Engineering Economy

[5-2]
Present Worth Analysis

Present Worth Analysis of Different-life Alternatives

- When the present worth method is used to compare mutually exclusive alternatives that have different lives, then the PW of the alternatives must be compared over the same number of years and end at the same time

- A fair comparison can be made only when the PW values represent costs (and receipts) *associated with equal periods*

- The equal-period requirement can be satisfied by comparing the alternatives over a period of time equal to the least common multiple (LCM) of their lives

Present Worth Analysis of Different-life Alternatives – The LCM Approach

- The LCM approach automatically makes the cash flows for all alternatives extend to the same time period

- For example, alternatives with expected lives of 2 and 3 years are compared over a 6-year time period

The LCM Approach – Example

- A project engineer is assigned to start up a new office in a city where a 6-year contract has been finalized

- Two lease options are available, each with a first cost, annual lease cost, and deposit-return estimates as shown below:

	Location A	Location B
First cost, $	-15,000	-18,000
Annual lease cost, $	-3,500	-3,100
Deposit return, $	1,000	2,000
Lease term, years	6	9

The LCM Approach – Example

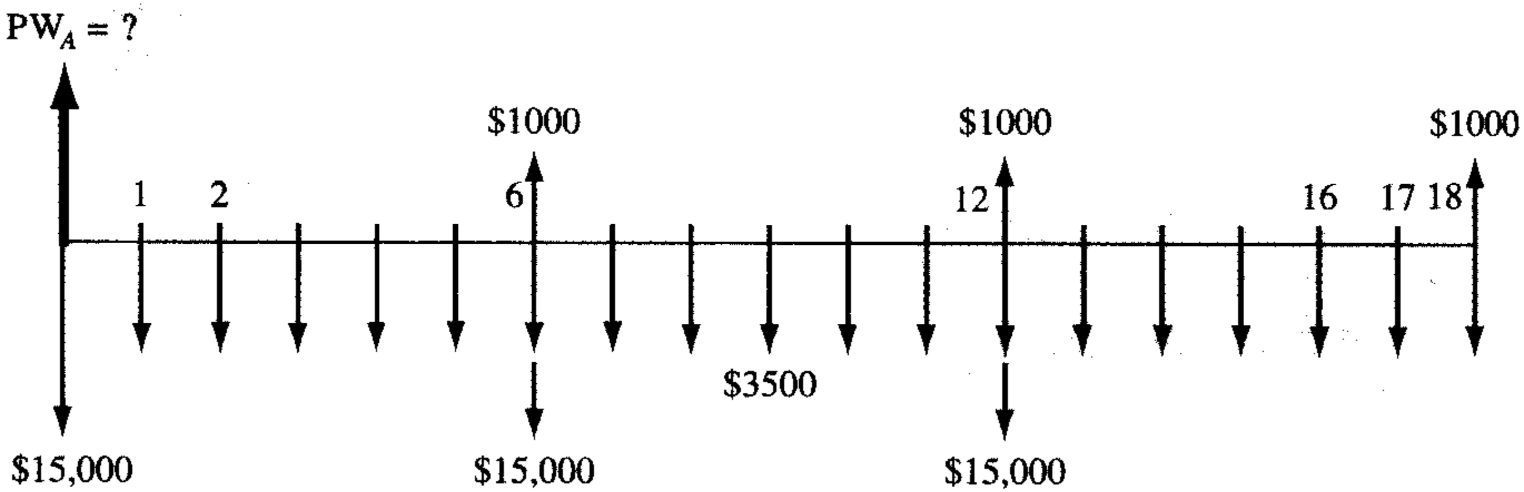
- Determine which lease option should be selected on the basis of a present worth comparison, if the MARR is 15% per year

- Since the leases have different lives, compare them over the LCM of 18 years

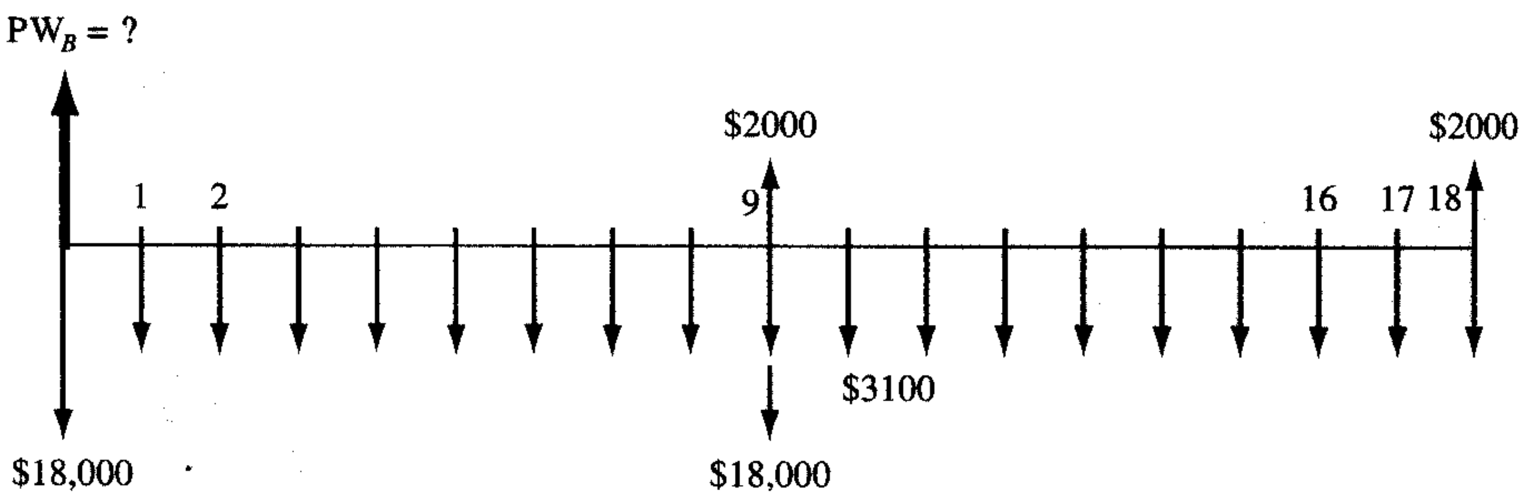
- Repeat the first cost in year 0 of **each new cycle**

- Calculate PW at 15% over 18 years

The LCM Approach – Example



Location *A*



Location *B*

The LCM Approach – Example

- PW_A = – 15,000 – 15,000(P/F,15%,6) + 1,000(P/F,15%,6) – 15,000 (P/F,15%,12) + 1,000(P/F,15%,12) + 1,000(P/F,15%,18) – 3,500(P/A,15%,18) = $ - 45,036

- PW_B = – 18,000 – 18,000(P/F,15%,9) + 2,000(P/F,15%,9) + 2,000(P/F,15%,18) – 3,100(P/A,15%,18) = $ - 41,384

- Location B is selected, since it costs less in PW terms; that is, the PW_B value is numerically larger than PW_A

Future Worth Analysis

- The future worth of an alternative (FW) can be used to compare alternatives

- Once the FW value is determined, the selection guidelines are the same as with PW analysis

- For one alternative, if *FW ≥ 0* means the MARR is *met* or exceeded

- For two mutually exclusive alternatives, select the one with the numerically larger FW value

Future Worth Analysis – Example

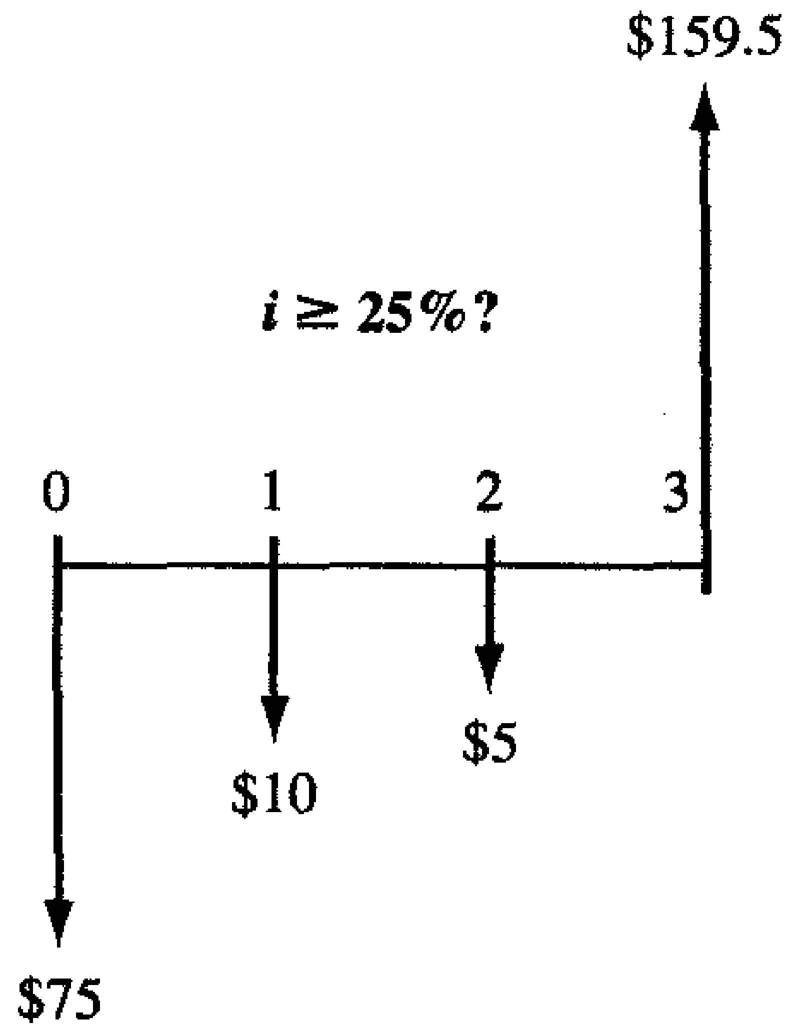
- A company purchased a store chain for $75 million three years ago
- There was a net loss of $10 million at the end of year 1 of ownership
- *Net* cash flow is increasing with an arithmetic gradient of $+5 million per year starting the second year, and this pattern is expected to continue for the foreseeable future. Expected MARR of 25% per year
- [1] The company has just been offered $159.5 million to sell the store. Use FW analysis to determine if the MARR will be realized at this selling price
- [2] If the company continues to own the chain, what selling price must be obtained at the end of 5 years of ownership to make the MARR?

Future Worth Analysis – Example

[1] Find the future worth in year 3 at i = 25% per year and an offer price of $159.5 million

- FW = – 75(F/P,25%,3) – 10(F/P,25%,2) – 5(F/P,25%,1) + 159.5 = –168.36 + 159.5 = $ –8.86 million

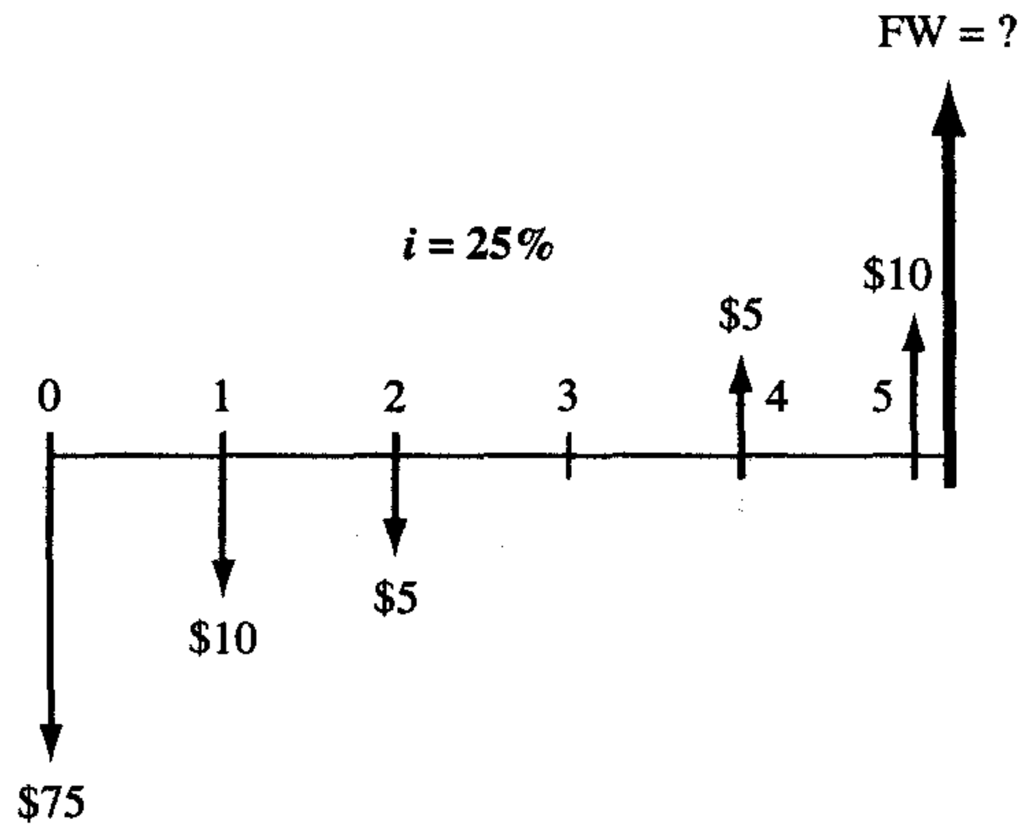
- No, the MARR of 25% *will not be realized* if the $159.5 million offer is accepted



Future Worth Analysis – Example

[2] Determine the future worth 5 years from now at 25% per year

- FW = – 75(F/P,25%,5) – 10(F/A,25%,5) + 5(A/G,25%,5)(F/A,25%,5) = $ –246.81 million
- The offer must be for at least *$246.81* million to make the MARR



Capitalized Cost Calculation and Analysis

- Capitalized cost (CC) is the present worth of an alternative that will last forever
- *Public sector projects* such as bridges, dams, irrigation systems, and railroads fall into this category
- **Capitalized cost** is the **present sum** of money that would need to be set aside now, at some interest rate, to yield the funds required to provide the service (or whatever)indefinitely.
- To accomplish this, the money set aside for future expenditures must not decline.
- The interest received on the money set aside can be spent, but not the principal.

Capitalized Cost Calculation and Analysis

- Thus, for any initial present sum P, there can be an end-of-period withdrawal of A equal to iP each period.
- These withdrawals may continue forever without diminishing the initial sum P.

- This gives us the basic relationship:

For n = 00, A = Pi

Capitalized Cost Calculation and Analysis

- The CC value can be computed from the following equation:

$$CC = \frac{A}{i}$$

  where A is the annual worth

- If $10,000 earns 20% per year, compounded annually, the *maximum* amount of money that can be withdrawn at the end of every year for *eternity* is $2,000, or the interest accumulated each year

- This leaves the original $10,000 to earn interest so that another $2,000 *will be accumulated the next year*

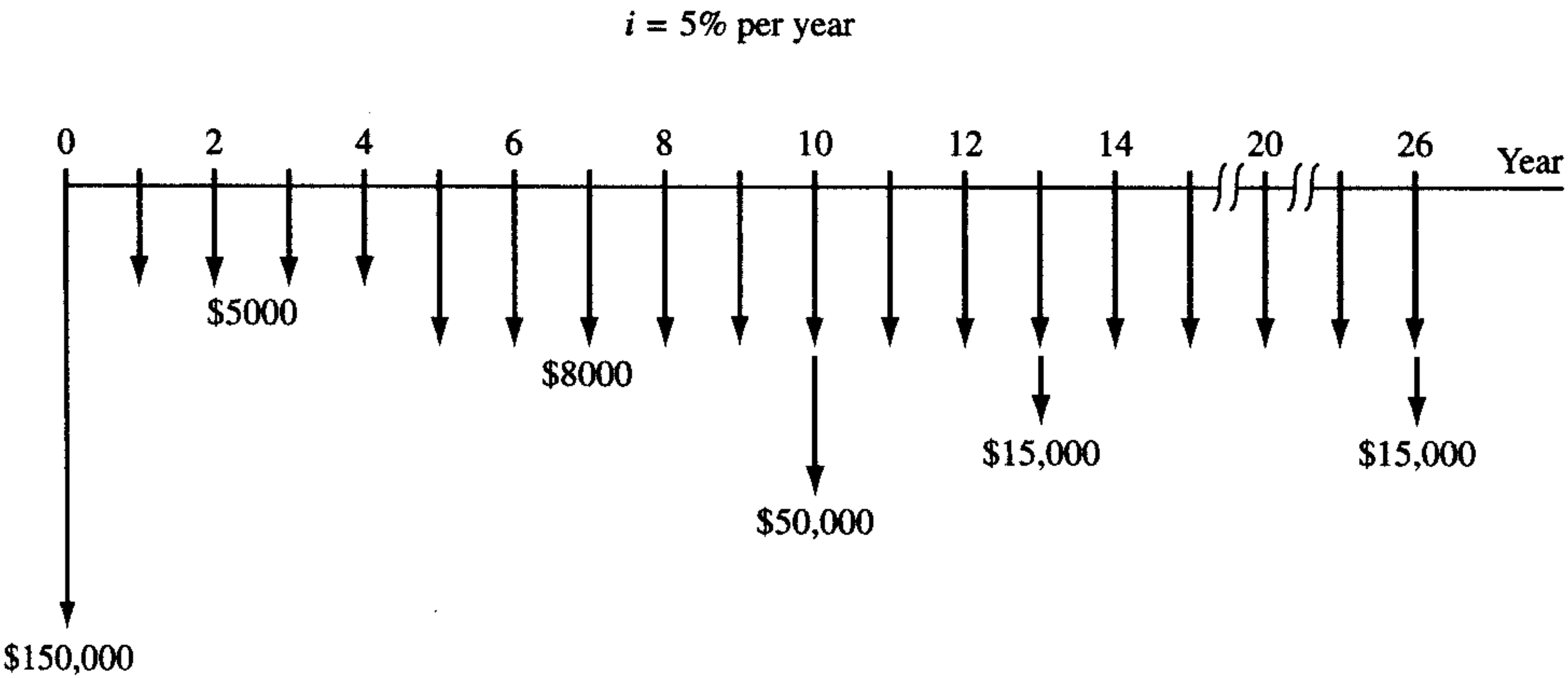
Capitalized Cost Calculation and Analysis
Example

- A new computer system will be used for the *indefinite* future, find the equivalent value (a) *now* and (b) for *each year hereafter*

- The system has an installed cost of $150,000 and an additional cost of $50,000 after 10 years. The annual maintenance cost is $5,000 for the first 4 years and $8,000 thereafter. In addition, it is expected to be a recurring major upgrade cost of $15,000 every 13 years

- Assume that i = 5% per year

Capitalized Cost Calculation and Analysis
Example



Capitalized Cost Calculation and Analysis

Example

1. Draw the cash flow diagram

2. Find the present worth of the *nonrecurring* costs of $150,000 now and $50,000 in year 10 at i = 5%. Label this CC1 where CC1 = – 150,000 – 50,000(P/F,5%,10) = $ – 180,695

3. Convert the recurring cost of $15,000 every 13 years into an annual worth A1 for the first 13 years. A1 = – 15,000(A/F,5%,13) = $ – 847. The same value, A1 = $ – 847, applies to all the other 13-year periods as well

Capitalized Cost Calculation and Analysis
Example

4. The capitalized cost for the two annual maintenance cost series can be determined by considering a series of \$ –5,000 from now to infinity and find the present worth of \$ –8,000 – (\$ –5,000) = \$ –3,000 from year 5 on. The annual cost (A2) is \$ –5,000 forever

   The capitalized cost CC2 of \$ –3,000 from year 5 to infinity is found using the present value at year 4 (A/i) and then multiply this by the P/F factor →

   CC2 = (– 3,000/0.05)(P/F,5%,4) = \$ –49,362

   The two annual cost series are converted into a capitalized cost CC3 →

   CC3 = (A1 + A2)/i = (-847 + (-5,000))/0.05 = \$ –116,940

Capitalized Cost Calculation and Analysis
Example

5. The total capitalized cost CC is obtained by adding the three CC values = – 180,695 – 49,362 – 116,940 = $ – 346,997

Capitalized Cost Calculation and Analysis

Procedure

1. Draw a cash flow diagram showing all nonrecurring (one-time) cash flows and at least two cycles of all recurring (periodic) cash flows

2. Find the present worth of all nonrecurring amounts. This is their CC value

3. Find the equivalent uniform annual worth (A value) through one life cycle of all recurring amounts. This is the same value in all succeeding life cycles. Add this to all other uniform amounts occurring in years 1 through infinity and the result is the total equivalent uniform annual worth (AW)

4. Divide the AW obtained in step 3 by the interest rate i to obtain a CC value

5. Add the CC values obtained in steps 2 and 4

Payback Period Analysis

- The payback period (n_p) is the estimated time in years it will take for the estimated revenues and other economic benefits to recover the initial investment

- The payback period analysis should provide initial screening or supplemental information in conjunction with an analysis performed using present worth or another method

- In order to find n_p, the *initial investment* should equal the present worth of net present value of all *estimated cash flows*

Payback Period Analysis
Example [1]

- An engineering firm has just approved an $18 million design contract
- The services are expected to generate new annual net cash flows of $3 million
- Contract period is 10 years
- If i = 15%, compute the payback period

Payback Period Analysis
Example [1]

- The initial investment = $18 million

- The present value of the expected return = A(P/A,i,n) when considering that A = $3 million → 3(P/A,15%,n)

- The two amounts ought to be equal→ 18 = 3(P/A,15%,n). This gives a value of n_p = 16.47 years

Payback Period Analysis
Example [2]

- Two machines are being considered for purchase by a company. Machine 2 is expected to be versatile and technologically advanced enough to provide net income longer than machine 1

- The quality manager used a rate of return of 15% per year and a PC-based economic analysis package. The manager recommended machine 1 because it has a shorter payback period of 6.57 years at i = 15%. Is this right?

	Machine 1	Machine 2
First cost, $	12,000	8,000
Annual NCF, $	3,000	1,000 (years 1-5) 3,000 (years 6-14)
Maximum life, years	7	14

Payback Period Analysis
Example [2]

- For Machine 1

  $12{,}000 = 3{,}000(P/A,15\%,n_p)$ which gives a payback period of *6.57 years*

- For Machine 2

  $8{,}000 = 1{,}000(P/A,15\%,5) + 3{,}000(P/A,15\%,n_p-5) \times (P/F,15\%,5)$ which gives a payback period of *9.52 years*

Payback Period Analysis
Example [2]

- If we would like to use PW analysis to compare the machines, then the following procedure ought to be considered:

- For Machine 1

  PW1 = -12,000 – 12,000(P/F,15%,7) + 3,000(P/A,15%,14) = $663

- For Machine 2

  PW2 = -8,000 + 1,000(P/A,15%,5) + 3,000(P/A,15%,9)(P/F,15%,5) = $2,470

- Machine 2 is selected since its PW value is larger