STUDY PROBLEMS #2

The principal purpose of the study problems is to assist you in understanding course concepts by applying them to specific problems. Simply getting the correct answer, without understanding how or why, is of little value. Therefore, you are strongly encouraged to work in groups of 2 or 3 on these problems, so that you can observe and discuss multiple ideas and approaches to solving the problems.

1. Problem 10, page 212 in the text.

2. Problem 12, page 212 in the text.

3. 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 may find it helpful to sketch the various scenarios.

Design Specifications			Manufacturing Process		Analysis			
Lower Spec Limit	Target Mean	Upper Spec Limit	Actual Mean	Standard Deviation	Cp	Cpk	Percent Defective	Percent Good
450	500		505	15				
2000		3200			2.0	1.67		
	1000		975	20	1.5			
-4σ	0σ	$+4\sigma$	-0.5σ	σ				
	0σ			σ	1.8	1.2		

4. Under what conditions do you consider it to be ethical for engineers to design and manufacture products with built-in obsolescence (i.e., products that wear out rapidly and cannot be repaired)? You may find it helpful to start by listing several examples of such products.

5. Which of the four moral theories (pp. 130-131) do you think is most applicable to engineering? It may be helpful to consider these theories relative to the four "Responsibilities of Engineers" listed on pages 131-132.

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Problem 2. (12 points)

A. (4 points) The tail-end Z function corresponds to the probability that a value randomly selected from a normally-distributed population will be greater than (to the right of) a specified value; i.e, $Z(x1) = Pr(x > x1)$, where x and x1 are expressed in units of standard deviation.

Since the Tail-End Z-Table distributed in class only includes positive values, it cannot be used directly to look up $Z(x1)$ if $x1 < 0$. Write an expression for $Z(x1)$, for $x1 < 0$, that can be evaluated using that table.

$$\underset{x1<0}{Z(x1)} =$$

Write an expression, in terms of the tail-end Z function, for determining the probability that a randomly selected value will fall between two values, x1 and x2, $x1 \le x2$. Then, compute this function for the two sets of x1 and x2 values given. Write your answers in the boxes at the right margin.

$Pr(x1 \le x \le x2) =$

$x1 = 1.07\,\sigma;\ x2 = 2.72\,\sigma$ [ ]

$x1 = (-2.13\,\sigma);\ x2 = 0.69\,\sigma$ [ ]

B. (8 points) A product design has the following specification for a particular parameter:

Target value: 400 Tolerance: ± 5%

When actually manufactured, this parameter varies according to a normal distribution. The following results are measured for this particular parameter:

Actual mean: 405 Standard Deviation: 10

Using the axis provided, sketch this situation in the space below. Include (and label) the target value, upper and lower specification limits, the actual mean, and the probability distribution curve. Compute the following values: percent of manufactured product below specification, percent of manufactured product above specification, the process capability index Cp, and the shifted process capability index Cpk. Write your answers in the boxes at the right margin.

% below [ ]

% above [ ]

Cp [ ]

Cpk [ ]

370 380 390 400 410 420 430

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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. Using the Tail-End Z-function, Z(x), the fraction of the normal distribution between $-1.5\ \sigma$ and $+3.0\ \sigma$ is given by which of the following computations? a b c d

(a) Z(3.0) – Z(1.5)
(b) Z(3.0) + Z(–1.5)
(c) Z(1.5) – Z(3.0)
(d) Z(–1.5) – Z(3.0)

B. The percentage of the normal distribution within $\pm$1.2 standard deviations of the mean is most closely equal to which of the following values? a b c d

(a) 11.5 %
(b) 23.0 %
(c) 77.0 %
(d) 89.5 %

C. The design specification for a part characteristic is 600 $\pm$ 40. The manufacturing process has an actual mean of 615 and a standard deviation of 10. The fraction of parts that are defective (out of spec) is given by which of the following computations? a b c d

(a) Z(2.5) + Z(5.5)
(b) 1 – Z(2.5) – Z(5.5)
(c) Z(4.0) + Z(4.0)
(d) (1 – Z(2.5)) + (1 – Z(5.5))

D. The reliability of a system can be increased by adding a redundant element in parallel, provided only one functioning element is required for the system to function correctly and the reliability of the added element is _______ the reliability of the original element. a b c d

(a) less than
(b) equal to
(c) greater than
(d) all of the above

E. To improve reliability, a single resistor (of value R) is replaced by the "quadded component" shown (each resistor has the value R). Assuming resistors may fail as either an open-circuit or as a short-circuit, what is the minimum number of resistors that must fail before the quadded component stops functioning as a resistor? a b c d

(a) 1
(b) 2
(c) 3
(d) 4

F. Which of the following is not a possible equivalent resistance for the quadded component from question E, after it "partially fails" but still functions as a resistor? a b c d

(a) R / 2
(b) 2R / 3
(c) 3R / 2
(d) 2R

G. Which of the following steps is not required to become a registered (licensed) professional engineer? a b c d

(a) complete a master's degree
(b) work as an engineer
(c) pass the Fundamentals of Engineering exam
(d) pass the Principles and Practices exam

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Problem 2. (16 points)

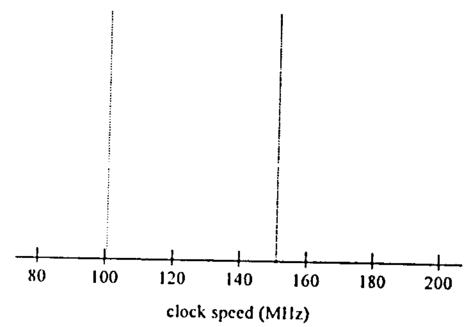
Just as manufacturers may use "binning" to select components close to a desired value, "speed grading" may be used to identify microprocessors that will work correctly at faster speeds, so that they can be sold for a higher price. Assume a manufacturer wishes to sell a particular microprocessor, with two possible speeds: 100 MHz and 150 MHz. Each chip is first tested at 150 MHz; those that fail are then tested again at 100 MHz. Chips that fail the second test are discarded, while the others are labeled based on the speed at which they passed the test.

While the manufacturing process is intended to produce devices that work at a particular clock speed, assume that the highest speed at which a specific chip will function is normally distributed. A and B, below, describe the distribution of maximum clock speeds for two possible manufacturing processes.

A. Actual mean: 120 MHz Standard Deviation: 10 MHz

B. Actual mean: 145 MHz Standard Deviation: 15 MHz

Using the axis provided below, sketch both distributions (label the curves "A" and "B"). For each option, compute the following values: percent sold as 150 MHz, percent sold as 100 MHz, and percent discarded. Write your answers in the boxes at the right margin. *Show your work*; if you need more space, use the back of this page.



Process A:

150 MHz ______

100 MHz ______

Discarded ______

Process B:

150 MHz ______

100 MHz ______

Discarded ______

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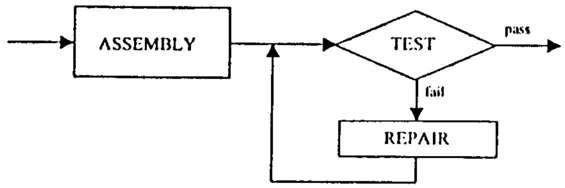
Problem 2. (12 points)

A portion of a multi-step manufacturing process is illustrated below. Operating costs (parts, electricity, labor, etc.) for the assembly step total \$237.28 per unit assembled. Upon completion of the assembly step, each unit has an average of 1.4 defects. The cost of each test is \$15.00 and the cost of repair averages \$42.00 per unit repaired. Assume that the repair process is perfect and that the test coverage is perfect (c = 1).



Answer each of the following questions regarding this process. Place your final answers in the boxes at the right edge. You must show equations and/or calculations to justify your answers in order to receive full credit.

A. (2 points) The equipment used in the assembly step costs \$65,000 and has an expected useful lifetime of 10 years and no salvage value. Assuming an interest rate of 7%, what is the annualized cost of this equipment?

B. (2 points) What percentage of units are defect-free after the assembly step?

C. (3 points) Assuming a total of 1000 units are built each year, what is the average cost of producing one unit?

A new engineer suggests that your company is spending too much on testing and repairing defective units. She suggests that defective units be scrapped, instead. Assume the salvage value of a scrapped unit is \$92.00 and that the existing assembly equipment has sufficient capacity to build the additional units.

D. (2 points) How many units will need to be assembled (on average) in order to yield one defect-free unit?

E. (3 points) Assuming a total of 1000 defect-free units are built each year, what is the average cost of producing one defect-free unit?

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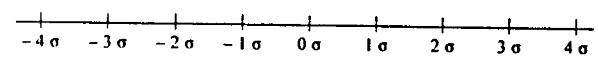
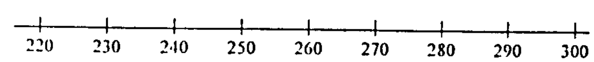
Problem 3. (16 points)

A. (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)
	0σ		-0.17σ	σ	0.9			
224.4		285.6					Z(4.0) ≈ 0.0032%	Z(3.2) ≈ 0.0687%

B. (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.





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Problem 3. (12 points)

Answer each of the following questions by circling either TRUE or FALSE in the left-hand column.

TRUE FALSE The primary purpose of accelerated stress testing is to reduce the failure rate during the "useful lifetime" of a product.

TRUE FALSE Under normal economic circumstances, the present value of a future transaction decreases as the time interval increases.

TRUE FALSE The "utilitarian" model of morality emphasizes maximizing the benefit of a decision; i.e., "the most good for the most people".

TRUE FALSE One of the major advantages of experiment-based design methods is that they produce globally-optimal solutions.

TRUE FALSE Engineering licensure was instituted by states to protect the life, health, and property of the general public.

TRUE FALSE The use of sampling techniques to characterize a product or process is more accurate for parameters that have a small standard deviation.

TRUE FALSE Most engineering disasters have a single, identifiable cause and could have been avoided by better design.

TRUE FALSE Given a geometric gradient series of payments over n years, there is always a uniform series of payments over n years that has the same present value.

TRUE FALSE One of the major causes of failures during the "infant mortality" period is latent defects that were not detected during the manufacturing process.

TRUE FALSE The "rights-based" model of morality is based on your right to act in your own best interest.

TRUE FALSE One of the major advantages of experiment-based design methods is that they can produce designs that are tolerant of normal manufacturing variation.

TRUE FALSE Given the tail-end Z-function, Z(x), the cumulative distribution function can be computed as follows: CDF(x) = Z(−x).

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Problem 4. (8 points)

Science and engineering often attempt to "maximize opportunity;" i.e., if something can be done, then it should be done – or at least tried. By contrast, the general public often seeks to "minimize risk." These attitudes lead to conflicts over projects as diverse as nuclear power, genetically-altered foods, and experimental medical treatments. Clearly, a balance must be struck between these two extremes in order for society to function smoothly.

Briefly discuss the issues that you feel are most relevant to this dilemma. What are (or should be) the responsibilities of scientists and engineers in such situations? How should conflicts be resolved? You may find it helpful to consider the various ethical models, the nature of professionalism, engineering codes of ethics, or examples of similar types of conflicts in other fields.

Problem 4. (8 points)

Legibly write your answers on the lines below. Your answer for each part is limited to the space provided. DO NOT write (or continue) your answers on the back of this page or anywhere else on this exam. Your answers will be graded on both appropriateness/correctness and on the quality/clarity of your writing. A longer answer is not necessarily a better answer.

You are a "junior engineer" for a large electronics/aerospace company. Your company has developed a state-of-the-art missile system that can track a target under zero visibility conditions. You have been working on the computer that controls this missile and have discovered a flaw in the hardware that has a one in one-thousand (0.1%) chance of causing the missile to blow up prior to achieving its mission. Furthermore, if the missile blows up prematurely, there is an estimated 20% chance of killing civilians or friendly forces (e.g., your own personnel).

You inform your immediate supervisor of this problem. Fixing the flaw would require a major hardware redesign. Manufacture of the missile begins in about one week and delaying manufacture will cost your company millions of dollars. Your supervisor says, "Don't worry about it. Nothing will go wrong."

What should you do next? Options include:

(1) Telling your supervisor's boss about the problem.
(2) Publicly informing the local television stations and newspapers.
(3) Leaking the information to the local television stations and newspapers.
(4) Forgetting about it, since you have done your duty.

A. (2 points) Based on the data provided, do you consider this flaw to pose a serious problem? Why or why not?

B. (3 points) Which of the options listed above, or another one of your choosing, do you feel is most appropriate action to take? What outcome do you hope to achieve by this action and why do you consider this to be the best possible outcome under the circumstances?

C. (3 points) In the space provided below, justify your answer to part B in terms of the general ethical responsibility of engineers, model codes of ethics, or the various ethical theories discussed [illegible] textbook.