Problem 1.

(a) There is typically higher tolerance for risk (perceived risk less than actual risk) if:
Voluntary
Familiar
In the future
One is in control
People affected are different from the assessor
Institution causing the risk is not a corporation or a government agency

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

(c) If F_1 is the first payment in a geometric series and F_n the nth payment, then

$$F_n = F_1(1+i)^{n-1},\ F_1 = F_n(1+i)^{-n+1},\ F_1 = 1{,}200(1+.04)^{-7},\ F_1=\$911.90$$

P= F_1(P/ F_1,g,i,n)=912(P/ F_1,4%,8%,8)=$5,941.12

(d) Maintenance expenses, as do most public benefits, occur over a period of time, so may be more appropriate to treat them as a disbenefit, as opposed to a cost, which typically occurs at the beginning or construction phase of a project. If a small additional item exists that could be classified as either a disbenefit or as an additional cost, classification as a disbenefit would result in a higher benefit-cost ratio. This can be proved algebraically, or can be verified by direct observation, e.g., that (100-10)/80> 100/(80+10).

Problem 2.

A manufacturing process is characterized by the following values:

Cp=8
Cpk = .752
USL=4.8 x 10^{-6}
LSL=1.6 x 10^{-6}

The characteristics of the manufactured item are distributed according to a normal (Gaussian) distribution, with the specification limits symmetric about the target mean.

Cp = (USL – LSL) / (6 sigma)=(4.8-1.6) x 10^{-6} /(6 sigma)= .8

Sigma = 6.67 x 10^{-7} ohms

Cpk = Cp (1 – k) .752=.8(1-k)

k = .06 = | Actual Mean – Target Mean | / ((USL – LSL) / 2)

(USL-LSL)= 3.2 x 10^{-6}

| Actual Mean – Target Mean | = .096 x 10^{-6}

Percentage shift=.096 x 10^{-6} /TM X 100%=+3% (AM>TM) or – 3% (AM<TM)
Defects below LSL = Z((3.2-1.696)/.667)=Z(2.544)
(in terms of tail-end Z function) (for AM>TM)

Defects above USL = Z((4.8-3.296)/.667)=Z(2.256)
(in terms of tail-end Z function) (for AM>TM)

Note: If AM<TM, answers for defects will be reversed.

Problem 3

A. 10,000 devices are being tested for 500 hours. The process is characterized by two parallel reliabilities with of .3 and .6 at 300 hours. The per-unit failure rate at 300 hours may be determined from the reliability at 400 hours: R=1-(1-R1)(1-R2)=.72. 10,000 $e^{-(.lambda)(300)}$ =10000(.72). Lambda=1.1 x 10^{-3}. (b)

B. A group of 10,000 devices is characterized by two sub-systems with series reliabilities and per unit failure rates of 3.0 x 10^{-3} hr^{-1} and 1.0 x 10^{-3} hr^{-1}. The overall per unit failure rate is 3.0 x 10^{-3} hr^{-1} + 1.0 x 10^{-3} hr^{-1}= 4.0 x 10^{-3} hr^{-1}.The number of devices that survive past 400 hours of their life=# of survivors at 400 hours= 10,000($e^{-(.004)(400)}$)=2019 (a)

C. A manufacturing process has an average defect rate of 1.8 defects per unit. The probability that a particular unit will have 2 or more defects is equal to 1 minus the probability that a unit have zero minus the probability that a unit have exactly one defect. Prob { k defects} = (dpu^k / k!) e^{-dpu} ; Prob { 0 defects } = (dpu^0 / 0!) e^{-dpu} = .1653 Prob { 1 defect} = (dpu^1 / 1!) e^{-dpu}.=.2975 Prob. of 2 or more=1-.1653-.2975=.5373=53.73% (c)

D. A manufacturing process step, involving inspection with perfect repair and 100% coverage, has a first-time yield of 75%. For a FTY of .75. dpu=-ln(.75)=.2877. While producing 1000 good units the number of total tests that will have to be performed is equal to (1+dpu)1000 = 1,288 (c)

E. A manufacturing line produces microprocessors whose average maximum operating clock speed is 180 MB/sec. Assuming a normal distribution of maximum operating speeds and a standard deviation of 40MB/sec , the percentage of microprocessors that will operate correctly at 120 MHz is 1-Z((180-120)/40))=1-.067=.933=93.3% (c)

F. The decision on the dollar amount to assign to represent the effect of a change of scenery is representative of the quantification of an intangible idea. Version #1 (a), Version #2 (d)

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

H. Three resistors are wired together in series, R=2R1+R2 (R1 is used twice). R1 has a mean value of 1 kilohm, with a variance of 0.3 $kilohm^2$. R2 has a mean value of 2 kilohms, with a variance of 0.4 $kilohm^2$. The equivalence has a mean value of 2(1) + 2 = 4kilohms. The variance is determined from the partial derivative formula, eq. 5A.4 in text, to be $(2)^2$(.3)+.4 = 1.6 $kilohms^2$. (d)

Problem 4.

(a) The engineers were aware that the O-ring was not rated safe for operation at the launch temperature. This was not forcefully communicated to management, and management made a bad decision, thinking, “it’ll probably be all right.” **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. This is an easier standard for a plaintiff to prove. **FALSE**

(c) (Version #1) A definition of the term “ukase” is a regulatory ruling with the force of law. **TRUE**
(Version #2) Refer to (d) below. **TRUE**

(d) (Version #1) A product whose design is based on worst case analysis is typically more expensive. TRU**E**
(Version #2) Refer to (e) below. **FALSE**

(e) (Version #1)The morning portion of the Fundamentals of Engineering Exam is a general examination and does include questions on both ethics and engineering economy. **FALSE**
(Version #2) Refer to (f) below. **FALSE**

(f) (Version #1) If a company has complied with ISO 9000:2000 standards, it means that the organization haa adopted procedures, practices, and standards for a quality system capable of meeting customer requirements, not that those customer requirements have necessarily been met. **FALSE**
(Version #2) Refer to (g) below. **TRUE**

(g) (Version #1)The infant mortality region of the “bathtub” model of device reliability is typically characterized by a decreasing per-unit failure rate. **TRUE**
(Version #2) Refer to (h) below. **FALSE**

(h) (Version #1) 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**
(Version #2) Refer to (c) above. **TRUE**

(i) The Baldridge Award is typically given to an organization that meets outstanding quality controls systems. The system must be capable of meeting customer requirements, not that those requirements are met. **FALSE**

(j) Both the ABET code and the NCEES code emphasize the public safety and welfare, and are quite similar. **FALSE**

Problem 5.

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

Alternative #1 expected revenue (annualized value) =

.7 (3200)+.3[(3000+3000(P/A, 6%,3)(P/F,6%,3)(A/P,6%,6)]=$3,551

Alternative #2 expected revenue (annualized value) =

.8(8000)(A/P,6%,6)+.2(8000))[(P/F,6%,1)+(P/F,6%,3) + (P/F,6%,5)](A/P,6%,6)=$2,125

Alternative #3 expected revenue (annualized value) =

4000+4000(A/P, 6%, 6)=$4,813

Choose alternative # 3

Note: The values above are exact, given our methods and definitions. We could use an approximate method, based on an average annual amount. In this case, the expected revenue from Alternative # 1 is overestimated, since the larger amounts occur in the last three years, and the expected revenue from Alternative # 2 is underestimated, since the larger amount of the two year cycle occurs in the first year. If an approximate calculation is used, then the argument needs to be made that, although Alternative #2 is underestimated, an exact calculation would not move the result sufficiently to make it be preferred to Alternative #3, since the results are so disparate.