Assignment 1

1. Choose the correct answer for the following questions:

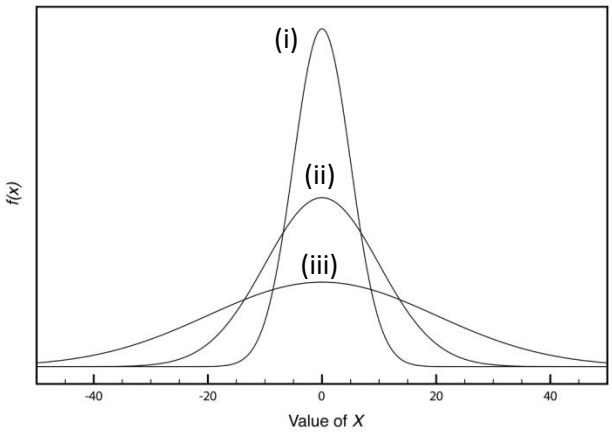
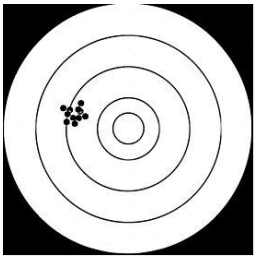


Figure 1

a. Which of the graphs drawn in figure 1 has the highest variance(i , ii or iii)



b. Which of the graphs drawn in figure 1 that best describes the above drawing (i , ii or iii)

c. The phenomena in which the output of the device depends on whether the measured variable is increasing or decreasing is called:
   i. Finesse
   ii. Hysteresis
   iii. Non linearity
   iv. Bias

d. The deviation of the sensitivity of a device from its ideal value is called
   i. Finesse
   ii. Hysteresis
   iii. Bias
   iv. Scale factor

e. A digital Vernier has reading of 0.03 mm when its jaws are fully closed. This value is called:
   i. Non linearity
   ii. Scale factor

iii. Standard deviation
iv. Bias

f. A measurement device in a real time system should have:
   i. Low response time
   ii. Zero bias
   iii. Wide dynamic range
   iv. High linearity

g. Which of the following instrument properties cannot be improved by calibration:
   i. Bias
   ii. Scale factor
   iii. Precision
   iv. Accuracy

h. A sensor measures a quantity that varies from 0 to 10 v. what's the least number of bits the converter could be, if it's required that the resolution should be at least 0.001
   i. 12
   ii. 13
   iii. 14
   iv. 15

i. What will be the actual resolution in (h) after choosing the appropriate converter
   i. 0.06
   ii. 0.0001
   iii. 0.01
   iv. 0.0006

2. A potentiometer is used to provide feedback for the angular position of a servo motor. During its calibration the following data was obtained:

θ^o	25	50	75	100	125	150	175	200	225	250
Volt(V)	5	5.5	6.1	6.6	7	7.5	8	8.5	8.9	9.4

a) **Plot** the relation between the angular position (θ^o) and output voltage (V) and thus **determine** the equation of the best fit line for the data and **plot** it.
b) From (a) **determine** the sensitivity of the potentiometer.
c) **Estimate** the offset (bias) of the device.
d) Can this device be considered linear or not? Why?

3. An accelerometer used to measure vibrations of mechanical part vibrating at 550Hz. To characterize the accelerometer at the operating frequency, it was excited by an electromagnetic shaker with different amplitudes and its output was recorded in the following table:

Acceleration(g)	1.1	1.4	1.5	1.6	1.8	1.9	2	2.2	2.6	3.5
Volt(mV)	4	5.8	4	6.2	6.3	7	6.8	6.3	9.5	11.5

a) **Determine** the equation of calibration curve and **plot** it.
b) **Determine** the sensitivity of the accelerometer.
c) **Estimate** the offset (bias) of the device.
d) Can this device be considered linear or not? Why?
e) **Verify** the results using any of spread sheet software (i.e. Microsoft Excel).

Useful relations:

Variance:

$$\sigma_x^2 = \frac{1}{N}\sum_{n=1}^{N}(X_n - \bar{X})^2$$

Standard deviation: square root of variance

Least square regression:

$$b = \frac{\bar{Y}\overline{X^2} - \bar{X}R_{xy}(0)}{\sigma_x^2}$$

$$m = \frac{R_{xy}(0) - \bar{X}\bar{Y}}{\sigma_x^2}$$

$$R_{xy}(0) = \frac{1}{N}\sum_{n=1}^{N} X_k Y_k$$

$$r \equiv \frac{1}{\sigma_x \sigma_y}|R_{xy}(0) - \bar{X}\bar{Y}|$$

$0 \le r \le 1$ Where r=1 indicates a perfect fit of the line