

Problem 1.

(a) There is typically higher tolerance for risk if:

Voluntary
Familiar
Uncertain

In the future
One is in control

Tolerance depends on who is affected.
Tolerance depends on the institution causing the risk.

(b) Most government standards are written as design standards, because they are easier to regulate and enforce

(c) The Hyatt walkway collapsed because there was a huge crowd of people, and the connecting pins were not constructed as designed.

Problem 2.

Assume that an engineer has determined the benefit of a project to be 6.0, and the cost to be 3.0. If a small additional item of magnitude .3 exists that could be classified as either a disbenefit or as an additional cost, classification as an additional cost would result in a lower benefit-cost ratio. This can be proved algebraically, or can be verified by direct observation, e.g., that $6/3.3 < 5.7/3$.

The benefit-cost ratio is usually used instead of the benefit-cost difference in order to account for projects of different scale. Two large numbers can have a seemingly large difference, even though the fractional difference is small.

Problem 3.

A manufacturing process is characterized by the following values:

LSL=24 K
USL=40 K
TM=32 K
AM=30 K
Sigma=4 K

The characteristics of the manufactured item are distributed according to a normal (Gaussian) distribution.

$$C_p = (USL - LSL) / (6 \text{ sigma}) = (40-24)/6(4) = .67$$

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

$$k = | \text{Actual Mean} - \text{Target Mean} | / ((USL - LSL) / 2) = (32-30)/((40-24)/2) = .25$$

$$C_{pk} = .67(1-.25) = .50$$

$$\text{Defects below LSL} = Z((30-24)/4) = Z(1.5)$$

(in terms of tail-end Z function)

$$\text{Defects above USL} = Z((40-30)/4) = Z(2.5)$$

(in terms of tail-end Z function)

Since $C_p < 1$, the design is intolerant. (b)

Problem 4

A. 10,000 devices are being tested for 500 hours. The process is characterized by a per unit failure rate of $4 \times 10^{-3} \text{ hr}^{-1}$. The number of devices that fail between 200 hours and 400 hours of their life = # of survivors at 200 hours - # of survivors at 400 hours = $10,000 e^{-(.004)(200)} - 10,000 e^{-(.004)(400)} = 4490 - 2020 = 2474$ (b)

B. A manufacturing process has an average defect rate of 1.8 defects per unit. The probability that a particular unit will have more than 1 defect is equal to one minus the number that have zero minus the number that have exactly one defect. $\text{Prob} \{ k \text{ defects} \} = (\text{dpu}^k / k!) e^{-\text{dpu}}$; $\text{Prob} \{ 0 \text{ defects} \} = (\text{dpu}^0 / 0!) e^{-\text{dpu}} = .1653$
 $\text{Prob} \{ 1 \text{ defect} \} = (\text{dpu}^1 / 1!) e^{-\text{dpu}} = .2975$
 Prob. of more than 1 = $1.0000 - (.1653 + .2975) = 1.0000 - .4628 = 53.7\%$. (d)

C. A manufacturing process step, involving inspection with perfect repair and 100% coverage, has a first-time yield (FTY) of 30.1%. For a FTY of .301, $\text{dpu} = -\ln(.301) = 1.2$. While producing 1000 good units the number of total tests will have to be performed is equal to $(1 + \text{dpu})1000 = 2,200$ (d)

D. A manufacturing line produce microprocessors whose average maximum operating clock speed is 120 MHz. Assuming a normal distribution of maximum operating speeds and a standard deviation of 20MHz, the percentage of microprocessors that will operate correctly at 90 MHz is $1 - Z((120 - 90)/20) = 1 - .067 = .933 = 93.3\%$ (d)

E. A system composed of two parallel subsystems of reliability .4 and .6 respectively, has a system reliability of $R = 1 - (1 - R_1)(1 - R_2) = 1 - (.6)(.4) = .76$ (c)

F. The Stancell Leadership Module discusses that effective leadership requires teamwork in diverse groups, integrity and self awareness, vision and risk taking. Aggressiveness in new situations is not specifically mentioned. (a)

G. In order to develop leadership skills, the Stancell Leadership Module discusses that a private victory in developing a sound set of personal principles must be achieved. (b)

H. The matrix method, as discussed in the guest lecture by Mr. Drapeau, is a method to select a vendor as a supplier. (d)

I. Most engineering disasters are a result of a rare combination of unexpected events. (a)

J. If one machine has a higher defect rate than does another machine, and together both machines produce all of the items, then if a defect is found, the probability that the item was made by the machine with a higher defect rate is increased, by Bayes' theorem. (d)

Problem 5.

(a) One is qualified to undertake an engineering job on the basis of experience and training, not by virtue of the discipline in which one passed the Principles and Practice Exam. **FALSE**

(b) Under the doctrine of strict liability, negligence does not have to be proved before a corporation is legally liable. All that must be shown is that the product was defective and unreasonably dangerous, the defect existed when the product left the defendant's control, the defect caused the harm, and the harm is appropriately assignable to the defect. The intent of the defendant is not the issue. **TRUE**

(c) A definition of the term "ukase" is a regulatory ruling with the force of law. **TRUE**

Name: _____

Student #: _____

- (d) If the initial payment of a geometric gradient series is \$100, and the gradient corresponds to 8%, then the second payment is increased by \$8 over the first, but each subsequent payment increases by more than \$8. Each of the last 8 terms of the geometric series is therefore greater than each of the corresponding terms of the arithmetic series, so entire geometric series has a higher present value. **TRUE**
- (e) It has not been determined that a no-growth policy is necessary to elevate overall living standards. No conclusive approach to the elevation of living standards consistent with achieving a sustainable society has been demonstrated. Significant counter-examples are in abundance. Most would agree that the United States has a higher living standard than that of a century ago, particularly in the areas of medical and dental care, yet we have experienced tremendous growth. **FALSE**
- (f) If a company has complied with ISO 9000:2000 standards, it means that the organization has adopted procedures, practices, and standards for a quality system capable of meeting customer requirements, not that those customer requirements have necessarily been met. **FALSE**
- (g) The useful lifetime region of the “bathtub” model of device reliability is typically characterized by a constant, or slightly increasing, per-unit failure rate. **FALSE**
- (h) The roof-top portion of the QFD diagram describes the trade-off among the engineering requirements. The trade-off between the consumer desires and the engineering requirements occurs in the main rectangular section of the diagram. **FALSE**
- (i) It is possible to include intangible factors in a numerical benefit-cost analysis. It is difficult to determine a numerical value, but it nearly always has to be done. **TRUE**
- (j) A system composed of two subsystems in parallel is always more reliable than a system composed of the same two subsystems in series, assuming that for each subsystem, $0 < R < 1$. $R = 1 - (1 - R_1)(1 - R_2) = R_1 + R_2 - R_1R_2 = R_1 + R_2(1 - R_1) > R_1$, for $0 < R_1, R_2 < 1$. **TRUE**

Problem 6.

A company is making a decision on which of three possible alternatives to design and build. A decision theory model for the projected revenue is to be used (dollar amounts are in millions). All systems cost the same. An interest rate of 6% is appropriate. Using an equivalent **present value** viewpoint, the present value of expected revenue of each alternative is:

Quiz #1

Alternative #1 expected revenue (present value) =
 $.8(3600) + .2(4800) = \$3,840$

Alternative #2 expected revenue (present value) =

$$800(P/A, 6\%, 6) - 200(P/A, 6\%, 3) = \$3,399$$

Alternative #3 expected revenue (present value) =

$$650 + 650(P/A, 6\%, 5) = \$3,388$$

Choose alternative # 1

Quiz #2

$$.8(3200) + .2(3600) = \$3,280$$

Choose alternative # 2