University of Ottawa Faculty of Administration

ADM 2303: STATISTICS FOR MANAGEMENT I
FINAL EXAMINATION December 9, 2004

NAME S.N. Section: A B C D E F G H

Time: 3 hours Total marks:63 *Put your name on THIS sheet too! – YOUR EXAM IS UNIQUE.*

Statement of Academic Integrity
The School of Management does not condone academic fraud, an act by a student that may result in a false academic evaluation of that student or of another student. Without limiting the generality of this definition, academic fraud occurs when a student commits any of the following offences: plagiarism or cheating of any kind, use of books, notes, mathematical tables, dictionaries or other study aid unless an explicit written note to the contrary appears on the exam, to have in his/her possession cameras, radios (radios with head sets), tape recorders, pagers, cell phones, or any other communication device which has not been previously authorized in writing. Note: an examination answer sheet without the signed statement will not be graded and will receive a final exam grade of zero.

ALL ANSWERS (INCLUDING BRIEF EXPLANATIONS) GO ON THE ***ANSWER*** SHEET. The exam question sheets will **not** be marked, though space on the back of sheets is provided here for your rough work. Deposit question sheets in the box provided to allow for verification if needed. Note that there are marks for explaining your answers, so make sure you include brief explanations on the ***ANSWER*** sheet. There are marks for identifying probability distributions. Calculators, 1 double-sided sheet of notes, on 8.5" by 11" paper (no stick-ons!) are allowed. In using tables, you do **not** need to interpolate, but take the nearest table value.

Q1. In 1903, K. Pearson and A . Lee published a paper entitled "On the Laws of Inheritance in Man. I. Inheritance of Physical Characters" (Biometrika, Vol 2). From information presented in that paper, forearm lengths of men, measured from the elbow to the middle fingertip have a mean of 47.8 centimeters and a standard deviation of 2.8 centimeters.

For the moment, assume the forearm length is Gaussian (normally) distributed.

a) [2] Compute the 90th percentile of the forearm length.

b) [3] It is believed that if a forearm length is shorter than 45.0 cm or longer than 52.2 cm that forearm is abnormal. Determine the probability that two randomly selected men will ***both*** have an abnormal forearm.

c) [4] Suppose that a set of 144 University of Ottawa male students is randomly selected. Regardless of the previous parts of the question, you decide to NOT assume that the data is normally distributed, so that you treat the data as a sample of 144 observations. Calculate the value of the ***mean*** forearm length of the 144 students that will be exceeded with 90% probability. Use the values of distribution parameters from the 1903 paper mentioned above.

d) [5] A further 9 University of Ottawa students are selected at random. Their forearm lengths are given below;
50.7, 50.6, 45.3, 47.7, 46.6, 51.7, 47.0, 44.6, 48.0
Would you accept that this sample is drawn from a population having a mean forearm length of 48 cm? Support your answer with an appropriate calculation of the approximate probability that you could observe such a sample. Be sure to explain any assumptions or theory you use.

e) [2] How would you modify your answer in (d) if the population standard deviation were given as 2 cm?

Q2. A new telephone company offers low cost long distance phone calls by transporting them over the Internet. The service involves installation of voice coding equipment at the customer's premises, which is economical for small businesses with more than 25 employees. In order to sell this service, telemarketers call small businesses in office buildings.

a) [4] City statistics show that one particular office building has 14 small businesses, and 4 of the 14 have more than 25 employees, but the statistics do not indicate which those 4 are. A telemarketer makes 8 calls to the office building at random. Out of those 8 calls, what is the chance of calling less than 2 companies with more than 25 employees.

b) [5] Across the whole city 32% of small businesses have more than 25 employees. Out of 1000 telemarketing calls to small businesses chosen at random, what is the probability of calling greater than or equal to 350 small businesses with more than 25 employees.

Q3. Your portfolio consists of 100 shares of company A and 200 shares of company B. Your brother's portfolio consists of 200 shares of company A and 300 shares of company C. Next year the expected value of shares A, B, and C are \$10, \$15, and \$20 respectively. The variances of the value of shares of A and B are 25 and 36 \$ squared and the standard deviation of the value of share C is \$7. The values of A and C are reliably believed to be independent, but the correlation between A and B values has been estimated to be 0.6.

a) [2] What is the expected return on your portfolio?

b) [2] What is the covariance between the values of A and B?

c) [3] What is the variance of your brother's portfolio?

d) [3] What is the standard deviation of your portfolio?

Q4. A new medical test for meningitis is evaluated on 500 patients, 50 of whom are known to have meningitis and 450 of whom are known not to have meningitis. The results are shown in the table:

	Patients known to have meningitis	Patients known NOT to have meningitis
Test +ve, i.e. indicates meningitis	47	13
Test -ve, i.e. indicates NO meningitis	3	437

a) [2] What is the probability the test comes out +ve for patients known to have meningitis?

b) [2] If the test comes out positive for a certain patient, what is the probability that the patient has meningitis?

c) [4] After a meningitis outbreak in a hospital, a doctor estimates there is a 20% chance that any given patient has meningitis. Each patient is tested using the above test. For patient A, the test comes out positive. What is the chance that patient A has meningitis?

Q5. A high-speed Internet Service Provider (ISP) has found that every day it receives, on the average, one service call every two hours, no matter what time of day or day of week. It is interested finding the probability of how many service calls it would get.

a) [2] What probability model or distribution function would or may be appropriate? Explain in brief.
Based on the probability model you use, find the probability that:

b) [2] In the next 30 minutes there are no service calls?

c) [3] In the next hour, there are more than two service calls?

d) [3] There are exactly 2 service calls between 10am and 11am today, given that there were no service calls between 9am and 10am today?.

Q6. NeoNatrium Nutrition (NNN) is a food packaging company that offers low-sodium products. Their Chicken Soup Sachets are very popular, particularly among folk trying to control blood pressure. One of the problems faced by NNN is that of ensuring they meet their label claims while keeping the soup tasty. While conventional chicken soup, as served, contains about 4.4g of salt per litre of soup, NNN's product tries to be less than half this. However, less than 1.8 g/litre of salt causes folk to think the soup is dishwater. Therefore NNN establishes a specification of 1.9 to 2 g/litre.

The packaging of the sachets, which are intended to make 250 ml of soup (1 cup), has a label claiming "Salt: 0.5g". However, the sachets are made by combining dry ingredients (dehydrated stock, flavouring, salt and other ingredients), so there is the possibility that by poor mixing or by poor measurement of the total sachet content, the overall salt content of a sachet may be too high or too low.

a) [2] Take as your specification that you want sachets to contain between .46 and .49 g of salt. If you can assume a roughly bell-shaped distribution for salt content of the sachets, what would be reasonable values for the mean and standard deviation of this distribution? Explain briefly how you get these values.

Regardless of your answers above, take a mean of 0.472g of salt per sachet and a standard deviation of 0.0049g of salt for the rest of this question.

b) [2] NNN is in competition with Sensible Seasonings in the chicken soup market. The sachets from Sensible Seasonings have nominally the same salt content at NNN. However a comparison of sachets is made and the following graphs are drawn. Maker 1 is NNN; maker 2 is Sensible Seasinings.

Boxplot

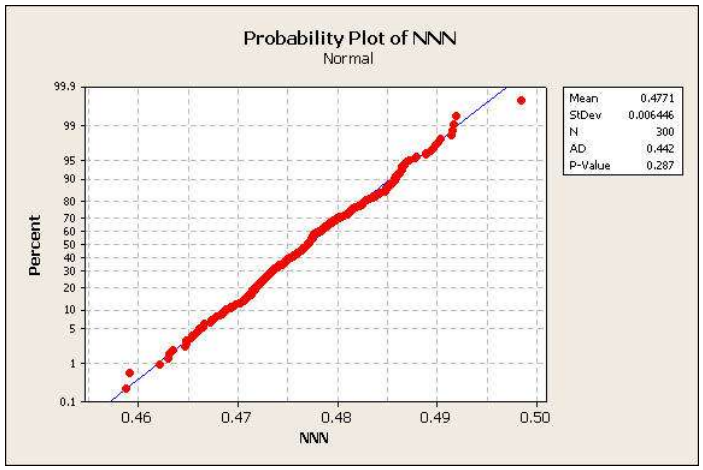
```
maker
                              ------------
1             **    -------------I    +     I-------------       *
                              ------------

                                 -----
2             OO    OO *******------I + I------*******OOOO       O
                                 -----
          +---------+---------+---------+---------+---------+------C21
     0.4560    0.4640    0.4720    0.4800    0.4880    0.4960
```

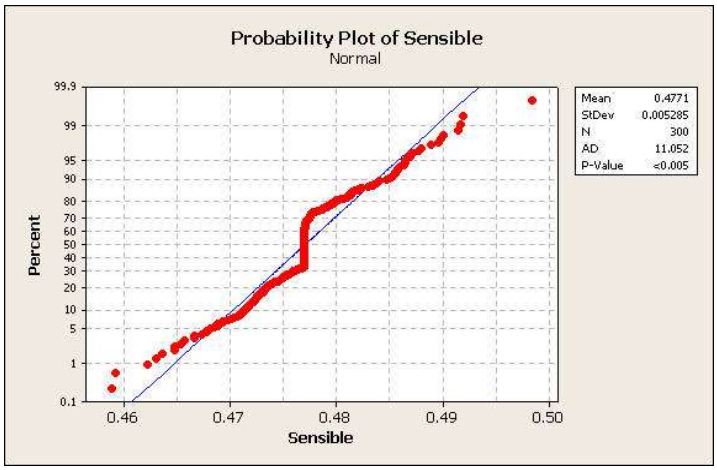
```
Stem-and-leaf of NNN  N  = 300
Leaf Unit = 0.0010

 2    45  89
 9    46  2333444
 36   46  555556666777777888888899999
 114  47  000000000011111111111111111222222222222222223333333333333333444+
(96)  47  555555555555555566666666666666666666777777777777777777777777778+
 90   48  000000111111111111112222222222233333333444444444
 39   48  555555555555566666666667777889999
 7    49  001111
 1    49  8
```

```
Stem-and-leaf of Sensible  N  = 300
Leaf Unit = 0.0010

 2     45  89
 7     46  23344
 21    46  556677788888999
 76    47  000001111111111112222222222222233333333333333344444444444
(167)  47  555555555555556666666666666666666666666666666666666666666666666+
 57    48  000111111111112222333333344 4
 29    48  55555555556666666777789 9
 5     49  0111
 1     49  8
```

Which maker better satisfies the specification given above? You need both QUANTITATIVE and QUALITATIVE components to your answer.

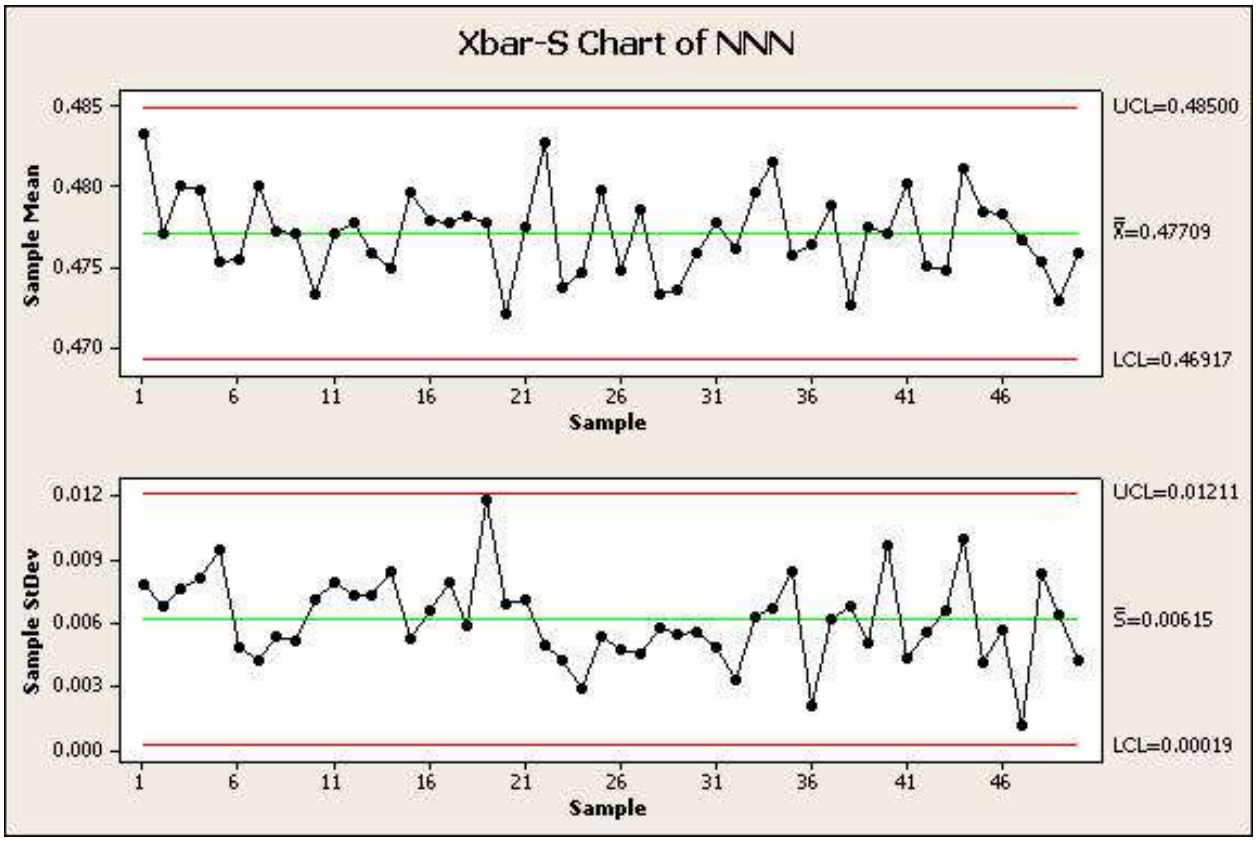
c) [2] You also decide to compare the distributional properties of the salt content of the sachets made by the two manufacturers. From the Stem and Leaf diagrams and/or the graphs below, can you suggest anything about the distribution of salt content in sachets from each manufacturer?



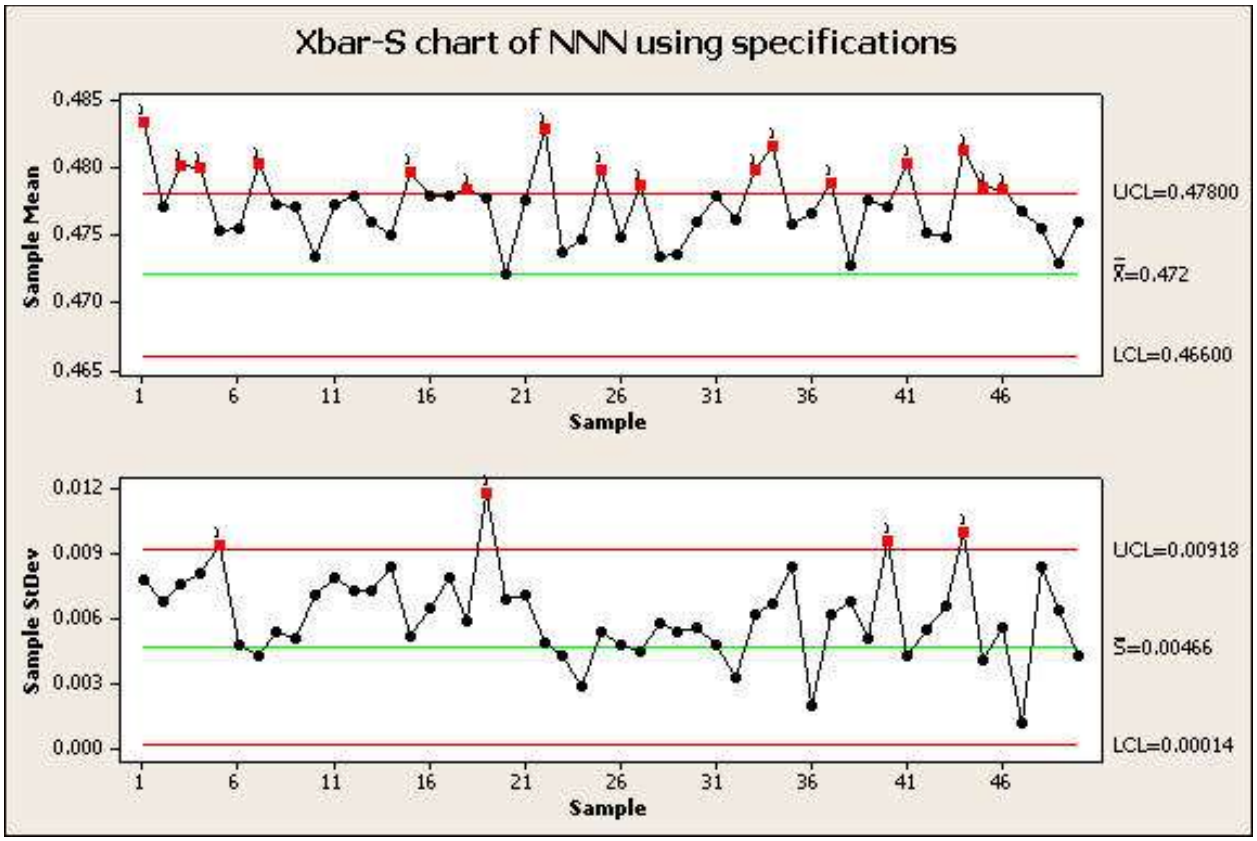


d) [2] To ensure quality, NNN monitors salt content of their sachets. Samples of 6 sachets are regularly drawn from the production line output and salt measured. On the next page are two possible sets of graphs (labelled A and B). Following the graphs are some text output that accompanied the drawing of graph B. Which set is more appropriate to use and why?

A



B



Graph B was accompanied by the following session output.

Xbar-S Chart of NNN

Test Results for Xbar Chart of NNN

```
TEST 1. One point more than 3.00 standard deviations from center line.
Test Failed at points:  1, 3, 4, 7, 15, 18, 22, 25, 27, 33, 34, 37, 41, 44, 45, 46
```

Test Results for S Chart of NNN

```
TEST 1. One point more than 3.00 standard deviations from center line.
Test Failed at points:  5, 19, 40, 44

* WARNING * If graph is updated with new data, the results above may no
          * longer be correct.
```

e) [2] Should NNN change the whole manufacturing process, adjust the existing process, or continue making sachets in the manner that gave rise to the samples used here? Explain briefly.