MA30118: MANAGEMENT STATISTICS
Assessed Coursework: Quality Control

Preamble

Set: Tuesday 3rd May, 2005.
Due in: Please hand the work in to the Mathematical Sciences Department Office, 1W3.12 by 12 noon on Thursday 26th May, 2005.
Notes on submission: The work should be accompanied by a completed Coursework Cover Sheet, available either in lectures or from the Departmental Office. Your submitted assignment should be stapled in the top left hand corner and must **not** be presented in either a folder or a plastic wallet. Your answers may be handwritten, typed or a mixture of both.
Time: The average student should spend approximately ten hours on this assignment.
Conditions: The assignment should be your own work, though you are free to discuss it with your peers. You may also consult me for general advice. It should be completed in your own time.
Value: This assignment carries 100% of the total marks for coursework, and 40% of the total marks for the course.

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1. A forging process is used to produce piston rings for an automotive engine. The inside diameter of the rings manufactured by this process is a measure of the quality of the rings and you have been employed to set up $\overline{x}$ and R-charts to monitor the process. In order to set up the charts, 25 samples, each of size five, have been taken when the process is thought to be in control. The inside diameter measurement data from these samples are shown in Table 1.

j	x_{j1}	x_{j2}	x_{j3}	x_{j4}	x_{j5}	$\overline{x}_j$	r_j
1	74.060	74.004	74.038	73.984	74.016	74.0204	0.076
2	73.990	73.984	74.002	74.022	74.008	74.0012	0.038
3	73.976	74.048	74.042	74.010	74.004	74.0160	0.072
4	74.004	73.992	73.986	74.030	74.018	74.0060	0.044
5	73.984	74.014	74.030	73.978	74.028	74.0068	0.052
6	74.018	73.988	73.994	73.970	73.986	73.9912	0.048
7	73.990	74.012	73.988	74.000	74.010	74.0000	0.024
8	73.970	74.006	73.986	74.030	73.976	73.9936	0.060
9	74.016	73.990	74.018	74.010	74.008	74.0084	0.028
10	73.996	74.000	73.980	74.014	73.990	73.9960	0.034
11	73.988	73.996	73.988	73.990	73.980	73.9884	0.016
12	74.008	74.000	74.014	74.000	73.992	74.0028	0.022
13	73.966	74.004	73.996	73.994	74.024	73.9968	0.058
14	74.012	73.934	73.988	74.000	73.968	73.9804	0.078
15	74.024	74.028	73.996	73.998	74.014	74.0120	0.032
16	74.000	73.968	74.010	73.996	73.992	73.9932	0.042
17	73.988	74.024	73.972	74.010	74.014	74.0016	0.052
18	74.012	74.020	74.036	74.006	74.000	74.0148	0.036
19	73.968	74.004	74.006	74.010	73.994	73.9964	0.042
20	74.000	74.020	74.026	74.040	74.006	74.0184	0.040
21	73.976	74.002	74.018	74.010	73.992		
22	74.008	73.998	73.980	74.012	74.018		
23	74.020	73.978	73.980	74.018	74.028		
24	74.030	74.016	73.986	74.000	74.020		
25	73.964	73.968	73.990	74.034	74.026		

Table 1: Inside diameter measurements (mm) on forged piston rings.

(a) For samples $j = 21$ to 25, calculate the corresponding values of $\overline{x}_j$ and r_j [5]

(b) Using the data in Table 1, set up the R-chart with 3-sigma control limits. Does the process variability appear to be in control? [8]

(c) Now construct the $\overline{x}$-chart, again with 3-sigma control limits. Is there any indication that the process was out of control when the data was collected? [8]

After the control charts were set up, 15 additional samples, each of size five, from the process were collected. The data from these new samples are shown in Table 2.

(d) Do the $\overline{x}$ and R-charts you have set up suggest that the process is in control for these additional samples? Explain your findings. [10]

(e) It is argued that the addition of upper and lower warning limits, placed two standard deviations away from the centre line, on each chart will improve the

j	x_{j1}	x_{j2}	x_{j3}	x_{j4}	x_{j5}	$\overline{x}_j$	r_j
26	74.024	74.030	74.060	73.973	74.000	74.0172	0.088
27	73.990	74.020	73.980	74.030	74.002	74.0044	0.050
28	73.974	73.998	73.970	74.000	73.980	73.9844	0.030
29	74.016	74.020	74.006	73.982	74.012	74.0072	0.038
30	74.006	74.000	74.002	73.972	73.994	73.9948	0.034
31	73.988	74.006	74.030	74.040	74.008	74.0144	0.052
32	74.016	74.004	74.036	73.990	74.010	74.0112	0.046
33	74.002	74.008	73.980	73.992	73.996	73.9956	0.028
34	74.030	74.000	74.032	74.050	74.000	74.0224	0.050
35	74.060	74.010	74.000	74.032	74.024	74.0252	0.060
36	74.002	73.980	73.990	74.020	74.048	74.0080	0.068
37	74.030	74.040	74.048	74.010	74.038	74.0332	0.038
38	74.070	74.020	74.024	74.030	74.052	74.0392	0.050
39	74.034	74.026	74.072	74.050	74.052	74.0468	0.046
40	74.020	74.030	74.058	74.000	74.040	74.0296	0.058

Table 2: Inside diameter measurements (mm) on forged piston rings taken after the control charts have been set up.

sensitivity of the charts. How do the addition of these limits affect the conclusions you made in part (d)? [5]

(f) Suppose that the company has cut the budget available to monitor the process. In future, at each time point, a sample of size four rather than five will be taken. As a result of this, explain carefully any changes you would make to the control charts you have set up. [10]

2. You are a management trainee in a manufacturing company that uses control charts, with mixed success, to control several different production lines. Your boss has heard about the following article:

Alwan, R.C. and Roberts, H.V. (1995) The Problem of Misplaced Control Limits. *Appl. Statist.,* **44**, 269-278.

The article makes some interesting observations about the placement of limits on control charts and the assumptions underlying their placement. Your boss, knowing that you studied Statistics in your degree course, asks you to read the paper and summarise its findings.

Write a report, in your own words, summarising what you consider to be the main points made by Alwan and Roberts and explaining the principles involved. You may assume that your boss has some, but not an extensive, knowledge of Statistics. Your boss is a busy person, so you should aim to be as concise as possible, and rambling answers should be avoided. Moreover, you have not been asked to write a general account of process control. Your boss does not expect that you will know every technical term or concept, which is used in the paper, but expects that you can meet the challenge of producing a good report even though there may be a few things in the paper you are not familiar with. Your report should be no more than 2000 words long. [54]