Solutions Manual

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# Chapter 1

# Introduction

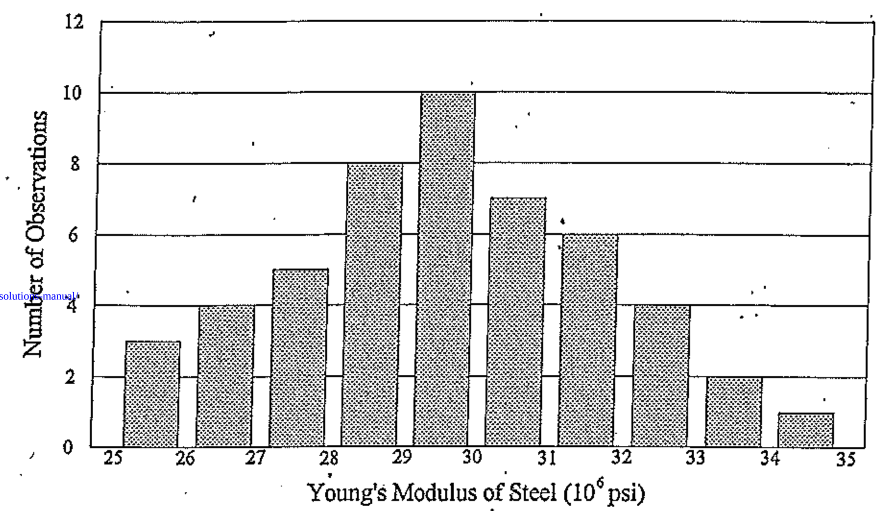
**1.1** (a)

Data

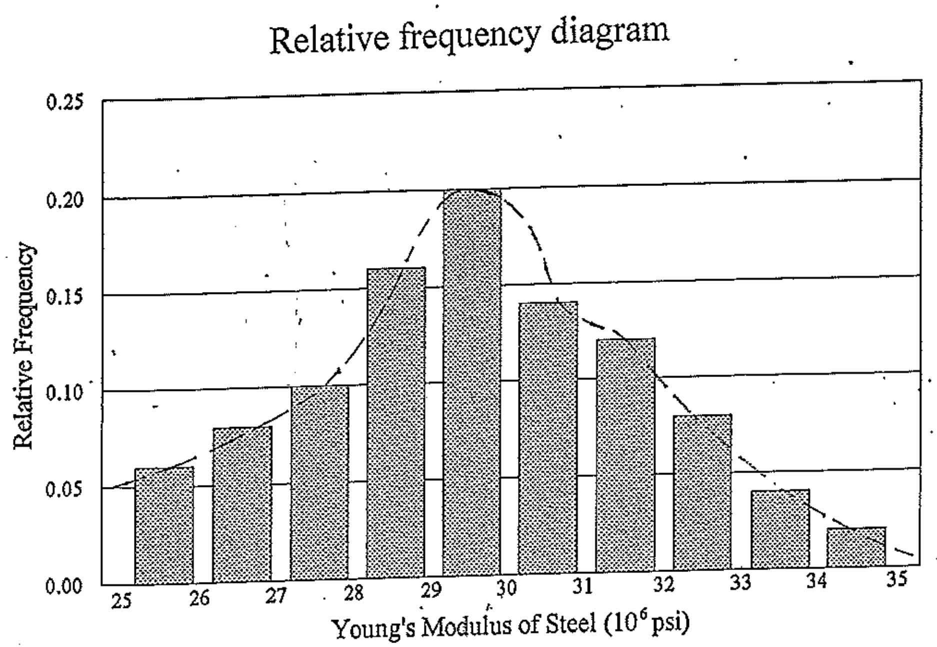
| | | | | |
|---|---|---|---|---|
| 25.1 | 27.7 | 29.1 | 30.1 | 31.6 |
| 25.4 | 27.8 | 29.2 | 30.3 | 31.8 |
| 25.9 | 28.1 | 29.3 | 30.4 | 31.9 |
| 26.5 | 28.3 | 29.4 | 30.5 | 32.3 |
| 26.6 | 28.3 | 29.5 | 30.6 | 32.5 |
| 26.8 | 28.4 | 29.6 | 30.8 | 32.7 |
| 26.9 | 28.5 | 29.6 | 30.9 | 32.8 |
| 27.2 | 28.6 | 29.7 | 31.2 | 33.4 |
| 27.4 | 28.7 | 29.8 | 31.3 | 33.8 |
| 27.6 | 28.9 | 29.9 | 31.4 | 34.7 |

| Interval | Observations | Freq |
|---|---|---|
| 25-26 | 3 | 0.060 |
| 26-27 | 4 | 0.080 |
| 27-28 | 5 | 0.100 |
| 28-29 | 8 | 0.160 |
| 29-30 | 10 | 0.200 |
| 30-31 | 7 | 0.140 |
| 31-32 | 6 | 0.120 |
| 32-33 | 4 | 0.080 |
| 33-34 | 2 | 0.040 |
| 34-35 | 1 | 0.020 |
| | 50 | 1.000 |

Histogram



(b)




(c)

| DATA | YOUNG'S MOD | Xi - Xave | (Xi - Xave)^2 |
|---|---|---|---|
| 25.1 | 25100000 | -4476000 | 2.0035E+13 |
| 29.9 | 29900000 | 324000 | 1.0498E+11 |
| 28.1 | 28100000 | -1476000 | 2.1786E+12 |
| 32.5 | 32500000 | 2924000 | 8.5498E+12 |
| 28.5 | 28500000 | -1076000 | 1.1578E+12 |
| 29.4 | 29400000 | -176000 | 3.0976E+10 |
| 25.4 | 25400000 | -4176000 | 1.7439E+13 |
| 33.4 | 33400000 | 3824000 | 1.4623E+13 |
| 31.9 | 31900000 | 2324000 | 5.401E+12 |
| 26.6 | 26600000 | -2976000 | 8.8566E+12 |
| 26.5 | 26500000 | -3076000 | 9.4618E+12 |
| 31.2 | 31200000 | 1624000 | 2.6374E+12 |
| 29.2 | 29200000 | -376000 | 1.4138E+11 |
| 26.9 | 26900000 | -2676000 | 7.161E+12 |
| 29.3 | 29300000 | -276000 | 7.6176E+10 |
| 30.5 | 30500000 | 924000 | 8.5378E+11 |
| 28.6 | 28600000 | -976000 | 9.5258E+11 |
| 28.3 | 28300000 | -1276000 | 1.6282E+12 |
| 33.8 | 33800000 | 4224000 | 1.7842E+13 |
| 26.8 | 26800000 | -2776000 | 7.7062E+12 |
| 27.4 | 27400000 | -2176000 | 4.735E+12 |
| 32.3 | 32300000 | 2724000 | 7.4202E+12 |
| 29.8 | 29800000 | 224000 | 5.0176E+10 |
| 30.3 | 30300000 | 724000 | 5.2418E+11 |
| 30.4 | 30400000 | 824000 | 6.7898E+11 |
| 31.6 | 31600000 | 2024000 | 4.0966E+12 |
| 29.5 | 29500000 | -76000 | 5776000000 |
| 28.7 | 28700000 | -876000 | 7.6738E+11 |
| 30.9 | 30900000 | 1324000 | 1.753E+12 |

| | | | |
|---|---|---|---|
| 27.8 | 27800000 | -1776000 | 3.1542E+12 |
| 28.4 | 28400000 | -1176000 | 1.383E+12 |
| 34.7 | 34700000 | 5124000 | 2.6255E+13 |
| 30.1 | 30100000 | 524000 | 2.7458E+11 |
| 25.9 | 25900000 | -3676000 | 1.3513E+13 |
| 31.4 | 31400000 | 1824000 | 3.327E+12 |
| 32.8 | 32800000 | 3224000 | 1.0394E+13 |
| 30.6 | 30600000 | 1024000 | 1.0486E+12 |
| 29.6 | 29600000 | 24000 | 576000000 |
| 29.6 | 29600000 | 24000 | 576000000 |
| 28.9 | 28900000 | -676000 | 4.5698E+11 |
| 29.1 | 29100000 | -476000 | 2.2658E+11 |
| 27.2 | 27200000 | -2376000 | 5.6454E+12 |
| 31.3 | 31300000 | 1724000 | 2.9722E+12 |
| 27.6 | 27600000 | -1976000 | 3.9046E+12 |
| 32.7 | 32700000 | 3124000 | 9.7594E+12 |
| 28.3 | 28300000 | -1276000 | 1.6282E+12 |
| 31.8 | 31800000 | 2224000 | 4.9462E+12 |
| 30.8 | 30800000 | 1224000 | 1.4982E+12 |
| 27.7 | 27700000 | -1876000 | 3.5194E+12 |
| 29.7 | 29700000 | 124000 | 1.5376E+10 |
| | | | |
| TOTAL SUM | 1478800000 | | 2.4079E+14 |
| MEAN VALUE | 29576000 | Lb/in² | |
| STD DEV | 2194498.58 | Lb/in² | |
| | | | |

$\therefore\ \bar{X} = 29.5760$ Mpsi = mean value

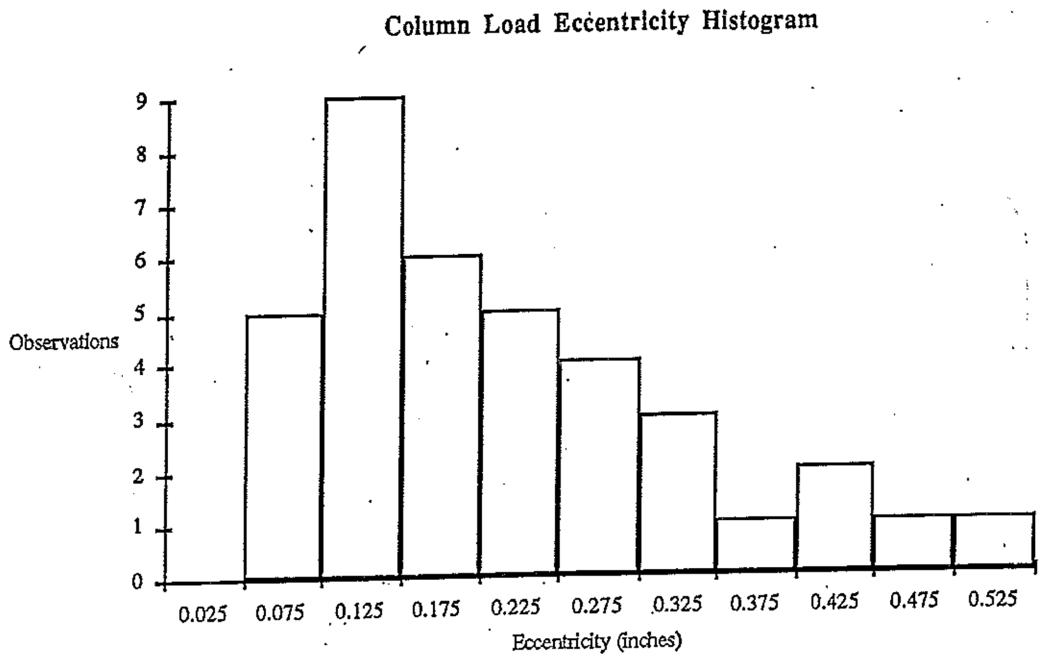
$s_x = 2.1945$ Mpsi = standard deviation

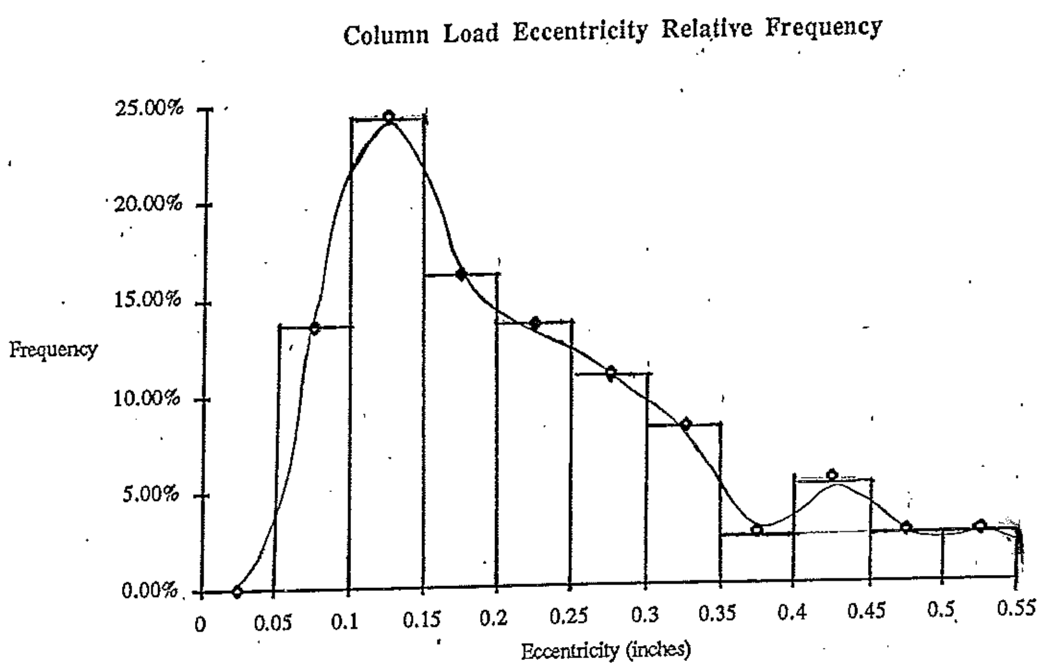
## 1.2

Observations of eccentricity of applied load

| n | e<br>inches | Σe<br>inches | Σe^2<br>inches^2 |
|---|---|---|---|
| 1 | 0.410 | 0.410 | 0.1681 |
| 2 | 0.050 | 0.460 | 0.1706 |
| 3 | 0.090 | 0.550 | 0.1787 |
| 4 | 0.195 | 0.745 | 0.216725 |
| 5 | 0.345 | 1.090 | 0.33575 |
| 6 | 0.155 | 1.245 | 0.359775 |
| 7 | 0.320 | 1.565 | 0.462175 |
| 8 | 0.120 | 1.685 | 0.476575 |
| 9 | 0.290 | 1.975 | 0.560675 |
| 10 | 0.065 | 2.040 | 0.5649 |
| 11 | 0.275 | 2.315 | 0.640525 |
| 12 | 0.230 | 2.545 | 0.693425 |
| 13 | 0.140 | 2.685 | 0.713025 |
| 14 | 0.265 | 2.950 | 0.78325 |
| 15 | 0.215 | 3.165 | 0.829475 |
| 16 | 0.070 | 3.235 | 0.834375 |
| 17 | 0.115 | 3.350 | 0.8476 |
| 18 | 0.305 | 3.655 | 0.940625 |
| 19 | 0.435 | 4.090 | 1.12985 |
| 20 | 0.130 | 4.220 | 1.14675 |
| 21 | 0.535 | 4.755 | 1.432975 |
| 22 | 0.110 | 4.865 | 1.445075 |
| 23 | 0.205 | 5.070 | 1.4871 |
| 24 | 0.085 | 5.155 | 1.494325 |
| 25 | 0.135 | 5.290 | 1.51255 |
| 26 | 0.125 | 5.415 | 1.528175 |
| 27 | 0.185 | 5.600 | 1.5624 |
| 28 | 0.480 | 6.080 | 1.7928 |
| 29 | 0.175 | 6.255 | 1.823425 |
| 30 | 0.145 | 6.400 | 1.84445 |
| 31 | 0.380 | 6.780 | 1.98885 |
| 32 | 0.165 | 6.945 | 2.016075 |
| 33 | 0.255 | 7.200 | 2.0811 |
| 34 | 0.180 | 7.380 | 2.1135 |
| 35 | 0.240 | 7.620 | 2.1711 |
| 36 | 0.220 | 7.840 | 2.2195 |
| 37 | 0.105 | 7.945 | 2.230525 |

| Number of observations in each interval | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| From: | 0 | 0.05 | 0.1 | 0.15 | 0.2 | 0.25 | 0.3 | 0.35 | 0.4 | 0.45 | 0.5 |
| To: | 0.05 | 0.1 | 0.15 | 0.2 | 0.25 | 0.3 | 0.35 | 0.4 | 0.45 | 0.5 | 0.55 |
| Midpoint | 0.025 | 0.075 | 0.125 | 0.175 | 0.225 | 0.275 | 0.325 | 0.375 | 0.425 | 0.475 | 0.525 |
| Total: | 0 | 5 | 9 | 6 | 5 | 4 | 3 | 1 | 2 | 1 | 1 |
| Frequency: | 0.00% | 13.51% | 24.32% | 16.22% | 13.51% | 10.81% | 8.11% | 2.70% | 5.41% | 2.70% | 2.70% |




Mean value of eccentricity $= \bar{E} \simeq \mu_E = \frac{1}{N}\sum_{i=1}^{N} E_i = \frac{7.945}{37}$

$= 0.215$ inch

Standard deviation of eccentricity $= \left\{\frac{1}{N}\sum_{i=1}^{N}(E_i - \bar{E})^2\right\}^{\frac{1}{2}}$

$= \left\{\frac{1}{N}\sum_{i=1}^{N} E_i^2 - \left(\frac{1}{N}\sum_{i=1}^{N} E_i\right)^2\right\}^{\frac{1}{2}} = 0.119$ inch

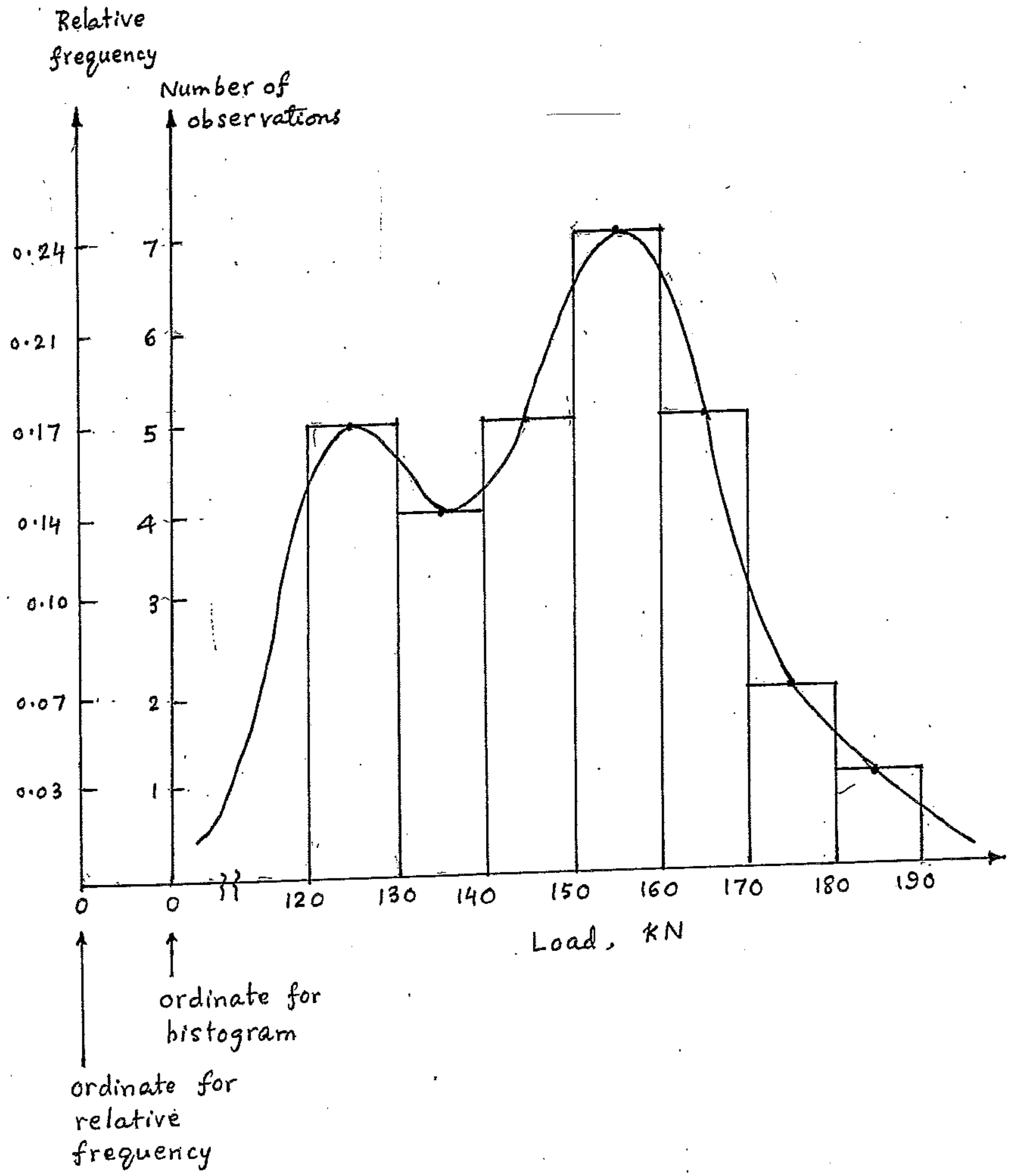
**1.3** 29 values of maximum load carried by welded beams given.

smallest value: 123.1 kN, Largest value: 186.9 kN

Range chosen: 120 kN – 190 kN

All data points are grouped into 7 intervals of 10 kN each.

| Range of load: | Frequency of load values falling in the range |
|---|---|
| ≥ 120 < 130 kN | 5 |
| ≥ 130 < 140 kN | 4 |
| ≥ 140 < 150 kN | 5 |
| ≥ 150 < 160 kN | 7 |
| ≥ 160 < 170 kN | 5 |
| ≥ 170 < 180 kN | 2 |
| ≥ 180 < 190 kN | 1 |


Relative frequency
Number of observations
0.24
0.21
0.17
0.14
0.10
0.07
0.03
0
7
6
5
4
3
2
1
0
120
130
140
150
160
170
180
190
Load, KN
ordinate for histogram
ordinate for relative frequency

**1.4** Compressive strength of concrete cylinders (in kpsi):

Data:

| | | | | | |
|---|---|---|---|---|---|
| 5.9 | 6.2 | 5.8 | 7.8 | 6.5 | → Σ = 32.2 |
| 6.3 | 8.9 | 5.3 | 3.7 | 1.4 | → Σ = 25.6 |
| 2.1 | 6.8 | 9.1 | 4.3 | 3.2 | → Σ = 25.5 |
| 7.2 | 6.1 | 5.7 | 4.9 | 2.6 | → Σ = 26.5 |
| 3.4 | 6.8 | 8.3 | 5.1 | 7.3 | → Σ = 30.9 |
| 8.2 | 7.7 | 5.4 | 3.7 | 4.5 | → Σ = 29.5 |
| 4.1 | 5.6 | 6.4 | 6.7 | 7.9 | → Σ = 30.7 |
| 6.9 | 7.5 | 5.2 | 4.3 | 6.6 | → Σ = 30.5 |
| 5.4 | 6.4 | | | | → Σ = 11.8 |

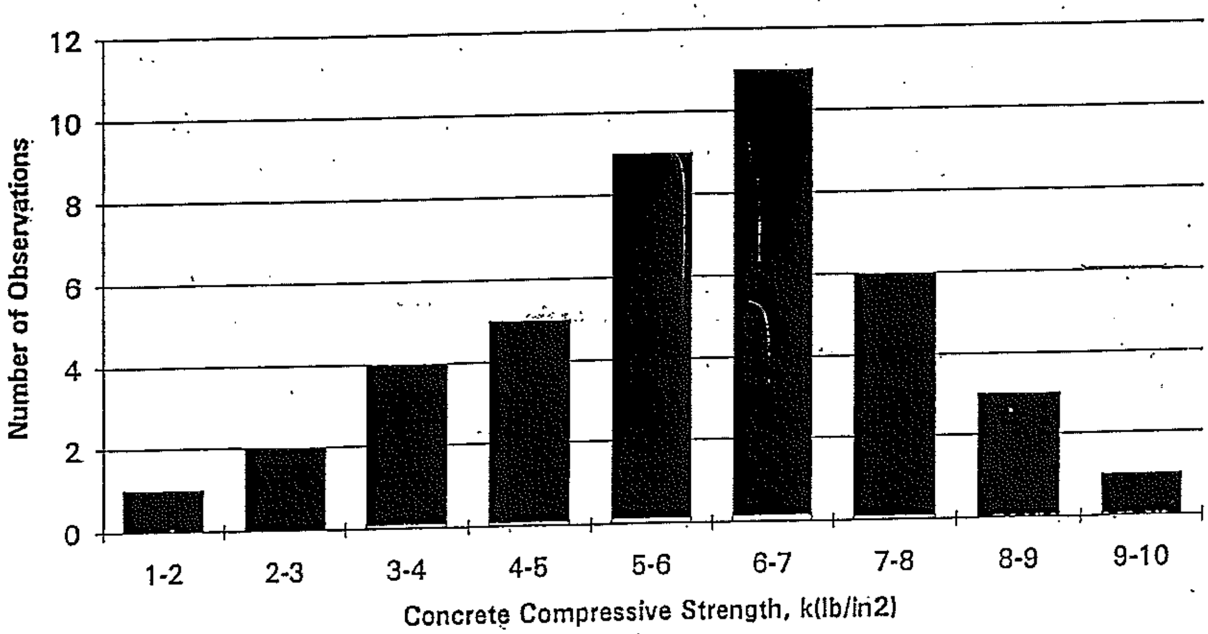
Total sum = 243.2

Mean value $= \bar{x} = \frac{243.2}{42} = 5.79$ kpsi

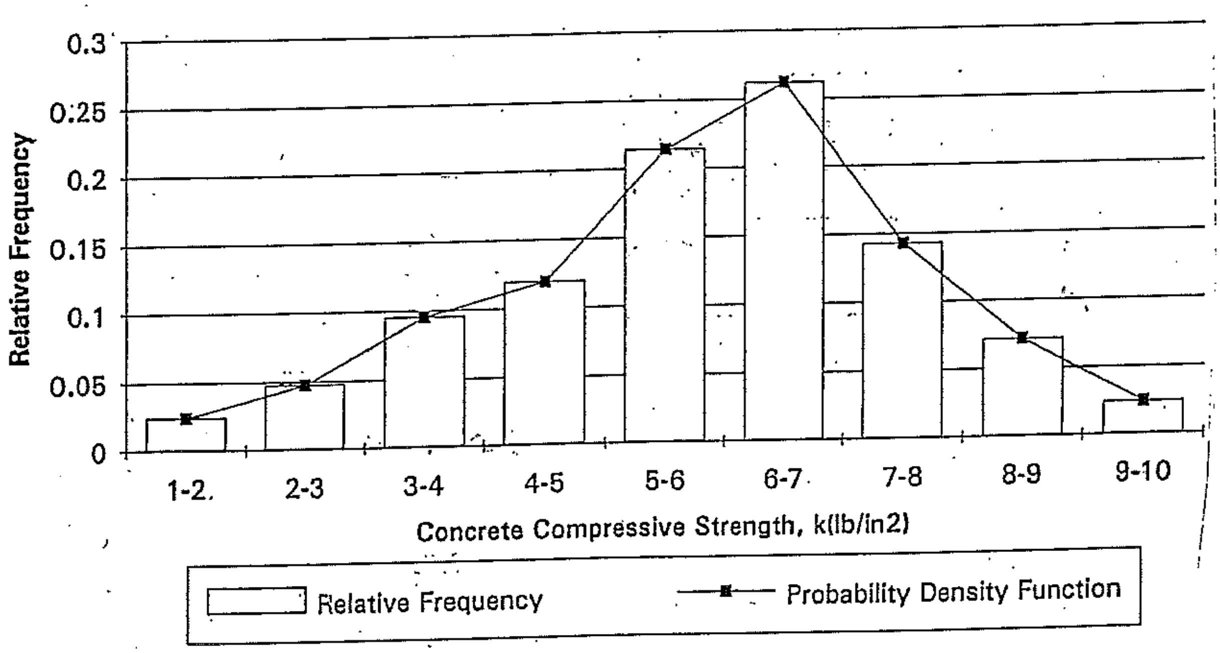
Standard deviation $= s_x = \left\{ \frac{1}{N-1} \sum_{i=1}^{N} (x_i - \bar{x})^2 \right\}^{\frac{1}{2}} = 1.81$ kpsi

| Range of compressive strength (kpsi) | Number of occurrances | Relative frequency |
|---|---|---|
| 1 – 2 | 1 | 1/42 = 0.024 |
| 2 – 3 | 2 | 2/42 = 0.048 |
| 3 – 4 | 4 | 4/42 = 0.095 |
| 4 – 5 | 5 | 5/42 = 0.119 |
| 5 – 6 | 9 | 9/42 = 0.214 |
| 6 – 7 | 11 | 11/42 = 0.262 |
| 7 – 8 | 6 | 6/42 = 0.143 |
| 8 – 9 | 3 | 3/42 = 0.071 |
| 9 – 10 | 1 | 1/42 = 0.024 |

Histogram



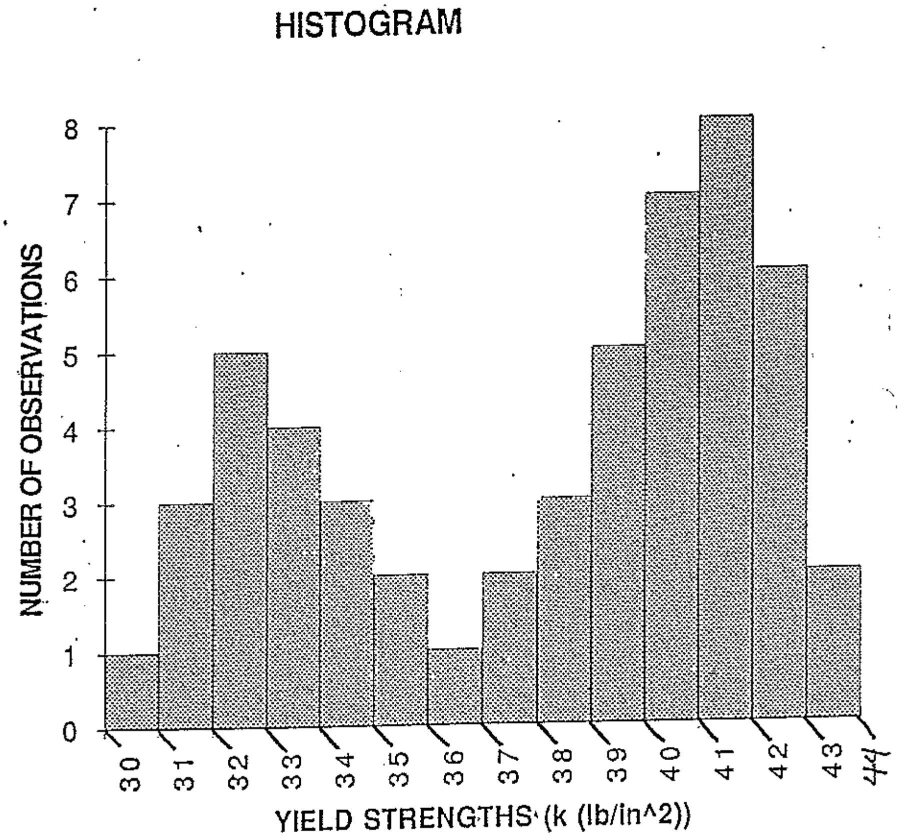

Relative frequency diagram



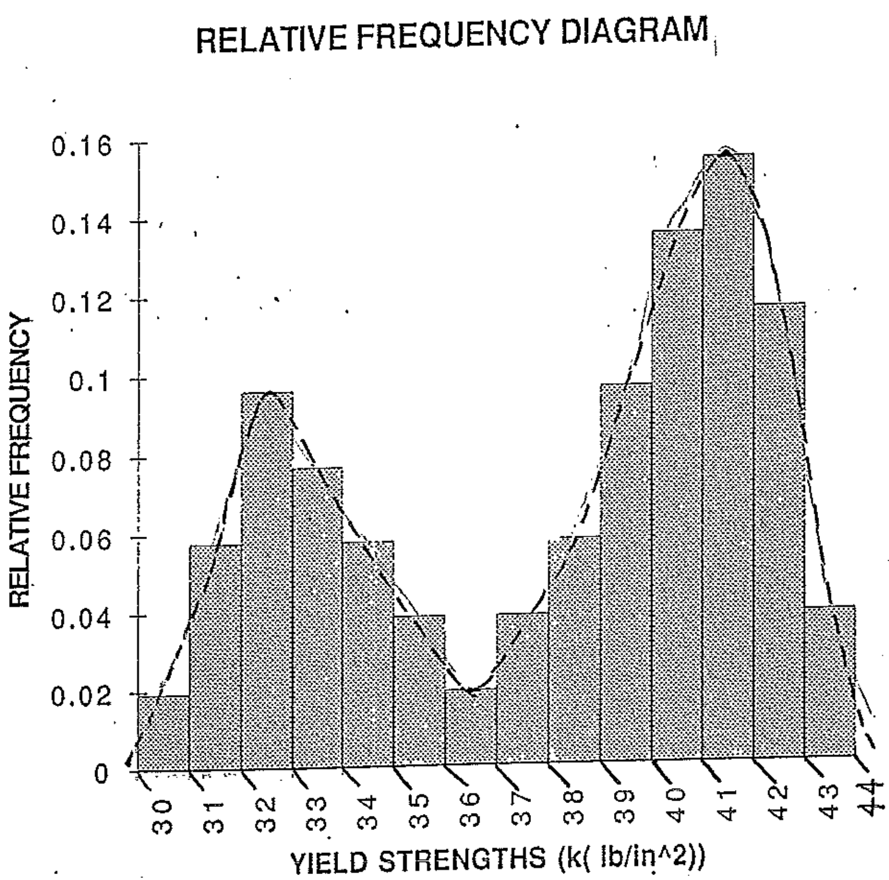
**1.5** yield strength data of reinforcing bars (in Kpsi) made of two different grades of steel:

| Range | # of Occourances | Relative Frequency |
|---|---|---|
| 30.0 - 30.9 | 1 | 0.019 |
| 31.0 - 31.9 | 3 | 0.058 |
| 32.0 - 32.9 | 5 | 0.096 |
| 33.0 - 33.9 | 4 | 0.077 |
| 34.0 - 34.9 | 3 | 0.058 |
| 35.0 - 35.9 | 2 | 0.038 |
| 36.0 - 36.9 | 1 | 0.019 |
| 37.0 - 37.9 | 2 | 0.038 |
| 38.0 - 38.9 | 3 | 0.058 |
| 39.0 - 39.9 | 5 | 0.096 |
| 40.0 - 40.9 | 7 | 0.135 |
| 41.0 - 41.9 | 8 | 0.154 |
| 42.0 - 42.9 | 6 | 0.115 |
| 43.0 - 43.9 | 2 | 0.038 |

(a)


HISTOGRAM
NUMBER OF OBSERVATIONS
0
1
2
3
4
5
6
7
8
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
YIELD STRENGTHS (k (lb/in^2))

(b)


RELATIVE FREQUENCY DIAGRAM
RELATIVE FREQUENCY
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
YIELD STRENGTHS (k( lb/in^2))

(c) The relative frequency diagram has two distinct peaks which shows that the two grades of steel have two different average yield strengths which are approximately 32.5 and 41.5 k(lb/in$^2$).

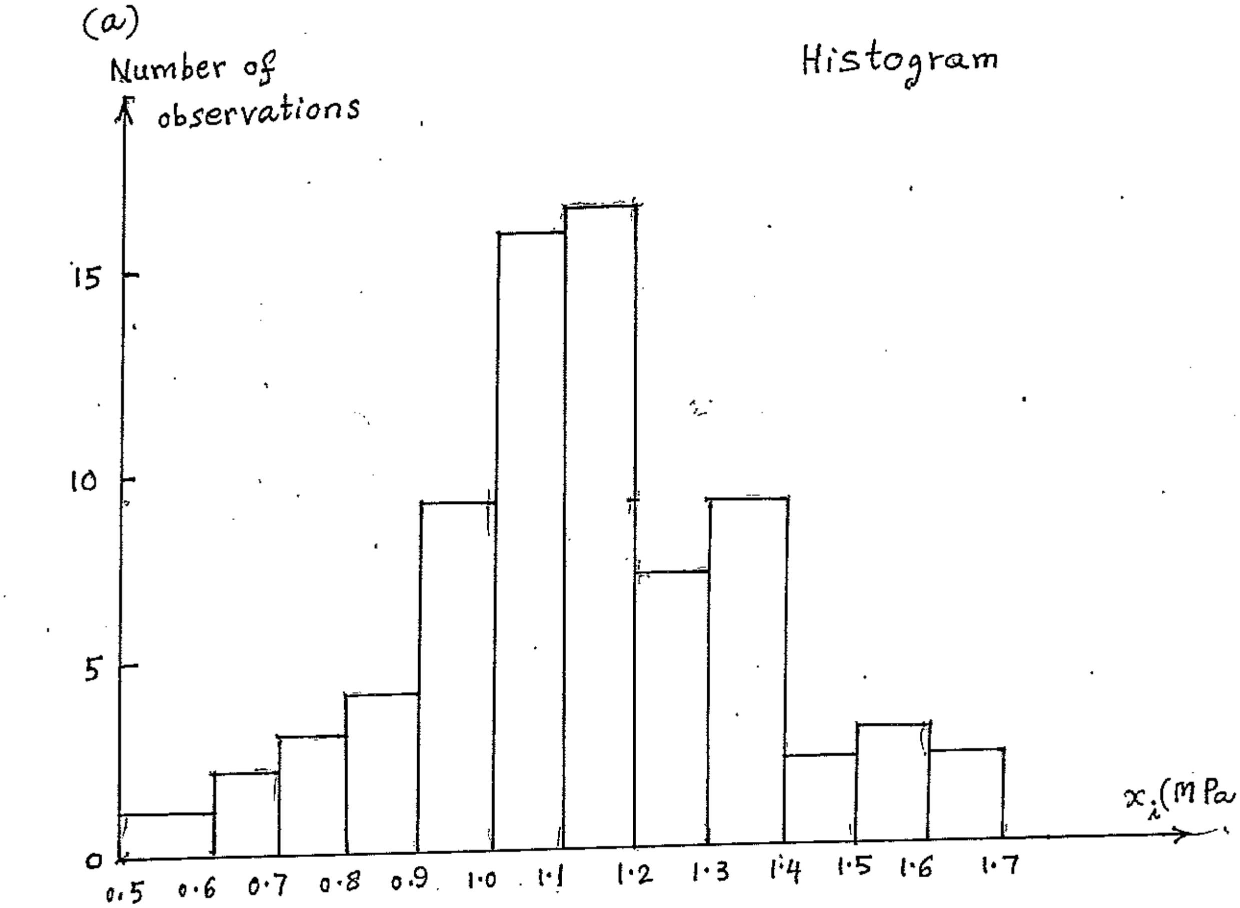
(d)

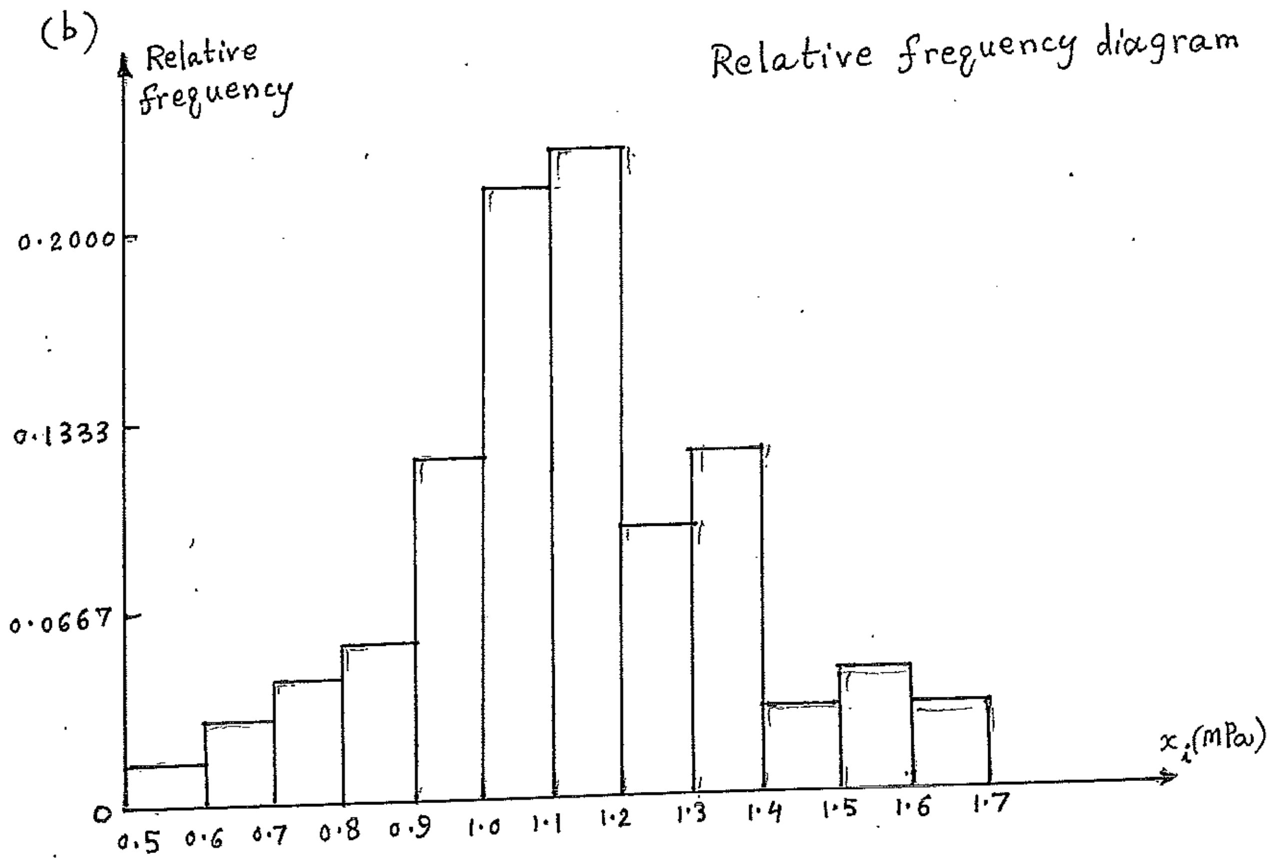
| DATA | Y.STRENGTHS | Xi - Xave | (Xi - Xave)^2 |
|---|---|---|---|
| 35.7 | 35700 | -2315.38462 | 5361005.92 |
| 31.1 | 31100 | -6915.38462 | 47822544.4 |
| 33.2 | 33200 | -4815.38462 | 23187929 |
| 42.5 | 42500 | 4484.61538 | 20111775.1 |
| 41.2 | 41200 | 3184.61538 | 10141775.1 |
| 42.8 | 42800 | 4784.61538 | 22892544.4 |
| 37.5 | 37500 | -515.384615 | 265621.302 |
| 40.7 | 40700 | 2684.61538 | 7207159.76 |
| 42.3 | 42300 | 4284.61538 | 18357929 |
| 42.2 | 42200 | 4184.61538 | 17511005.9 |
| 34.1 | 34100 | -3915.38462 | 15330236.7 |
| 40.9 | 40900 | 2884.61538 | 8321005.92 |
| 43.3 | 43300 | 5284.61538 | 27927159.8 |
| 38.8 | 38800 | 784.615385 | 615621.302 |
| 40.4 | 40400 | 2384.61538 | 5686390.53 |
| 42.9 | 42900 | 4884.61538 | 23859467.5 |
| 38.4 | 38400 | 384.615385 | 147928.994 |
| 41.7 | 41700 | 3684.61538 | 13576390.5 |
| 42.7 | 42700 | 4684.61538 | 21945621.3 |
| 40.1 | 40100 | 2084.61538 | 4345621.3 |
| 41.4 | 41400 | 3384.61538 | 11455621.3 |
| 39.2 | 39200 | 1184.61538 | 1403313.61 |
| 43.4 | 43400 | 5384.61538 | 28994082.8 |
| 40.8 | 40800 | 2784.61538 | 7754082.84 |
| 39.6 | 39600 | 1584.61538 | 2511005.92 |
| 33.8 | 33800 | -4215.38462 | 17769467.5 |
| 36.6 | 36600 | -1415.38462 | 2003313.61 |
| 39.9 | 39900 | 1884.61538 | 3551775.15 |
| 32.3 | 32300 | -5715.38462 | 32665621.3 |
| 32.6 | 32600 | -5415.38462 | 29326390.5 |
| 32.9 | 32900 | -5115.38462 | 26167159.8 |
| 34.5 | 34500 | -3515.38462 | 12357929 |
| 30.2 | 30200 | -7815.38462 | 61080236.7 |
| 38.1 | 38100 | 84.6153846 | 7159.76331 |
| 41.5 | 41500 | 3484.61538 | 12142544.4 |
| 31.2 | 31200 | -6815.38462 | 46449467.5 |
| 31.7 | 31700 | -6315.38462 | 39884082.8 |
| 34.6 | 34600 | -3415.38462 | 11664852.1 |
| 41.1 | 41100 | 3084.61538 | 9514852.07 |

| | | | |
|---|---|---|---|
| 37.2 | 37200 | -815.384615 | 664852.071 |
| 39.5 | 39500 | 1484.61538 | 2204082.84 |
| 39.3 | 39300 | 1284.61538 | 1650236.69 |
| 35.5 | 35500 | -2515.38462 | 6327159.76 |
| 33.7 | 33700 | -4315.38462 | 18622544.4 |
| 32.5 | 32500 | -5515.38462 | 30419467.5 |
| 40.3 | 40300 | 2284.61538 | 5219467.46 |
| 41.8 | 41800 | 3784.61538 | 14323313.6 |
| 32.2 | 32200 | -5815.38462 | 33818698.2 |
| 40.6 | 40600 | 2584.61538 | 6680236.69 |
| 33.4 | 33400 | -4615.38462 | 21301775.1 |
| 41.6 | 41600 | 3584.61538 | 12849467.5 |
| 41.3 | 41300 | 3284.61538 | 10788698.2 |
| | | | |
| TOTAL SUM | 1976800 | LB/IN^2 | 816187692 |
| MEAN VALUE | 38015.3846 | LB/IN^2 | |
| STD. DEV. | 3961.80731 | LB/IN^2 | |
| | | | |

**1.6** Data on compressive strength of aluminum-lithium specimens (in MPa):

| Interval of compressive strength (MPa) | Number of observed values | Relative frequency Value |
|---|---|---|
| 0.5001 – 0.6000 | 1 | 0.0133 |
| 0.6001 – 0.7000 | 2 | 0.0267 |
| 0.7001 – 0.8000 | 3 | 0.0400 |
| 0.8001 – 0.9000 | 4 | 0.0533 |
| 0.9001 – 1.0000 | 9 | 0.1200 |
| 1.0001 – 1.1000 | 16 | 0.2133 |
| 1.1001 – 1.2000 | 17 | 0.2267 |
| 1.2001 – 1.3000 | 7 | 0.0933 |
| 1.3001 – 1.4000 | 9 | 0.1200 |
| 1.4001 – 1.5000 | 2 | 0.0267 |
| 1.5001 – 1.6000 | 3 | 0.0400 |
| 1.6001 – 1.7000 | 2 | 0.0267 |
| Total | 75 | 1.0000 |


(a)
Number of observations
Histogram
15
10
5
0
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
$x_i$(MPa


(b)
Relative frequency
Relative frequency diagram
0.2000
0.1333
0.0667
0
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
$x_i$(MPa)

(c) Mean value $= \bar{x} = \frac{1}{75}\sum_{i=1}^{75} x_i = \frac{1}{75}\left(1.0335 + 0.9302 + \cdots + 1.3091\right)$

$= 1.1227$ MPa

Standard deviation $= s_x = \left\{\frac{1}{75}\sum_{i=1}^{75}\left(x_i - \bar{x}\right)^2\right\}^{\frac{1}{2}}$

$= \left\{\frac{1}{75}\left[\left(1.0335 - 1.1227\right)^2 + \cdots + \left(1.3091 - 1.1227\right)^2\right]\right\}^{\frac{1}{2}}$

$= 0.0227$ MPa

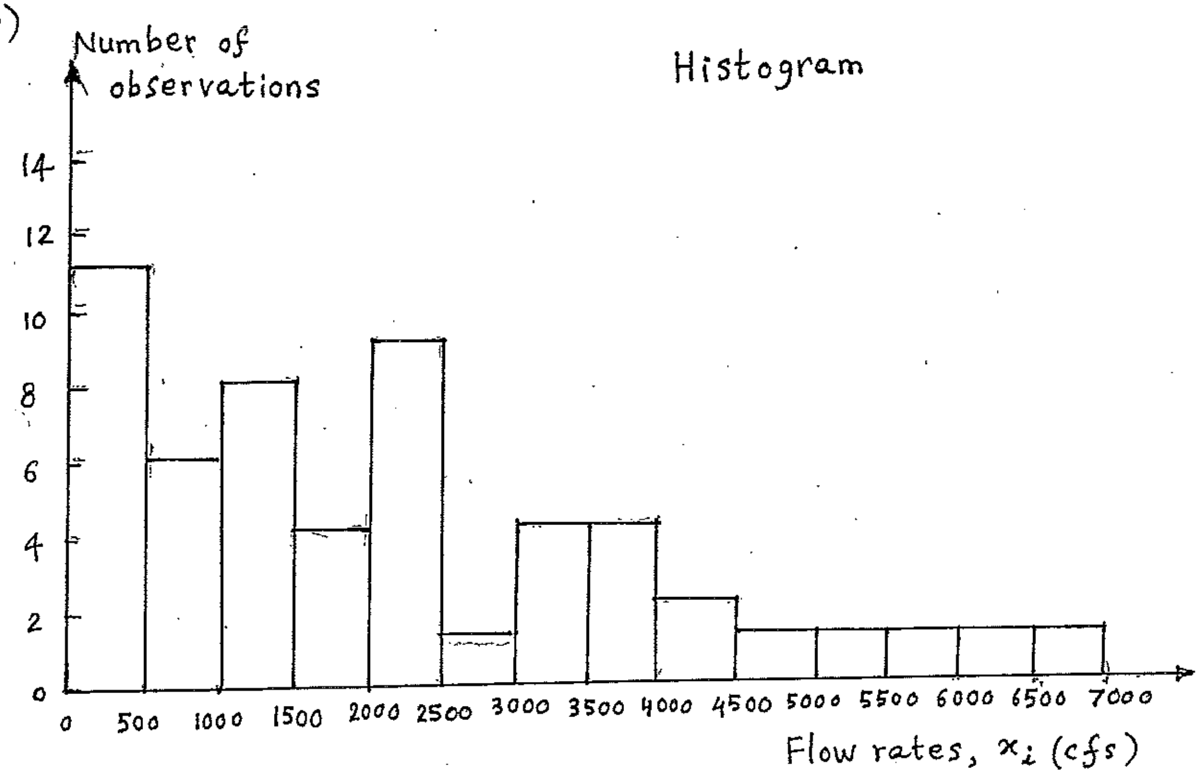
(d) From the given data, number of specimens that gave a value of $x_i$ below 1 MPa = 19 out of 75 $= \frac{19}{75} = 0.2533$ or 25.33 %.

---

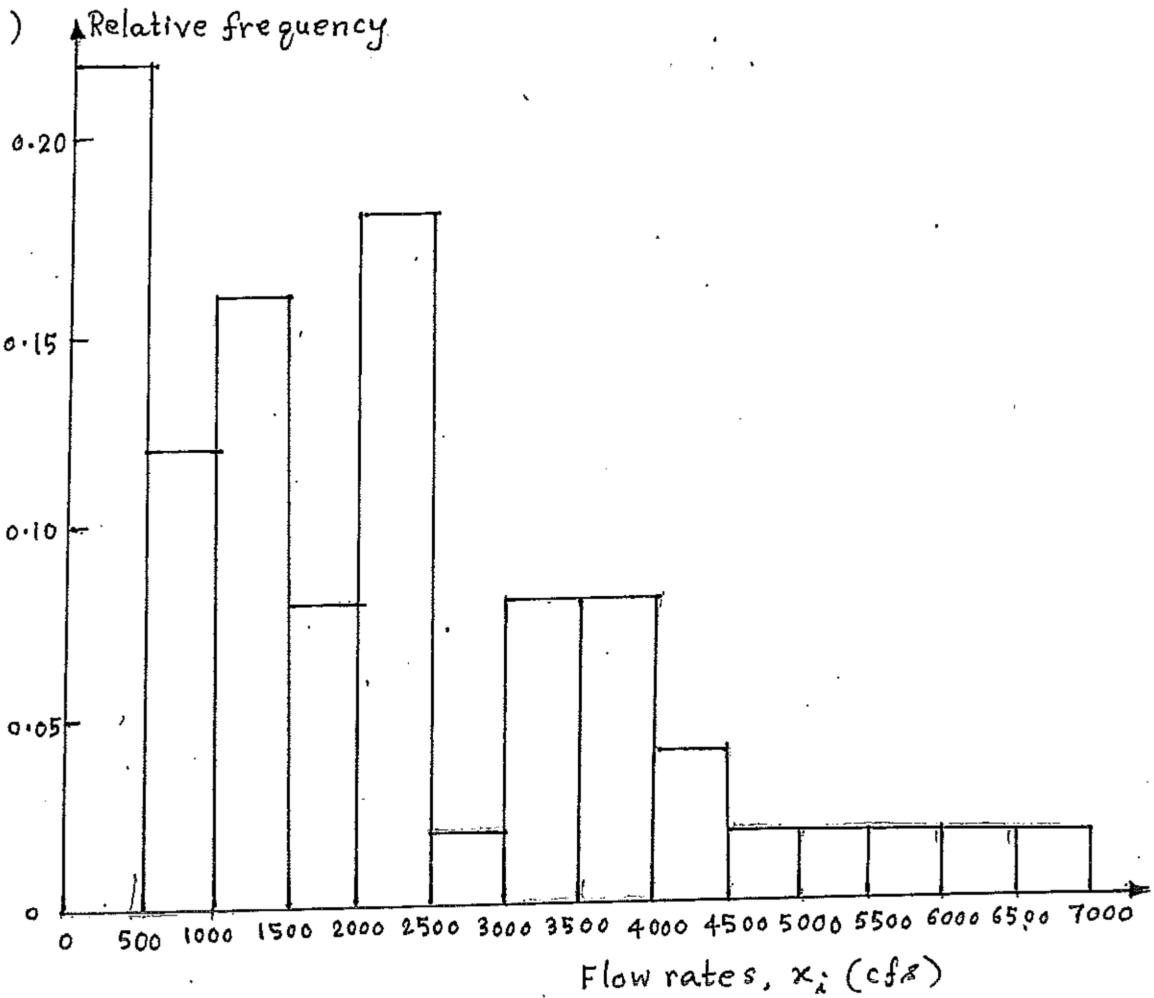
**1.7** Data on annual flow rates in a river (in cfs):
50 data points:

| Interval of flow rate (cfs) | Number of observed values | Relative frequency |
|---|---|---|
| 0 - 500 | 11 | 0.22 |
| 501 – 1000 | 6 | 0.12 |
| 1001 – 1500 | 8 | 0.16 |
| 1501 – 2000 | 4 | 0.08 |
| 2001 – 2500 | 9 | 0.18 |
| 2501 – 3000 | 1 | 0.02 |
| 3001 – 3500 | 4 | 0.08 |
| 3501 – 4000 | 4 | 0.08 |
| 4001 – 4500 | 2 | 0.04 |
| 4501 – 5000 | 0 | 0 |
| 5001 – 5500 | 0 | 0 |
| 5501 – 6000 | 0 | 0 |
| 6001 – 6500 | 0 | 0 |
| 6501 – 7000 | 1 | 0.02 |
| Total | 50 | 1.00 |

(a)


Number of observations
Histogram
14
12
10
8
6
4
2
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
Flow rates, $x_i$ (cfs)

(b)


Relative frequency
0.20
0.15
0.10
0.05
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
Flow rates, $x_i$ (cfs)

(c) Mean value $= \bar{X} = \frac{1}{50} \sum_{i=1}^{50} x_i = \frac{88579}{50}$

$= 1,771.58$ cfs

Standard deviation $= s_x = \left\{ \frac{1}{50} \sum_{i=1}^{50} (x_i - 1771.58)^2 \right\}^{\frac{1}{2}}$

$= 1,382.9$ cfs

(d) Percentage of flow rates exceeding a value of 4000 cfs = 3 out of 50 = 0.06

or 6%

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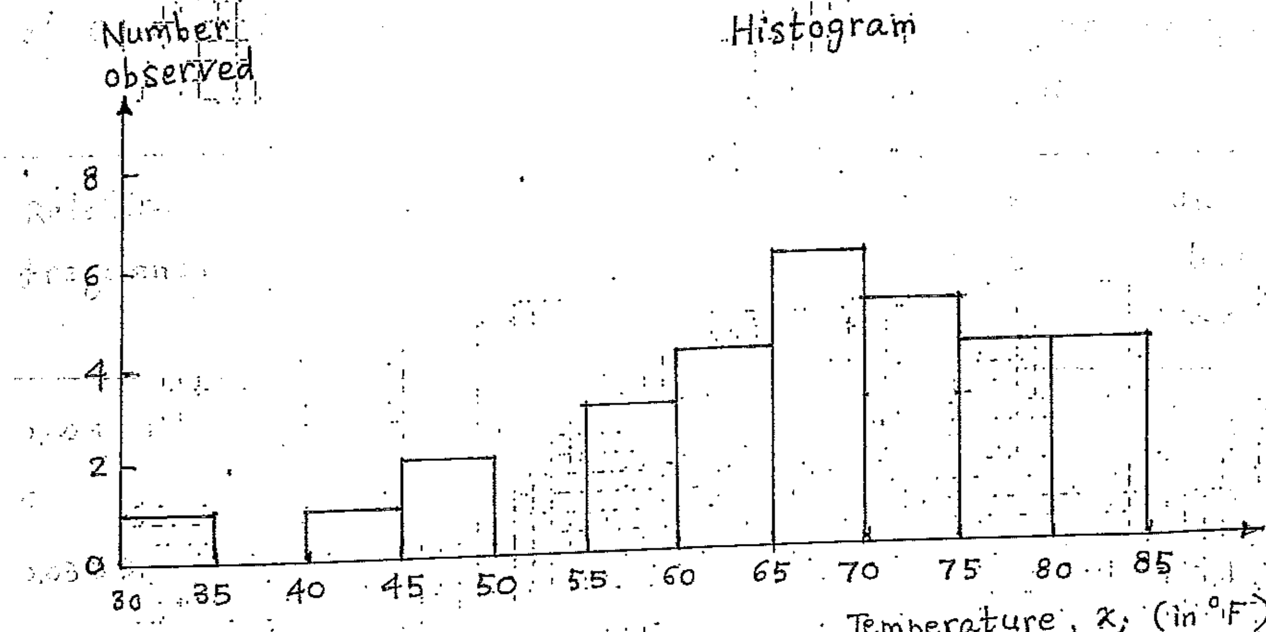
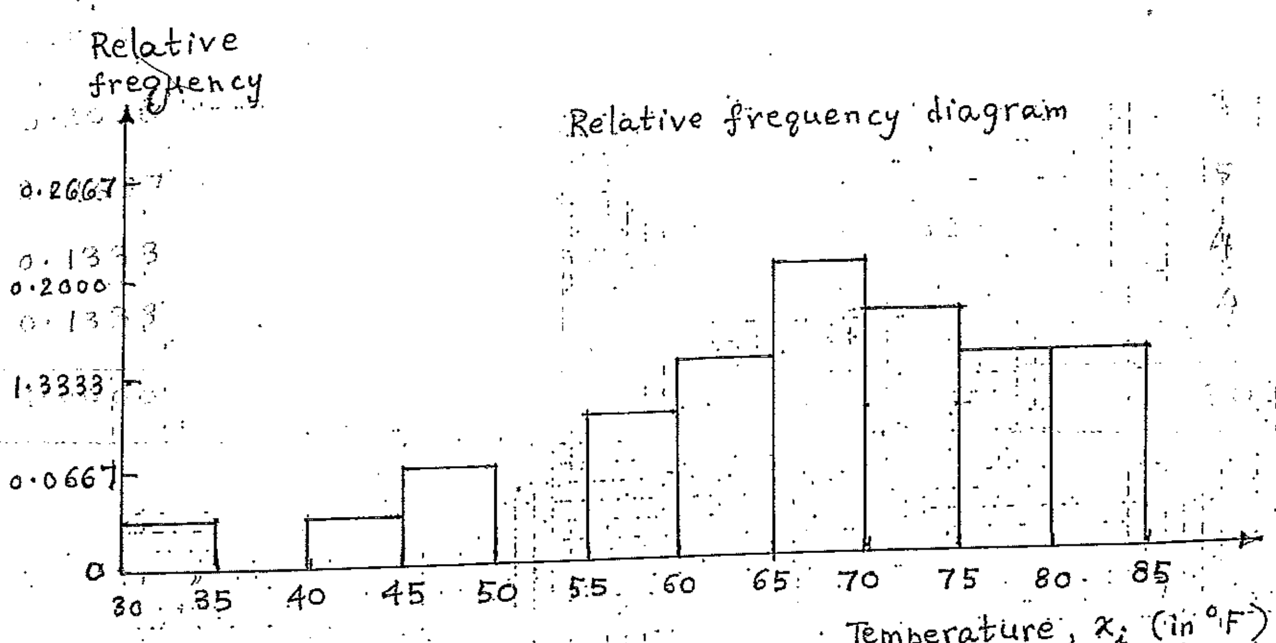
**1.8** Data on joint temperatures of O-rings (in °F); 30 data points.

| Interval of temperature (°F) | Number of observed values | Relative frequency |
|---|---|---|
| 30 – 35 | 1 | 0.0333 |
| 35 – 40 | 0 | 0 |
| 40 – 45 | 1 | 0.0333 |
| 45 – 50 | 2 | 0.0667 |
| 50 – 55 | 0 | 0 |
| 55 – 60 | 3 | 0.1000 |
| 60 – 65 | 4 | 0.1333 |
| 65 – 70 | 6 | 0.2000 |
| 70 – 75 | 5 | 0.1667 |
| 75 – 80 | 4 | 0.1333 |
| 80 – 85 | 4 | 0.1333 |
| Total | 30 | 1.0000 |

(a)


Number observed
Histogram
8
6
4
2
0
30
35
40
45
50
55
60
65
70
75
80
85
Temperature, $x_i$ (in °F)

(b)


Relative frequency
Relative frequency diagram
0.2667
0.2000
1.3333
0.0667
0
30
35
40
45
50
55
60
65
70
75
80
85
Temperature, $x_i$ (in °F)

(c) Mean value $= \bar{X} = \frac{1}{30}\sum_{i=1}^{30} x_i = \frac{1976}{30} = 65.8667\,^\circ F$

Standard deviation $= s_X = \left\{\frac{1}{30}\sum_{i=1}^{30}(x_i - 65.8667)^2\right\}^{\frac{1}{2}}$

$= 2.5498\,^\circ F$

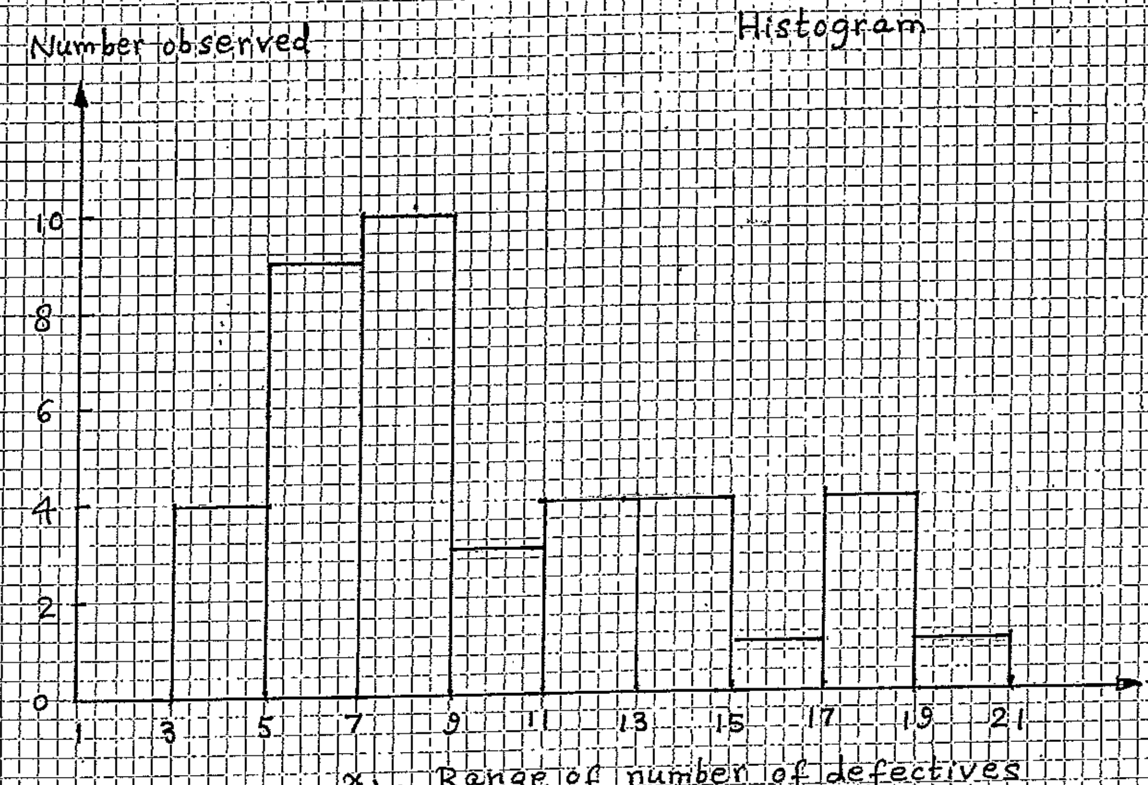
(d) Percentage of joint temperatures falling below freezing point of water ($32^\circ F$) is, from the observed data, 0 out of 30, i.e. 0%.

**1.9** Data on number of defective leaf springs in samples of size 50:

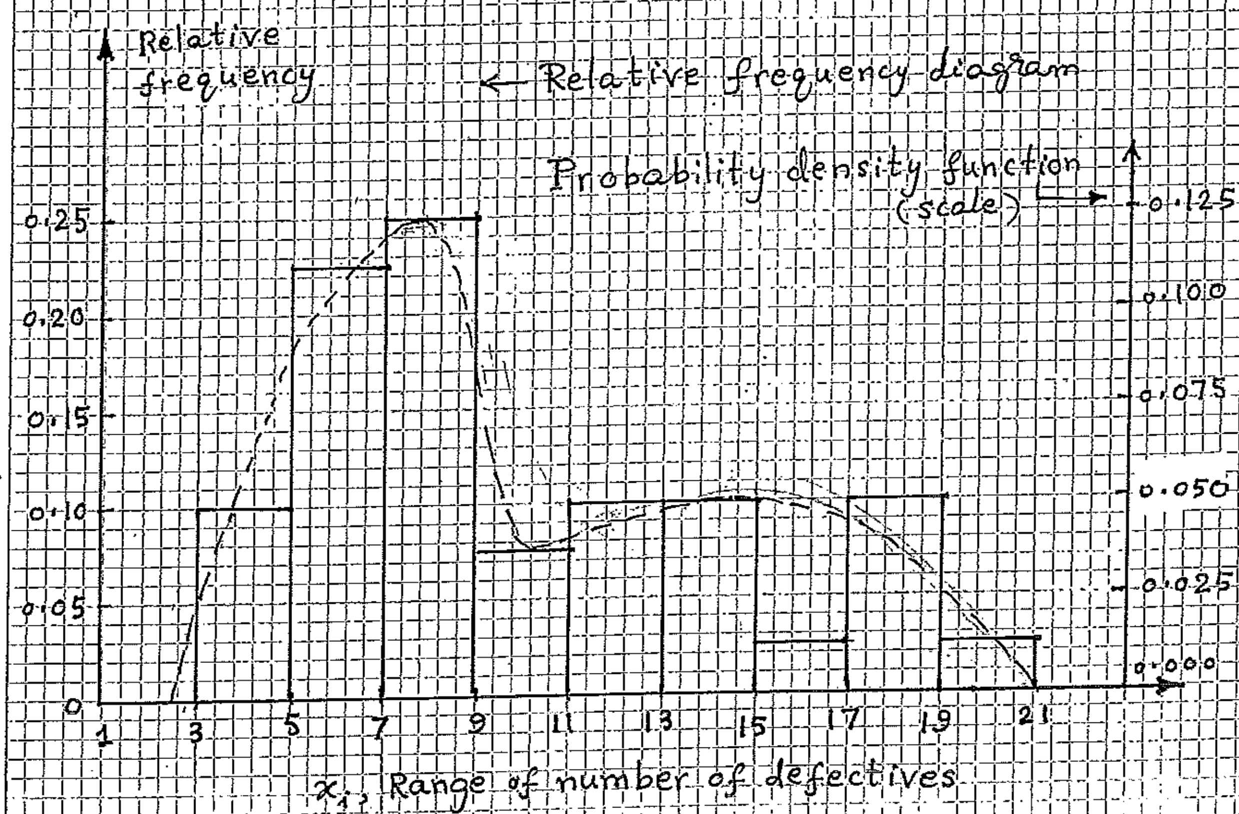
Total data points = 40

| Range of number of defective springs | Number of observed values | Relative frequency |
|---|---|---|
| 3 – 4.9 | 4 | 0.100 |
| 5 – 6.9 | 9 | 0.225 |
| 7 – 8.9 | 10 | 0.250 |
| 9 – 10.9 | 3 | 0.075 |
| 11 – 12.9 | 4 | 0.100 |
| 13 – 14.9 | 4 | 0.100 |
| 15 – 16.9 | 1 | 0.025 |
| 17 – 18.9 | 4 | 0.100 |
| 19 – 20.9 | 1 | 0.025 |
| Total: | 40 | 1.000 |

(a)


Number observed
Histogram
0
2
4
6
8
10
1
3
5
7
9
11
13
15
17
19
21
$x_i$, Range of number of defectives

(b)


Relative frequency
← Relative frequency diagram
Probability density function (scale)
0
0.05
0.10
0.15
0.20
0.25
0.000
0.025
0.050
0.075
0.100
0.125
1
3
5
7
9
11
13
15
17
19
21
$x_i$, Range of number of defectives

(c) Mean value = $\bar{X} = \frac{1}{40} \sum_{i=1}^{40} x_i = 9.375$

Standard deviation = $s_X = \left\{ \frac{1}{40} \sum_{i=1}^{40} (x_i - 9.375)^2 \right\}^{\frac{1}{2}}$

$= 4.4761$

(d) Percentage of defective springs that fall outside the band defined by (mean ± 3 standard deviations)

i.e., $9.375 \pm 3(4.4761) = 9.375 \pm 13.4283$

i.e., $-4.0533$ to $22.8033$

i.e., $0$ to $22.8033$

From the given data, we find that none of the data falls outside $0 - 22.8033$

Hence the required percentage is zero.

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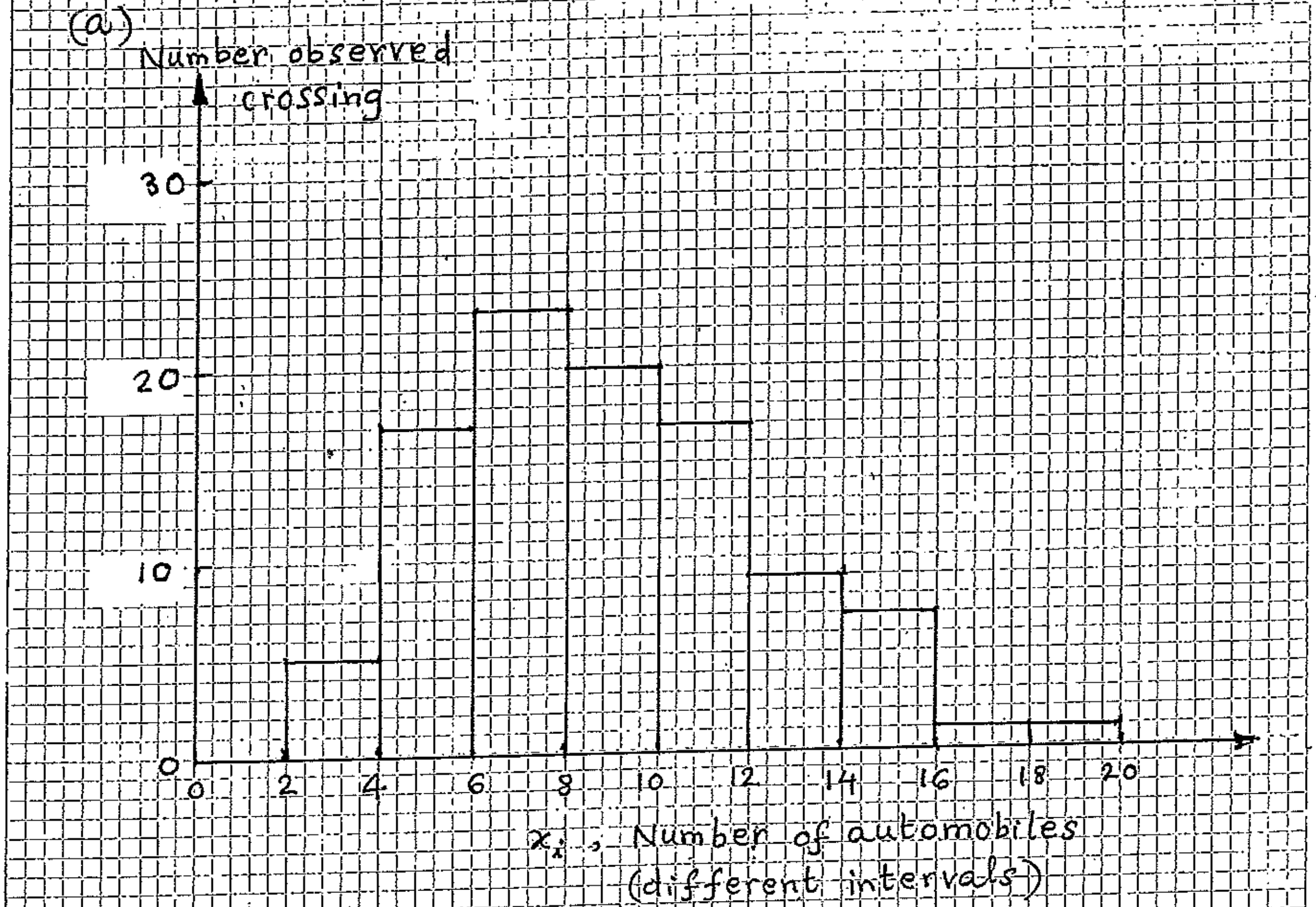
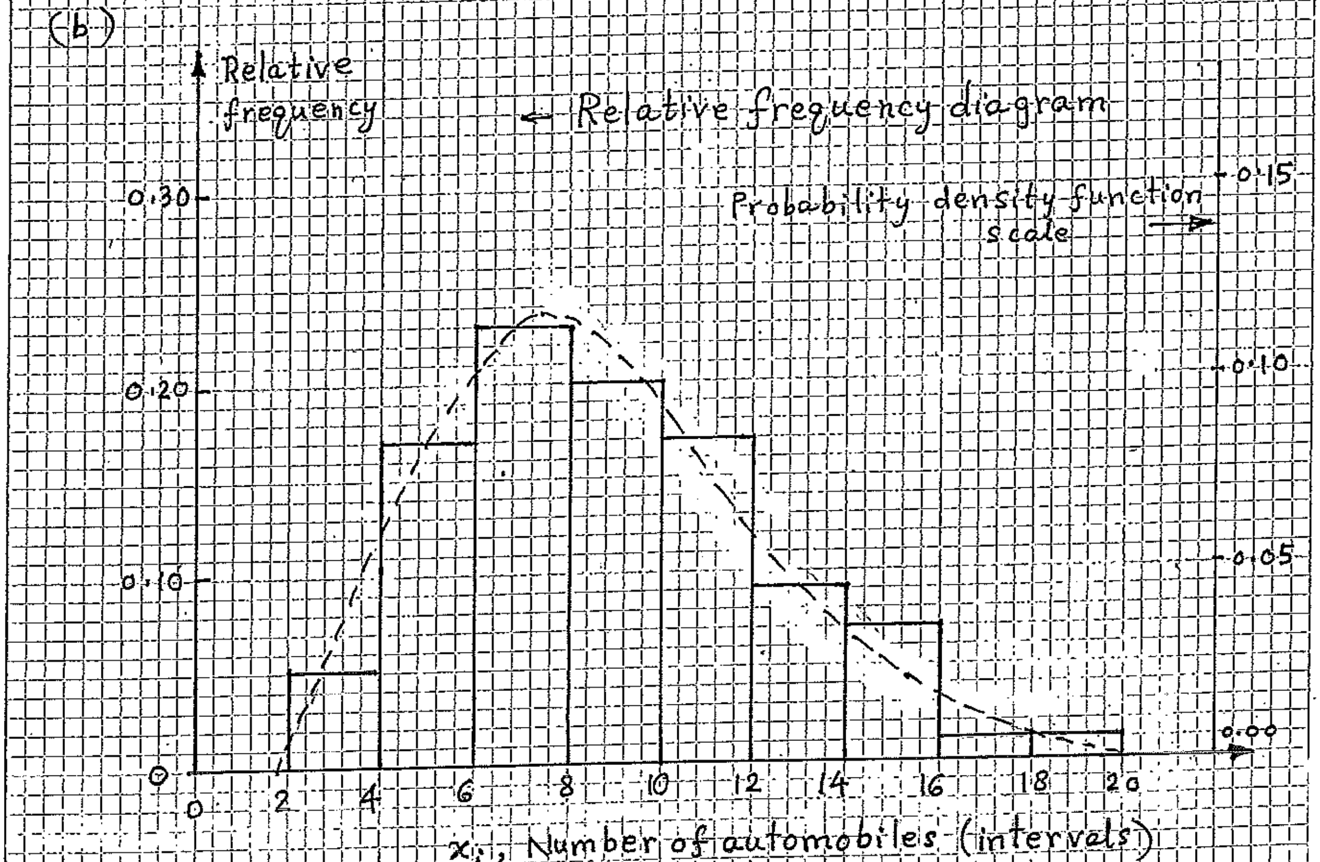
**1.10** Data on number of automobiles crossing an intersection:

Data points: 100

| Number of automobiles crossing intersection | Number observed | Relative frequency |
|---|---|---|
| 1 | 0 | 0 |
| 2 | 0 | 0 |
| 3 | 2 | 0.02 |
| 4 | 3 | 0.03 |
| 5 | 7 | 0.07 |
| 6 | 10 | 0.10 |
| 7 | 11 | 0.11 |
| 8 | 12 | 0.12 |
| 9 | 14 | 0.14 |
| 10 | 6 | 0.06 |
| 11 | 7 | 0.07 |
| 12 | 10 | 0.10 |
| 13 | 6 | 0.06 |
| 14 | 3 | 0.03 |
| 15 | 6 | 0.06 |
| 16 | 1 | 0.01 |
| 17 | 1 | 0.01 |
| 18 | 0 | 0 |
| 19 | 1 | 0.01 |
| 20 | 0 | 0 |
| Total: | 100 | 1.00 |


(a)
Number observed crossing
30
20
10
0
0
2
4
6
8
10
12
14
16
18
20
$x_i$, Number of automobiles
(different intervals)


(b)
Relative frequency
← Relative frequency diagram
Probability density function scale →
0.30
0.20
0.10
0
0.15
0.10
0.05
0.00
0
2
4
6
8
10
12
14
16
18
20
$x_i$, Number of automobiles (intervals)

(c) Sample mean = $\frac{1}{100} \sum_{i=1}^{100} x_i = 9.31 = \overline{X}$

Sample standard deviation = $\left\{ \frac{1}{99} \sum_{i=1}^{100} (x_i - 9.31)^2 \right\}^{\frac{1}{2}}$

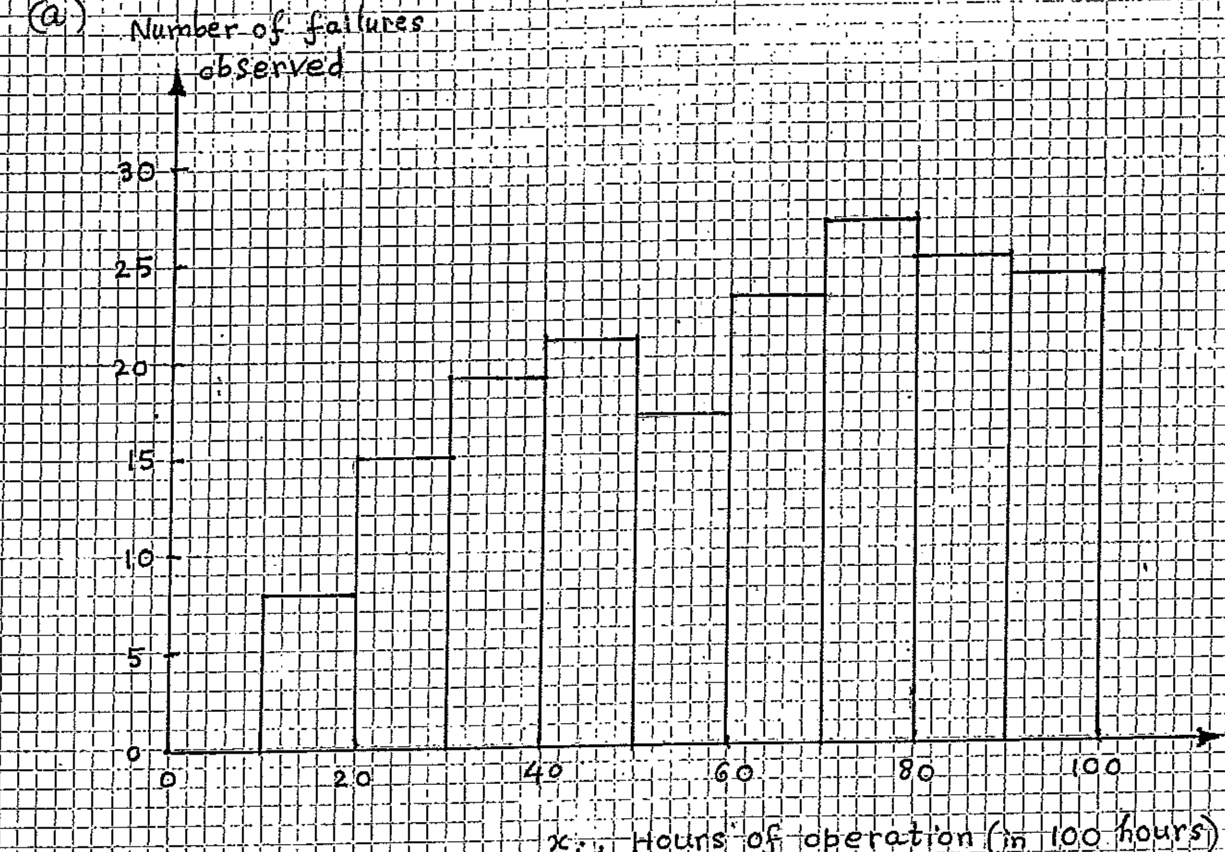
$= s_X = 3.3795$

(d) Percentage of number of automobiles exceeding a value of 15 (from given data) is 3 out of 100, i.e., 3%.

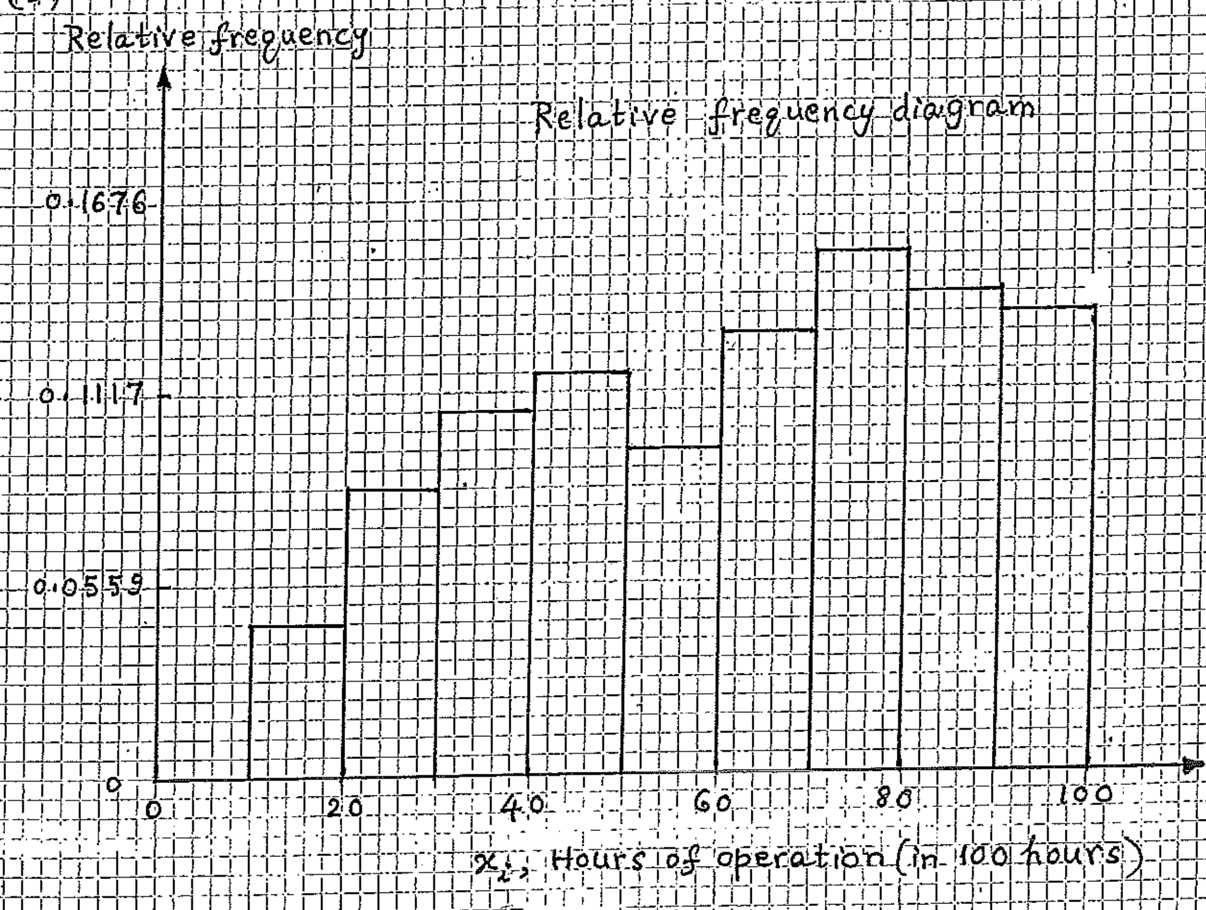
**1.11** Failure data of disk drives:
Total number of failures: 179

| Hours of operation (unit: 100 hours) | Number of failures observed | Relative frequency |
|---|---|---|
| 0 – 10.0 | 0 | 0 |
| 10.1 – 20.0 | 8 | 0.0447 |
| 20.1 – 30.0 | 15 | 0.0838 |
| 30.1 – 40.0 | 19 | 0.1061 |
| 40.1 – 50.0 | 21 | 0.1173 |
| 50.1 – 60.0 | 17 | 0.0950 |
| 60.1 – 70.0 | 23 | 0.1285 |
| 70.1 – 80.0 | 27 | 0.1508 |
| 80.1 – 90.0 | 25 | 0.1397 |
| 90.1 – 100.0 | 24 | 0.1341 |
| Total: | 179 | 1.0000 |

(a)


Number of failures observed
30
25
20
15
10
5
0
0
20
40
60
80
100
$x_i$, Hours of operation (in 100 hours)

(b)


Relative frequency
Relative frequency diagram
0.1676
0.1117
0.0559
0
0
20
40
60
80
100
$x_i$, Hours of operation (in 100 hours)

(c) Sample mean = $\overline{X} = \left(\frac{1}{179} \sum_i x_i\right) = 61.257 \times 100$ hours

Sample standard deviation = $s_X = 23.99 \times 100$ hours

(d) Expected reliability of disk drives at 8,000 hours of operation (from given data)

= Probability of hours of operation $\geq 80$ units

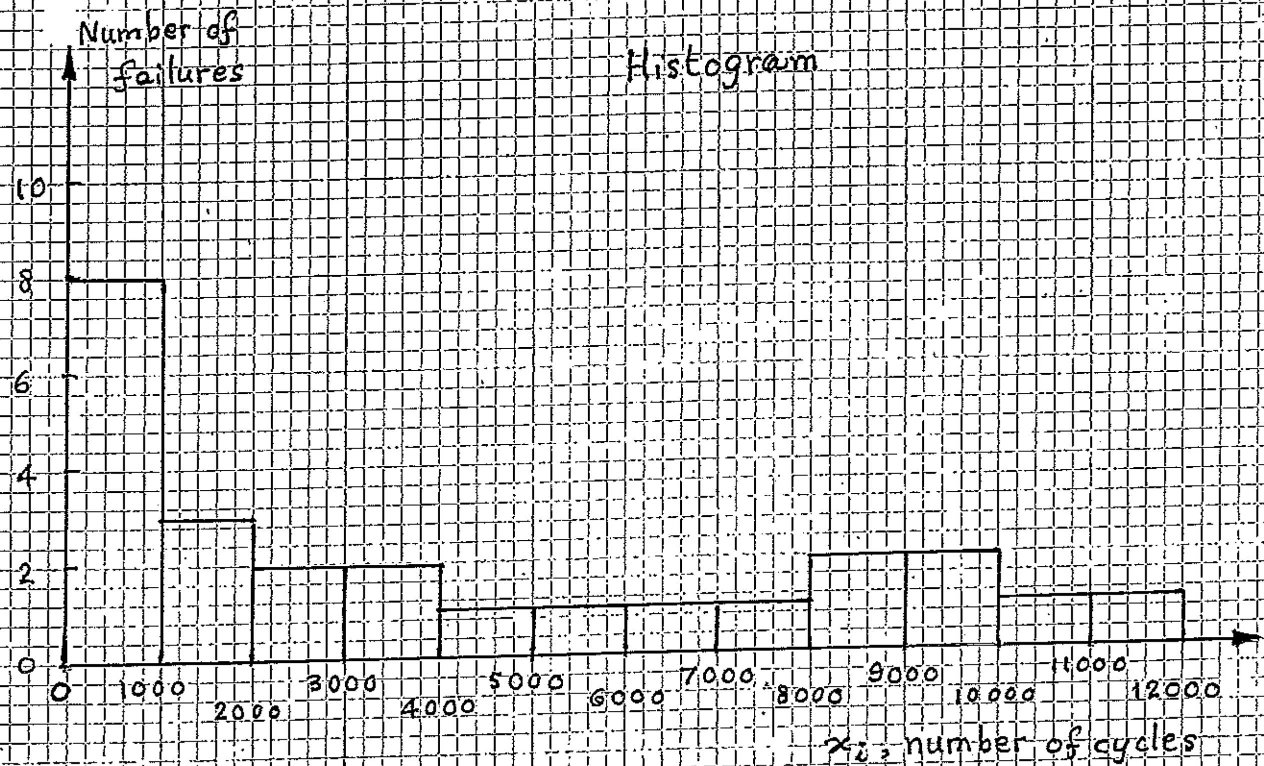
= (25 + 24) out of 179 failures

= 0.2737

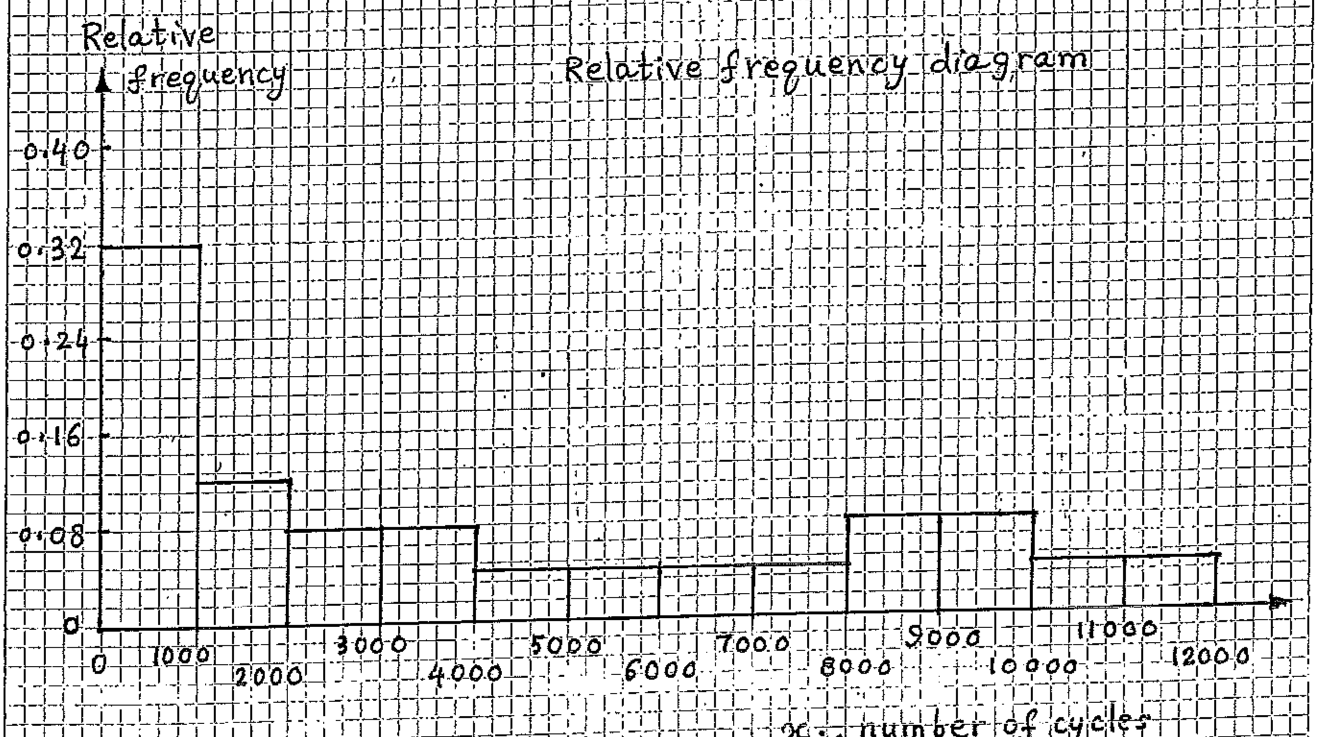
**1.12** Failure data of turbine blades
Data points: 25

| Number of cycles at failure (Range) | Number of failures observed in the range | Relative frequency |
|---|---|---|
| 0 – 1000 | 8 | 0.32 |
| 1001 – 2000 | 3 | 0.12 |
| 2001 – 3000 | 2 | 0.08 |
| 3001 – 4000 | 2 | 0.08 |
| 4001 – 5000 | 1 | 0.04 |
| 5001 – 6000 | 1 | 0.04 |
| 6001 – 7000 | 1 | 0.04 |
| 7001 – 8000 | 1 | 0.04 |
| 8001 – 9000 | 2 | 0.08 |
| 9001 – 10000 | 2 | 0.08 |
| 10001 – 11000 | 1 | 0.04 |
| 11001 – 12000 | 1 | 0.04 |
| Total: | 25 | 1.00 |

(a)


Number of failures
Histogram
10
8
6
4
2
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
$x_i$, number of cycles

(b)


Relative frequency
Relative frequency diagram
0.40
0.32
0.24
0.16
0.08
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
$x_i$, number of cycles

(c) Sample mean = $\overline{x} = \frac{1}{25} \sum_{i=1}^{25} x_i = 4125.16$ cycles

Sample standard deviation = $s_x = \left\{ \frac{1}{25} \sum_{i=1}^{25} (x_i - \overline{x})^2 \right\}^{\frac{1}{2}}$

$= 3765.42$ cycles

(d) Percentage of turbine blades that have a life greater than 7500 cycles (from given data)

= 7 out of 25 = 28%.