Chapter 11 Replacement Decisions

11.1)

| | Tax Rate(%) = | 0.00% | | PW(i) = | ($20,065) |
| | MARR(%) = | 10.00% | | AE(%) = | ($6,329.8) |

	0	1	2	3	4
Income Statement					
Revenues (savings)					
Expenses:					
O&M		$2,500	$3,000	$3,500	$4,000
Depreciation		$0	$0	$0	$0
Taxable Income		($2,500)	($3,000)	($3,500)	($4,000)
Income Taxes (%)		0	0	0	0
Net Income		($2,500)	($3,000)	($3,500)	($4,000)
Cash Flow Statement					
Operating Activities:					
Net Income		$ (2,500)	$ (3,000)	$ (3,500)	$ (4,000)
Depreciation		$0	$0	$0	$0
Investment Activities:					
Investment	$ (12,000)				
Salvage					$ 3,000
Gains Tax					$0.00
Net Cash Flow	($12,000)	($2,500)	($3,000)	($3,500)	($1,000)

$$PW(10\%) = -\$12,000 - \$2,500(P/F,10\%,1)\cdots\cdots -\$1,000(P/A,10\%,4)$$

$$= -\$20,065$$

$$AEC(10\%) = \$20,065(A/P,10\%,4)$$

$$= \boxed{\$6,329.8}$$

11.2)
    A. Original cost: The printing machine was purchased for $20,000
    B. Market value: The old machine's market value is estimated at $10,000.
    C. Book value: If the machine sold now its book value is $14,693.
    D. Trade in allowance: This amount is the same as the market value.

The market value is the most relevant information, but the defender's current book value is also relevant as this will be the basis to determine the gains or losses related to disposal of the defender.

11.3)

Option 1: Keep the defender

$$\text{PW}(12\%)_D = -\$8,000(P/A,12\%,3) + \$2,500(P/F,12\%,3)$$
$$= -\$17,434.9$$
$$\text{AEC}(12\%)_D = \$17,434.9(A/P,12\%,3)$$
$$= \boxed{\$7,259.1}$$

Option 2: Replace the defender with the challenger

$$\text{PW}(12\%)_C = -\$5,000 - \$6,000(P/A,12\%,3) + \$5,500(P/F,12\%,3)$$
$$= -\$15,495.9$$
$$\text{AEC}(12\%)_C = \$15,495.9(A/P,12\%,3)$$
$$= \boxed{\$6,451.9}$$

The replacement should be made now.

11.4)

Option 1: Sold today

$$\text{PW}(15\%)_1 = \$2,500$$

Option 2:

$$\text{PW}(15\%)_2 = -\$8,000 + \$3,000(P/A,15\%,5)$$
$$= \$2,056.6$$

Option 3:

$$\text{PW}(15\%)_3 = -\$20,000 + \$3,000(P/F,15\%,5) + \$6,000(P/A,15\%,5)$$
$$= \$1,604.8$$

Select Option 1. (or Select 1 & 3 as these two options may not be viewed as mutually exclusive alternatives.)

11.5)

(a) Purchase cost = $22,000, market value = $6,000, sunk cost = $22,000 - $6,000 = $16,000

(b) opportunity cost = $6,000

(c)

$$\begin{aligned} \text{PW}(15\%) &= -\$6,000 - \$2,500 - \$5,000(P/F,15\%,1) \\ &\quad -(\$5,500 - \$3,500)(P/F,15\%,2) \\ &= -\$14,360.2 \end{aligned}$$

$$\begin{aligned} \text{AEC}(15\%) &= \$14,360.2(A/P,15\%,2) \\ &= \boxed{\$8,832.96} \end{aligned}$$

(d)

$$\begin{aligned} \text{PW}(15\%) &= -\$8,500 - \$5,000(P/F,15\%,1) - \$5,500(P/F,15\%,2) \\ &\quad -\$6,000(P/F,15\%,3) - \$9,500(P/F,15\%,4) \\ &\quad -(\$7,500 - \$2,000)(P/F,15\%,5) \\ &= -\$29,117.84 \end{aligned}$$

$$\begin{aligned} \text{AEC}(15\%) &= \$29,117.84(A/P,15\%,5) \\ &= \boxed{\$8,686.30} \end{aligned}$$

11.6)

(a) Opportunity cost = $30,000

(b) Assume that the old machine's operating cost is $35,000 per year. Then the new machine's operating cost is zero per year. The cash flows associated with the retaining the defender for two more years are

n	0	1	2
Cash Flows:	-$30,000	-$35,000	-$25,000

$$\begin{aligned} \text{PW}(12\%)_D &= -\$30,000 - \$35,000(P/A,12\%,2) + \$10,000(P/F,12\%,2) \\ &= -\$81,180 \end{aligned}$$

$$\begin{aligned} \text{AEC}(12\%)_D &= \$81,180(A/P,12\%,2) \\ &= \boxed{\$48,034} \end{aligned}$$

(b) Cash flows for the challenger: Year 0: -$175,000; Years 1-7: 0; Year 8: $8,000

$$PW(12\%)_C = -\$175,000 + \$8,000(P/F,12\%,8)$$
$$= -\$171,769$$
$$AEC(12\%)_C = \$171,769(A/P,12\%,8)$$
$$= \boxed{\$34,578}$$

(d) Since $AEC_D > AEC_C$, we should replace the defender now.

11.7)

(a) Initial cash outlay for the new machine = \$144,000

(b) Cash flows for the defender: Year 0: -\$13,000 Years 1-5: 0

(c)
$$AEC(15\%)_D = \$13,000(A/P,15\%,5) = \$3,877.9$$
$$AEC(15\%)_C = \left[(\$144,000 - \$40,000)(A/P,15\%,7) + \$40,000(0.15)\right]$$
$$-\$60,000$$
$$= -\$29,003 \text{ (savings)}$$

Replace the defender now.

11.8)

(a) Cash flows

Year:	0	1	2	3	4	5
Defender	-\$10K	0	0	0	0	\$5K
Challenger	-\$75K	\$33K	\$33K	\$33K	\$33K	\$33K

(b)

$$PW(10\%)_D = -\$10K + \$5K(P/F,10\%,5) = -\$6,895.5$$
$$PW(10\%)_C = -\$75K + \$33K(P/A,10\%,5) = \$50,096.4$$

Should replace the defender.

11.9)

(a) and (b) Cash flows:

Year:	0	1	2	3	4	5
Defender	-\$6,000	\$24,500	\$24,500	\$26,000		
Challenger	-\$38,500	\$31,500	\$31,500	\$31,500	\$31,500	\$38,500

- Revenue for defender = ($22 - $15) × 3,500 = $24,500 per year
- Revenue for challenger = ($22 - $13) × 3,500 = $31,500 per year

(c)

$$AE_D(15\%) = -\left[(\$6,000 - \$1,500)(A/P,15\%,3) + \$1,500(0.15)\right] + \$24,500$$
$$= \$22,304$$
$$AE_C(15\%) = -\left[(\$38,500 - \$7,000)(A/P,15\%,5) + \$7,000(0.15)\right] + \$31,500$$
$$= \$21,053.55$$

Keep the defender for now.

11.10) The economic service life is 4 years.

Annual changes in MV			$ (1,000)		
Annual increases in O&M			$ 1,500		
Interest rate		12%			

n	Market Value	O&M Costs	CR(12%)	OC(12%)	AEC(12%)
0	$20,000				
1	$10,000	$20,000	$12,400	$20,000	$32,400
2	$9,000	$21,500	$7,589	$20,708	$28,296
3	$8,000	$23,000	$5,956	$21,387	$27,343
4	$7,000	$24,500	$5,120	$22,038	$27,158
5	$6,000	$26,000	$4,604	$22,662	$27,266

11.11)

At $i = 12\%$, the economic service life is 1 year.

	Interest rate		12%		

n	Market Value	O&M Costs	CR(12%)	OC(12%)	AEC(12%)
0	$30,000				
1	$25,800	$5,000	$7,800	$5,000	$12,800
2	$16,000	$6,500	$10,204	$5,708	$15,911
3	$10,000	$10,000	$9,527	$6,980	$16,507
4	$5,000	$12,500	$8,831	$8,135	$16,966
5	$0	$14,800	$8,322	$9,184	$17,506

11.12) Economic service life is 6 years.

	Annual changes in MV		-25%		
	Annual increases in O&M		15%		
	Interest rate		15%		

n	Market Value	O&M Costs	CR(15%)	OC(15%)	AEC(15%)
0	$18,000				
1	$10,000	$1,000	$10,700	$1,000	$11,700
2	$7,500	$1,150	$7,584	$1,070	$8,653
3	$5,625	$1,323	$6,264	$1,143	$7,406
4	$4,219	$1,521	$5,460	$1,218	$6,678
5	$3,164	$4,749	$4,900	$1,742	$6,642
6	$2,373	$2,011	$4,485	$1,773	$6,258
7	$1,780	$6,813	$4,166	$2,228	$6,394
8	$1,335	$2,660	$3,914	$2,260	$6,174
9	$1,001	$3,059	$3,713	$2,307	$6,020
10	$751	$3,518	$3,550	$2,367	$5,916
11	$563	$4,045	$3,416	$2,436	$5,852
12	$422	$4,652	$3,306	$2,512	$5,818
13	$317	$5,350	$3,215	$2,595	$5,810

11.13)

(a) At $i = 12\%$, the economic service life for the defender is 2 years:

	Annual changes in MV				
	Annual increases in O&M				
	Interest rate		12%		
	Market	O&M			
n	Value	Costs	CR(12%)	OC(12%)	AEC(12%)
0	$7,700				
1	$4,300	$3,200	$4,324	$3,200	$7,524
2	$3,300	$3,700	$2,999	$3,436	$6,435
3	$1,100	$4,800	$2,880	$3,840	$6,720
4	$0	$5,850	$2,535	$4,261	$6,796

$N_D^* = 2$ and $AEC_D = \$6,435$.

(b) & (c)

$N_C = 10$ years

$$AEC_C = \$31,000(A/P,12\%,10) + \$1,000 - \$2,500(A/F,12\%,10)$$
$$= \$6,344$$

Since $AEC_D > AEC_C$, the defender should be replaced now.

11.14) **Correction**: Two different O&M figures were given for the new machine in the first printing. The correct figure is $4,200 for the first year, increasing at an annual rate of $500.

$$AEC_C = \$53,500(A/P,12\%,5) - \$12,000(A/F,12\%,5)$$
$$+\$4,200 + \$500(A/G,12\%,5)$$
$$= \$18,039.80$$
$$AEC_D = \$8,500(A/P,12\%,5) + \$8,700$$
$$= \$11,057.98$$

Since $AEC_C > AEC_D$, don't purchase the challenger.

11.15)

- Defender: Economic service year is 2 years

	Interest rate			15%	

n	Market Value	O&M Costs	CR(15%)	OC(15%)	AEC(15%)
0	$5,000	$1,200			
1	$4,000	$2,000	$1,750	$3,380	$5,130
2	$3,000	$3,500	$1,680	$3,436	$5,116
3	$2,000	$5,000	$1,614	$3,886	$5,500
4	$1,000	$6,500	$1,551	$4,410	$5,961
5	$0	$8,000	$1,492	$4,942	$6,434

- Challenger: Economic service year is 4 years

	Interest rate			15%	

n	Market Value	O&M Costs	CR(15%)	OC(15%)	AEC(15%)
0	$10,000				
1	$6,000	$2,000	$5,500	$2,000	$7,500
2	$5,100	$2,800	$3,779	$2,372	$6,151
3	$4,335	$3,600	$3,131	$2,726	$5,857
4	$3,685	$4,400	$2,765	$3,061	$5,826
5	$3,132	$5,200	$2,519	$3,378	$5,897

Since $\text{AEC}_D < \text{AEC}_C$, we should not replace the defender now. If no technological advances are expected in the next few years, the defender should be used for at least 2 more years. However, it is not necessarily best to replace the defender at the end of its economic year either.

- Marginal analysis:

    1. Opportunity cost at the end of year two, which is equal to the market value then, or $3,000
    2. Operating cost for the third year: $5,000
    3. Salvage value of the defender at the end of year three: $2,000

    The cost of using the defender for one more year from the end of its economic service life is

    $$F_3 = \$3,000(F/P,15\%,1) + \$5,000 - \$2,000$$
    $$= \$6,450$$

    Compare this cost with $AEC_{C^*} = \$5,826$ of the challenger.

    Since keeping the defender for the 3rd year is more expensive than replacing it with the challenger, do not keep the defender beyond its economic service life.

11.16)
    It is assumed that the required service period is very long.

    $$AEC_D = \$7,000(A/P,12\%,6) + \$3,000 - \$2,500(A/F,12\%,6)$$
    $$= \$4,394.4$$
    $$AEC_C = \$24,000(A/P,12\%,12) + \$1,500 - \$2,000(A/F,12\%,12)$$
    $$= \$5,290.8$$

    We should continue to use the old machine. The economic advantage is $5,290.8-$4,394.4 = $896.4 per year.

11.17) (a) and (b)

n	Defender	Challenger
0	-$5,000	-$10,000
1	-$3,000	-$2,000
2	-$4,500	-$3,000
3	-$4,000	-$0

$$AEC_C(15\%) = \big(\$10,000 + \$2,000(P/F,15\%,1) + \$3,000(P/F,15\%,2)\big)(A/P,15\%,3)$$
$$= \$6,135.29$$

$$AEC_D(15\%) = (\$5,000 + \frac{\$3,000}{1.15} + \frac{\$4,500}{1.15^2} + \frac{\$4,000}{1.15^3})(A/P,15\%,3)$$
$$= \$5,974.94$$

    Do not replace the defender now.

11.18)

   (a) opportunity cost $= \$0$

   (b) The cash flows are:

Year:	0	1	2	3	4	5
Defender	$0	-$3K	-$3K	-$3K	-$3K	-$3K
Challenger	-$10K	0	0	0	0	0
C - D	-$10K	$3K	$3K	$3K	$3K	$3K

   (c)
$$PW(i)_{C-D} = -\$10,000 + \$3,000(P/A,i,5)$$
$$= 0$$

   We find $i^* = 15.24\%$. Since $i^* > MARR$, the replacement should be made now.

11.19)

   (a)

$$AE(12\%)_D = -\$2,000(A/P,12\%,3) + \$10,000 - \$7,000$$
$$= \$2,167.4$$
$$AE(12\%)_C = -\$14,000(A/P,12\%,5) + \$12,500 - \$5,000 + \$4,000(A/F,12\%,5)$$
$$= \$4,246$$

   Yes, the new machine should be purchased now.

   (b)
   Let
   $$-P(A/P,12\%,5) + \$7,500 + \$4,000(A/F,12\%,5) = \$2,167.4$$

   We find $P = \$21,493.15$

11.20)

   Assume that the old system has a current market value of P.

$$AEC_D = P(A/P,14\%,5) + \$20,000$$
$$AEC_C = (\$200,000 - \$18,000)(A/P,14\%,10) + (0.14)(\$18,000) + \$5,000$$
$$= \$42,411.86$$

   Let $AEC_D = AEC_C$ and solve for P. We find that $P = \$76,942$. If the resale value of the defender is higher than $76,941.73, the installation of the new system is justified.

11.21)

$$AEC(12\%)_D = \$60,000(A/P,12\%,10) + \$18,000$$
$$= \$28,619$$
$$AEC(12\%)_C = (\$200,000 - \$20,000)(A/P,12\%,10) + \$20,000(0.12) + \$4,000$$
$$= \$38,260$$

Since $AEC_D < AEC_C$, do not replace the defender.

11.22)

For the challenger, we have:

$$AEC_C = \$50,000(A/P,10\%,12) + \$3,000 - \$6,000 - \$3,000(A/F,10\%,12)$$
$$= \$4,198$$

For the defender, we need to find its economic life. Since the annual operating cost is constant and the salvage value declines as it ages, the annual equivalent cost is a decreasing function of the holding period. This means that the economic life is equal to its physical life, as illustrated in the following table. $(N_D = 6$ years, $AEC_D = \$4,213)$. With $i = 10\%$

	Interest rate		10%		
n	Market value	O&M Costs	CR(10%)	OC(10%)	AEC(10%)
0	$2,000				
1	$1,500	$3,800	$700	$3,800	$4,500
2	$1,125	$3,800	$617	$3,800	$4,417
3	$844	$3,800	$549	$3,800	$4,349
4	$633	$3,800	$495	$3,800	$4,295
5	$475	$3,800	$450	$3,800	$4,250
6	$356	$3,800	$413	$3,800	$4,213

Since $AEC_D > AEC_C$, the new machine should be purchased.

11.23)

$$AEC_{Option\ 1} = \$15,000 + \$48,000(A/P,12\%,10) + \$12,000 - \$5,000(A/F,12\%,10)$$
$$= \$35,210.32$$
$$AEC_{Option\ 2} = (\$84,000 - \$6,000)(A/P,12\%,10) + \$24,000 - \$9,000(A/F,12\%,10)$$
$$= \$37,291.91$$

Since $AEC_{Option\ 1} < AEC_{Option\ 2}$ Option 1 should be selected.

11.24)

| | Tax Rate(%) = | 40.00% | | PW(i) = | ($13,087) |
| | MARR(%) = | 8.00% | | AE(%) = | ($3,951.1) |

	0	1	2	3	4
Income Statement					
Revenues (savings)					
Expenses:					
O&M		$2,500	$3,000	$3,500	$4,000
Depreciation		$2,400	$3,840	$2,304	$691
Taxable Income		($4,900)	($6,840)	($5,804)	($4,691)
Income Taxes (%)		−1,960	−2,736	−2,322	−1,876
Net Income		($2,940)	($4,104)	($3,482)	($2,815)
Cash Flow Statement					
Operating Activities:					
Net Income		$ (2,940)	$ (4,104)	$ (3,482)	$ (2,815)
Depreciation		$2,400	$3,840	$2,304	$691
Investment Activities:					
Investment	$ (12,000)				
Salvage					$ 3,000
Gains Tax					($94)
Net Cash Flow	($12,000)	($540)	($264)	($1,178)	$782

$$AEC(8\%) = \$13,087(A/P,8\%,4)$$
$$= \boxed{\$3,951}$$

11.25)

- Defender

  Cash flows for the defender: Year 0: -$13,000 Years 1-5: 0

  $$AEC(12\%)_D = \$13,000(1-0.40)(A/P,12\%,5) = \$2,164$$

- Challenger

	Input			Output			
Tax Rate(%) =	40.00%			PW(i) =	$70,499		
MARR(%) =	12.00%			AE(%) =	$15,448		

	0	1	2	3	4	5	6	7
Income Statement								
Revenues (savings)		$60,000	$60,000	$60,000	$60,000	$60,000	$60,000	$60,000
Expenses:								
O&M		$0	$0	$0	$0	$0	$0	$0
Depreciation		$20,578	$35,266	$25,186	$17,986	$12,859	$12,845	$6,430
Taxable Income		$39,422	$24,734	$34,814	$42,014	$47,141	$47,155	$53,570
Income Taxes (%)		15,769	9,894	13,926	16,806	18,856	18,862	21,428
Net Income		$23,653	$14,841	$20,889	$25,209	$28,284	$28,293	$32,142
Cash Flow Statement								
Operating Activities:								
Net Income		$23,653	$14,841	$20,889	$25,209	$28,284	$28,293	$32,142
Depreciation		$20,578	$35,266	$25,186	$17,986	$12,859	$12,845	$6,430
Investment Activities:								
Investment	$(144,000)							
Salvage								$40,000
Gains Tax								($10,859)
Net Cash Flow	$(144,000)	$44,231	$50,106	$46,074	$43,194	$41,144	$41,138	$67,713

Replace the defender now as the challenger would provide an annual savings equivalent to $15,448 whereas the defender would cost $2,164 annually.

11.26)

(a) Cash Flows

- Defender

Tax Rate(%) =	35.00%			PW(i) =	($1,059)
MARR(%) =	12.00%			AEC(%) =	($294)

	0	1	2	3	4	5
Income Statement						
Revenues (savings)						
Expenses:						
Depreciation		$5,625	$5,625	$5,625	$5,625	$5,625
Taxable Income		($5,625)	($5,625)	($5,625)	($5,625)	($5,625)
Income Taxes (%)		(1,969)	(1,969)	(1,969)	(1,969)	(1,969)
Net Income		($3,656)	($3,656)	($3,656)	($3,656)	($3,656)
Cash Flow Statement						
Operating Activities:						
Net Income		$ (3,656)	$ (3,656)	$ (3,656)	$ (3,656)	$ (3,656)
Depreciation		$5,625	$5,625	$5,625	$5,625	$5,625
Investment Activities:						
Investment	$ (10,000)					
Salvage						$5,000
Gains Tax						−$1,750
Net Cash Flow	($10,000)	$1,969	$1,969	$1,969	$1,969	$5,219

- Challenger

| | | Tax Rate(%) = | 35.00% | | PW(i) = | $20,801 |
| | | MARR(%) = | 12.00% | | AE(%) = | $5,770 |

	0	1	2	3	4	5
Income Statement						
Revenues (savings)		$33,000	$33,000	$33,000	$33,000	$33,000
Expenses:						
Depreciation		$10,718	$18,368	$13,118	$9,368	$3,349
Taxable Income		$22,283	$14,633	$19,883	$23,633	$29,651
Income Taxes (%)		$7,799	$5,121	$6,959	$8,271	$10,378
Net Income		$14,484	$9,511	$12,924	$15,361	$19,273
Cash Flow Statement						
Operating Activities:						
Net Income		$14,484	$9,511	$12,924	$15,361	$19,273
Depreciation		$10,718	$18,368	$13,118	$9,368	$3,349
Investment Activities:						
Investment	$ (75,000)					
Salvage						$0
Gains Tax						$7,028
Net Cash Flow	$ (75,000)	$25,201	$27,879	$26,041	$24,729	$29,651

(b) Yes, should replace the defender

11.27)
At $i = 10\%$ and tax rate = 40%, the economic service life is 1 year.

Tax Rate	40%									
MARR	10%									

Holding	Permitted Annual Depreciation Amounts over the Holding Period								Total	Book
Period	1	2	3	4	5	6	7	8	Depreciatio	Value
0										$30,000
1	$4,287								$4,287	$25,713
2	$4,287	$3,674							$7,961	$22,040
3	$4,287	$7,347	$2,624						$14,258	$15,743
4	$4,287	$7,347	$5,247	$1,874					$18,755	$11,246
5	$4,287	$7,347	$5,247	$3,747	$1,340				$21,968	$8,033

Holding	Annual O&M Costs over the Holding Period								Total PW o	Total PW of A/T
Period	1	2	3	4	5	6	7	8	O&M Cost	O&M Costs
0										
1	$5,000								$4,545	$2,727
2	$5,000	$6,500							$9,917	$5,950
3	$5,000	$6,500	$10,000						$17,431	$10,458
4	$5,000	$6,500	$10,000	$12,500					$25,968	$15,581
5	$5,000	$6,500	$10,000	$12,500	$14,800				$35,158	$21,095

Holding Period	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Market Value	A/T Operating Costs (in PW) over the Holding Period			OC(10%)	CR(10%)	Total AEC(10%)
					O&M Costs	Tax Shield	Total OC			
0										
1	$25,800	$87	$35	$25,765	$2,727	$1,559	$1,168	$1,285	$7,235	$8,520
2	$16,000	($6,040)	($2,416)	$18,416	$5,950	$2,773	$3,177	$1,831	$8,516	$10,347
3	$10,000	($5,743)	($2,297)	$12,297	$10,458	$4,776	$5,682	$2,285	$8,348	$10,633
4	$5,000	($6,246)	($2,498)	$7,498	$15,581	$6,076	$9,505	$2,998	$7,848	$10,847
5	$0	($8,033)	($3,213)	$3,213	$21,095	$6,921	$14,174	$3,739	$7,388	$11,127

11.28)
(a) Interest $i = 10\%$ Defender:

The depreciation schedule when the defender was placed in service: $D_1 = \$3,573$, $D_2 = \$6,123$, $D_3 = \$4,373$, $D_4 = \$3,125$, $D_5 = \$2,231$, $D_6 = \$2,231$, $D_7 = \$2,231$, $D_8 = \$1,116$.

Tax Rate	35%									
MARR	10%									

	Permitted Annual Depreciation Amounts over the Holding Period								Total Depreciation	Book Value
Holding Period	1	2	3	4	5	6	7	8		
0										$7,809
1	$2,231								$2,231	$5,578
2	$2,231	$2,231							$4,462	$3,347
3	$2,231	$2,231	$2,231						$6,693	$1,116
4	$2,231	$2,231	$2,231	$1,116					$7,809	$0

	Annual O&M Costs over the Holding Period								Total PW of O&M Costs	Total PW of A/T O&M Costs
Holding Period	1	2	3	4	5	6	7	8		
0								`		
1	$3,200								$2,909	$1,891
2	$3,200	$3,700							$5,967	$3,879
3	$3,200	$3,700	$4,800						$9,573	$6,223
4	$3,200	$3,700	$4,800	$5,850					$13,569	$8,820

Holding Period	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Market Value	A/T Operating Costs (in PW) over the Holding Period			OC(10%)	CR(10%)	Total AEC(10%)
					O&M Costs	Tax Shield	Total OC			
0	$7,700			$8,285						
1	$4,300	($1,278)	($447)	$4,747	$1,891	$710	$1,181	$1,299	$3,843	$5,142
2	$3,300	($47)	($16)	$3,316	$3,879	$1,355	$2,523	$1,454	$2,920	$4,374
3	$1,100	($16)	($6)	$1,106	$6,223	$1,942	$4,281	$1,721	$2,806	$4,527
4	$0	$0	$0	$0	$8,820	$2,209	$6,611	$2,086	$2,464	$4,549

Note that the cost of retaining the defender on after-tax basis is $8,285, instead of $7,700. The scheduled depreciation amount during the fourth year of ownership is $3,125. Since the asset will be disposed of during the recovery period, the allowed depreciation amount will be $(0.5)(\$3,125) = \$1,561$. Then, the book value becomes $9,370, instead of $7,809. With the market value of $7,700, there will be a loss of $1,670. The tax credit on this loss will be $\$1,670(0.35) = \$584.50$. Finally, the net proceeds from sale of old asset will be $8,285 (= $7,700 + $584.50).

The defender's remaining useful (economic) life is 2 more years with an AEC value of $4,374, i.e., $N_D = 2, \text{AEC}_D = \$4,374$.

(b) $N_C = 10$ years

$$\text{AEC}_C = \$4,319$$

	Input		Output	
Tax Rate(%) =	35.00%		PW(i) =	($26,540)
MARR(%) =	10.00%		AE(%) =	($4,319.2)

	0	1	2	3	4	5	6	7	8	9	10
Income Statement											
Revenues (savings)											
Expenses:											
O&M		$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000
Depreciation		$4,430	$7,592	$5,422	$3,872	$2,768	$2,765	$2,768	$1,383	$0	$0
Taxable Income		($5,430)	($8,592)	($6,422)	($4,872)	($3,768)	($3,765)	($3,768)	($2,383)	($1,000)	($1,000)
Income Taxes (%)		−1,900	−3,007	−2,248	−1,705	−1,319	−1,318	−1,319	−834	−350	−350
Net Income		($3,529)	($5,585)	($4,174)	($3,167)	($2,449)	($2,447)	($2,449)	($1,549)	($650)	($650)
Cash Flow Statement											
Operating Activities:											
Net Income		$ (3,529)	$ (5,585)	$ (4,174)	$ (3,167)	$ (2,449)	$ (2,447)	$ (2,449)	$ (1,549)	$ (650)	$ (650)
Depreciation		$4,430	$7,592	$5,422	$3,872	$2,768	$2,765	$2,768	$1,383	$0	$0
Investment Activities:											
Investment	$ (31,000)										
Salvage											$ 2,500
Gains Tax											($875)
Net Cash Flow	$ (31,000)	$900	$2,007	$1,248	$705	$319	$318	$319	($166)	($650)	$ 975

(c) Marginal analysis:

- From $n = 2$ to $n = 3$:

$$\$3,316(1.10) - \$1,106 + \$4,280 = \$6,824.6 > \$4,319$$

Keep the defender for two years, which happens to be the same as the economic service life as calculated before. (In general, you should not expect this to happen all the time.)

11.29) **Corrections**: In the first printing, the book values for years 5 and 6 were stated incorrectly. The correct figures should be: $B_5 = \$576$ and $B_6 = 0$.

(a) Economic service life = 6 years with MARR is 15%

Tax Rate	40%		Investment	$10,000							
MARR	15%		Book value	$10,000							

Holding Period	Permitted Annual Depreciation Amounts over the Holding Period								Total Depreciatior	Book Value
	1	2	3	4	5	6	7	8		
0										$10,000
1	$2,000								$2,000	$8,000
2	$2,000	$3,200							$5,200	$4,800
3	$2,000	$3,200	$1,920						$7,120	$2,880
4	$2,000	$3,200	$1,920	$1,152					$8,272	$1,728
5	$2,000	$3,200	$1,920	$1,152	$1,152				$9,424	$576
6	$2,000	$3,200	$1,920	$1,152	$1,152	$576			$10,000	$0

Holding Period	Annual O&M Costs over the Holding Period								Total PW of O&M Costs	Total PW of A/T O&M Costs
	1	2	3	4	5	6	7	8		
0								`		
1	$1,500								$1,304	$783
2	$1,500	$2,100							$2,892	$1,735
3	$1,500	$2,100	$2,700						$4,668	$2,801
4	$1,500	$2,100	$2,700	$3,400					$6,612	$3,967
5	$1,500	$2,100	$2,700	$3,400	$4,200				$8,700	$5,220
6	$1,500	$2,100	$2,700	$3,400	$4,200	$4,900			$10,818	$6,491

Holding Period	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Market Value	A/T Operating Costs (in PW) over the Holding Period			OC(15%)	CR(15%)	Total AEC(15%)
					O&M Costs	Tax Shield	Total OC			
0										
1	$5,300	($2,700)	($1,080)	$6,380	$783	$696	$87	$100	$5,120	$5,220
2	$3,900	($900)	($360)	$4,260	$1,735	$1,664	$72	$44	$4,170	$4,214
3	$2,800	($80)	($32)	$2,832	$2,801	$2,168	$632	$277	$3,564	$3,841
4	$1,800	$72	$29	$1,771	$3,967	$2,432	$1,535	$538	$3,148	$3,686
5	$1,400	$824	$330	$1,070	$5,220	$2,661	$2,559	$763	$2,824	$3,588
6	$600	$600	$240	$360	$6,491	$2,761	$3,730	$986	$2,601	$3,587

(b) Economic service life = 5 years with MARR is 10%

| Tax Rate | 40% | Investment | $10,000 |
| MARR | 10% | Book value | $10,000 |

Holding Period	Permitted Annual Depreciation Amounts over the Holding Period								Total Dep.	Book Value
	1	2	3	4	5	6	7	8		
0										$10,000
1	$2,000								$2,000	$8,000
2	$2,000	$3,200							$5,200	$4,800
3	$2,000	$3,200	$1,920						$7,120	$2,880
4	$2,000	$3,200	$1,920	$1,152					$8,272	$1,728
5	$2,000	$3,200	$1,920	$1,152	$1,152				$9,424	$576
6	$2,000	$3,200	$1,920	$1,152	$1,152	$576			$10,000	$0

Holding Period	Annual O&M Costs over the Holding Period								Total PW of O&M Costs	Total PW of A/T O&M Costs
	1	2	3	4	5	6	7	8		
0										
1	$1,500								$1,364	$818
2	$1,500	$2,100							$3,099	$1,860
3	$1,500	$2,100	$2,700						$5,128	$3,077
4	$1,500	$2,100	$2,700	$3,400					$7,450	$4,470
5	$1,500	$2,100	$2,700	$3,400	$4,200				$10,058	$6,035
6	$1,500	$2,100	$2,700	$3,400	$4,200	$4,900			$12,824	$7,694

Holding Period	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Market Value	A/T Operating Costs (in PW) over the Holding Period			OC (10%)	CR (10%)	Total AEC (10%)
					O&M Costs	Tax Shield	Total OC			
0										
1	$5,300	($2,700)	($1,080)	$6,380	$818	$727	$91	$100	$4,620	$4,720
2	$3,900	($900)	($360)	$4,260	$1,860	$1,785	$74	$43	$3,733	$3,776
3	$2,800	($80)	($32)	$2,832	$3,077	$2,362	$715	$287	$3,166	$3,453
4	$1,800	$72	$29	$1,771	$4,470	$2,677	$1,793	$566	$2,773	$3,339
5	$1,400	$824	$330	$1,070	$6,035	$2,963	$3,072	$810	$2,463	$3,273
6	$600	$600	$240	$360	$7,694	$3,093	$4,601	$1,056	$2,249	$3,306

11.30)

(a) At $i = 10\%$, the economic service life = 7 years:

| Tax Rate | 40% | Investment | $30,000 |
| MARR | 10% | Book value | $30,000 |

Holding Period	Permitted Annual Depreciation Amounts over the Holding Period										Total Depreciation	Book Value
	1	2	3	4	5	6	7	8	9	10		
0												
1	$3,000										$3,000	$27,000
2	$3,000	$3,000									$6,000	$24,000
3	$3,000	$3,000	$3,000								$9,000	$21,000
4	$3,000	$3,000	$3,000	$3,000							$12,000	$18,000
5	$3,000	$3,000	$3,000	$3,000	$3,000						$15,000	$15,000
6	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000					$18,000	$12,000
7	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000				$21,000	$9,000
8	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000			$24,000	$6,000
9	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000		$27,000	$3,000
10	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$30,000	$0

Holding Period	Annual O&M Costs over the Holding Period								Total PW of O&M Costs	Total PW of A/T O&M Costs
	1	2	3	4	5	6	7	8		
0										
1	$3,000								$2,727	$1,636
2	$3,000	$3,450							$5,579	$3,347
3	$3,000	$3,450	$3,968						$8,560	$5,136
4	$3,000	$3,450	$3,968	$4,563					$11,676	$7,006
5	$3,000	$3,450	$3,968	$4,563	$5,247				$14,934	$8,961
6	$3,000	$3,450	$3,968	$4,563	$5,247	$6,034			$18,340	$11,004
7	$3,000	$3,450	$3,968	$4,563	$5,247	$6,034	$6,939		$21,901	$13,141
8	$3,000	$3,450	$3,968	$4,563	$5,247	$6,034	$6,939	$7,960	$25,615	$15,369
9	$3,000	$3,450	$3,968	$4,563	$5,247	$6,034	$6,939	$7,960	$9,177	$29,506	$17,704
10	$3,000	$3,450	$3,968	$4,563	$5,247	$6,034	$6,939	$7,960	$9,177	$10,554	$33,576	$20,145

Holding Period	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Market Value	A/T Operating Costs (in PW) over the Holding Period			OC (10%)	CR (10%)	Total AEC (10%)
					O&M Costs	Tax Shield	Total OC			
0										
1	$20,000	($7,000)	($2,800)	$22,800	$1,636	$1,091	$545	$600	$10,200	$10,800
2	$18,000	($6,000)	($2,400)	$20,400	$3,347	$2,083	$1,264	$729	$7,571	$8,300
3	$16,000	($5,000)	($2,000)	$18,000	$5,136	$2,984	$2,152	$865	$6,625	$7,491
4	$14,000	($4,000)	($1,600)	$15,600	$7,006	$3,804	$3,202	$1,010	$6,103	$7,113
5	$12,000	($3,000)	($1,200)	$13,200	$8,961	$4,549	$4,412	$1,164	$5,752	$6,916
6	$10,000	($2,000)	($800)	$10,800	$11,004	$5,226	$5,778	$1,327	$5,488	$6,815
7	$8,000	($1,000)	($400)	$8,400	$13,141	$5,842	$7,299	$1,499	$5,277	$6,776
8	$6,000	$0	$0	$6,000	$15,369	$6,402	$8,967	$1,681	$5,099	$6,779
9	$4,000	$1,000	$400	$3,600	$17,704	$6,911	$10,793	$1,874	$4,944	$6,818
10	$2,000	$2,000	$800	$1,200	$20,145	$7,373	$12,772	$2,079	$4,807	$6,886

(b) At $i = 25\%$, the economic service life = 10 years

Tax Rate	40%			Investment	$30,000							
MARR	25%			Book value	$30,000							

Holding Period	Permitted Annual Depreciation Amounts over the Holding Period										Total Depreciation	Book Value
	1	2	3	4	5	6	7	8	9	10		
0												
1	$3,000										$3,000	$27,000
2	$3,000	$3,000									$6,000	$24,000
3	$3,000	$3,000	$3,000								$9,000	$21,000
4	$3,000	$3,000	$3,000	$3,000							$12,000	$18,000
5	$3,000	$3,000	$3,000	$3,000	$3,000						$15,000	$15,000
6	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000					$18,000	$12,000
7	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000				$21,000	$9,000
8	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000			$24,000	$6,000
9	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000		$27,000	$3,000
10	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$30,000	$0

Holding Period	Annual O&M Costs over the Holding Period								Total PW of O&M Costs	Total PW of A/T O&M Costs
	1	2	3	4	5	6	7	8		
0										
1	$3,000								$2,400	$1,440
2	$3,000	$3,450							$4,608	$2,765
3	$3,000	$3,450	$3,968						$6,640	$3,984
4	$3,000	$3,450	$3,968	$4,563					$8,509	$5,105
5	$3,000	$3,450	$3,968	$4,563	$5,247				$10,228	$6,137
6	$3,000	$3,450	$3,968	$4,563	$5,247	$6,034			$11,810	$7,086
7	$3,000	$3,450	$3,968	$4,563	$5,247	$6,034	$6,939		$13,265	$7,959
8	$3,000	$3,450	$3,968	$4,563	$5,247	$6,034	$6,939	$7,960	$14,600	$8,760
9	$3,000	$3,450	$3,968	$4,563	$5,247	$6,034	$6,939	$7,960	$9,177	$15,832	$9,499
10	$3,000	$3,450	$3,968	$4,563	$5,247	$6,034	$6,939	$7,960	$9,177	$10,554	$16,965	$10,179

Holding Period	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Market Value	A/T Operating Costs (in PW) over the Holding Period				OC(10%)	CR(10%)	Total AEC(10%)
					O&M Costs	Tax Shield	Total OC				
0											
1	$20,000	($7,000)	($2,800)	$22,800	$1,440	$960	$480		$600	$14,700	$15,300
2	$18,000	($6,000)	($2,400)	$20,400	$2,765	$1,728	$1,037		$720	$11,767	$12,487
3	$16,000	($5,000)	($2,000)	$18,000	$3,984	$2,342	$1,641		$841	$10,648	$11,488
4	$14,000	($4,000)	($1,600)	$15,600	$5,105	$2,834	$2,271		$962	$9,998	$10,959
5	$12,000	($3,000)	($1,200)	$13,200	$6,137	$3,227	$2,910		$1,082	$9,547	$10,629
6	$10,000	($2,000)	($800)	$10,800	$7,086	$3,542	$3,544		$1,201	$9,205	$10,406
7	$8,000	($1,000)	($400)	$8,400	$7,959	$3,793	$4,166		$1,318	$8,933	$10,251
8	$6,000	$0	$0	$6,000	$8,760	$3,995	$4,766		$1,432	$8,710	$10,141
9	$4,000	$1,000	$400	$3,600	$9,499	$4,156	$5,344		$1,543	$8,523	$10,066
10	$2,000	$2,000	$800	$1,200	$10,179	$4,285	$5,895		$1,651	$8,366	$10,017

(c) At $i = 0\%$, the economic service life = 4 years:

- Capital recovery cost:

$$\text{gain} = S_n - B_n$$

$$\text{gain tax} = t_m (S_n - B_n)$$

$$\begin{aligned}
\text{net proceeds} &= (1 - t_m) S_n + t_m B_n \\
&= (1 - 0.40)(22,000 - 2000n) + 0.40(30,000 - 3,000n)
\end{aligned}$$

$$\begin{aligned}
CR &= \frac{I - (1 - t_m) S_n - t_m B_n}{n} \\
&= \frac{4,800 + 2,400n}{n} \\
&= \frac{4,800}{n} + 2,400
\end{aligned}$$

- Equivalent annual O&M cost:

$$\begin{aligned}
\text{A/T O\&M} &= (1 - t_m)\left[3,000(1.15)^{n-1} \right] \\
&= 1,800(1.15)^{n-1}
\end{aligned}$$

$$\begin{aligned}
AE_{O\&M} &= \frac{\sum_{n=1}^{n} 1,800(1.15)^{n-1}}{n} \\
&= 1,800 \frac{\sum_{n=1}^{n} (1.15)^{n-1}}{n} \\
&= \frac{1,800}{n} \frac{(1.15^n - 1)}{1.15 - 1} = 12,000 \frac{(1.15^n - 1)}{n}
\end{aligned}$$

- Depreciation tax credit:

$$\begin{aligned}
AE_D &= \frac{\sum_{n=1}^{n} (t_m \times D_n)}{n}, \quad \text{where } D_n = \$3,000 \\
&= 1,200
\end{aligned}$$

- Minimum total annual equivalent cost:

$$AEC = \frac{4,800}{n} + 2,400 + 12,000\frac{(1.15^n - 1)}{n} - 1,200$$

$$= \frac{4,800}{n} + 12,000\frac{(1.15^n - 1)}{n} + 1,200$$

$$= 12,000\frac{1.15^n}{n} - \frac{7,200}{n} + 1,200$$

Using Excel, we find the economic service life at $n = 5$ years.

n	AEC
1	$ 7,800
2	$ 5,535
3	$ 4,884
4	$ 4,647
5	$ 4,587
6	$ 4,626
7	$ 4,731
8	$ 4,889
9	$ 5,091
10	$ 5,335

11.31) Economic service life

With i = 12% and tax rate = 40%: Economic service life = 1 year

Tax Rate	40%		Investment	$30,000						
MARR	12%		Book value	$30,000						

Holding Period	Permitted Annual Depreciation Amounts over the Holding Period								Total Depreciation	Book Value
	1	2	3	4	5	6	7	8		
0										
1	$6,000								$6,000	$24,000
2	$6,000	$4,800							$10,800	$19,200
3	$6,000	$9,600	$2,880						$18,480	$11,520
4	$6,000	$9,600	$5,760	$1,728					$23,088	$6,912
5	$6,000	$9,600	$5,760	$3,456	$1,728				$26,544	$3,456

Holding Period	Annual O&M Costs over the Holding Period								Total PW of O&M Costs	Total PW of A/T O&M Costs
	1	2	3	4	5	6	7	8		
0										
1	$5,000								$4,464	$2,679
2	$5,000	$6,500							$9,646	$5,788
3	$5,000	$6,500	$10,000						$16,764	$10,058
4	$5,000	$6,500	$10,000	$12,500					$24,708	$14,825
5	$5,000	$6,500	$10,000	$12,500	$14,800				$33,106	$19,863

Holding Period	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Market Value	A/T Operating Costs (in PW) over the Holding Period			OC(12%)	CR(12%)	Total AEC(12%)
					O&M Costs	Tax Shield	Total OC			
0										
1	$25,800	$1,800	$720	$25,080	$2,679	$2,143	$536	$600	$8,520	$9,120
2	$16,000	($3,200)	($1,280)	$17,280	$5,788	$3,673	$2,114	$1,251	$9,600	$10,851
3	$10,000	($1,520)	($608)	$10,608	$10,058	$6,024	$4,034	$1,680	$9,347	$11,026
4	$5,000	($1,912)	($765)	$5,765	$14,825	$7,283	$7,541	$2,483	$8,671	$11,154
5	$0	($3,456)	($1,382)	$1,382	$19,863	$8,115	$11,749	$3,259	$8,105	$11,364

11.32) Replacement Analysis

Correction: In the first printing, the current book value is listed as $6,248. It should be stated as $5,623.

Replacement analysis:

(a) Keep the defender

Financial Data	n	-4	-3	-2	-1	0	1	2	3	4	5	6
Depreciation			$2,572	$4,408	$3,148	$2,248	$1,607	$1,606	$1,607	$803		
Book value		$18,000	$15,428	$11,020	$7,871	$5,623	$4,016	$2,410	$803	($0)	($0)	($0)
Salvage value												$2,500
O&M cost							$3,000	$3,000	$3,000	$3,000	$3,000	$3,000

Cash Flow Statement												
(−0.7)*(O&M cost)							($2,100)	($2,100)	($2,100)	($2,100)	($2,100)	($2,100)
+(.3)*(Depreciation)							$482	$482	$482	$241	$0	$0
Investment						($7,000)						
Net proceeds from sale												1,750
Net Cash Flow		$0	$0	$0	$0	($7,000)	($1,618)	($1,618)	($1,618)	($1,859)	($2,100)	($350)

PW (8%) = ($14,186)   AEC(8%) = $3,069

(b) Replace the defender

Financial Data	n	1	2	3	4	5	6	7	8	9	10–11	12
Depreciation		$3,144	$5,388	$3,848	$2,748	$1,965	$1,962	$1,965	$981	$0	$0	$0
Book value	$22,000	$18,856	$13,468	$9,621	$6,873	$4,908	$2,946	$981	$0	$0	$0	$0
Salvage value												$2,000
O&M cost		$1,500	$1,500	$1,500	$1,500	$1,500	$1,500	$1,500	$1,500	$1,500	$1,500	$1,500

Cash Flow Statement												
+(.3)*(Depreciation)		$943	$1,616	$1,154	$824	$589	$589	$589	$294	$0	$0	$0
(−0.7)*(O&M cost)		($1,050)	($1,050)	($1,050)	($1,050)	($1,050)	($1,050)	($1,050)	($1,050)	($1,050)	($1,050)	($1,050)
Investment	($22,000)											
Net proceeds from sale												$1,400
Net Cash Flow	($22,000)	($107)	$566	$104	($226)	($461)	($461)	($461)	($756)	($1,050)	($1,050)	$350

PW (8%) = ($24,301)   AEC(8%) = $3,225

Keep the defender.
Note: The salvage value of the defender is reduced by the removal cost at the end of its service life ($2,500 = $4,000 - $1,500).

11.33) (a), (b), and (c):

(a), (b) and (c)

Option 1 : Keep the defender

Financial Data	n	0	1	2	3	4	5
Depreciation			$800	$800	$800	$800	$800
Book value		$4,000	$3,200	$2,400	$1,600	$800	$0
Expected Market value		$0	$0	$0	$0	$0	$0
O&M cost			$0	$0	$0	$0	$0
Cash Flow Statement							
$(-0.6)*$(O&M cost)			0	0	0	0	0
$+(.4)*$(Depreciation)			320	320	320	320	320
Investment		(1,600)					
Net proceeds from sale							
Net Cash Flow		($1,600)	$320	$320	$320	$320	$320

PW (10%) = ($387)   AEC(10%) = $102

Option 2 : Replace the defender

Financial Data	n	0	1	2	3	4	5
Depreciation			$1,429	$2,449	$1,749	$1,249	$446
Book value		$10,000	$8,571	$6,122	$4,373	$3,124	$2,678
Expected Market value		$0	$0	$0	$0	$0	$0
Savings in O&M cost			$3,000	$3,000	$3,000	$3,000	$3,000
Cash Flow Statement							
$+(.4)*$(Depreciation)			$572	$980	$700	$500	$178
$(0.6)*$(Savings in O&M cost)			$1,800	$1,800	$1,800	$1,800	$1,800
Investment		($10,000)					
Net proceeds from sale							$1,071
Net Cash Flow		($10,000)	$2,372	$2,780	$2,500	$2,300	$3,049

PW (10%) = ($205)   AEC(10%) = $54

Should replace the defender.

11.34) Replacement analysis: Let X denote the current market value of the old call-switching system:

$$\text{AEC}(14\%)_{defender} = \$20,000(0.60) + 0.60X(A/P,14\%,5)$$
$$= \$12,000 + (0.6X)(0.29128)$$
$$= \$12,000 + 0.1748X$$
$$\text{AEC}(14\%)_{challenger} = \$156,291(A/P,14\%,10)$$
$$= \$29,963$$

To justify the new call-switching system now, we must have

$$\text{AEC}(14\%)_{defender} > \text{AEC}(14\%)_{challenger}$$
$$\$12,000 + 0.1748X > \$29,962$$
$$X > \boxed{\$102,757}$$

- Challenger:

Challenger

Financial Data	n	0	1	2	3	4	5
Depreciation			$40,000	$64,000	$38,400	$23,040	$23,040
Book value		$200,000	$160,000	$96,000	$57,600	$34,560	$11,520
Salvage value							
O&M cost			$5,000	$5,000	$5,000	$5,000	$5,000
Cash Flow Statement							
−(0.6)*(O&M cost)			($3,000)	($3,000)	($3,000)	($3,000)	($3,000)
+(.4)*(Depreciation)			$16,000	$25,600	$15,360	$9,216	$9,216
Investment		($200,000)					
Net proceeds from sale							
Net Cash Flow		($200,000)	$13,000	$22,600	$12,360	$6,216	$6,216

Financial Data	n	6	7	8	9	10
Depreciation		$11,520	$0	$0	$0	$0
Book value		$0	$0	$0	$0	$0
Salvage value						$18,000
O&M cost		$5,000	$5,000	$5,000	$5,000	$5,000
Cash Flow Statement						
−(0.6)*(Savings in O&M cost)		($3,000)	($3,000)	($3,000)	($3,000)	($3,000)
+(.4)*(Depreciation)		$4,608	$0	$0	$0	$0
Investment						
Net proceeds from sale						$10,800
Net Cash Flow		$1,608	($3,000)	($3,000)	($3,000)	$7,800

11.35)

- Defender:

| Tax Rate | 35% | Investment | $12,725 |
| MARR | 18% | Book value | $15,000 |

Holding Period	Permitted Annual Depreciation Amounts over the Holding Period								Total Depreciation	Book Value
	1	2	3	4	5	6	7	8		
0										$15,000
1	$4,000								$4,000	$11,000
2	$4,000	$4,000							$8,000	$7,000
3	$4,000	$4,000	$4,000						$12,000	$3,000

Holding Period	Annual O&M Costs over the Holding Period								Total PW of O&M Costs	Total PW of A/T O&M Costs
	1	2	3	4	5	6	7	8		
0										
1	$4,500								$3,814	$2,479
2	$4,500	$5,300							$7,620	$4,953
3	$4,500	$5,300	$6,100						$11,333	$7,366

Holding Period	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Market Value	A/T Operating Costs (in PW) over the Holding Period			OC(18%)	CR(18%)	Total AEC(18%)
					O&M Costs	Tax Shield	Total OC			
0										
1	$5,200	($5,800)	($2,030)	$7,230	$2,479	$1,186	$1,292	$1,525	$7,786	$9,311
2	$3,500	($3,500)	($1,225)	$4,725	$4,953	$2,192	$2,761	$1,764	$5,960	$7,724
3	$1,200	($1,800)	($630)	$1,830	$7,366	$3,044	$4,322	$1,988	$5,340	$7,328

Note: The opportunity cost of retaining the defender is as follows:

- Current market value = $11,500
- Current book value = $15,000
- Losses = ($11,500 - $15,000) = ($3,500)
- Loss tax credit = $3,500(0.35) = $1,225
- Cost of retaining the defender = $11,500+ $1,225 = $12,725

- Challenger:

Financial Data

n	0	1	2	3	4	5
Depreciation		$6,216	$10,653	$7,608	$5,433	$3,885
Book value	$43,500	$37,284	$26,631	$19,023	$13,589	$9,705
Salvage value						
O&M cost		$1,500	$1,500	$1,500	$1,500	$1,500

Cash Flow Statement

−(0.65)*(O&M cost)		($975)	($975)	($975)	($975)	($975)
+(.35)*(Depreciation)		$2,176	$3,729	$2,663	$1,902	$1,360
Investment	($43,500)					
Net proceeds from sale						
Net Cash Flow	($43,500)	$1,201	$2,754	$1,688	$927	$385

Financial Data

n	6	7	8	9	10
Depreciation	$3,880	$3,885	$1,940	$0	$0
Book value	$5,825	$1,940	($0)	($0)	($0)
Salvage value					$3,500
O&M cost	$1,500	$1,500	$1,500	$1,500	$1,500

Cash Flow Statement

−(0.65)*(O&M cost)	($975)	($975)	($975)	($975)	($975)
+(.35)*(Depreciation)	$1,358	$1,360	$679	$0	$0
Investment					
Net proceeds from sale					$2,275
Net Cash Flow	$0	$383	$385	($296)	($975)	$1,300

PW (18%) =	($38,619)
AEC(18%) =	$8,593

Optimal time to replace: Since the remaining useful life for the defender is 3 years, which is the same as the physical life, keep the defender for 3 years.

11.36)

Decision: Do not replace the defender now.

Keep the defender

Financial Data	n	0	1	2	3	4	5
Depreciation			$0	$0	$0	$0	$0
Book value		$0	$0	$0	$0	$0	$0
Market value		$8,500					
Operation Cost			$8,700	$8,700	$8,700	$8,700	$8,700

Cash Flow Statement							
+(.35)*(Depreciation)			$0	$0	$0	$0	$0
Opportunity cost		($5,525)					
−(1−0.35)*(Operation cost)			($5,655)	($5,655)	($5,655)	($5,655)	($5,655)
Net Cash Flow		($5,525)	($5,655)	($5,655)	($5,655)	($5,655)	($5,655)

PW (12%) = ($25,910)   AEC(12%) = $7,188

Replace the defender

Financial Data	n	0	1	2	3	4	5
Depreciation			$7,645	$13,102	$9,357	$6,682	$2,386
Book value		$53,500	$45,855	$32,753	$23,396	$16,713	$14,327
Market value		$53,500					$12,000
Operation Cost			$4,200	$4,700	$5,200	$5,700	$6,200

Cash Flow Statement							
Investment		($53,500)					
Net proceeds from sale							$12,815
+(.35)*(Depreciation)			$2,676	$4,586	$3,275	$2,339	$835
−(1−0.35)*(Operation cost)			($2,730)	($3,055)	($3,380)	($3,705)	($4,030)
Net Cash Flow		($53,500)	($54)	$1,531	($105)	($1,366)	$9,620

PW (12%) = ($47,813)   AEC(12%) = $13,264

11.37)

- **Option 1:**

Option 1

Financial Data	n	0	1	2	3	4	5
Depreciation			$6,859	$11,755	$8,395	$5,995	$4,286
Book value		$48,000	$41,141	$29,386	$20,990	$14,995	$10,709
Current Market value		$6,000					
O&M cost			$27,000	$27,000	$27,000	$27,000	$27,000
Cash Flow Statement							
−(0.60)*(O&M cost)			($16,200)	($16,200)	($16,200)	($16,200)	($16,200)
+(.40)*(Depreciation)			$2,744	$4,702	$3,358	$2,398	$1,715
Opportunity cost		($3,600)					
Investment		($48,000)					
Net proceeds from sale							
Net Cash Flow		($51,600)	($13,456)	($11,498)	($12,842)	($13,802)	($14,485)

Financial Data	n	6	7	8	9	10
Depreciation		$4,282	$4,286	$2,141	$0	$0
Book value		$6,427	$2,141	$0	$0	$0
Salvage value						$5,000
O&M cost		$27,000	$27,000	$27,000	$27,000	$27,000
Cash Flow Statement						
−(0.60)*(O&M cost)		($16,200)	($16,200)	($16,200)	($16,200)	($16,200)
+(.40)*(Depreciation)		$1,713	$1,715	$856	$0	$0
Investment						
Net proceeds from sale						3,000
Net Cash Flow		($14,487)	($14,485)	($15,344)	($16,200)	($13,200)

PW (12%) =	($129,093)	AEC(12%) =	$22,847

- Option 2:

Option 2

	0	1	2	3	4	5
Depreciation		$12,004	$20,572	$14,692	$10,492	$7,501
Book value	$84,000	$71,996	$51,425	$36,733	$26,242	$18,740
O&M cost		$24,000	$24,000	$24,000	$24,000	$24,000
Cash Flow Statement						
−(0.60)*(O&M cost)		($14,400)	($14,400)	($14,400)	($14,400)	($14,400)
+(.40)*(Depreciation)		$4,801	$8,229	$5,877	$4,197	$3,000
Investment	($84,000)					
Net proceeds from sale						
Net Cash Flow	($84,000)	($9,599)	($6,171)	($8,523)	($10,203)	($11,400)

	6	7	8	9	10
Depreciation	$7,493	$7,501	$3,746	$0	$0
Book value	$11,248	$3,746	($0)	($0)	($0)
Salvage value					$9,000
O&M cost	$24,000	$24,000	$24,000	$24,000	$24,000
Cash Flow Statement					
−(0.60)*(O&M cost)	($14,400)	($14,400)	($14,400)	($14,400)	($14,400)
+(.40)*(Depreciation)	$2,997	$3,000	$1,499	$0	$0
Investment					
Net proceeds from sale					$5,400
Net Cash Flow	($11,403)	($11,400)	($12,901)	($14,400)	($9,000)

PW (12%) =	($140,744)	
AEC(12%) =	$24,910	

Select Option 1.

11.38)

The remaining useful life of the defender is 1 year. Its annual equivalent cost is $1,666. When the defender is replaced now by the challenger, its equivalent annual cost is $2,191, indicating that the defender should be kept for now.

(a) Economic service life = one year

Tax Rate	30%		Investment	$1,050						
MARR	12%		Book value	$0						

Holding Period	Permitted Annual Depreciation Amounts over the Holding Period								Total Depreciation	Book Value
	1	2	3	4	5	6	7	8		
0										
1									$0	$0
2									$0	$0
3									$0	$0
4									$0	$0
5									$0	$0

Holding Period	Annual O&M Costs over the Holding Period								Total PW of O&M Costs	Total PW of A/T O&M Costs
	1	2	3	4	5	6	7	8		
0										
1	$1,900								$1,696	$1,188
2	$1,900	$2,300							$3,530	$2,471
3	$1,900	$2,300	$2,700						$5,452	$3,816
4	$1,900	$2,300	$2,700	$3,100					$7,422	$5,195
5	$1,900	$2,300	$2,700	$3,100	$3,400				$9,351	$6,546

Holding Period	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Market Value	A/T Operating Costs (in PW) over the Holding Period			OC(12%)	CR(12%)	Total AEC(12%)
					O&M Costs	Tax Shield	Total OC			
0										
1	$1,200	$1,200	$360	$840	$1,188	$0	$1,188	$1,330	$336	$1,666
2	$1,000	$1,000	$300	$700	$2,471	$0	$2,471	$1,462	$291	$1,753
3	$500	$500	$150	$350	$3,816	$0	$3,816	$1,589	$333	$1,922
4	$0	$0	$0	$0	$5,195	$0	$5,195	$1,710	$346	$2,056
5	$0	$0	$0	$0	$6,546	$0	$6,546	$1,816	$291	$2,107

(b) Replace the defender

Financial Data	n	0	1	2	3	4	5
Depreciation			$1,200	$1,920	$1,152	$691	$346
Book value		$6,000	$4,800	$2,880	$1,728	$1,037	$691
Salvage value							$1,000
O&M cost			$1,100	$1,300	$1,500	$1,700	$1,800

Cash Flow Statement							
Investment		($6,000)					
Net proceeds from sale							$907
+(.30)*(Depreciation)			$360	$576	$346	$207	$104
−(1−0.30)*(O&M cost)			($770)	($910)	($1,050)	($1,190)	($1,260)
Net Cash Flow		($6,000)	($410)	($334)	($704)	($983)	($249)

PW (12%) : ($7,899)
AEC(12%) = $2,191

Note: The purchase of a new machine will result in the combined savings in delays, operation and repairs in the amount of $200 a year, so that the O&M cost for the new machine will be reduced by $200 each year. For example, $1300 - $200 = $1,100 for n = 1.

11.39)

(a) and (b): Quintana should purchase the new equipment.

Financial Data	n	0	1	2	3	4	5	6	7	8	9	10
Depreciation			$21,435	$36,735	$26,235	$18,735	$13,395	$13,380	$13,395	$6,690	$0	$0
Book value		$150,000	$128,565	$91,830	$65,595	$46,860	$33,465	$20,085	$6,690	$0	$0	$0
Market value		$150,000										
Savings			$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000
Cash Flow Statement												
+(1−0.40)*(Savings)			$18,000	$18,000	$18,000	$18,000	$18,000	$18,000	$18,000	$18,000	18,000	18,000
+(.4)*(Depreciation)			$8,574	$14,694	$10,494	$7,494	$5,358	$5,352	$5,358	$2,676	0	0
Investment		($150,000)										
Net Cash Flow		($150,000)	$26,574	$32,694	$28,494	$25,494	$23,358	$23,352	$23,358	$20,676	$18,000	$18,000

PW (10%) =	$3,889		AE (10%) =	$633

(b) Defender

Financial Data	n	0	1	2	3	4	5	6	7	8	9	10
Depreciation			$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$0	$0	$0	$0
Book value		$72,000	$60,000	$48,000	$36,000	$24,000	$12,000	$0	$0	$0	$0	$0
Current market value												
Cash Flow Statement												
+(.4)*(Depreciation)			$4,800	$4,800	$4,800	$4,800	$4,800	$4,800	0	0	0	0
Investment		($28,800)										
Net Cash Flow		($28,800)	$4,800	$4,800	$4,800	$4,800	$4,800	$4,800	$0	$0	$0	$0

PW (10%) =	($7,895)		AE (10%) =	($1,285)

(c): Purchase the new equipment; (d): Retain the old machine

(c) Defender with a current market value of $ 45,000

Financial Data	n	0	1	2	3	4	5	6	7	8	9 – 10
Depreciation			$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$0	$0	$0
Book value		$72,000	$60,000	$48,000	$36,000	$24,000	$12,000	$0			
Current market value		$45,000									
Cash Flow Statement											
+(.4)*(Depreciation)			$4,800	$4,800	$4,800	$4,800	$4,800	$4,800			
Investment		($55,800)									
Net Cash Flow		($55,800)	$4,800	$4,800	$4,800	$4,800	$4,800	$4,800			

PW (10%) = ($34,895)   AEC(10%) = $5,679

(d) Challenger with an extended service life of 12 years

Financial Data	n	0	1	2	3	4	5	6	7	8	9-12
Depreciation			$21,435	$36,735	$26,235	$18,735	$13,395	$13,380	$13,395	$6,690	$0
Book value		$150,000	$128,565	$91,830	$65,595	$46,860	$33,465	$20,085	$6,690	$0	$0
Savings			$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000
Cash Flow Statement											
+(.4)*(Depreciation)			$8,574	$14,694	$10,494	$7,494	$5,358	$5,352	$5,358	$2,676	$0
+(0.60)*(Savings)			$9,000	$9,000	$9,000	$9,000	$9,000	$9,000	$9,000	$9,000	$9,000
Investment		($150,000)									
Net Cash Flow		($150,000)	$17,574	$23,694	$19,494	$16,494	$14,358	$14,352	$14,358	$11,676	$9,000

PW (10%) = ($45,390)   AEC(10%) = $6,662

(e) and (f):

(e) Defender (Model A)

Original Investment = $150,000

n	0	1	2	3	4	5	6	7	8
Depreciation		$26,235	$18,735	$13,395	$13,380	$13,395	$6,690	$0	$0
Book value	$91,830	$65,595	$46,860	$33,465	$20,085	$6,690	$0	$0	$0
Current market value	$0								
Cash Flow Statement									
+(.4)*(Depreciation)		$10,494	$7,494	$5,358	$5,352	$5,358	$2,676	$0	$0
Investment	($36,732)								
Net Cash Flow	($36,732)	$10,494	$7,494	$5,358	$5,352	$5,358	$2,676	$0	$0

PW (10%) = ($8,480)   AEC(10%) = $1,590

Decision: Replace Model A with Model B

(f) It is rather difficult to predict what technological advances would be made on a typical equipment in the future. If the industrial engineer had all the information available in one or two years, he could defer the replacement decision. Since Model A was already placed in service, the amount of $ 150,000 expended is a sunk cost, and it should not be considered in future replacement decisions.

Challenger (Model B)

n	0	1	2	3	4	5	6	7	8	9	10
Depreciation		$42,870	$73,470	$52,470	$37,470	$26,790	$26,760	$26,790	$13,380		
Book value	$300,000	$257,130	$183,660	$131,190	$93,720	$66,930	$40,170	$13,380	$0		
Savings		$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000
Cash Flow Statement											
+(.4)*(Depreciation)		$17,148	$29,388	$20,988	$14,988	$10,716	$10,704	$10,716	$5,352	$0	0
+(0.60)*(Savings)		$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	$45,000	45,000
Investment	($300,000)										
Net Cash Flow	($300,000)	$62,148	$74,388	$65,988	$59,988	$55,716	$55,704	$55,716	$50,352	$45,000	$45,000

PW (10%) = $63,079   AE (10%) = $10,266

11.40)

- **Option 1: Keep the defender**

Option 1 : Keep the defender

Financial Data	n	0	1	2	3	4	5	6	7	8
Depreciation		$8,930	$8,920	$4,460						
Book value		$13,387	$4,460							
Market value		$40,000								
Setup cost			$16,000	$16,000	$16,000	$16,000	$16,000	$16,000	$16,000	$16,000
Operating cost			$15,986	$16,785	$17,663	$18,630	$19,692	$20,861	$22,147	$23,562

Cash Flow Statement										
+(.4)*(Depreciation)			$3,568	$1,784						
Opportunity cost		($31,141)								
−(1−0.40)*(Setup)			($9,600)	($9,600)	($9,600)	($9,600)	($9,600)	($9,600)	($9,600)	($9,600)
−(1−0.40)*(Operating cost)			($9,592)	($10,071)	($10,598)	($11,178)	($11,815)	($12,517)	($13,288)	($14,137)
Net Cash Flow		($31,141)	($15,624)	($17,887)	($20,198)	($20,778)	($21,415)	($22,117)	($22,888)	($23,737)

PW (12%) =	($130,228)
AEC(12%) =	$26,215

Note: Opportunity cost (Investment required to keep the defender)

$$\$40,000 - 0.4(\$40,000 - (\$13,387+0.5(\$8,930))) = \$31,141$$

- ## Option 2: Purchase a used machine

Option 2 : Purchase a used machine

Financial Data	n	0	1	2	3	4	5	6	7	8
Depreciation			$21,178	$36,294	$25,920	$18,510	$13,234	$13,219	$13,234	$6,610
Book value		$148,200	$127,022	$90,728	$64,808	$46,298	$33,063	$19,844	$6,610	$0
Salvage value									$0	$0
Setup cost			$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000
Operating cost			$11,500	$11,950	$12,445	$12,990	$13,590	$14,245	$14,950	$15,745
Savings			36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000
Cash Flow Statement										
+(1−0.40)*(Savings)			$21,600.00	$21,600.00	$21,600.00	$21,600.00	$21,600.00	$21,600.00	$21,600.00	$21,600.00
+(.4)*(Depreciation)			$8,471.11	$14,517.67	$10,368.07	$7,404.07	$5,293.70	$5,287.78	$5,293.70	$2,643.89
Investment		($148,200.00)								
−(1−0.40)*(Setup)			($9,000.00)	($9,000.00)	($9,000.00)	($9,000.00)	($9,000.00)	($9,000.00)	($9,000.00)	($9,000.00)
−(1−0.40)*(Operating cost)			($6,900.00)	($7,170.00)	($7,467.00)	($7,794.00)	($8,154.00)	($8,547.00)	($8,970.00)	($9,447.00)
Net Cash Flow		($148,200)	$14,171	$19,948	$15,501	$12,210	$9,740	$9,341	$8,924	$5,797

PW (12%) = ($84,215)
AEC(12%) = $16,953

- Option 3: Keep the defender one year and switch to a brand new machine

Option 3 : Keep the old machine for one more year (Assume that the market value will be $ 30,000.)

Financial Data	n	0	1	2	3	4	5	6	7
Depreciation		$8,930	$4,460						
Book value		$13,138	$8,927						
Market value		$40,000	$30,000						
Setup cost			$16,000						
Operating cost			$16,785						
Cash Flow Statement									
+(.4)*(Depreciation)			$1,784						
Opportunity cost		($31,041)							
−(1−0.40)*(Setup)			($9,600)						
−(1−0.40)*(Operating cost)			($10,071)						
Net proceeds from sale			$21,570						
Net Cash Flow		($31,041)	$3,683						

Option 3 : Purchase a new machine after 1 year

Financial Data	n	0	1	2	3	4	5	6	7	8	9
Depreciation				$28,644	$49,090	$35,059	$25,036	$17,900	$17,880	$17,900	$8,940
Book value			$200,450	$171,806	$122,715	$87,657	$62,621	$44,720	$26,840	$8,940	$0
Market value			$200,450							$0	$0
Setup cost				$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000
Operating cost				$10,350	$10,755	$11,200	$11,691	$12,231	$12,821	$13,455	$14,171
Savings				$36,000	$36,000	$36,000	$36,000	$36,000	$36,000	$36,000	$36,000
Cash Flow Statement											
+(1−0.40)*(Savings)				$21,600.00	$21,600.00	$21,600.00	$21,600.00	$21,600.00	$21,600.00	$21,600.00	$21,600.00
+(.4)*(Depreciation)				$11,457.72	$19,636.08	$14,023.48	$10,014.48	$7,160.07	$7,152.06	$7,160.07	$3,576.03
Investment			($200,450.00)								
−(1−0.40)*(Setup)				($9,000.00)	($9,000.00)	($9,000.00)	($9,000.00)	($9,000.00)	($9,000.00)	($9,000.00)	($9,000.00)
−(1−0.40)*(Operating cost)				($6,210.00)	($6,453.00)	($6,720.00)	($7,014.60)	($7,338.60)	($7,692.60)	($8,073.00)	($8,502.60)
Net Cash Flow			($200,450)	$17,848	$25,783	$19,903	$15,600	$12,421	$12,059	$11,687	$7,673
Combined cash flow		($31,041)	($196,767)	$17,848	$25,783	$19,903	$15,600	$12,421	$12,059	$11,687	$7,673

PW (12%) = ($133,410)   AEC(12%) = $25,038

Conclusion: Option 2 is the least cost option.

(b) Answer is not provided. (Note: Analysis similar to Part(a) except that all cash flows will be truncated over 5 years.)