YILDIZ TECHNICAL UNIVERSITY

2022 – FALL SEMESTER

INDUSTRIAL MEASUREMENT SYSTEMS

MKT4171 KADİR ERKAN

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1806A004

HOMEWORK1

Industrial Measurement Systems / MKT 4171

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1806A004

HW 1

1-) Given reading list

a) Arithmetic mean

$$\bar{X} = \frac{x_1 + x_2 + \dots + x_n}{n} = \frac{\sum_{i=1}^{n} x}{n} = \frac{127.411}{25} = 5.09644$$ //

b) Average deviation

$d_n = x_n - \bar{X}$ → deviation for one sample.

$$D = \frac{|d_1| + |d_2| + \dots + |d_n|}{n} = \frac{\sum_{i=1}^{n} |d_n|}{n}$$ → average deviation

deviation All ⇒ $|4.617 - 5.09644| + |4.436 - 5.09644| + |5.039 - 5.09644| + |6.053 - 5.09644| +$
$|4.642 - 5.09644| + |4.859 - 5.09644| + |5.583 - 5.09644| + |5.606 - 5.09644| +$
$|5.242 - 5.09644| + |5.513 - 5.09644| + |5.435 - 5.09644| + |4.809 - 5.09644| + |5.214 - 5.09644|$
$+ |4.850 - 5.09644| + |4.550 - 5.09644| + |5.317 - 5.09644| + |5.033 - 5.09644| + |4.906 - 5.09644|$
$+ |5.145 - 5.09644| + |5.493 - 5.09644| + 5.196 - 5.09644| + |5.097 - 5.09644| + |5.139 - 5.09644| + 5.025 -$
$5.09644| + |4.612 - 5.8644|$ ⇒ $SUM = \frac{7.558852}{25} = 0.3140073$ //

c) Standard Deviation

$$Std = \sqrt{\text{Average Dev.}} = \sqrt{\frac{\sum d_t^2}{n-1}}$$

$$= \sqrt{\frac{3.60880616}{24}} = 0.387717413$$ //

d) Variance

Variance is square of standard deviation

$$\text{Variance} = \sigma^2 = (0.387717413)^2 = 0.150366923$$ //

Question 2

a) Linear fit

$y = ax + b \rightarrow A \cdot X = B \Rightarrow A^T \cdot A \cdot X = A^T \cdot B \Rightarrow$

$$\begin{bmatrix} 0 & 0.5 & 1 & 1.5 & 2 & 2.5 & 3 & 3.5 & 4 & 4.5 & 5 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} 0 & 1 \\ 0.5 & 1 \\ 1 & 1 \\ 1.5 & 1 \\ 2 & 1 \\ 2.5 & 1 \\ 3 & 1 \\ 3.5 & 1 \\ 4 & 1 \\ 4.5 & 1 \\ 5 & 1 \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix} = A^T B$$

$a = 6.93$

$b = -5.82$

$y = 6.93x - 5.82$

b) 2nd Order Polynomial fit

$y = ax^2 + bx + c$ For this question matrix are below;

$$A = \begin{bmatrix} 0 & 0 & 1 \\ 0.125 & 0.5 & 1 \\ 1 & 1 & 1 \\ 2.25 & 1.5 & 1 \\ 4 & 2 & 1 \\ 6.25 & 2.5 & 1 \\ 9 & 3 & 1 \\ 12.25 & 3.5 & 1 \\ 16 & 4 & 1 \\ 20.25 & 4.5 & 1 \\ 25 & 5 & 1 \end{bmatrix} \quad B = \begin{bmatrix} -1 \\ 0 \\ 1.5 \\ 3 \\ 4 \\ 8 \\ 12.4 \\ 16 \\ 20.3 \\ 26.3 \\ 36 \end{bmatrix} \quad X = \begin{bmatrix} a \\ b \\ c \end{bmatrix}$$

Applaying

$A^T A x = A^T B$

$a = 1.49$

$b = -0.518$

$c = -0.1234$

and

$y = 1.49x^2 - 0.518x - 0.234$

c) 3rd order polynomial fit.

$y = ax^3 + bx^2 + cx + d$

$-1 = 0a + 0b + 0c + d$

$0 = 0.125a + 0.25b + 0.5c + d$

$1.5 = 1a + 1b + 1c + d$

$3 = 3.375a + 2.25b + 1.5c + d$

$4 = 8a + 4b + 2c + d$

$8 = 15.625a + 6.25b + 2.5c + d$

$12.4 = 27a + 9b + 3c + d$

$16 = 42.875a + 12.25b + 3.5c + d$

$20.3 = 64a + 16b + 4c + d$

$26.3 = 91.125a + 20.25b + 4.5c + d$

$36 = 125a + 25b + 5c + d$

$$\begin{bmatrix} 0 & 0 & 0 & 1 \\ 0.125 & 0.25 & 0.5 & 1 \\ 1 & 1 & 1 & 1 \\ 3.375 & 2.25 & 1.5 & 1 \\ 8 & 4 & 2 & 1 \\ 15.625 & 6.25 & 2.5 & 1 \\ 27 & 9 & 3 & 1 \\ 42.875 & 12.25 & 3.5 & 1 \\ 64 & 16 & 4 & 1 \\ 91.125 & 20.25 & 4.5 & 1 \\ 125 & 25 & 5 & 1 \end{bmatrix} \quad B = \begin{bmatrix} -1 \\ 0 \\ 1.5 \\ 3 \\ 4 \\ 8 \\ 12.4 \\ 16 \\ 20.3 \\ 26.3 \\ 36 \end{bmatrix} \quad X = \begin{bmatrix} a \\ b \\ c \\ d \end{bmatrix}$$

$A \cdot X = B$.

$A^T \cdot A \cdot X = A^T \cdot B$

} Equations obtained by putting the matrix into the place are solve

$a = 0.19$

$b = 0.0671$

$c = 2.19$

$d = -1.09$

$Y = 0,19x^3 + 0,0671x^2 + 2,19x - 1,09$

KEMALETTİN KARA 1806A004 - HW1

QUESTİON 1

```
reading = [4.617,4.436,5.039,6.053,4.642,4.859,5.583,5.606,5.242,5.513,5.435,4.809,5.214,4.850,
total =0 ;
devTotal = 0 ;
deviations=[];
```

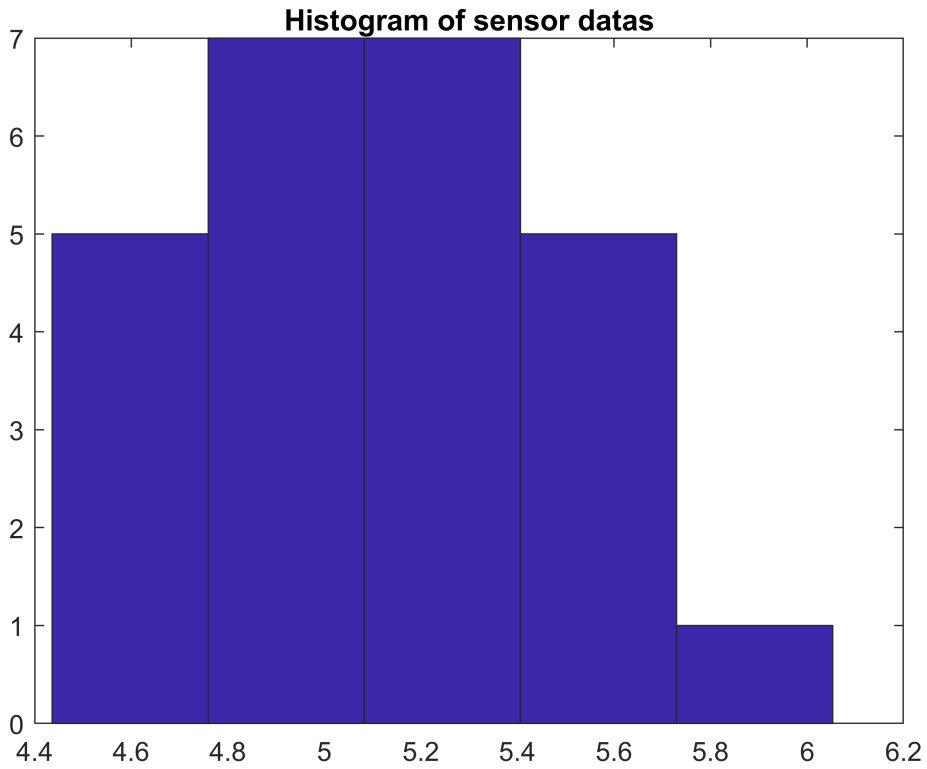
```
%%%%%%%%%%%%%%%%%%%% mean calculation  %%%%%%%%%%%%%%%%%%%%
for n = reading
    total = n + total;
end
averageMean = total / size(reading,2);
```

```
%%%%%%%%%%%%%%%%%%%% deviation calculation  %%%%%%%%%%%%%%%%%%%%
% dn = xn - xmean
for d = reading
    deviations = [deviations (d-averageMean)];
end
for n = deviations
    devTotal = abs(n) + devTotal;

end
deviationMean = devTotal / size(reading,2);
```

```
%%%%%%%%% Standard deviation calculation and variance  %%%%%
std = sqrt(sum(deviations.^2)/(size(reading,2)-1));
var = std^2;
```

```
%%%%%%%%%%%%%%%%%%%% PLotting Histogram  %%%%%%%%%%%%%%%%%%%%
 figure;
 hist(reading,5)
 title("Histogram of sensor datas")
```

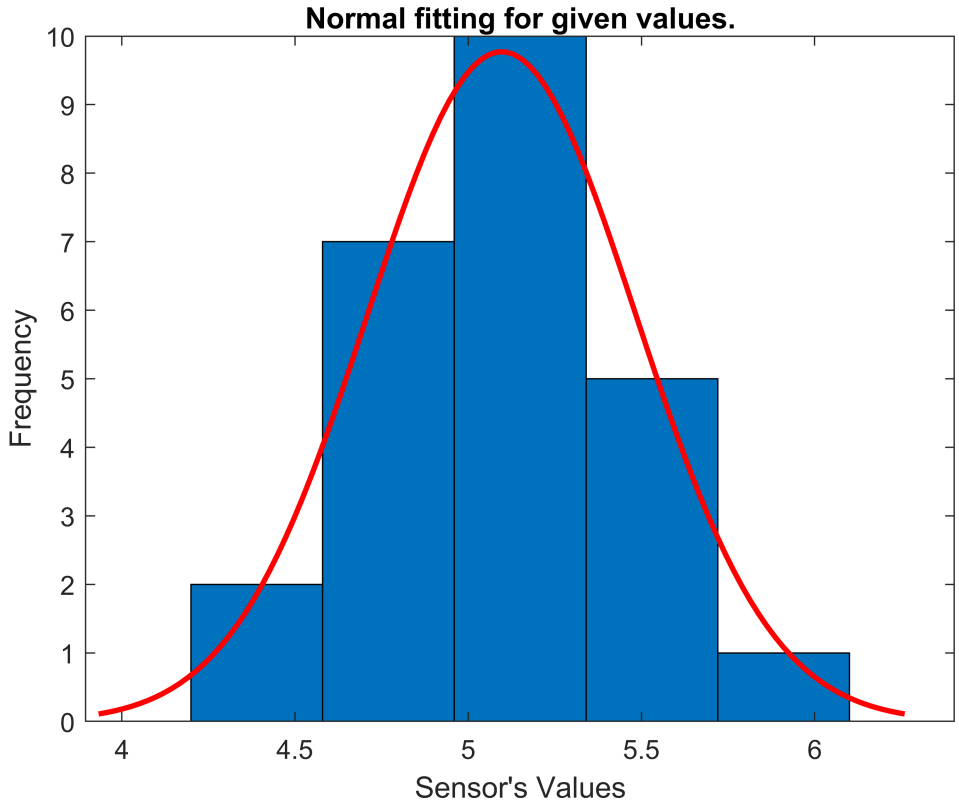


QUESTION 1 - PART F

```
% Normal distribution has two parameter and these parameters are declared
% in above mean and standard deviation.

% Normal distribution fitting
figure;
histfit(reading)

ylabel("Frequency")
xlabel("Sensor's Values")
title("Normal fitting for given values.")
```



QUESTION 1 - PART G

```
%%%%%%%%%%%%%%%%%%% Writing all results  %%%%%%%%%%%%%%%%%
fprintf("Summing of all element in the reading: %f\n",total)
```

```
Summing of all element in the reading: 127.411000
```

```
fprintf("Sum of deviations: %f\n",devTotal)
```

```
Sum of deviations: 7.558560
```

```
fprintf("Average mean: %f\n",averageMean)
```

```
Average mean: 5.096440
```

```
fprintf("Deviation mean: %f\n",deviationMean)
```

```
Deviation mean: 0.302342
```

```
fprintf("Standard deviation: %f\n",std)
```

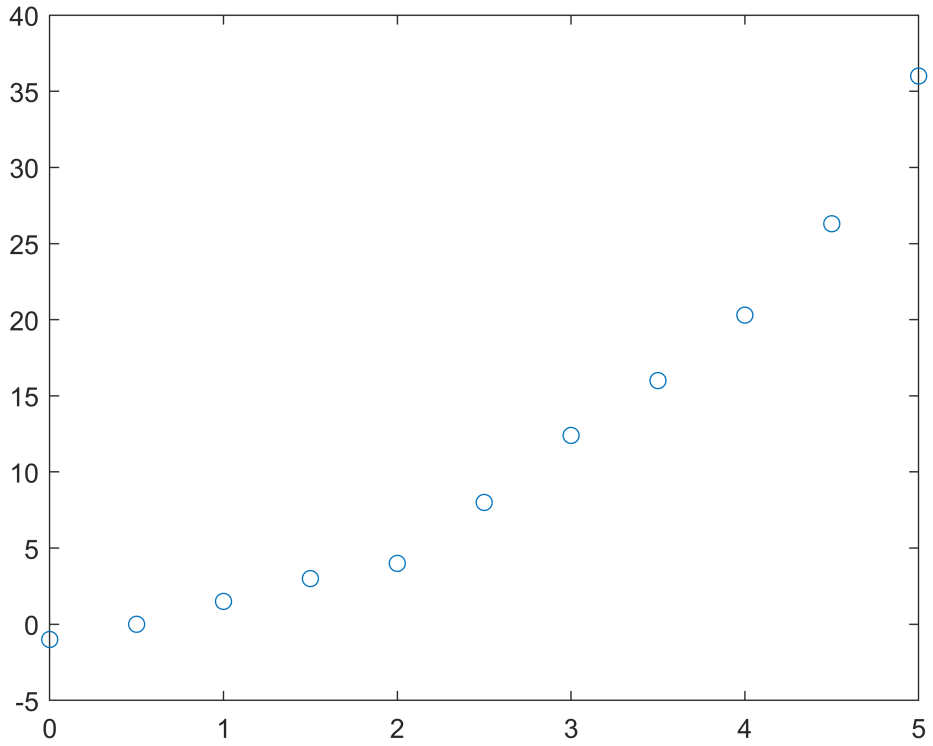
```
Standard deviation: 0.387772
```

```
fprintf("Variance: %f\n",var)
```

```
Variance: 0.150367
```

QUESTION 2

```
%%%%%%%%%%%%%%%%%%%%%% Question 2  %%%%%%%%%%%%%%%%%%%%%%
X = [0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0];        %volt
Y = [-1.0, -0.0, 1.5, 3.0, 4.0, 8.0, 12.4, 16.0, 20.3, 26.3, 36.0]; % Newton
figure;
plot(X,Y,"o")
```



A) LİNEAR FİT

```
func1 = polyfit(X,Y,1)
```

```
func1 = 1×2
    6.9273   -5.8182
```

```
c = func1'  %transpoze
```

```
c = 2×1
    6.9273
   -5.8182
```

```
poly1 = vpa(poly2sym(func1),3);
X1=X
```

```
X1 = 1×11
         0    0.5000    1.0000    1.5000    2.0000    2.5000    3.0000    3.5000 ···
```

```
Y1=polyval(func1,X1)
```

```
Y1 = 1×11
   -5.8182   -2.3545    1.1091    4.5727    8.0364   11.5000   14.9636   18.4273 ···
```

b) 2nd Order Polynomial Fit

```
func2=polyfit(X,Y,2)
```

```
func2 = 1×3
    1.4890   -0.5179   -0.2343
```

```
c=func2'    %transpoze
```

```
c = 3×1
    1.4890
   -0.5179
   -0.2343
```

```
poly2=vpa(poly2sym(func2),3)
```

poly2 = $1.49\,x^2 - 0.518\,x - 0.234$

```
X2=X
```

```
X2 = 1×11
         0    0.5000    1.0000    1.5000    2.0000    2.5000    3.0000    3.5000 ···
```

```
Y2=polyval(func2,X2)
```

```
Y2 = 1×11
   -0.2343   -0.1210    0.7368    2.3392    4.6860    7.7774   11.6133   16.1937 ···
```

c) 3rd Order Polynomial Fit

```
func3=polyfit(X,Y,3)
```

```
func3 = 1×4
    0.1896    0.0671    2.1932   -1.0874
```

```
c=func3' %transpoze
```

```
c = 4×1
    0.1896
    0.0671
    2.1932
   -1.0874
```

```
poly3=vpa(poly2sym(func3),3)
```

poly3 = $0.19\,x^3 + 0.0671\,x^2 + 2.19\,x - 1.09$

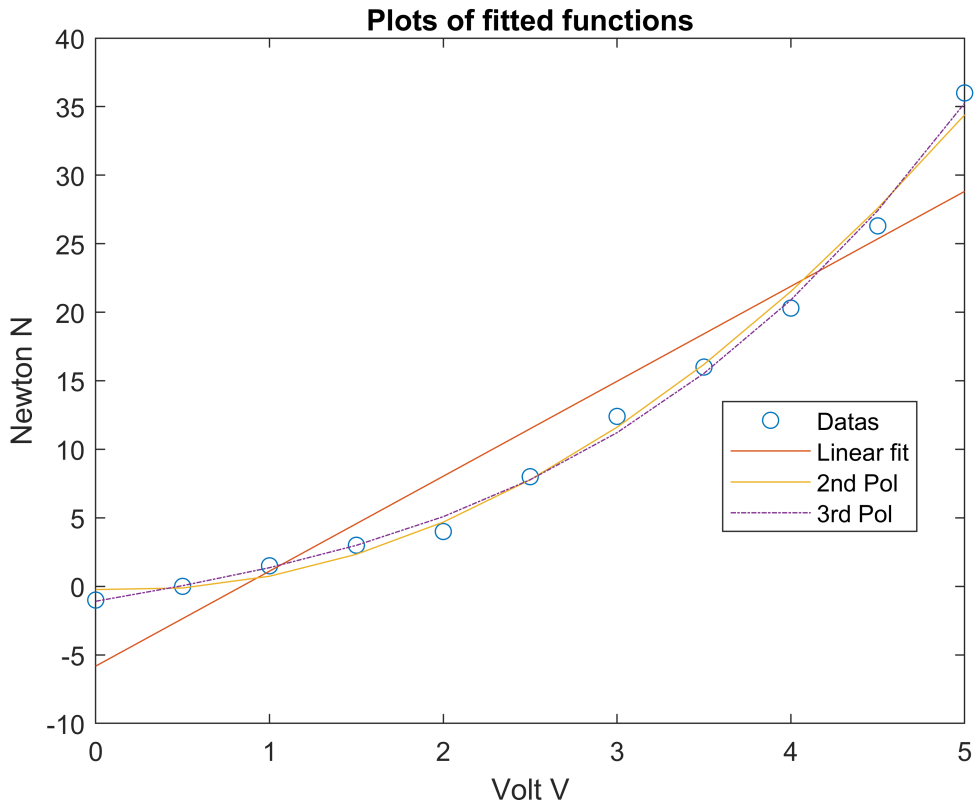
```
X3=X
```

```
X3 = 1×11
         0    0.5000    1.0000    1.5000    2.0000    2.5000    3.0000    3.5000 ···
```

```
Y3=polyval(func3,X3)
```

```
Y3 = 1×11
   -1.0874    0.0497    1.3625    2.9932    5.0841    7.7774   11.2152   15.5396 ···
```

```
plot(X,Y,'o',X1,Y1,'-',X2,Y2,'-',X3,Y3,'-.')
title("Plots of fitted functions")
xlabel("Volt V")
ylabel("Newton N")
legend('Datas','Linear fit','2nd Pol','3rd Pol','Location', 'Best')
```




```
func1
```

```
func1 = 1×2
    6.9273   -5.8182
```

```
func2
```

```
func2 = 1×3
    1.4890   -0.5179   -0.2343
```

```
func3
```

```
func3 = 1×4
    0.1896    0.0671    2.1932   -1.0874
```

```
%KEMALETTİN KARA HOMEWORK1 END
```

Comparison and Comment

When I compared it with hand calculations, I noticed that there were errors due to rounding errors. In general, I think that hand calculations will be a hundred percent match when these errors are ignored.That's all I can see, thank you sir.