

Problem 1. (14 points)

For each of the following questions, circle the letter in the right-hand column that corresponds to the best answer.

- A. The percentage of the normal distribution more than 1.5 standard deviations away from the mean is most closely equal to which of the following values? a  b c d
- $2 * z(1.5)$
- (a) 6.7 % (c) 86.6 %  
 (b) 13.4 % (d) 93.3 %

- B. A manufacturing line produce microprocessors whose average maximum operating clock speed is 150 MHz. Assuming a normal distribution of maximum operating speeds and a standard deviation of 30MHz, approximately what percentage of microprocessors will operate correctly at 200 MHz? a b  c d
- $z(1.67)$
- (a) less than 1 % (c) 5 %  
 (b) 2 % (d) 10 %

- C. A manufacturing process has an average defect rate of 1.8 defects per unit. What is probability that a particular unit will have 3 defects? a b c  d
- $\frac{1.8^3}{3!} e^{-1.8}$
- (a) 0 % (c) 5.8 %  
 (b) 5.4 % (d) 16.1 %

- D. A manufacturing process has a first-time yield (FTY) of 92.4%. While producing 1000 good units, approximately how many defective units will be manufactured? a b  c d
- $\frac{1000}{0.92} - 1000$
- (a) 0 (c) 82  
 (b) 76 (d) 92

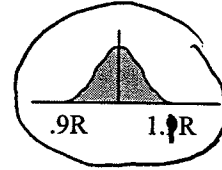
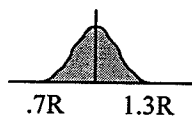
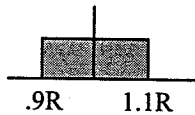
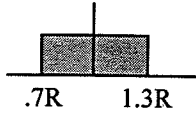
For each of the following statements, circle the appropriate response in the right-hand column.

- E. Professional engineers are licensed by the US government and may legally practice in all 50 states. TRUE  FALSE
- F. Given a geometric gradient series of payments over n years at interest rate i, there is an arithmetic gradient series of payments also over n years at interest rate i that has the same value.  TRUE FALSE
- G. The failure of the walkways in the Hyatt Regency hotel was primarily the result of errors in the original design specifications. TRUE  FALSE

## Problem 2. (10 points)

Three resistors ( $R_1$ ,  $R_2$ , and  $R_3$ ) are connected in series to form a resistance  $R = R_1 + R_2 + R_3$ .

- A. (2 points) Assume  $R_1$ ,  $R_2$ , and  $R_3$  are randomly selected from large supplies of resistors manufactured to provide a uniform distribution of resistor values within  $\pm 10\%$  tolerance. Which of the following figures most closely describes the expected distribution of values for  $R$ ? Circle the best response.



- B. (2 points) Assume  $R_1$ ,  $R_2$ , and  $R_3$  are randomly selected from large supplies of resistors manufactured to provide a normal (Gaussian) distribution of resistor values, with  $\pm 3\sigma = \pm 10\%$  of the resistor value. How would the standard deviation of the expected distribution of values for  $R$  under these conditions compare to the standard deviation of the expected distribution of values for  $R$  under the conditions in part A? Circle the best response.

\* Less than in part A

\* Greater than in part A

\* Approximately the same as in part A

\* Cannot be determined from the information provided

In lecture, the design of an RLC filter bank was described as an example of using experiment-based design methods to determine component values and tolerances.

- C. (3 points) Identify and briefly describe at least two significant advantages of experiment-based design compared to traditional design methods (e.g., critical path, worst case) for determining component values and tolerances.

- HANDLES COMPLEX COMPONENT INTERACTIONS
- NOT NECESSARY TO IDENTIFY CRITICAL PATH OR WORST-CASE CONDITIONS
- MORE REALISTIC REPRESENTATION OF MFG VARIATION

- D. (3 points) Identify and briefly describe at least two significant limitations or weaknesses of experiment-based design compared to traditional design methods (e.g., critical path, worst case) for determining component values and tolerances.

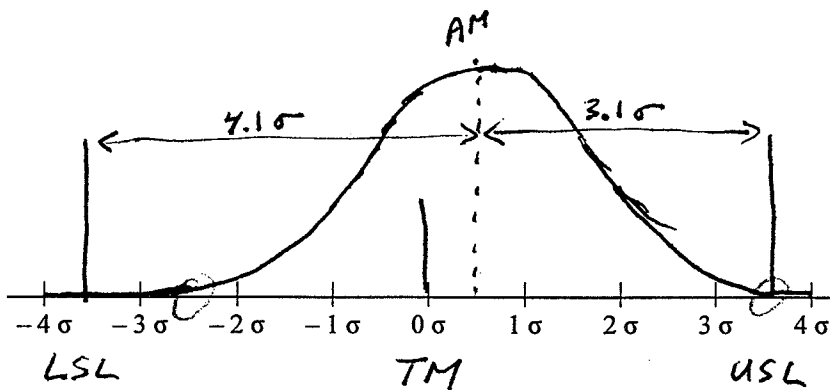
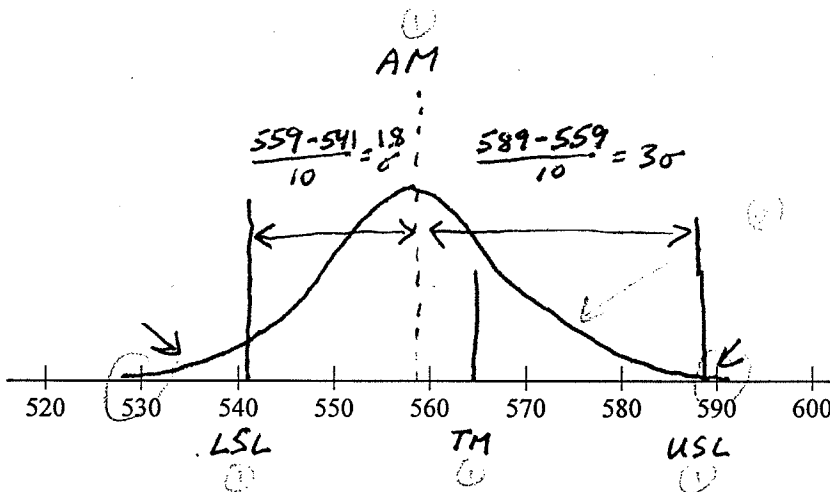
- MAY FIND LOCAL OPTIMUM, RATHER THAN GLOBAL
- LARGE NUMBER OF SIMULATIONS REQUIRED
- ASSUMES SMOOTH RESPONSE SURFACE

Problem 3. (16 points)

E. (10 points) Complete the following table. Assume design specifications are symmetric around the target mean and that the characteristics of the manufactured item are distributed according to a normal (Gaussian) distribution. You must show your calculations in the space below (or on the back of *this* page) in order to receive full credit.

Lower Spec Limit	Target Mean	Upper Spec Limit	Actual Mean	Standard Deviation	Cp	Cpk	Defective (Below LSL)	Defective (Above USL)
541	565	589	559	10	0.8	0.6	$Z(1.8) \approx 3.59\%$	$Z(3.0) \approx 0.135\%$
$-3.6\sigma$	$0\sigma$	$3.6\sigma$	$0.5\sigma$	$\sigma$	1.2	1.033	$Z(4.1) \approx 0.0021\%$	$Z(3.1) \approx 0.0968\%$

F. (6 points) Using the axes provided, sketch these situations in the spaces below. Include (and label) the target value, upper and lower specification limits, the actual mean, and the probability distribution curve.



$$C_p = 0.8 = \frac{USL - LSL}{6\sigma}$$

$$USL - LSL = 4.8\sigma \begin{cases} +2.4\sigma \\ -2.4\sigma \end{cases}$$

$$C_{pk} = C_p(1 - k)$$

$$0.6 = 0.8(1 - k) \Rightarrow k = 0.25$$

$$k = 0.25 = \frac{|AM - TM|}{\frac{1}{2}(USL - LSL)}$$

$$(0.25)(2.4\sigma) = |AM - TM|$$

$$0.6\sigma = |559 - 565|$$

$$\sigma = 10$$

$$USL - LSL = 3.1\sigma + 4.1\sigma = 7.2\sigma$$

$$\therefore USL = +3.6\sigma$$

$$LSL = -3.6\sigma$$

$$C_p = \frac{USL - LSL}{6\sigma} = \frac{7.2\sigma}{6\sigma} = 1.2$$

$$k = \frac{|AM - TM|}{\frac{1}{2}(USL - LSL)} = \frac{0.5\sigma}{3.6\sigma} = 0.1389$$

$$C_{pk} = C_p(1 - k) = 1.2(0.861) = 1.033$$