

RAB



The University of Calgary
Schulich School of Engineering

ENGG 319 Probability & Statistics for Engineers (Fall 2014)

Final Examination

Wednesday, 17 December 2014, 12:00 - 15:00, Red Gym

Instructions:

- **Write your name and student ID on the blue exam booklet provided.**
- **Write all answers on the booklet.**
- This is an open textbook and open notes exam.
- The duration of examination is 180 minutes.
- 47 is the full marks for this final exam.
- Marks for each question are indicated beside the question number.

1. From the 15 fluid pressure data you collected, you find a sample average of 8 MPa and a sample standard deviation of 1.4 MPa.
 - (a) **(4 marks)** Determine the maximum fluid pressure with 90% confidence.
 - (b) **(4 marks)** Determine the minimum standard deviation for the fluid pressure with 70% confidence.
 - (c) **(4 marks)** Using the sample average of 8 MPa and a ^{sample} standard deviation of 1.4 MPa, obtain the probability for the fluid pressure to be above 9 MPa. Use linear interpolation to obtain an accurate result.

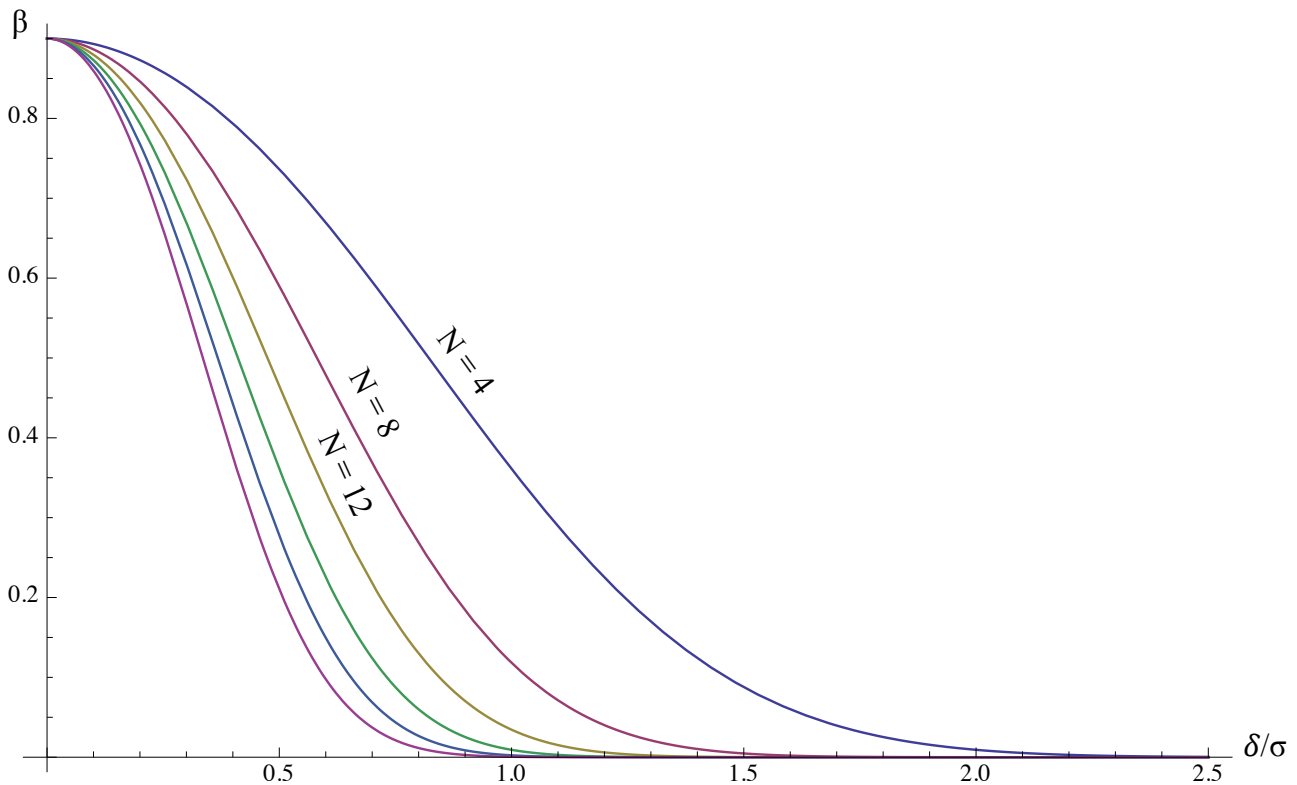
2. Your inspection team found 2 defects from inspecting a 500-meter long pipe section. A defect can be a scratch spot or a corroded spot.
 - (a) **(4 marks)** Determine the probability of finding between 1 and 4 pipeline failures in a 1000-meter pipe section.
 - (b) **(4 marks)** How long should the pipe length be so that there is a 90% probability for 1 pipeline failure?

3. In the engineering firm you work for, Mechanical Piping team works together with Chemical Processing team on designing an Upgrader facility to be built in Fort McMurray. When they work together, the Chemical Processing team has to complete its chemical processing design first *before* Mechanical Piping team can complete its mechanical piping design of the Upgrader facility. Denoting y to be the Chemical Processing Completion Time and x to be the Mechanical Piping Completion Time, they are constrained therefore by the $y < x$ relationship. The two completion times can be modelled by the following joint probability density function:

$$f(x,y) = \lambda_x (\lambda_x + \lambda_y) \exp(-\lambda_x x) \exp(-\lambda_y y).$$
 where $\lambda_x = 0.08$ and $\lambda_y = 0.13$ per month.
 - (a) **(5 marks)** What is the expected Chemical Processing Completion Time given that the Mechanical Processing Completion Time is 5 months?
 - (b) **(5 marks)** What is the probability of Mechanical Processing Completion Time between 5 and 8 months given that the Chemical Processing Completion Time is 3 months?

4. As a risk engineer in the engineering company, you are assigned to design a pressure measurement method for the Upgrader facility. Figure below plots Type II error probability with $\alpha = 0.10$ for $N = 4, 8,$

12, 16, 20, 24 as a function of δ/σ . (The $N = 12$ curve is sequentially followed by the $N = 16, 20, 24$ curves.)



- (a) **(3 marks)** Given that the pressure of fluid flowing in pipeline is normally distributed, determine using Figure 1 the minimum number of data points collected so that there is at most 10% Type II error probability for $\delta/\sigma = 1$. *Your answer should be one of six N 's listed.*
- (b) **(3 marks)** What does the 10% Type II error probability in ^{4(a)}~~2(a)~~ imply? Choose your answer from one of 4 options below.
- (1) In at least 9 out of 10 measurements, you can accurately use sample (average) pressure as the reported (claim) pressure without risking that the true pressure were closer than $\delta/\sigma = 1$ from the sample pressure.
 - (2) In at least 9 out of 10 measurements, you can accurately use sample (average) pressure as reported (claim) pressure without risking that the true pressure were farther than $\delta/\sigma = 1$ from the sample pressure.
 - (3) In at most 1 out of 10 measurements, you can accurately use sample (average) pressure as the reported (claim) pressure without risking that the true pressure were farther than $\delta/\sigma = 1$ from the sample pressure.

- (4) In at most 1 out of 10 measurements, you can accurately use sample (average) pressure as the reported (claim) pressure without risking that the true pressure were closer than $\delta/\sigma = 1$ from the sample pressure.
- (c) **(4 marks)** You are to design a pipe with the design (claim) pressure of 20% higher than the sample pressure with a ± 1.0 MPa tolerance for safety factor consideration. The sample pressure is normally distributed and is read by a pressure gauge that has a 0.05 MPa standard deviation. What should be the maximum pressure reading (regarded therefore as the true pressure) if the design pressure is falsely accepted with 10% probability? Use $N = 1$ to obtain the maximum pressure reading.
5. You are evaluating the effect of rough internal surface of a cylindrical pipe on the pipe's hoop stress (circumferential stress) due to fluid pressure flowing inside the pipe. The hoop stress formula is

$$\sigma = \frac{P r}{(t_0 + s)}$$

where P , r , t_0 , and s are, respectively, fluid pressure; pipe's radius; average pipe thickness; and surface roughness. These four constants are all positive. Such surface roughness can come from scaling or fouling in the pipe.

- (a) **(4 marks)** Determine the probability density function obeyed by the hoop stress given that the surface roughness s obeys a uniform distribution from 0 to 1 mm.
- (b) **(3 marks)** Determine the average hoop stress for $P = 9$ MPa, $r = 20$ mm, $t_0 = 2$ mm using the probability density function obtained in ^{5(a)}~~3(a)~~. **If you use an alternative method to approximate the average hoop stress, you will receive 1 mark instead.** Note: the uniform probability density function for the surface roughness has 1/mm unit in case you would like to verify the pressure unit for the average hoop stress obtained.

== end of final exam ==