

**Problem 1. (30 points)**

- |  |                           |                                  |
|--|---------------------------|----------------------------------|
| <u>  C  </u> Quality Function Deployment | <u>  G  </u> utilitarian  | <u>  K  </u> recycling           |
| <u>  D  </u> decomposition               | <u>  P  </u> amortize     | <u>  Q  </u> arithmetic gradient |
| <u>  M  </u> non-recurring cost          | <u>  L  </u> interest     | <u>  F  </u> modularity          |
| <u>  O  </u> duty-based                  | <u>  T  </u> partitioning | <u>  U  </u> simulation          |
| <u>  R  </u> cash flow diagram           | <u>  I  </u> virtue-based | <u>  A  </u> inflation           |

**Problem 2. (25 points)**

- A. (5 points) What fixed amount should you set aside for each of the next 8 years, assuming an interest rate of 7.5%, in order to accumulate \$90,000 at the end of the 8-year period?
- (a) (A/F, 7.5%, 8)  
 (b) \$8615.43

$$90000 (A/F, 7.5\%, 8) = 90000 [0.075 / (1.075^8 - 1)] = 90000 (.0957) = 8615.43$$

- B. (5 points) *Either of the two solutions listed below was considered acceptable.* You currently spend \$35 per month buying gasoline for your car. Assuming the price of gasoline increases by 7% each year and an interest rate of 5%, what is the present value of your gasoline purchases for the next 6 years?

(a) (P/F, i=5%, g=7%, 6)  
 (35)(12) (P/F, 5%, 7%, 6) = 420 [(1.05<sup>6</sup> - 1.07<sup>6</sup>) / ((.05 - .07) 1.05<sup>6</sup>)]  
 = 420 [1.1606 / .0268] = 420 (5.993) = 2517.23  
 (b) \$2517.23

(a) (P/F, 5/12%, 7/12%, 72)  
 (35) (P/F, 5/12%, 7/12%, 72) = (35) (P/F, .00417, .00583, 72)  
 = 35 [(1.00417<sup>72</sup> - 1.00583<sup>72</sup>) / ((.00417 - .00583) 1.00417<sup>72</sup>)]  
 = 35 [(1.17109) / (.00225)] = 35 (76.094) = 2663.30  
 (b) \$2663.30

- C. (5 points) A new house costs \$280,000 today. Assuming an annual interest rate of 3.5%, what would have been an equivalent value 20 years ago?
- (a) (P/F, 3.5%, 20)  
 (b) \$140,718.45

$$280000 (P/F, 3.5\%, 20) = 280000 (1.035^{-20}) = 280000 (.5026) = 140718.45$$

- D. (10 points) Your company purchases a machine with a present cost of \$750,000. The machine is expected to have a useful lifetime of 12 years and a salvage value of \$50,000. Assuming an interest rate of 6%, what is the annualized cost of this machine over its useful life?
- (a) (P/F, 6%, 12)  
(A/P, 6%, 12)  
 (b) \$86,493.92

$$\text{net PV} = 750000 - 50000 (P/F, 6\%, 12) = 750000 - 50000 (1.06^{-12}) = 725151.53$$

$$\text{annualized: } 725151.53 (A/P, 6\%, 12) = 725151.53 [.06 (1.06^{12}) / (1.06^{12} - 1)]$$

$$= 725151.53 [.1207 / 1.0122] = 725151.53 (.1193) = 86493.92$$

Equivalent alternate solution: 750000 (A/P, 6%, 12) - 50000 (A/F, 6%, 12)

**Problem 3. (20 points)**

- A. (3 points) Which of the following statements is **NOT** true?
- (c) For the listed engineering characteristics, all changes that make it easier to close the door also make it easier to open the door.  
**(increasing door seal resistance makes it harder to close the door, but easier to open)**
- B. (5 points) Which one of the listed customer desires is likely to be most difficult to achieve?
- (d) Doesn't kick back **(depends on most factors, both positively and negatively)**
- C. (5 points) Which one of the listed engineering characteristics is likely to have the greatest effect on customer satisfaction with this product?
- (d) Door seal resistance **(affects most customer desires, both positively and negatively)**
- D. (7 points) *Acceptable answers may vary.* **Door seal resistance affects customer desires both positively and negatively and has both positive and negative correlations with other engineering factors. Thus, the optimal value is probably not maximal, but an intermediate value that balances competing goals. Other entries in the QFD diagram would not necessarily change.**

**Problem 4. (15 points)** *Acceptable answers may vary for this problem.*

- A. (4 points) **Advantages:** Different parts of the design can be done in parallel (concurrently), reducing elapsed time. Facilitates design of each element by specialists (e.g., discipline-based). Reduces complexity of each design task. **Disadvantage/Limitation:** Success is more dependent on completeness and correctness of the initial specifications. Specifying interfaces early may result in a less optimal solution, since it may not be possible to benefit from information learned later in design process.
- B. (5 points) **Advantages:** Reduces total design effort and time. Reduced inventory, since there are fewer unique parts. Lower manufacturing costs (larger quantities of fewer unique items). **Disadvantage:** Limits flexibility of design choices. May result in a less optimal solution. **Example:** Standard TTL parts library. Use of user-programmable logic devices (e.g., FPGAs).
- C. (6 points) **Recycling benefit:** Reprocessing may cost less than using raw material. Reduces demand for scarce source materials. **Re-use benefit:** No design costs for re-used item. Lower manufacturing costs. **Factors:** Future needs unknown or may change. Optimal design may not be compatible with limitations imposed by re-use or recycling (e.g., use of composite structural materials).

**Problem 5. (10 points)** *Acceptable answers may vary for this problem.*

- A. (3 points) **Probabilistic is similar to utilitarian, since emphasizing the most likely outcomes will tend to produce the most benefit for the largest number of people. Many of you also compared it to duty-based, which emphasizes the responsibilities of those making the decisions, typically those in power. Possibilistic is similar to rights-based in attempting to ensure that no one is adversely affected and to virtue-based, since protecting the weak and disadvantaged generally would be considered a virtue.**
- B. (7 points) **A possibilistic model requires the designer to consider all foreseeable circumstances, even those of low probability. Thus, designs would tend to be more complex and more expensive, since they would need to satisfy a significantly broader range of specifications. However, such designs would benefit by working under a broader range of conditions and would be more widely applicable. Additionally, by considering all foreseeable circumstances, the design also is likely to be more robust under unanticipated conditions. Many examples are possible, including medical devices, aircraft flight control systems, and electrically-powered consumer products. Design choices will depend on the specific example chosen.**