University of Waterloo STAT 221 – J.C. Robinson

Assignment 4

A4 – 1. Two lines in a factory produce two different parts *A* and *B*. For each line, a daily record was kept of the number of tonnes of scrap and the type of part involved. At the end of the financial year, management presented the 2 line supervisors with the data in the table at the right.

(a) Construct a histogram for each line from the data in the Table; comment briefly on relevant similarities and differences.

(b) Calculate the approximate *average* tonnes of scrap per day for each line.

(c) Find approximately how many more tonnes of scrap were produced in a *year* on Line 2 than on Line 1.

Class Interval	Frequency Line 1	Line 2
[1.25, 1.75)	2	3
[1.75, 2.25)	12	8
[2.25, 2.75)	28	12
[2.75, 3.25)	44	16
[3.25, 3.75)	39	17
[3.75, 4.25)	27	29
[4.25, 4.75)	20	35
[4.75, 5.25)	19	50
[5.25, 5.75)	8	21
[5.75, 6.25)	5	8
	204	199

The supervisor of Line 2 took issue with a criticism based on the difference found in (c) because she knew that her line produced a higher proportion of part *B* than did Line 1 and, historically, part *B* had always had the higher scrap rate. After searching through the year's production records, she produced the *lower* table given at the right.

(d) On the basis of the data in the lower table at the right, find the approximate *average* tonnes of scrap per day for each part made on each line.

(e) Prepare a concise case for presentation to management that could be used by the supervisor of Line 2; include histograms if appropriate.

Class Interval	Frequency Line 1 Part *A*	Line 1 Part *B*	Line 2 Part *A*	Line 2 Part *B*
[1.25, 1.75)	2		3	
[1.75, 2.25)	12		8	
[2.25, 2.75)	28		12	
[2.75, 3.25)	40	4	15	1
[3.25, 3.75)	32	7	8	9
[3.75, 4.25)	16	11	4	25
[4.25, 4.75)	5	15	5	30
[4.75, 5.25)		19		50
[5.25, 5.75)		8		21
[5.75, 6.25)		5		8
	135	69	55	144

A4 – 2. A manufacturer of O-rings was having difficulty maintaining the internal diameter (ID) of their viton O-rings to their customer's specification of 2.05 ± 0.15 cm. To investigate the problem, a sample of 12 O-rings was selected equiprobably from each hour's production. The completed data recording sheet is shown at the right.

(a) Construct an appropriate histogram of the data on the sheet.

(b) Find the average, median and modal ID.

(c) Find the range, standard deviation and IQR for the ID.

Part No. 3756-25 **Customer:** Hustin Corp.
Item: Viton O-ring **Specification:** ID 2.05 ± 0.15 cm
Date: Jan. 12, 1989 **Collected by:** R.J.
Shift: *1*st **Measured by:** M.Y.

2.03	2.07	2.06	1.95	2.18	2.12	2.09	2.10	1.99	2.00	1.89	2.00
2.14	2.10	2.03	2.11	2.10	1.95	2.11	1.96	2.07	2.16	1.99	2.03
2.08	2.04	1.98	2.00	2.06	2.09	2.10	2.17	1.99	2.13	2.00	1.96
2.18	2.13	2.13	2.00	2.08	1.99	1.99	2.04	2.15	2.05	2.05	2.05
2.10	2.17	2.00	2.04	1.93	1.96	1.95	2.13	1.83	2.08	1.98	2.15
2.14	2.14	2.12	2.00	2.18	2.15	1.91	1.98	2.05	1.99	2.12	2.14
1.93	2.03	2.12	1.94	1.97	2.11	2.00	1.98	2.06	2.00	1.96	2.12
2.04	1.96	2.04	2.19	2.12	2.13	2.12	2.02	2.00	2.22	2.10	2.01
2.08	1.99	2.01	2.10	1.88	1.98	2.13	2.08	2.08	2.10	2.08	2.07
1.97	1.95	2.20	2.04	1.99	2.07	2.03	2.05	1.95	2.08	2.00	2.05

After looking at the data, R.J. of the Quality Assurance Department asked M.Y. if the *cavity* had been recorded for each O-ring; it had *not* but, fortunately, the samples were still on M.Y's desk in a bag for each cavity, so R.J. asked M.Y. to measure them again and report the results by cavity number; the revised data are shown in the *lower* table at the right.

(d) Display the data by cavity using boxplots (*e.g.*, as in the Text *3*rd edition, page 47); comment briefly on the relevant features of your display.

(e) Describe briefly how the sampling could be improved in future.

(f) What information has been lost by the failure to set up a proper data recording sheet? Indicate briefly how serious this omission is.

Part No. 3756-25 **Customer:** Hustin Corp.
Item: Viton O-ring **Specification:** ID 2.05 ± 0.15 cm
Date: Jan. 12, 1989 **Collected by:** R.J.
Shift: *1*st **Measured by:** M.Y.

Cavity 1		Cavity 2		Cavity 3		Cavity 4		Cavity 5		Cavity 6	
2.12	2.10	1.96	1.99	2.03	2.12	2.17	2.11	2.00	2.00	2.10	1.99
2.08	2.13	1.98	1.95	2.15	2.00	2.13	2.09	2.00	1.96	2.15	1.98
2.12	2.20	1.91	1.99	2.00	2.00	2.17	2.12	1.98	1.99	2.07	2.05
2.08	2.12	2.00	1.95	2.08	2.08	2.14	2.18	1.98	2.04	2.03	2.07
2.13	2.08	2.00	2.00	2.16	2.05	2.10	2.06	1.98	2.12	2.10	2.14
2.14	2.10	1.93	1.95	1.94	1.83	2.06	2.08	2.00	2.01	1.99	2.03
2.09	2.13	1.97	1.97	2.07	2.05	2.04	2.10	2.05	1.99	1.99	2.18
2.00	2.13	1.88	2.01	2.15	2.03	2.06	2.10	1.95	1.99	2.08	1.93
2.12	2.18	1.96	1.96	1.95	2.14	2.08	2.11	2.02		2.05	1.96
2.05		2.03	2.04	2.11		2.10	2.13			2.22	1.89
		2.04	2.04			2.19				2.07	
		2.04									

(*continued overleaf*)

A4 – 3. The data below are the output voltages of 40 power supplies representing a sample, selected equiprobably from a large production run of these items. Construct an appropriate *histogram* of these data and comment briefly on its important features.

110	100	102	106	96	105	100	95	95	95	100	98	92	103	106	97	99	102	98	94
104	100	108	96	105	106	108	95	102	104	96	100	91	98	106	91	100	94	102	92.

A4 – 4. A manager with no *formal* background in statistics asks you: *What does it mean to say that a process is in control? Is being in control a guarantee that the quality of the product is good?* Answer these questions in language the manager can understand.

A4 – 5. A maker of automobile air conditioners checks a sample of 5 thermostatic controls selected every 12 minutes over each hour's production. The standard for the process average is 25°C, so the thermostats are set at 25°C and then placed in a chamber where the temperature is raised gradually; the temperature at which each thermostat turns on its air conditioner is recorded. Past experience indicates that the response temperature of properly adjusted thermostats varies with a standard deviation of 0.40°C. The average response temperature, $\bar{y}$, for each hour's sample is plotted on a control chart for averages which is to be used to help decide if the manufacturing process of the thermostats needs **adjustment**. Calculate the centre line and control limits for such a chart.

A4 – 6. Ceramic insulators are baked in batches in a large oven. After baking, 3 insulators are selected equiprobabky from each batch and tested for breaking strength. The average breaking strength for these samples is then plotted on a control chart. The specifications call for an average breaking strength of at least 10 pounds per square inch (p.s.i.). Past experience indicates that, if the ceramic is properly formed and baked, the standard deviation in the breaking strength is about 1.2 p.s.i. The sample averages for the last 15 batches are as follows:

Batch	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Average	12.94	11.45	11.78	13.11	12.69	11.77	11.66	12.60	11.23	12.02	10.93	12.38	7.59	13.17	12.14.

(a) Find the centre line and control limits for a control chart for averages which is to be used for the purpose of **process improvement**. Make a control chart with these lines drawn on it and plot the averages on the chart.

(b) In this situation, a process average breaking strength *greater* than 10 p.s.i. is acceptable, so points out of control in the high direction do not call for remedial action. With this in mind, use both the "one point out" and "run of nine" signals to assess the stability of the process. What *action* would you recommend on the basis of your findings?

(c) Approximately what proportion of insulators from the process do *not* meet the specification for average breaking strength. Show your reasoning clearly.

NOTE: For your convenience, there is a grid in Section 0 of the Course Materials for the control chart in (a).

A4 – 7. A pharmaceutical manufacturer forms tablets by compressing a granular material that contains the active ingredient and various fillers. The hardness of a sample from each lot of tablets is measured in order to **monitor** the compression process. The table at the right gives three sets of data, each representing $\bar{y}$ for 20 successive samples of 4 tablets. One set remains in control at the target value of 11.5 (in suitable units) for the hardness; in a second set, the process average shifts suddenly to a new value; in a third set, the process average drifts gradually.

(a) Show that the *averages* in data sets **A**, **B** and **C** have respective standard deviations (or 'standard errors') of about 0.135, 0.095 and 0.165.

(b) Draw a separate control chart for averages for each of the three data sets. Circle any points that are beyond the control limits. Also, check for runs of 9 points above or below the centre line and mark the ninth point of any run as being out of control.

(c) Based on your work in (b) and the appearance of the control charts, which set of data comes from a process that is in control? In which case does the process average shift suddenly and at about which observation does this change occur? Finally, in which case does the average gradually shift?

NOTE: For your convenience, there is a page of grids in Section 0 of the Course Materials for the three control charts in (b).

Sample No.	DATA SET A	B	C
1	11.602	11.627	11.495
2	11.547	11.613	11.475
3	11.312	11.493	11.465
4	11.449	11.602	11.497
5	11.401	11.360	11.573
6	11.608	11.374	11.563
7	11.471	11.592	11.321
8	11.453	11.458	11.533
9	11.446	11.552	11.486
10	11.522	11.463	11.502
11	11.664	11.383	11.534
12	11.823	11.715	11.624
13	11.629	11.485	11.629
14	11.602	11.509	11.575
15	11.756	11.429	11.730
16	11.707	11.477	11.680
17	11.612	11.570	11.729
18	11.628	11.623	11.704
19	11.603	11.472	12.052
20	11.816	11.531	11.905