Problem 1. (25 points)

(3 points each) Answer the following multiple-choice questions by circling the letter in the right-hand column that corresponds to the most appropriate response.

A. If interest is compounded multiple times during each period, the effective interest rate will be _____ the nominal interest rate. **C**

(a) less than
(b) equal to
(c) greater than
(d) unrelated to

B. Which of the following is the best example of **partitioning** in the design process? **B**

(a) dividing the functions of a system between hardware and software elements
(b) dividing a schematic diagram into sections for multiple printed circuit boards
(b) using multiple copies of the same sub-circuit in several different parts of a design
(d) combining several pieces of a design into a single unit

C. Which of the following is the best example of **modularity** in the design process? **C**

(a) dividing the functions of a system between hardware and software elements
(b) dividing a schematic diagram into sections for multiple printed circuit boards
(c) using multiple copies of the same sub-circuit in several different parts of a design
(d) combining several pieces of a design into a single unit

D. Which of the following factors most strongly contributed to the collapse of the Hyatt Regency walkway? **D**

(a) rare combination of unexpected events
(b) clearly defined ethical lapse
(c) management communication failure
(d) improper implementation of design

E. Which of the following generally is **not** one of the benefits of dividing a large design project into multiple, parallel activities? **A**

(a) fewer workers needed
(b) utilize discipline-specific knowledge
(c) reduce elapsed time to completion
(d) localize effects of design changes

(2 points each) For each of the following statements, circle the most appropriate response in the right-hand column.

F. The terms "hierarchical decomposition" and "bottom-up" generally mean the same thing in describing a design process. **FALSE**

G. Given a geometric gradient series of payments over n years at interest rate i, there is an equivalent uniform series of payments also over n years at interest rate i. **TRUE**

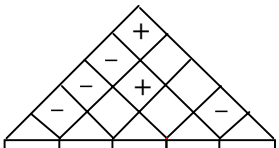
H. A rare combination of events that were individually anticipated may lead to an unexpected disaster, even in a good design. **TRUE**

I. The principal advantage of simulation compared to building a prototype is reduced cost. **FALSE**

J. One of the primary purposes of QFD diagrams is to identify and clarify relationships between different levels of abstraction or different stages in the design process. **TRUE**

Problem 2. (20 points)

This QFD diagram maps customer desires into engineering characteristics for a battery-powered "electronic textbook". Students would download books from an on-line database and would be able to annotate pages by writing on the screen with a stylus. This diagram was developed to assist in establishing requirements and specifications for this new product.



	– Power consumption	+ Display size and resolution	+ Amount of memory	+ Color graphics capability	– File size for books & annotations
Ease of annotation		+			
Long battery life	+	–	–	–	
High quality image	–	+	+	+	–
Low price		–	–	–	

Answer the following questions **based on this QFD diagram**.

A. (3 points) Which of the following engineering characteristics is likely to have the greatest affect on customer satisfaction with this product?

(a) Power consumption
(b) Display size and resolution
(c) Amount of memory
(d) Color graphics capability
(e) File size for books & annotations

B. (3 points) Which one of the following pairs of customer desires is not in conflict?

(a) Ease of annotation and long battery life
(b) Long battery life and high quality image
(c) Long battery life and low price
(d) High quality image and low price

C. (3 points) Given its interactions with other engineering characteristics, which one of the engineering characteristics is likely to be most difficult to achieve?

(a) Power consumption
(b) Display size and resolution
(c) Amount of memory
(d) Color graphics capability
(e) File size for books & annotations

D. (3 points) Which one of the following customer desires is likely to be most difficult to achieve?

(a) Ease of annotation
(b) Long battery life
(c) High quality image
(d) Low price

E. (8 points) On the QFD diagram, add one more significant customer desire and "+" or "–" signs in the lower matrix showing how this desire relates to the listed engineering characteristics. In the space below, briefly justify your choices.

Answers will vary

Problem 3. (15 points)

Your company is preparing to buy a major computer and telecommunications system with the following economic characteristics:

Purchase Price:	$250,000	
Expected Lifetime:	10 years	
Salvage Value:	$25,000	
Electricity cost	$6,000	first year; increases 3% per year
Annual Interest Rate:	7%	

A. (10 points) The manufacturer offers two maintenance options. **Option 1:** Pay for routine maintenance charges as needed, estimated to cost $5,000 per year, plus major system upgrades costing $20,000 at the end of the 4th and 8th years. **Option 2:** Buy a five-year maintenance/upgrade contract for $30,000 at the time of initial purchase, with annual renewal charges of $9,000 at the end of years 5 through 9.

Determine the **present value** of the lifetime maintenance costs for each of these options:

Option 1: $PV_{MAINT} = 5000\ (P/A, 7\%, 10) + 20{,}000\ (P/F, 7\%, 4) + 20{,}000\ (P/F, 7\%, 8)$
$= 5000\ [(1.07^{10} - 1)/(.07\ (1.07^{10}))] + 20{,}000\ (1.07^{-4}) + 20{,}000\ (1.07^{-8})$
$= 5000\ (7.024) + 20{,}000\ (0.763) + 20{,}000\ (0.582) =$ **62,016**

Option 2: (note: annual sequence years 5–9 equivalent to sequence years 1–9 minus sequence years 1–4)
$PV_{MAINT} = 30000 + 9000\ [(P/A, 7\%, 9) - (P/A, 7\%, 4)]$
$= 30000 + 9000\ [(1.07^{9} - 1)/(.07\ (1.07^{9})) - (1.07^{4} - 1)/(.07\ (1.07^{4}))]$
$= 30000 + 9000\ [6.515 - 3.387] =$ **58,152**

B. (5 points) Determine the **annualized** cost of this system, including all of the above factors and selecting the less expensive maintenance option.

Annualized cost $= PV_{TOTAL}\ (A/P, 7\%, 10)$

$PV_{TOTAL} = PV_{PURCHASE} - PV_{SALVAGE} + PV_{ELECTRICITY} + PV_{MAINTENANCE}$
$= 250{,}000 - 25{,}000\ (P/F, 7\%, 10) + 6000\ (P/F_1, 7\%, 3\%, 10) + PV_{MAINT}$
$= 250{,}000 - 25{,}000\ (1.07^{-10}) + 6000\ [(1.07^{10} - 1.03^{10})/((.07 - .03)\ 1.07^{10})] + 58{,}152$
$= 250{,}000 - 25{,}000\ (0.508) + 6000\ (7.921) + 58{,}152 =$ **342,966**

Annualized cost $= 342{,}966\ [(.07\ (1.07^{10}))/(1.07^{10} - 1)]$
$= 342{,}966\ (0.142)$
$=$ **48,831**

Problem 4. (25 points)

For each of the following economic computations, (a) list the conversion factor to be used, specifying the parameter values, and (b) compute the result, showing your work. Write your answers on the blank lines on the right edge of this page; correct answers in other locations may not receive full credit. An example is provided.

EXAMPLE:

If you invest \$100 in a bank account today, at an interest rate of 6.5%, how much will you have after five years?

(a) **(F/P, 6.5%, 5)**

(b) **\$ 137.01**

100 (F/P, 6.5%, 5) = 100 (1 + 0.065)^5 = 100 * 1.3701 = 137.01

A. (5 points) New manufacturing equipment will cost \$400,000, with an expected salvage value of \$50,000 after 30 years of use. Assuming an interest rate of 6.5%, what is the net present cost?

(a) **(P/F, 6.5%, 30)**

(b) **\$392,440.70**

400,000 – 50,000 (P/F, 6.5%, 30) =
400,000 – 50,000 (1.065^{-30}) =
400,000 – 7559.30

B. (5 points) You decide to buy a \$250,000 house. Assuming a 20% down payment and a 6% annual interest rate, what will be the monthly payment on a 30-year mortgage?

(a) **(A/P, 0.5%, 360)**

(b) **\$1199.10**

. note: need to convert annual interest rate to monthly rate
250,000 (0.8) (A/P, 6%/12, 30*12) =
200,000 [0.005 (1.005^{360})/(1.005^{360} – 1)] =
200,000 (0.005996)

C. (5 points) You deposit \$1000 into a savings account at the end of each year. Assuming the account earns 8.5% annually, how many years are required for account to reach (or exceed) \$15, 000?

(a) **(F/A, 8.5%, ?)**

(b) **10.076 years**

1000 (F/A, 8.5%, n) $\geq$ 15,000
1000 [(1.085^n – 1)/(0.085)] $\geq$ 15,000
$1.085^n \geq 2.275$
n log (1.085) $\geq$ log (2.275)
n $\geq$ 10.076 (or 11 years if you assume interest is only paid at the end of the year)

D. (10 points) Your company purchases a machine with a present cost of \$50,000. The payment plan consists of four annual payments of \$10,000 and a final payment at the end of the fifth year. Assuming an interest rate of 7%, what will be the amount of the final payment?

NOTE: This problem may require the use of more than one conversion factor. List all factors used.

(a) **(P/A, 7%, 4)**
(P/F, 7%, 5)

(b) **\$22,620.20**

50,000 = 10,000 (P/A, 7%, 4) + FinalPayment (P/F, 7%, 5)
50,000 = 10,000 [(1.07^4 – 1)/(0.07 (1.07^4))] + FinalPayment (1.07^{-5})
50,000 = 10,000 (3.3872) + FinalPayment 0.713)