

Name: _____

Recitation Section: L _____

Student Number: _____

1. Check that your exam includes all 10 pages. There is a separate two sided formula sheet.
2. Complete the information requested in the spaces above.
3. PRINT your name and student number in the spaces at the top of pages 2 – 10 of this exam.
4. Read all problem statements carefully. Points will be deducted for failure to follow instructions.
5. **Show ALL of your work on these pages.** The pages in this exam may be separated for grading; therefore, if you need extra space for a particular problem, write on the back of the page for that problem. The instructions for a specific question may limit the amount of space allowed for an answer.
6. You are permitted three sheets (8 1/2 x 11), double-sided, of handwritten notes. Use of any other notes, books, or other resources is prohibited.
7. Calculators are permitted; however, you are not allowed to use the calculator memory to store notes, etc.
8. This exam lasts for 170 minutes. Point values are listed for each problem to assist you in best using your time.
9. This exam will not be returned. You may review it in Dr. Callen's office during summer 2003.

_____	Problem 1.	(16 points possible)
_____	Problem 2.	(16 points possible)
_____	Problem 3.	(12 points possible)
_____	Problem 4.	(14 points possible)
_____	Problem 5.	(12 points possible)
_____	Problem 6.	(12 points possible)
_____	Problem 7.	(12 points possible)
_____	Problem 8.	(6 points possible)
_____	TOTAL.	(100 points possible)

Manufacturing-Related Formulas

$$C_p = (USL - LSL) / (6 \sigma)$$

$$C_{pk} = C_p (1 - k), \quad k = | \text{Actual Mean} - \text{Target Mean} | / ((USL - LSL) / 2)$$

$$\text{First-time yield, FTY} = e^{-dpu}$$

$$\text{Prob } \{ k \text{ defects} \} = (dpu^k / k!) e^{-dpu}$$

Problem 1. (16 points)

For each of the following multiple-choice questions, circle the letter in the right column that corresponds to the most appropriate answer. Each question is worth 2-points.

- A. Which of the following statements is NOT an accurate description of the waterfall (V-shaped) model of software development? **a b c d**
- (a) completeness and correctness of the initial system specifications is very important
 - (b) effective for management of large design teams
 - (c) user feedback can be easily incorporated during the design process
 - (d) most of the coding must be completed before system-level testing can be started
- B. Which of the following statements BEST describes the spiral model of software development? **a b c d**
- (a) best choice for projects involving simultaneous hardware and software development
 - (b) balances structured process with the ability to adapt specifications during development
 - (c) does not allow effective use of multiple design teams
 - (d) since each design iteration has been tested, final system testing is not needed
- C. For the “bathtub curve” model of reliability, which of the following statements is NOT true? **a b c d**
- (a) the per unit failure rate decreases rapidly during the infant mortality period
 - (b) the per unit failure rate is approximately constant during the useful lifetime
 - (c) the per unit failure rate is lowest during the useful lifetime
 - (d) the per unit failure rate decreases rapidly during the wearout period
- D. The approximate worth of a corporation upon dissolution and sale of assets is the **a b c d e**
- (a) enterprise value
 - (b) value of the initial public offering
 - (c) liquidation value
 - (d) book value
 - (e) stockholder equity minus net liabilities
- E. The balance sheet of a corporation expresses which one of the following relationships? **a b c d e**
- (a) Assets = Liabilities
 - (b) Assets = Liabilities + Stockholder Equity
 - (c) Assets + Stockholder Equity = Liabilities
 - (d) Capitalization = Debt + Equity
 - (e) Current Ratio = Debt /Equity

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- F. According to the S-curve model discussed in class, a major reason that many high-tech firms fail to sustain their early success is that **a b c d**
- (a) the company fails to make the necessary investment to develop the next innovation
 - (b) the product becomes obsolete
 - (c) the company is unable to obtain additional financing
 - (d) the founder retires
- G. Two machines are involved in producing a part for a printed circuit board. **a b c d e**
For a batch of 10000 boards, 6000 of the boards have the part made by machine A, and 4000 have the part made by machine B. Machine A has a defect rate of 1 %, and machine B has a defect rate of 5%. If a board is randomly selected after the part has been inserted, and it is determined that the part is defective, what may one conclude?
- (a) The probability that machine A made the part is 60%, and the probability that Machine B made the part is greater than 40%
 - (b) The probability that machine A made the part is 60%, and the probability that Machine B made the part is 40%
 - (c) The probability that machine A made the part is greater than 60%, and the probability that Machine B made the part is less than 40%
 - (d) The probability that machine A made the part is less than 60%, and the probability that Machine B made the part is greater than 40%
 - (e) The probability that machine A made the part is greater than 60%, and the probability that Machine B made the part is 40%
- H. The term “overhead” in a Georgia Tech engineering project budget is usually determined **a b c d e**
- (a) As a percent of fringe benefits
 - (b) as a sum of all salaries applied to the project
 - (c) as a percent of the total project cost
 - (d) as a percent of the total salaries, fringe benefits, materials and supplies, and travel
 - (e) as the difference between the total project budget and the salaries portion of the total project budget.

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Problem 2. (16 points)

For each of the following statements, circle either TRUE or FALSE.

- | | | |
|--|-------------|--------------|
| A. In group decision-making, the number of possible communication interactions is linearly proportional to the number of group members. | TRUE | FALSE |
| B. Once you pass the Fundamentals of Engineering Examination in one State of the USA, you can use your examination score to satisfy this examination requirement in other States. | TRUE | FALSE |
| C. In the design process, one of the major advantages of partitioning is the ability to work on multiple tasks in parallel, leading to shorter calendar time to completion. | TRUE | FALSE |
| D. The principal cause of the Challenger rocket disaster was a failure to understand the thermal conductivity of the O-rings. | TRUE | FALSE |
| E. By purchasing a corporate bond, you are obtaining a partial ownership of that company. | TRUE | FALSE |
| F. In a two-person, two-by-two, positive sum game expressed as a payoff matrix, it is always best to use a pure strategy of always selecting the same row or column to maximize gain (or minimize loss) . | TRUE | FALSE |
| G. Given two possible economic outcomes of equal expected value, a person characterized as risk-prone will more likely choose the outcome with the lower probability of occurrence than would a person characterized as risk-averse. | TRUE | FALSE |
| H. In utility theory, the utility assigned to a given outcome is determined strictly by its expected economic payoff. | TRUE | FALSE |

Problem 3. (12 points)

The activities A_1 , A_2 , and A_3 form a critical path for a PERT Chart. The characteristics of these activities are listed in the table below:

Activity	Expected time (months)	Variance (months ²)
A_1	3.25	0.40
A_2	2.40	0.20
A_3	1.85	0.30

- A. (4 points) Determine both the project duration and the variance of the project completion time.

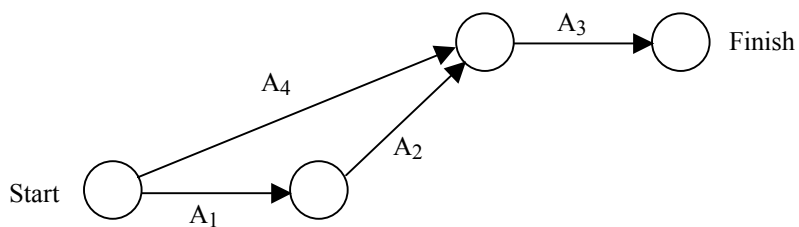
Project Duration = _____

Variance = _____

- B. (4 points) Determine the probability that the project will be completed in less than 7 months.

Probability = _____

- C. (4 points) The complete PERT chart is shown below. Activity A_4 has an expected time of 5 months. Determine the latest start for activity A_4 and the float for activity A_3 .

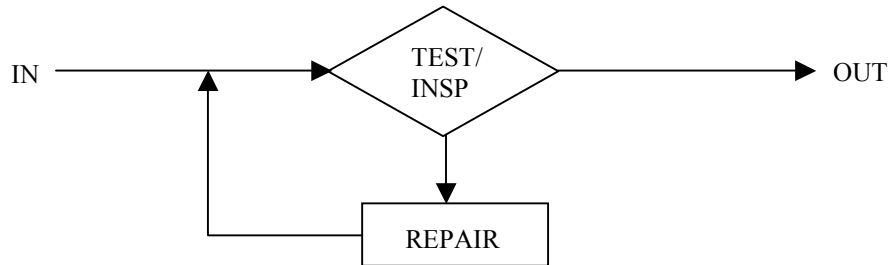


A_4 Latest Start = _____

A_3 Float = _____

Problem 4. (14 points)

A manufacturing process is characterized by an average of 1.3 defects per unit. Assume perfect repair. The diagram below applies to both parts A and B.

**A. TEST**

- (a) (3 points) How many total tests must be performed to produce 10,000 defect-free units out?

- (b) (3 points) How many of the 10,000 defect-free units produced had only one test applied to them?

- (c) (1 points) How many of the 10,000 defect-free units produced had two or more tests applied to them?

B. INSPECTION

- (a) (3 points) How many total inspections must be performed to produce 10,000 defect-free units out?

- (b) (3 points) How many of the 10,000 defect-free units produced had only one inspection applied to them?

- (c) (1 points) How many of the 10,000 defect-free units produced had two or more inspections applied to them?

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Problem 5. (12 points)

- A. (2 points) State one significant reason that software design and production is different from standard electromechanical design.

- B. (4 points) In benefit-cost analysis, is the B-C difference or the B/C ratio usually used? State why.

Difference Ratio (circle one)

Why: _____

- C. (3 points) As stated in the NCEES Rules of Professional Conduct, what is the first and foremost responsibility of an engineer?

- D. (3 points) State the behavioral significance and consequence when two entities have reached a Pareto Optimal point.

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Problem 6. (12 points)

Your company is preparing to buy a major piece of equipment with the following economic characteristics:

Purchase Price:	\$200,000
Expected Lifetime:	15 years
Interest Rate: (nominal)	8%
Maintenance cost (annual):	\$4,000
Salvage Value:	\$5,000
Electricity cost: (annual, assume increases \$500/year)	\$2,000

- A. Determine the present value of the lifetime operating cost of the machine, including all of the above factors.
- B. The purchase price is to be paid by making an initial payment of 20% of the purchase price, and then the remaining 80% is to be paid quarterly (every 3 months) for 15 years. Determine the amount of each quarterly payment.

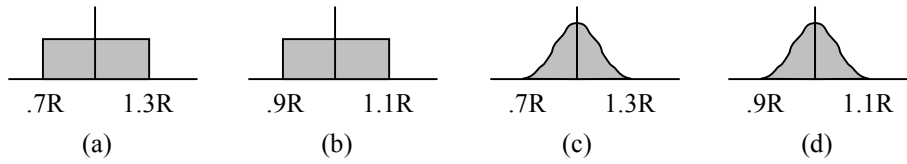
You **MUST** show your work (formulas and numeric values) to justify your answers. Correct answers without supporting work will not receive full credit.

A. (7 points) Present Value = _____

B. (5 points) Each Payment = _____

Problem 7. (12 points)

- 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. These resistors are connected in series to form a resistance $R = R_1 + R_2 + R_3$. Which of the following figures most closely describes the expected distribution of values for R ? **a b c d**



- 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 values, with $\pm 3\sigma = \pm 10\%$ of the resistor value. These resistors are connected in series, as in part A. How would the standard deviation of the expected distribution of values for R compare to the standard deviation of the expected distribution of values for R under the conditions in part A? **a b c d**

- (a) Less than in part A
 (b) Approximately the same as in part A
 (c) Greater than in part A
 (d) Cannot be determined from the information provided

- C. (2 points) Assume incoming inspection uses random sampling to characterize electronic components. Which one of the following attributes is most difficult to accurately characterize with a moderate sample size? **a b c d**

- (a) Average (mean) value
 (b) Standard deviation
 (c) Extreme values (minimum, maximum)
 (d) General shape (e.g., uniform, Gaussian)

- D. (6 points) Your company contracts with a manufacturer to produce a large quantity of 2000Ω resistors with a tolerance of $\pm 5\%$. Incoming inspection measures a mean value of 1975Ω and a standard deviation of 40Ω .

Assume the manufacturing process produces a normal distribution of resistance values. 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: the process capability index C_p , the shifted process capability index C_{pk} , and the percentage of manufactured resistors that are good (satisfy the tolerance specification). Write your answers in the boxes at the right margin. Show your work on the back of this page.



C_p

C_{pk}

% good

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Problem 8. (6 points)

A semiconductor materials design problem can be characterized by a linear maximization function subject to linear constraints. The conductivity K can be characterized in normalized units as

$$K = n + 5p,$$

where n is the electron concentration, and p is the hole concentration. Because of other features of the process, n and p are subject to the three constraint equations below:

C1: $n + 4p < 8$

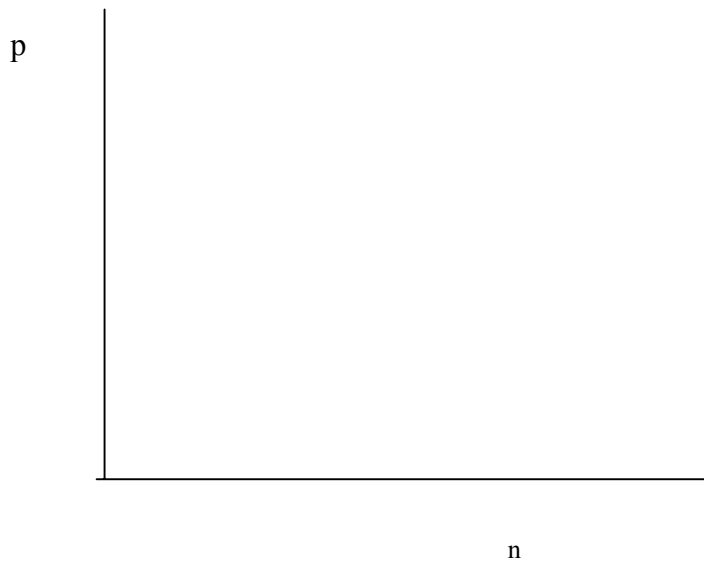
C2: $2n + 3p < 12$

C3: $7n + 4p < 28$

A. Sketch and label the three constraint equations (each expressed as an equality) in the indicated space below.

B. Determine the maximum value of the conductivity, expressed in these normalized units.

A. (3 points)



B. (3 points) $K =$ _____