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# **APL103 Lab**

## **Experiment 1**

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### **OBJECTIVES:**

- a) Pictorial representation of experimental data
- b) To obtain various measures of true value and the precision from a given data set

### **APPARATUS:**

Glass marbles-100, Rivets-100, Micrometer screw gauge and digital weighing scale

### **PROCEDURE:**

- 1) Note down the zero error and least count of the Micrometer screw gauge.
- 2) Note down the zero error and least count of the digital weighing scale.
- 3) Measure the diameter of any 100 marbles chosen at random from the box of marbles. Correct each reading for zero error, if any.
- 4) Measure the mass of any 100 rivets chosen at random from the lot provided.

## ANALYSIS:

### A) Marble Data(All data in mm)

First 50 marbles: (unsorted)

	A	B	C	D	E
1	15.56		15.51		14.83
2	15.61		15.45		16.08
3	14.97		15.03		16.36
4	15.81		16.5		15.07
5	14.23		16.3		15.49
6	15.64		14.88		15.79
7	15.42		15.65		16.15
8	15.74		16.36		16.56
9	15.06		12.31		15.63
10	15.61		15.14		16.6
11	15.18		15.41		15.73
12	15.4		14.95		15.36
13	15.38		15.07		14.43
14	14.93		15.39		15.37
15	14.6		15.87		15.99
16	14.83		14.92		16.05
17	15.2		14.34		

First 50 marbles(sorted) :

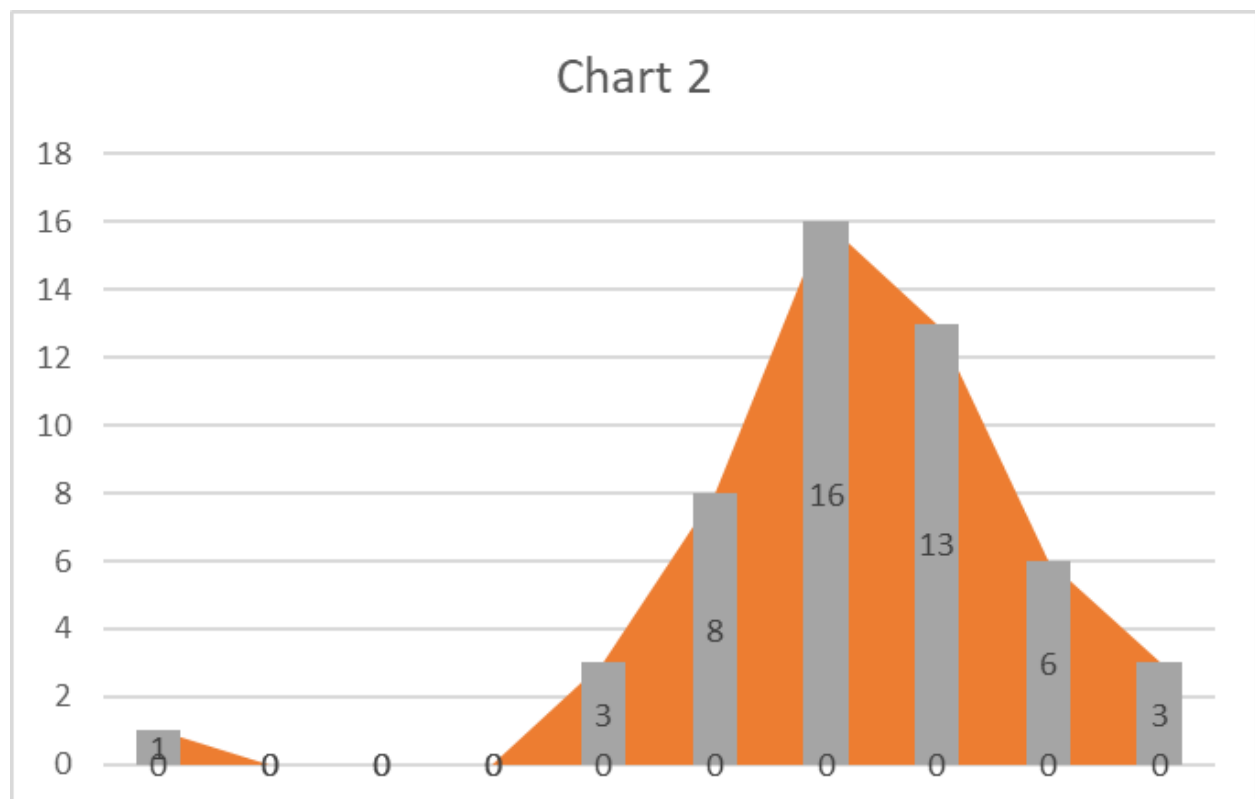
	A	B	C	D	E
1	12.31		15.18		15.65
2	14.23		15.2		15.73
3	14.34		15.36		15.74
4	14.43		15.37		15.79
5	14.6		15.38		15.81
6	14.83		15.39		15.87
7	14.83		15.4		15.99
8	14.88		15.41		16.05
9	14.92		15.42		16.08
10	14.93		15.45		16.15
11	14.95		15.49		16.3
12	14.97		15.51		16.36
13	15.03		15.56		16.36
14	15.06		15.61		16.5
15	15.07		15.61		16.56
16	15.07		15.63		16.6
17	15.14		15.64		

**$X_{min} = 12.31$  |  $X_{max} = 16.60$  | Median = 15.415 | Mean = 15.3948**

**Range = 4.29**

C.I.	x	LL	UL	f	F	cf	F*x	MD	Abs MD	F*MD^2
12 - 12.5	12.25	12	12.5	1	0.02	1	0.245	12.25	12.25	3.00125
12.5 - 13	12.75	12.5	13	0	0	1	0	12.75	12.75	0
13 - 13.5	13.25	13	13.5	0	0	1	0	13.25	13.25	0
13.5 - 14	13.75	13.5	14	0	0	1	0	13.75	13.75	0
14 - 14.5	14.25	14	14.5	3	0.06	4	0.855	14.25	14.25	12.18375
14.5 - 15	14.75	14.5	15	8	0.16	12	2.36	14.75	14.75	34.81
15 - 15.5	15.25	15	15.5	16	0.32	28	4.88	15.25	15.25	74.42
15.5 - 16	15.75	15.5	16	13	0.26	41	4.095	15.75	15.75	64.49625
16 - 16.5	16.25	16	16.5	6	0.12	47	1.95	16.25	16.25	31.6875
16.5 - 17	16.75	16.5	17	3	0.06	50	1.005	16.75	16.75	16.83375

Mean	15.39
Median	15.40625
Mode	15.36364
SD	0.76184



**First 100 marbles(unsorted) :**

15.56		14.83		15.56
15.61		16.08		16.41
14.97		16.36		16.01
15.81		15.07		16.22
14.23		15.49		14.81
15.64		15.79		15.66
15.42		16.15		15.48
15.74		16.56		16.28
15.06		15.63		16.3
15.61		16.6		16.04
15.18		15.73		15.45
15.4		15.36		15.59
15.38		14.43		15.56
14.93		15.37		15.41
14.6		15.99		14.58
14.83		16.05		16.35
15.2		15.59		15.81
15.51		14.26		16.19
15.45		15.19		14.28
15.03		16.34		16.25
16.5		14.95		16.52
16.3		15.39		15.61
14.88		15.45		15.57
15.65		14.31		15.98
16.36		15.48		15.34
12.31		15.25		15.38
15.14		16.54		15.07
15.41		16.25		15.35
14.95		15.17		14.26
15.07		15.34		15.46
15.39		15.35		15.81
15.87		15.96		15.88
14.92		14.53		15.88
14.34				

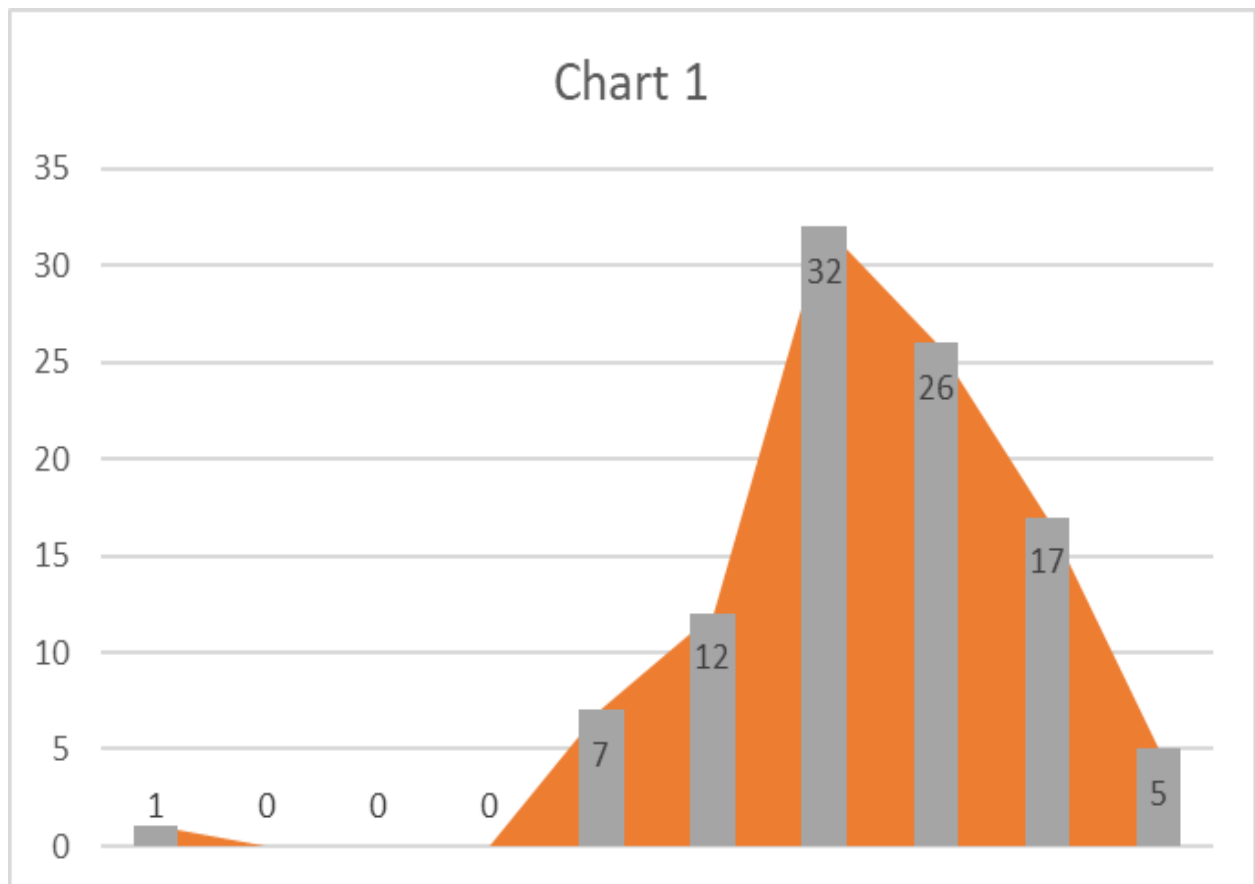
First 100 marbles(sorted) :

12.31		15.35		15.74
14.23		15.36		15.79
14.26		15.37		15.81
14.26		15.38		15.81
14.28		15.38		15.81
14.31		15.39		15.87
14.34		15.39		15.88
14.43		15.4		15.88
14.53		15.41		15.96
14.58		15.41		15.98
14.6		15.42		15.99
14.81		15.45		16.01
14.83		15.45		16.04
14.83		15.45		16.05
14.88		15.46		16.08
14.92		15.48		16.15
14.93		15.48		16.19
14.95		15.49		16.22
14.95		15.51		16.25
14.97		15.56		16.25
15.03		15.56		16.28
15.06		15.56		16.3
15.07		15.57		16.3
15.07		15.59		16.34
15.07		15.59		16.35
15.14		15.61		16.36
15.17		15.61		16.36
15.18		15.61		16.41
15.19		15.63		16.5
15.2		15.64		16.52
15.25		15.65		16.54
15.34		15.66		16.56
15.34		15.73		16.6
15.35				

**$X_{max} = 16.6$  |  $X_{min} = 12.31$  |  $Mean = 15.4732$  |  $Median = 15.48$**   
 **$Range = 4.29$**

C.I.	x	LL	UL	f	F	cf	F*x	MD	Abs MD	F*MD^2
12 - 12.5	12.25	12	12.5	1	0.01	1	0.1225	-3.215	3.215	0.103362
12.5 - 13	12.75	12.5	13	0	0	1	0	-2.715	2.715	0
13 - 13.5	13.25	13	13.5	0	0	1	0	-2.215	2.215	0
13.5 - 14	13.75	13.5	14	0	0	1	0	-1.715	1.715	0
14 - 14.5	14.25	14	14.5	7	0.07	8	0.9975	-1.215	1.215	0.103336
14.5 - 15	14.75	14.5	15	12	0.12	20	1.77	-0.715	0.715	0.061347
15 - 15.5	15.25	15	15.5	32	0.32	52	4.88	-0.215	0.215	0.014792
15.5 - 16	15.75	15.5	16	26	0.26	78	4.095	0.285	0.285	0.021119
16 - 16.5	16.25	16	16.5	17	0.17	95	2.7625	0.785	0.785	0.104758
16.5 - 17	16.75	16.5	17	5	0.05	100	0.8375	1.285	1.285	0.082561

Mean	15.4732
Median	15.48
Mode	15.07
SD	0.67005



## B) Rivets(All data in gm)

First 50 rivets(unsorted):

2.49		2.49		2.47
2.48		2.45		2.47
2.52		2.46		2.47
2.49		2.47		2.48
2.47		2.47		2.49
2.47		2.49		2.49
2.47		2.47		2.48
2.48		2.48		2.45
2.47		2.48		2.51
2.47		2.47		2.48
2.49		2.46		2.49
2.47		2.46		2.47
2.47		2.5		2.5
2.46		2.46		2.46
2.46		2.48		2.48
2.48		2.49		2.48
2.48		2.47		



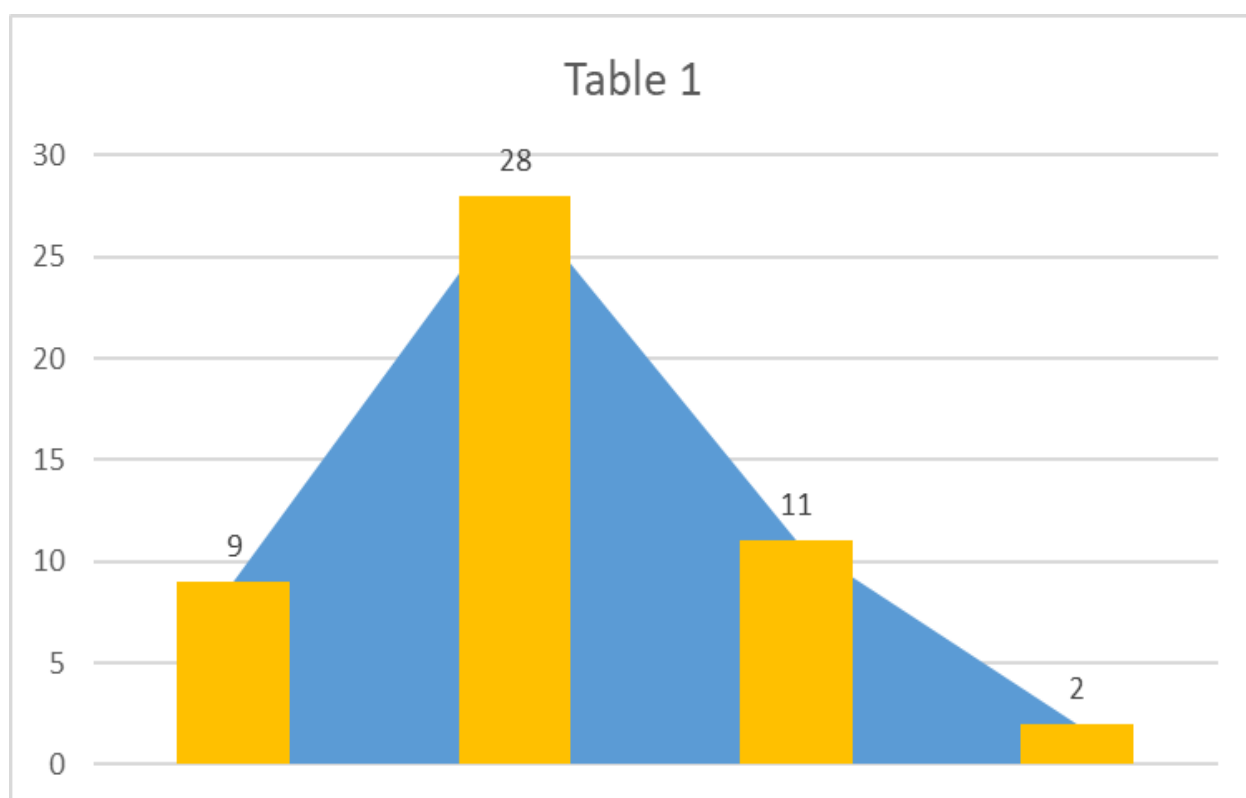
**First 50 rivets(sorted):**

2.45		2.47		2.48
2.45		2.47		2.48
2.46		2.47		2.48
2.46		2.47		2.49
2.46		2.47		2.49
2.46		2.47		2.49
2.46		2.47		2.49
2.46		2.47		2.49
2.46		2.48		2.49
2.47		2.48		2.49
2.47		2.48		2.49
2.47		2.48		2.49
2.47		2.48		2.5
2.47		2.48		2.5
2.47		2.48		2.51
2.47		2.48		2.52
2.47		2.48		

**$X_{min} = 2.45$  |  $X_{max} = 2.52$  |  $Mean = 2.4768$  |  $Median = 2.475$**   
 **$Range = 0.07$**

Class Intervals	Class Marks (x)	Lower Limits	Upper Limits	Frequency (f)	Relative Frequency (F)	Cumulative Frequency	F*x	MD	Abs MD	F*MD^2
2.45 - 2.47	2.46	2.45	2.47	9	0.18	9	0.4428	-0.0224	0.0224	9.0317E-05
2.47 - 2.49	2.48	2.47	2.49	28	0.56	37	1.3888	-0.0024	0.0024	3.2256E-06
2.49 - 2.51	2.5	2.49	2.51	11	0.22	48	0.55	0.0176	0.0176	6.8147E-05
2.51 - 2.53	2.52	2.51	2.53	2	0.04	50	0.1008	0.0376	0.0376	5.6555E-05

Mean	2.4824
Median	2.4814
Mode	2.4805
SD	0.01477



**First 100 rivets(unsorted):**

2.49		2.47		2.46
2.48		2.47		2.49
2.52		2.47		2.46
2.49		2.48		2.49
2.47		2.49		2.45
2.47		2.49		2.46
2.47		2.48		2.47
2.48		2.45		2.5
2.47		2.51		2.49
2.47		2.48		2.47
2.49		2.49		2.46
2.47		2.47		2.47
2.47		2.5		2.46
2.46		2.46		2.5
2.46		2.48		2.48
2.48		2.48		2.5
2.48		2.48		2.5
2.49		2.47		2.48
2.45		2.48		2.48
2.46		2.47		2.47
2.47		2.47		2.49
2.47		2.48		2.48
2.49		2.47		2.48
2.47		2.46		2.5
2.48		2.48		2.49
2.48		2.5		2.48
2.47		2.48		2.46
2.46		2.47		2.48
2.46		2.47		2.45
2.5		2.48		2.48
2.46		2.47		2.48
2.48		2.46		2.45
2.49		2.48		2.47
2.47				

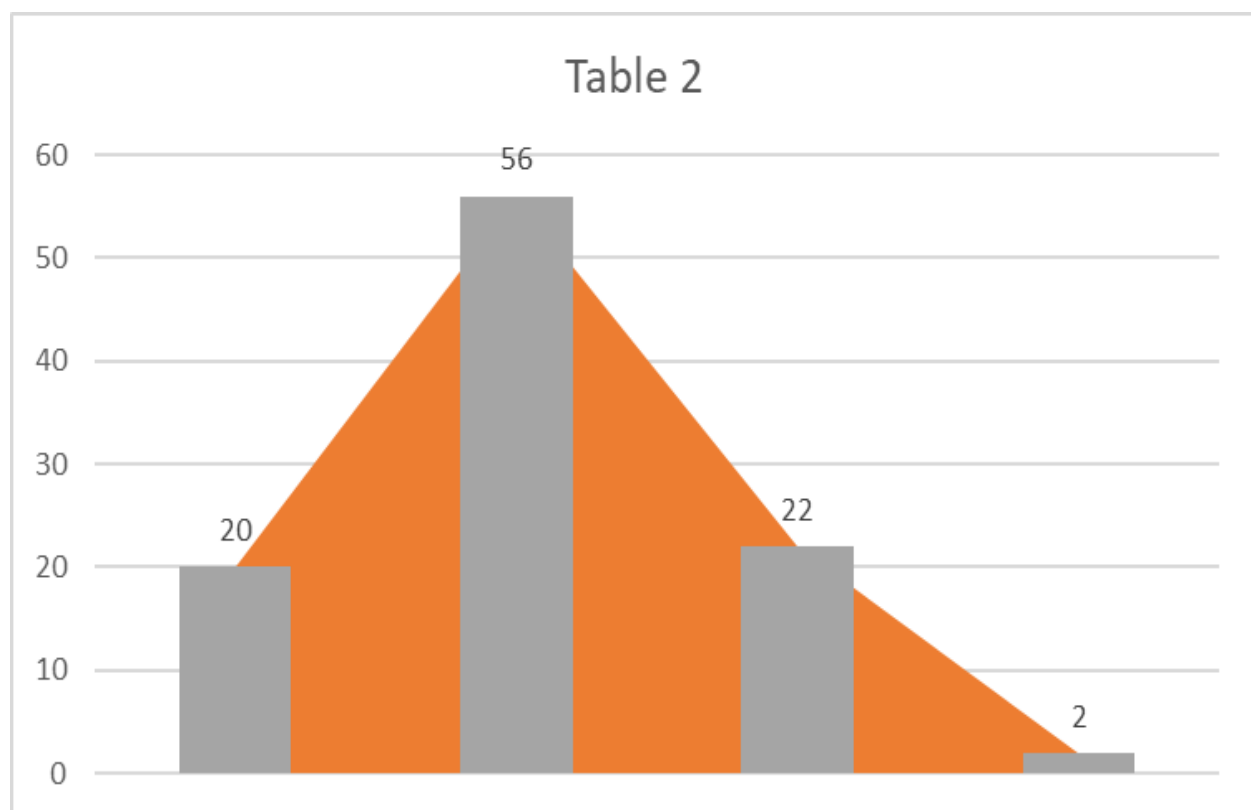
First 100 rivets(sorted):

2.45		2.47		2.48
2.45		2.47		2.48
2.45		2.47		2.48
2.45		2.47		2.48
2.45		2.47		2.48
2.46		2.47		2.48
2.46		2.47		2.48
2.46		2.47		2.48
2.46		2.47		2.48
2.46		2.47		2.49
2.46		2.47		2.49
2.46		2.47		2.49
2.46		2.47		2.49
2.46		2.47		2.49
2.46		2.48		2.49
2.46		2.48		2.49
2.46		2.48		2.49
2.46		2.48		2.49
2.46		2.48		2.49
2.46		2.48		2.49
2.46		2.48		2.49
2.47		2.48		2.49
2.47		2.48		2.49
2.47		2.48		2.49
2.47		2.48		2.5
2.47		2.48		2.5
2.47		2.48		2.5
2.47		2.48		2.5
2.47		2.48		2.5
2.47		2.48		2.5
2.47		2.48		2.5
2.47		2.48		2.5
2.47		2.48		2.5
2.47		2.48		2.51
2.47		2.48		2.52
2.47				

$X_{max} = 2.52$  |  $X_{min} = 2.45$  |  $Mean = 2.4764$  |  $Median = 2.48$   
 $Range = 0.07$

Class Intervals	Class Marks (x)	Lower Limits	Upper Limits	Frequency (f)	Relative Frequency (F)	Cumulative Frequency F*x	MD	Abs MD	F*MD^2
2.45 - 2.47	2.46	2.45	2.47	20	0.2	20	0.492	-0.0212	8.9888E-05
2.47 - 2.49	2.48	2.47	2.49	56	0.56	76	1.3888	-0.0012	8.064E-07
2.49 - 2.51	2.5	2.49	2.51	22	0.22	98	0.55	0.0188	7.7757E-05
2.51 - 2.53	2.52	2.51	2.53	2	0.02	100	0.0504	0.0388	3.0109E-05

Mean	2.4812
Median	2.4807
Mode	2.4803
SD	0.014091



## Discussion

**Q1) What are the various means of the graphical display of data? When is a Histogram used?**

Ans)

The different types of graphical representation are line graphs, bar graphs, histograms, line plots, frequency table, circle graph, stem and leaf plot, box and whisker plot.

A histogram is used when we need to observe the normal distribution for a process.

Also, any variation is quickly detected in a histogram by routinely producing histograms.

**Q2) Describe any peculiarities you notice in the frequency polygons and try to explain the cause for them?**

Ans)

**A) For rivets**

i) The shape of the frequency polygon for both sets (50 and 100) almost remains the same. This is probably because 50 samples were sufficient for predicting the weight of the rivet, and adding more samples is not affecting the polygon much.

ii) The class intervals are continuous, i.e. the four class intervals are having a non-zero frequency.

**B) For marbles**

i) The shape of the frequency polygon for both sets (50 and 100) almost remains the same. This is probably because 50 samples were sufficient for predicting the diameter of the marble, and adding more samples is not affecting the polygon much.

ii) There is a one-off sample (12.31 mm) having significant deviation from mean. Because of this, the frequency of two in-between class intervals remains null.

**Q3) How do you obtain the internal estimate of error from the statistical quantities determined above?**

Ans)

It can be obtained by dividing Standard Deviation by the total number of samples, i.e.

$$U = S/\sqrt{n}$$

**A) For rivets**

$$S = 0.014091 \text{ gm}, n = 100 \Rightarrow U = 0.0014091 \text{ gm}$$

**B) For marbles**

$$S = 0.67005 \text{ mm}, n = 100 \Rightarrow U = 0.067005 \text{ mm}$$