* for 'times' and .^ for 'exponent' or 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
```

```
A =

     1     1     1
     1     2     4
     1     4    16
     1     5    25
     1     8    64


errorQuad =

    0.6055
```



third model: [STUDENT FILL IN:] cubic y=a0+a1*x+a2*x^2+a3*x^3

[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=[1 x(1) x(1)^2 x(1)^3;
   1 x(2) x(2)^2 x(2)^3;
   1 x(3) x(3)^2 x(3)^3;
   1 x(4) x(4)^2 x(4)^3;
   1 x(5) x(5)^2 x(5)^3]
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);
a3=xhat(4);
% [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
```

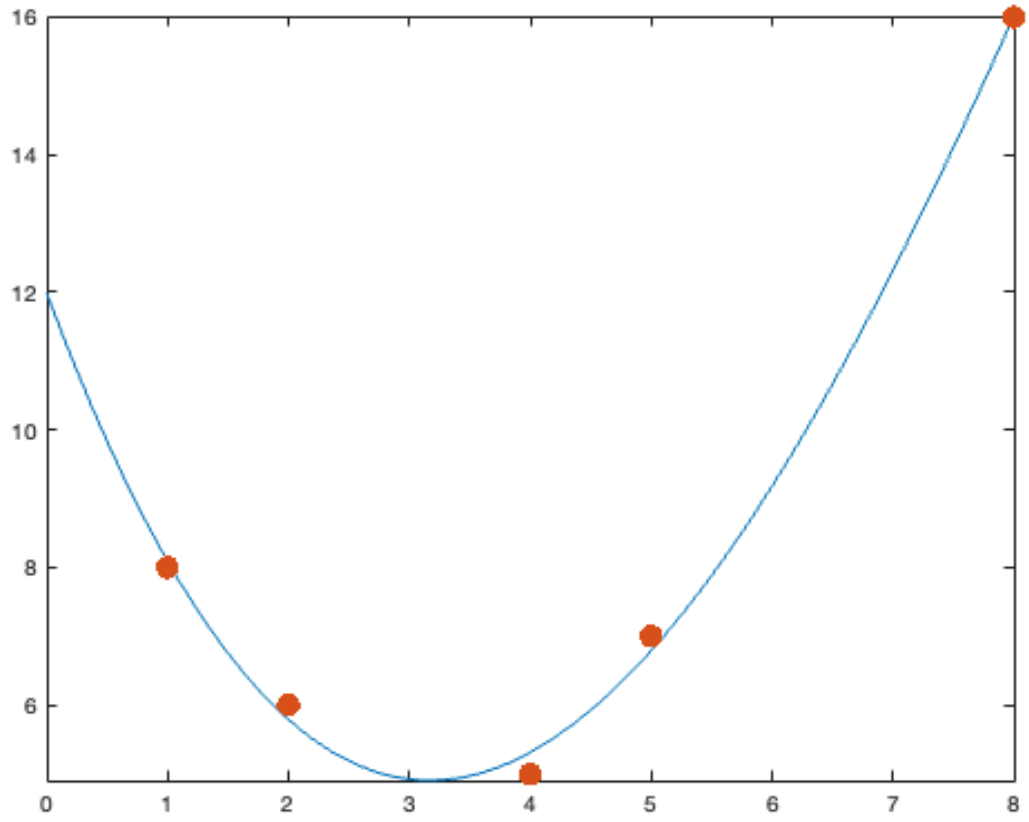
```
f3=@(x) a0+a1.*x+a2.*x.^2+a3.*x.^3;
% least squares error is ||A*xhat-b||
errorStudentModelforData1=sqrt((A*xhat-b)'*(A*xhat-b))
% draws figure
figure(3)
fplot(f3,[0 8])
hold on
plot(x,y,'.','markersize',28)
hold off
```

```
A =

     1     1     1     1
     1     2     4     8
     1     4    16    64
     1     5    25   125
     1     8    64   512


errorStudentModelforData1 =

    0.4407
```



answer questions: [STUDENT FILL IN:] answer questions as comments

Q1: which model has the best error (smallest error value)? Ans1: Quadratic Q2: what does the value of the error |`A*hat-b`| represent geometrically? Ans2: The standard deviation from the actual data points on the graph.

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=[2 2; 5 7; 4 3; 1 3; 7 4; 9 3];
% 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:] cosine + exponential y = a0+a1*cos(x)+a2*exp(x)

[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=[1 cos(x(1)) exp(x(1));
   1 cos(x(2)) exp(x(2));
   1 cos(x(3)) exp(x(3));
   1 cos(x(4)) exp(x(4));
   1 cos(x(5)) exp(x(5));
   1 cos(x(6)) exp(x(6))]
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) a0+a1.*cos(x)+a2.*exp(x);
% 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
```

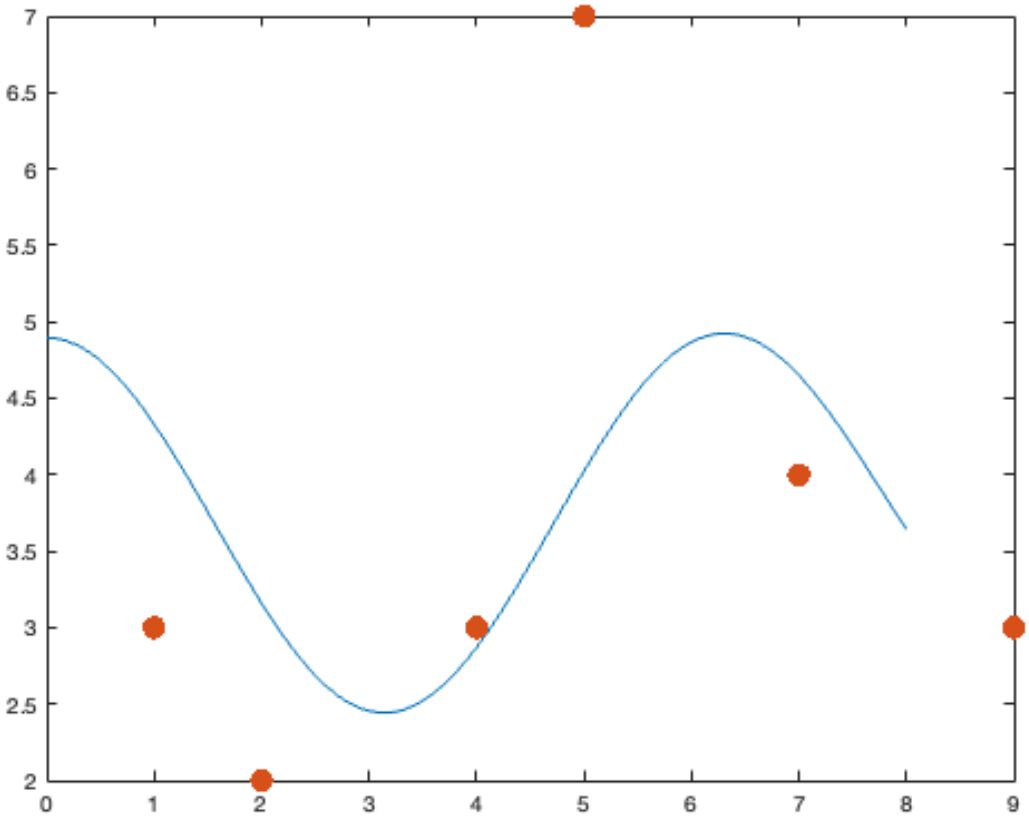
```
A =

   1.0e+03 *

    0.0010   -0.0004    0.0074
    0.0010    0.0003    0.1484
    0.0010   -0.0007    0.0546
    0.0010    0.0005    0.0027
    0.0010    0.0008    1.0966
    0.0010   -0.0009    8.1031


errorStudentModelforData2 =

    3.5229
```



Published with MATLAB® R2022a