Name: SOLUTION KEY Student #:

Problem 1. (~~18~~ 18 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. (~~8~~ 4 points) How much would you need to invest annually, at an interest rate of 4%, in order to have \$12,000 after 10 years?

(a) $(A/F, 4\%, 10)$

(b) \$ 999.49

$$12000 * (A/F, 4\%, 10) = 12000 * \frac{.04}{(1+.04)^{10}-1}$$

$$= 12000 * .0833 = 999.49$$

B. (~~8~~ 4 points) A bond will be worth \$50,000 in 30 years. At a discount rate of 8%, how much would you pay for that bond today?

(a) $(P/F, 8\%, 30)$

(b) \$ 4968.87

$$50000 * (P/F, 8\%, 30) = 50000 * \frac{1}{(1+.08)^{30}}$$

$$= \frac{50000}{10.063} = 4968.87$$

C. (~~8~~ 6 points) A maintenance fund has been established that currently contains \$8500. Assuming the fund earns 7% annually, how much can be spent each year if the fund is to last for 12 years?

(a) $(A/P, 7\%, 12)$

(b) \$ 1070.17

$$8500 * (A/P, 7\%, 12) = 8500 * \frac{.07(1+.07)^{12}}{(1+.07)^{12}-1}$$

$$= 8500 * \frac{.1577}{1.252} = 1070.17$$

D. (~~8~~ 5 points) The first-year operating costs for a machine are estimated to be \$5000 and are expected to increase 6% each year. What is the present value of the lifetime operating costs, assuming a useful life of 15 years and an interest rate of 10%?

(a) $(P/F, i=10\%, g=6\%, 15)$

(b) \$ 53285.38

$$5000 * \frac{(1+.1)^{15} - (1+.06)^{15}}{(.1-.06)(1+.1)^{15}} = 5000 * \frac{1.781}{.167} = 53285.38$$

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Problem 2. (10 points)

A. (8 points) Two machinery options are described below. Complete the table below, indicating the **present value** of each of the items specified. Assume an interest rate of 6% and a useful lifetime of 8 years. Show all of the necessary work to calculate the values. If you need more space, use the back of **this sheet**.

You may find the following conversion factors to be useful:

(F/P, 6%, 8) =	1.5938	(P/F, 6%, 8) =	0.6274
(A/F, 6%, 8) =	0.1010	(F/A, 6%, 8) =	9.8975
(A/P, 6%, 8) =	0.1610	(P/A, 6%, 8) =	6.2098
(P/G, 6%, 8) =	19.8416		

OPTION 1: The initial purchase price of the machine is $25,000. The salvage value at the end of the useful life will be $5000. Maintenance costs are $2000 for the first year and are estimated to increase by $150 per year.

OPTION 2: The machine is leased for an initial payment of $2000 plus annual payments of $3500. There is no salvage value. A maintenance contract is purchased for a single payment of $10,000 at the start of the lease period.

(1) $-5000 * (P/F, 6\%, 8) =$
$-5000 * 0.6274 = -3137$

$2000 * (P/A, 6\%, 8) + 150 * (P/G, 6\%, 8)$
$= 2000 * 6.2098 + 150 * 19.8416$
$= 12419.60 + 2976.24 = 15395.84$

(2) $2000 + 3500 * (P/A, 6\%, 8)$
$= 2000 + 3500 * 6.2098$
$= 2000 + 21734.3 = 23734.3$

	Present Value of Item	
	OPTION 1	**OPTION 2**
Purchase/Lease	25000	23734
Salvage Value	(3137)	0
Maintenance	15396	10000
TOTAL	37,259	33,734

B. (2 points) What is the equivalent annualized total cost, over the 8-year lifetime, for the machine with the lowest "present value of lifecycle cost"? Show your work.

$33734 * (A/P, 6\%, 8) = 33734 * 0.1610 = \boxed{5431.17}$

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Problem 3. (12 points)

A D. (4 points) Match each of the following terms to its definition. On the blank line in front of each term, write the letter corresponding to the best definition. In the definitions, "item" may refer to a component, element, module, system, etc.

d	Hierarchy	a.	dividing a single item at a particular level of abstraction into a set of items, typically at that same level of abstraction
b	Modularity	b.	describing items in such a way as to reduce interactions between items and increase self-containment and potential re-use
a	Partitioning	c.	dividing an item at one level of abstraction into multiple items at a lower level of abstraction
c	Decomposition	d.	a multi-level description in which an item at one level of abstraction is generally composed of multiple items at the next-lower level

B E. (2 points) List two specific examples of the benefits of increased modularity. One example should relate to the design portion and one example should relate to the manufacturing portion of the product lifecycle.

- REDUCED DESIGN TIME, SINCE THE MODULE IS USED MULTIPLE TIMES, BUT IS ONLY DESIGNED ONCE
- REDUCED INVENTORY COST, SINCE THERE ARE FEWER DISTINCT ELEMENTS IN THE DESIGN

C F. (6 points) Briefly describe how partitioning would be used in the following examples of steps in the product design process. For each example, briefly explain the basis on which partitioning would occur, the principal expected benefit(s) of partitioning, and a significant potential disadvantage or weakness of partitioning at that step in the design process.

Preliminary design of a new automobile

- PARTITIONED BASED ON FUNCTIONAL AREAS (BODY, ENGINE, ELECTRICAL SYSTEMS, FRAME, ETC.)
- REDUCED TIME DUE TO PARALLEL EFFORTS; SPECIALIZED KNOWLEDGE OF EACH TEAM
- COMMUNICATION OVERHEAD + MULTIPLE ITERATIONS, SINCE CHANGES LIKELY TO AFFECT MORE THAN ONE GROUP

Detailed circuit-level design of a large electronic system

- PARTITIONED BY TECHNOLOGY (ANALOG, DIGITAL, POWER SUPPLY) OR PROBABLE IMPLEMENTATION (MULTIPLE CIRCUIT BOARDS)
- REDUCED DESIGN TIME DUE TO PARALLEL EFFORTS
- EACH MODULE OPTIMIZED INDEPENDENTLY, RATHER THAN OPTIMIZING TOTAL DESIGN

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Problem 4. (10 points)

A 4. (4 points) During the design process, a product may be described at various levels of abstraction. For each of the following statements, check the appropriate box indicating if the statement more accurately describes a high-level or low-level product description.

	High-level	Low-level
The description emphasizes product functionality or behavior, rather than implementation.	X	
It is relatively easy to determine specific product characteristics such as cost, timing, or component count.		X
The description is usually shorter, but may be ambiguous or incomplete.	X	
It is relatively easy to modify the product description to reflect changes in user desires or expectations.	X	

B 5. (6 points) Sustainability can be defined as doing things in a way that minimizes the negative effects on future generations. One approach to sustainability is to design products so that components can be **re-used** or **recycled**, rather than thrown away, at the end of their useful lifetime. Briefly discuss the effect of emphasizing re-use/recycling on the design process. Potential issues: What is difference between re-use and recycling? What key design decisions will most likely be affected? How does the expected product lifetime affect re-use or recycling? Be as specific as possible in your answer, including examples where possible.

Write your answer in the space remaining at the bottom of this page. Your answer is limited to this space only. **DO NOT** write (or continue) your answer on the back of this page or anywhere else on this exam.

- RE-USED: COMPONENT USED AGAIN (ALTERNATOR OR WATER PUMP IN CAR)
  RECYCLING: MATERIALS IN COMPONENTS SEPARATED AND USED INSTEAD OF ~~RAW~~ RAW MATERIAL TO CREATE NEW ITEMS (GLASS, STEEL, ALUMINUM)
- RE-USE REQUIRES EARLY DESIGN DECISIONS TO IDENTIFY POTENTIAL COMMON ELEMENTS AND CONTROL DESIGN TO MAINTAIN COMPATIBILITY
- RECYCLING AFFECTS IMPLEMENTATION DECISIONS ON MATERIALS (SEPARABLE VS. COMPOSITES)
- RE-USE DIFFICULT W/ LONG PRODUCT LIFE-TIMES SINCE DESIGN LIKELY TO CHANGE OVER TIME.