MA30118: MANAGEMENT STATISTICS
Assessed Coursework: Quality Control

Preamble

Set: Monday 24 April 2006.
Due in: Please hand the work in to the Mathematical Sciences Department Office, 1W3.12 by 12 noon on Friday 12 May 2006.
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. You may use any computer package you like to construct any of the required charts but all working should be clearly shown.
Time: The average student should spend no more than 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 production process produces primer paint. The viscosity of the paint is used as a measure of its quality 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 viscosity 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	34.1968	34.2000	34.1840	34.2112	34.1920	34.19680	0.0272
2	34.2000	34.1744	34.2080	34.1968	34.1936	34.19456	0.0336
3	34.2032	34.1936	34.1888	34.2240	34.2144	34.20480	0.0352
4	34.1744	34.2032	34.2048	34.2080	34.1952	34.19712	0.0336
5	34.2096	34.1472	34.1904	34.2000	34.1744	34.18432	0.0624
6	34.2240	34.2128	34.1888	34.2000	34.2160	34.20832	0.0352
7	34.2480	34.2032	34.2304	34.1872	34.2128	34.21632	0.0608
8	34.1920	34.2096	34.1904	34.2000	34.2080	34.20000	0.0192
9	34.2064	34.1984	34.1840	34.2096	34.2144	34.20256	0.0304
10	34.2064	34.2000	34.2112	34.2000	34.1936	34.20224	0.0176
11	34.2128	34.1920	34.2144	34.2080	34.2064	34.20672	0.0224
12	34.1808	34.2384	34.2336	34.2080	34.2032	34.21280	0.0576
13	34.2144	34.1904	34.1952	34.1760	34.1888	34.19296	0.0384
14	34.2192	34.2224	34.1968	34.1984	34.2112	34.20960	0.0256
15	34.1920	34.1872	34.2016	34.2176	34.2064	34.20096	0.0304
16	34.1904	34.2192	34.1776	34.2080	34.2112	34.20128	0.0416
17	34.2160	34.1824	34.1840	34.2144	34.2224	34.20384	0.0400
18	34.1872	34.2112	34.2240	34.1824	34.2224	34.20544	0.0416
19	34.1904	34.1968	34.1904	34.1920	34.1840	34.19072	0.0128
20	34.2000	34.2160	34.2208	34.2320	34.2048	34.21472	0.0320
21	34.1760	34.2048	34.1888	34.2240	34.1808		
22	34.2096	34.2160	34.2288	34.2048	34.2000		
23	34.1728	34.2032	34.1968	34.1952	34.2192		
24	34.1808	34.2016	34.2144	34.2080	34.1936		
25	34.1712	34.1744	34.1920	34.2272	34.2208		

Table 1: Viscosity of primer paint.

(a) For samples $j = 21$ to 25, calculate the corresponding values of $\overline{x}_j$ and r_j. Show your working. [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	34.2192	34.2240	34.2480	34.1776	34.2000	34.21376	0.0704
27	34.1920	34.2160	34.1840	34.2240	34.2016	34.20352	0.0400
28	34.1792	34.1984	34.1760	34.2000	34.1840	34.18752	0.0240
29	34.2128	34.2160	34.2048	34.1856	34.2096	34.20576	0.0304
30	34.2048	34.2000	34.2016	34.1776	34.1952	34.19584	0.0272
31	34.1904	34.2048	34.2240	34.2320	34.2064	34.21152	0.0416
32	34.2128	34.2032	34.2288	34.1920	34.2080	34.20896	0.0368
33	34.2016	34.2064	34.1840	34.1936	34.1968	34.19648	0.0224
34	34.2240	34.2000	34.2256	34.2400	34.2000	34.21792	0.0400
35	34.2480	34.2080	34.2000	34.2256	34.2192	34.22016	0.0480
36	34.2016	34.1840	34.1920	34.2160	34.2384	34.20640	0.0544
37	34.2240	34.2320	34.2384	34.2080	34.2304	34.22656	0.0304
38	34.2560	34.2160	34.2192	34.2240	34.2416	34.23136	0.0400
39	34.2272	34.2208	34.2576	34.2400	34.2416	34.23744	0.0368
40	34.2160	34.2240	34.2464	34.2000	34.2320	34.22368	0.0464

Table 2: Viscosity of primer paint, samples 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, L.C. and Roberts, H.V. (1988) Time-Series Modeling for Statistical Process Control. *Journal of Business & Economic Statistics,* **6(1)**, 87-95.

The article highlights some limitations of the traditional implementation of statistical process control and the assumptions underpinning the theory. The authors propose an approach to process control using time-series models. Your boss, knowing you had studied process control during 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 (and may indeed be shorter). [54]