Engineering Economics

Lecture 5

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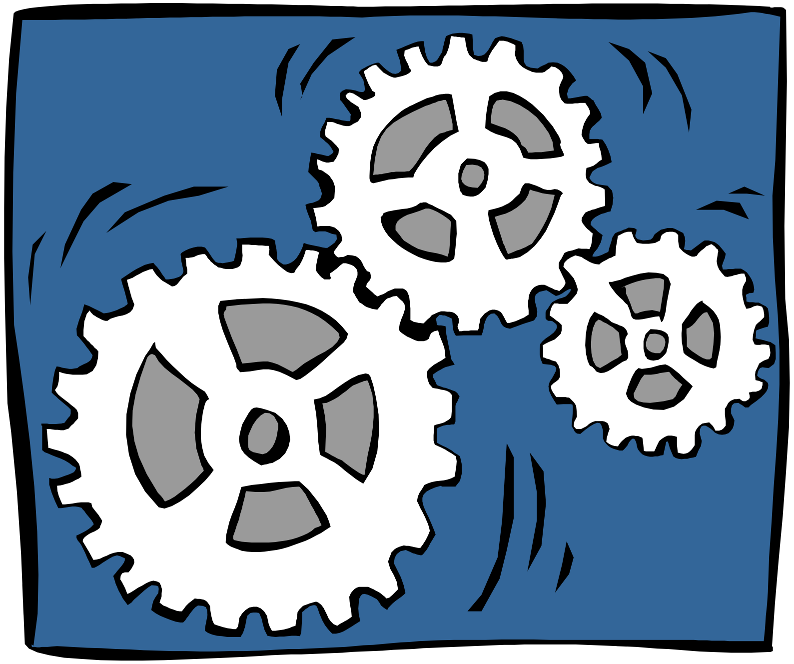
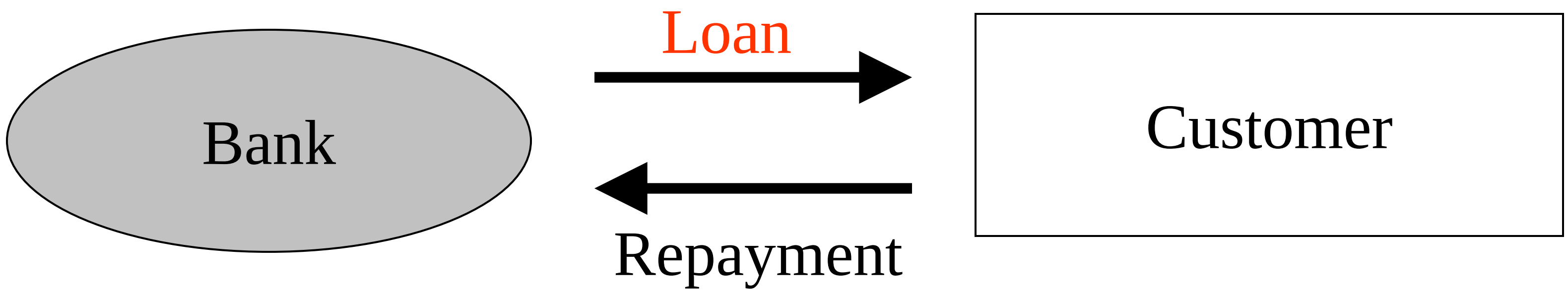
Chapter 7
Present Worth Analysis

- Describing Project Cash Flows
- Initial Project Screening Method
- Present Worth Analysis
- Variations of Present Worth Analysis
- Comparing Mutually Exclusive Alternatives

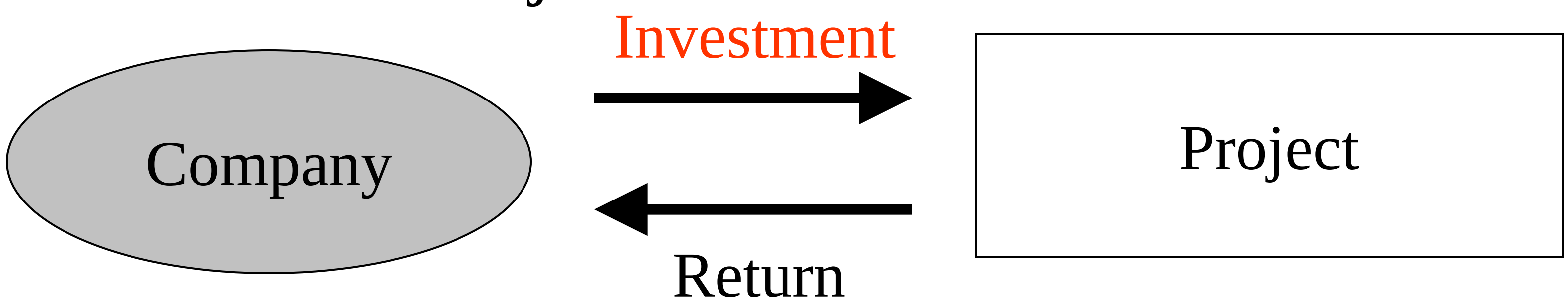


Bank Loan vs. Investment Project

- Bank Loan



- Investment Project



Describing Project Cash Flows

Year (n)	Cash Inflows (Benefits)	Cash Outflows (Costs)	Net Cash Flows
0	0	$650,000	-$650,000
1	215,500	53,000	162,500
2	215,500	53,000	162,500
…	…	…	…
8	215,500	53,000	162,500

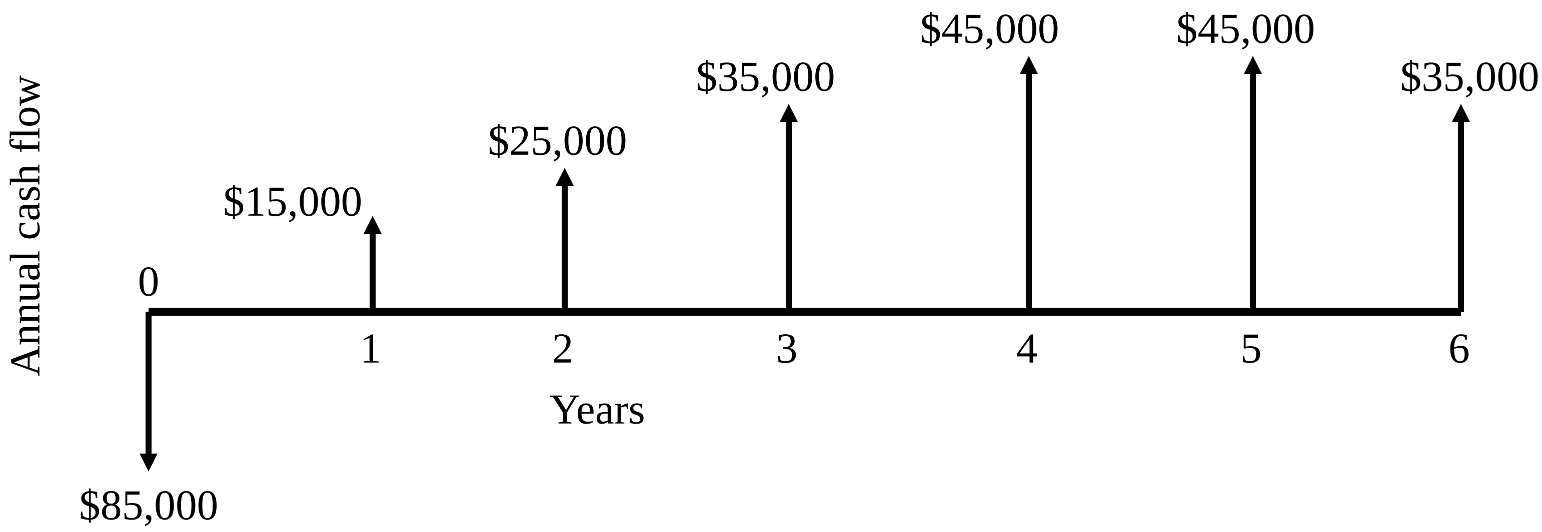
Payback Period

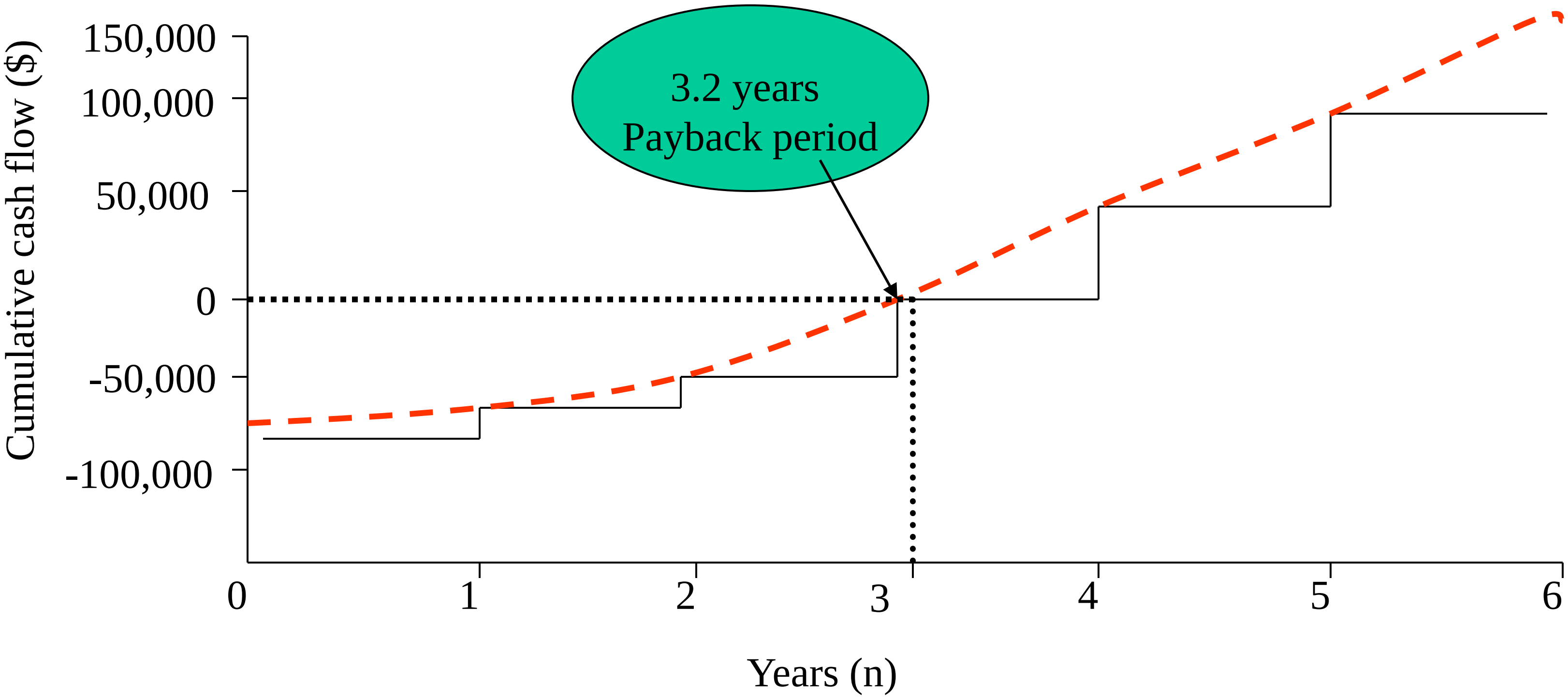
- Principle:
  How fast can I recover my initial investment?
- Method:
  Based on cumulative cash flow (or accounting profit)
- Screening Guideline:
  If the payback period is less than or equal to some specified payback period, the project would be considered for further analysis.
- Weakness:
  Does not consider the time value of money

Example 7.3 Payback Period

N	Cash Flow	Cum. Flow
0	-$105,000+$20,000	-$85,000
1	$35,000	-$50,000
2	$45,000	-$5,000
3	$50,000	$45,000
4	$50,000	$95,000
5	$45,000	$140,000
6	$35,000	$175,000

Payback period should occurs somewhere between N = 2 and N = 3.


Annual cash flow
0
$15,000
$25,000
$35,000
$45,000
$45,000
$35,000
1
2
3
4
5
6
Years
$85,000

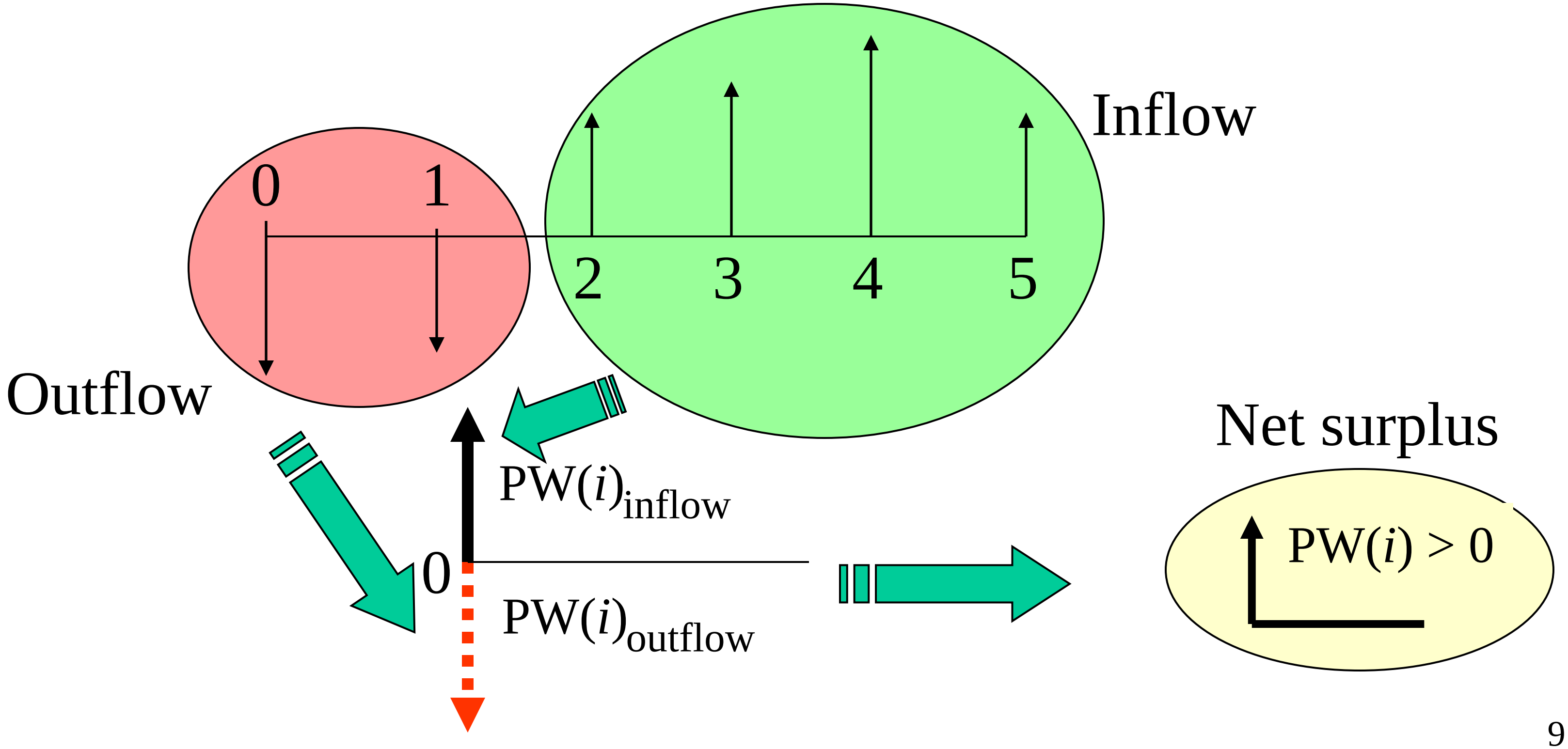

Cumulative cash flow ($)
150,000
100,000
50,000
0
-50,000
-100,000
3.2 years
Payback period
0
1
2
3
4
5
6
Years (n)

Discounted Payback Period Calculation

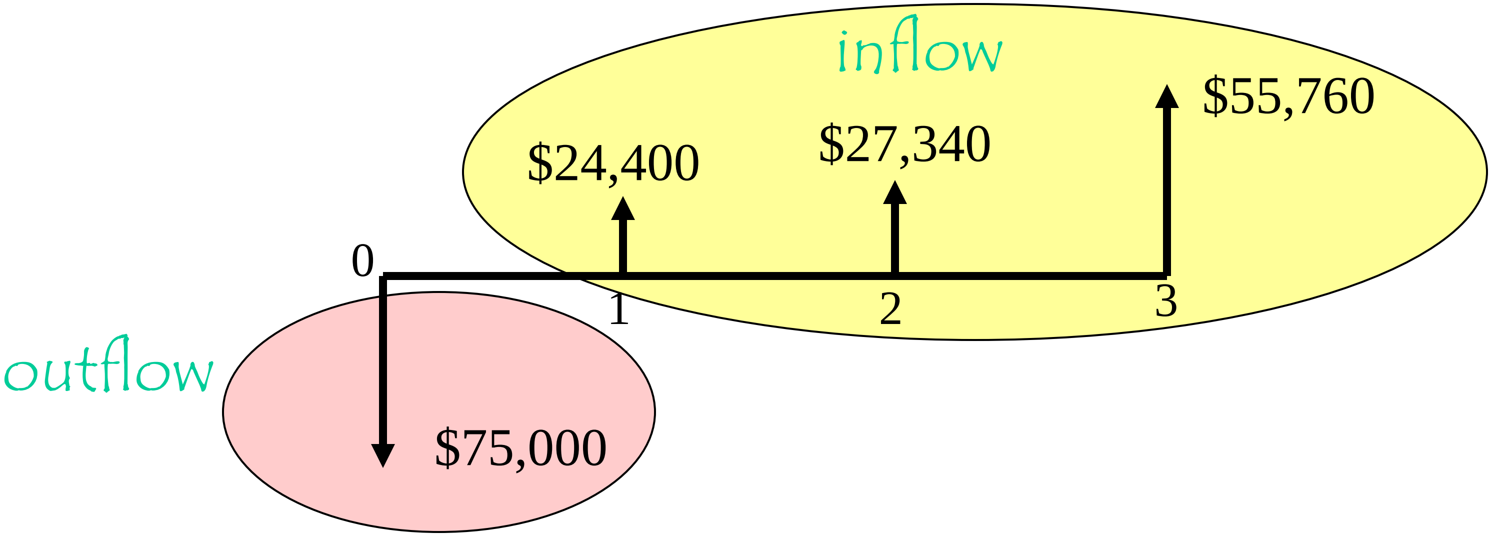
Period	Cash Flow	Cost of Funds (15%)*	Cumulative Cash Flow
0	-$85,000	0	-$85,000
1	15,000	-$85,000(0.15)= -$12,750	-82,750
2	25,000	-$82,750(0.15)= -12,413	-70,163
3	35,000	-$70,163(0.15)= -10,524	-45,687
4	45,000	-$45,687(0.15)=-6,853	-7,540
5	45,000	-$7,540(0.15)= -1,131	36,329
6	35,000	$36,329(0.15)= 5,449	76,778

Net Present Worth Measure

- Principle: Compute the equivalent net surplus at $n = 0$ for a given interest rate of i.
- Decision Rule: Accept the project if the net surplus is positive.



Example 7.5 - Tiger Machine Tool Company

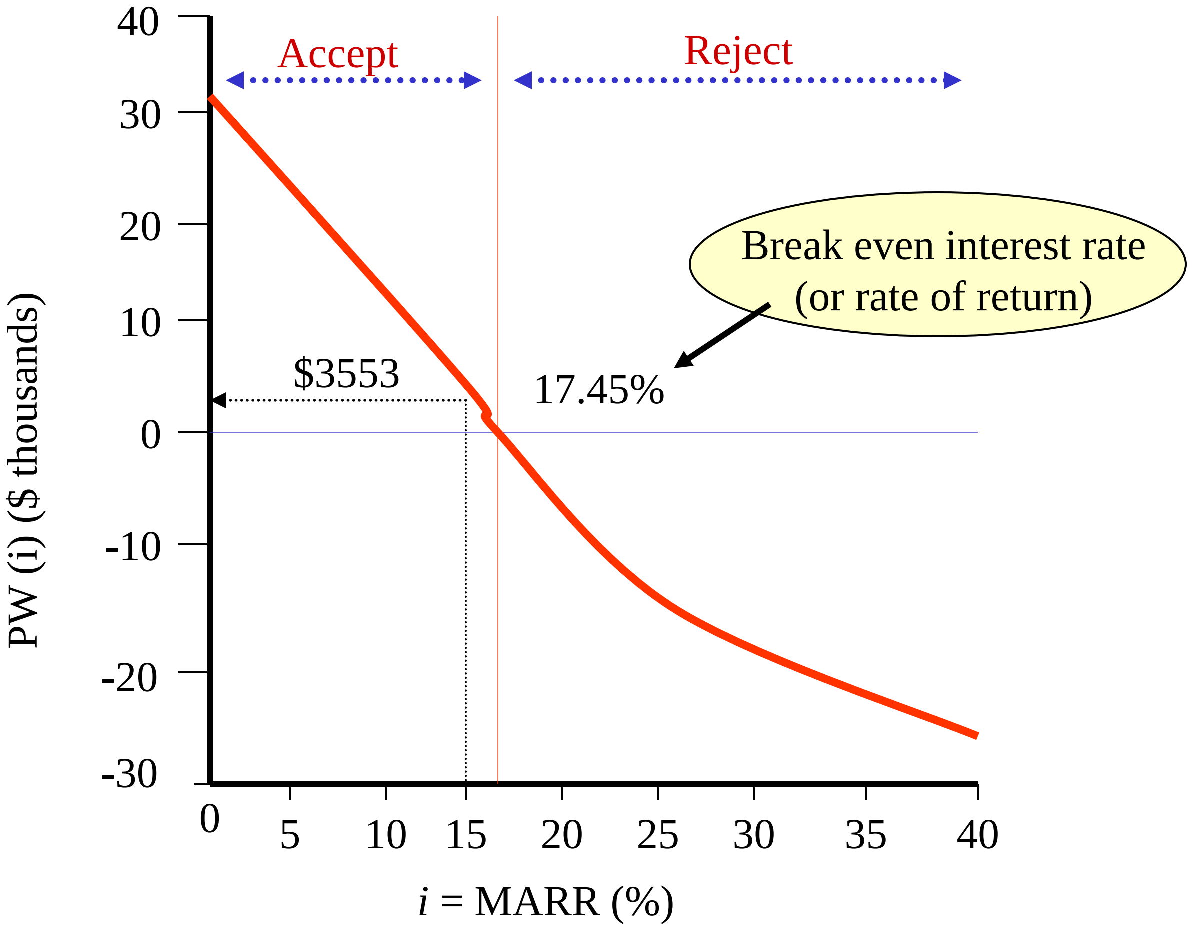


Present Worth Amounts at Varying Interest Rates

i (%)	PW(*i*)	*i*(%)	PW(*i*)
0	$32,500	20	-$3,412
2	27,743	22	-5,924
4	23,309	24	-8,296
6	19,169	26	-10,539
8	15,296	28	-12,662
10	11,670	30	-14,673
12	8,270	32	-16,580
14	5,077	34	-18,360
16	2,076	36	-20,110
17.45*	0	38	-21,745
18	-751	40	-23,302

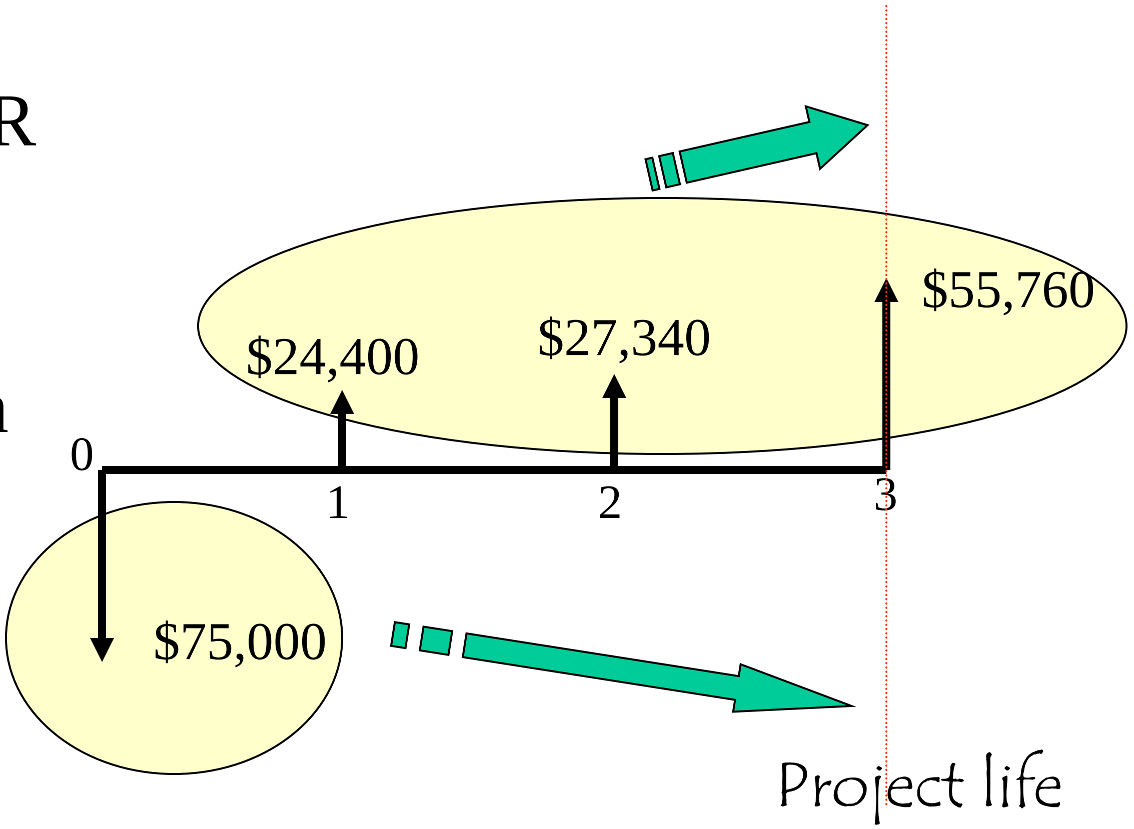
*Break even interest rate

Present Worth Profile



Future Worth Criterion

- Given: Cash flows and MARR (i)
- Find: The net equivalent worth at the end of project life



Future Worth Criterion

$$\begin{aligned}
FW(15\%)_{\text{inflow}} &= \$24{,}400(F/P,15\%,2) + \$27{,}340(F/P,15\%,1) \\
&\quad + \$55{,}760(F/P,15\%,0) \\
&= \boxed{\$119{,}470} \\
FW(15\%)_{\text{outflow}} &= \$75{,}000(F/P,15\%,3) \\
&= \boxed{\$114{,}066} \\
FW(15\%) &= \$119{,}470 - \$114{,}066 \\
&= \boxed{\$5{,}404 > 0,\ \text{Accept}}
\end{aligned}$$

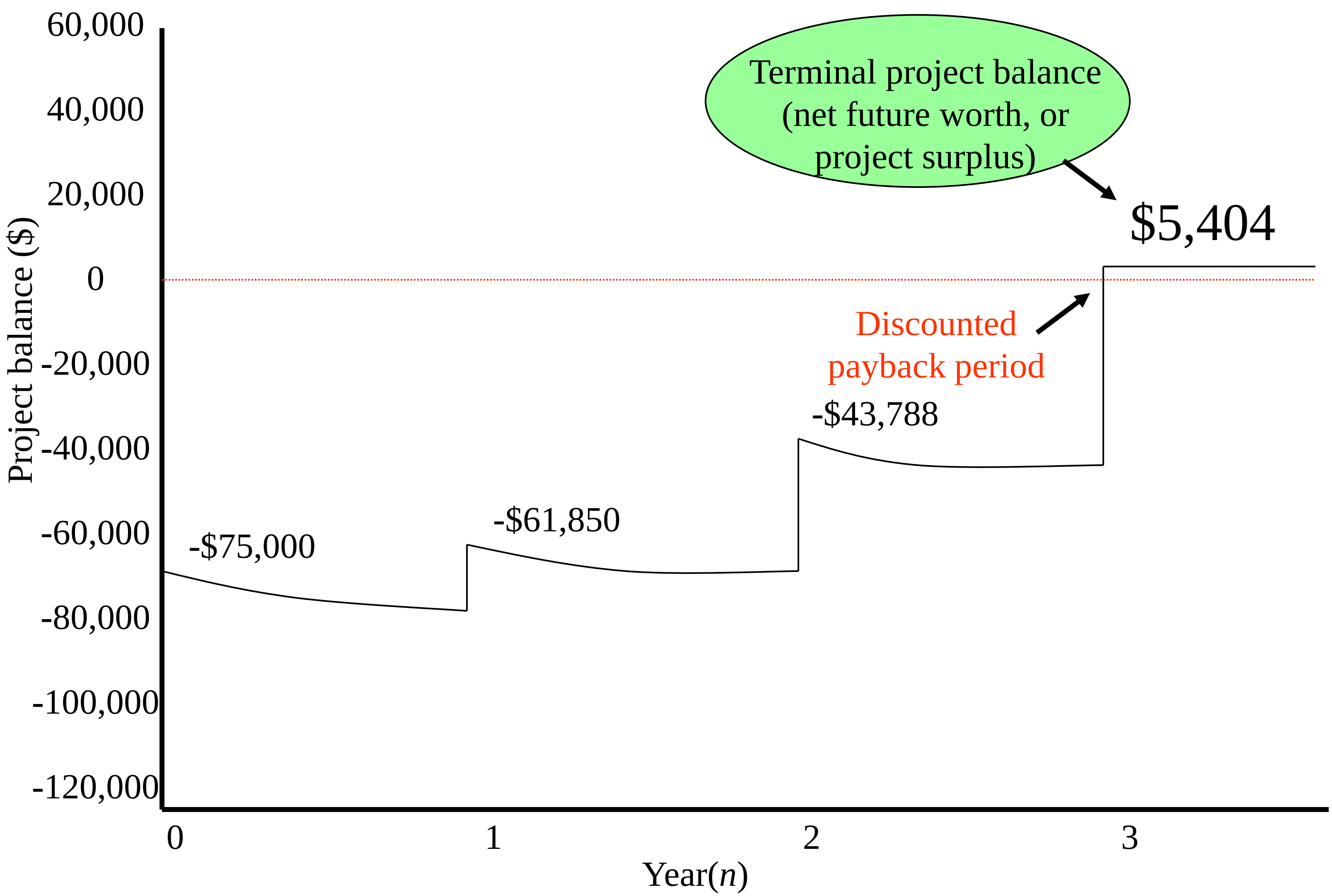
Project Balance Concept

N	0	1	2	3
Beginning Balance		-\$75,000	-\$61,850	-\$43,788
Interest		-\$11,250	-\$9,278	-\$6,568
Payment	-\$75,000	+\$24,400	+\$27,340	+\$55,760
Project Balance	-\$75,000	-\$61,850	-\$43,788	+\$5,404

Net future worth, FW(15%)

PW(15%) = \$5,404 (P/F, 15%, 3) = \$3,553

Project Balance Diagram

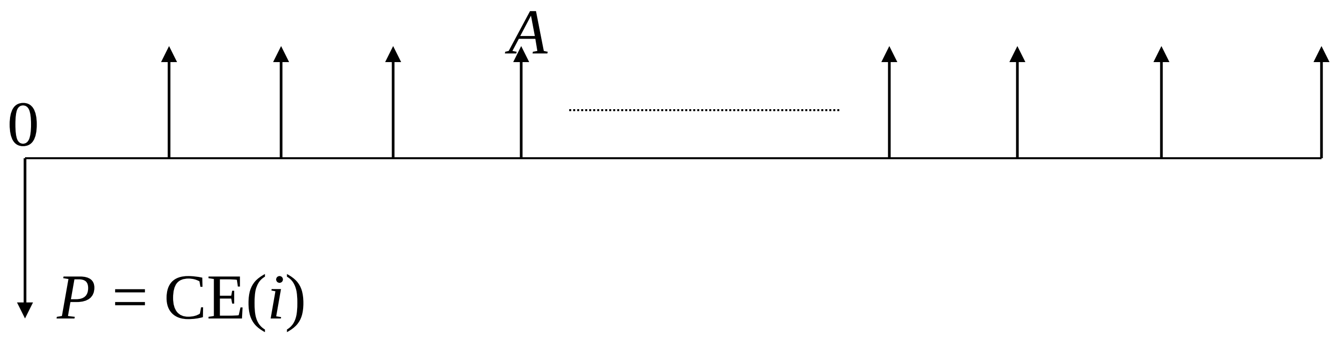


Capitalized Equivalent Worth

Principle: PW for a project with an annual receipt of *A* over infinite service life

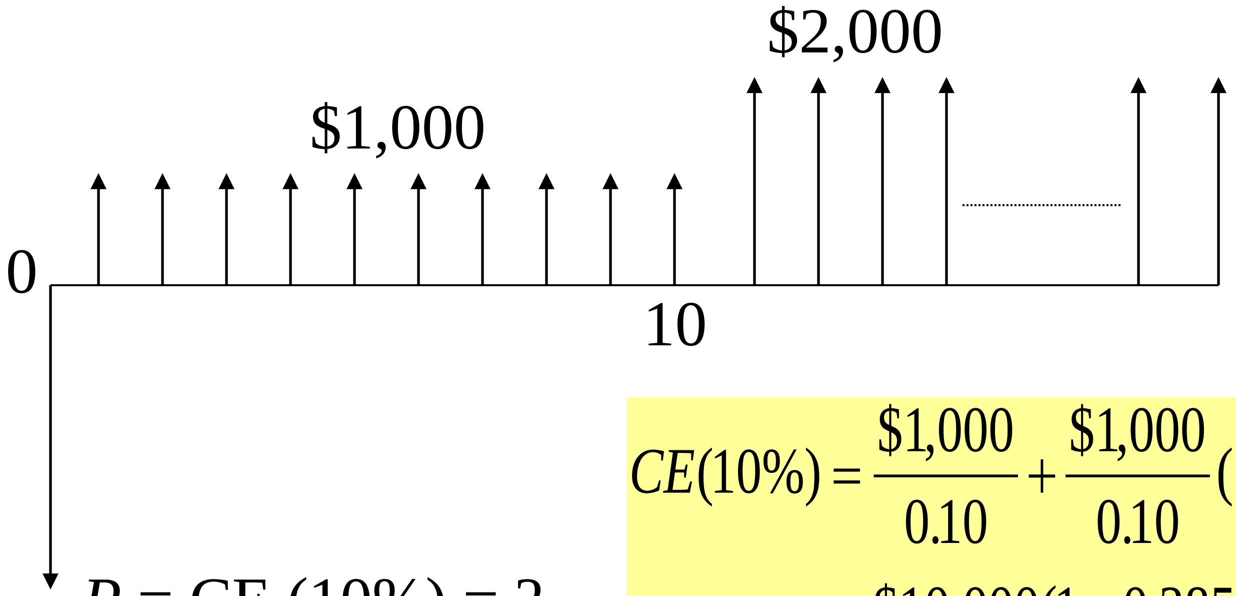
Equation:

$$CE(i) = A(P/A, i, \infty) = A/i$$



Given: $i = 10\%$, $N = \infty$

Find: P or CE (10%)



P = CE (10%) = ?

$$CE(10\%) = \frac{\$1,000}{0.10} + \frac{\$1,000}{0.10}(P/F, 10\%, 10)$$
$$= \$10,000(1 + 0.3855)$$
$$= \$13,855$$

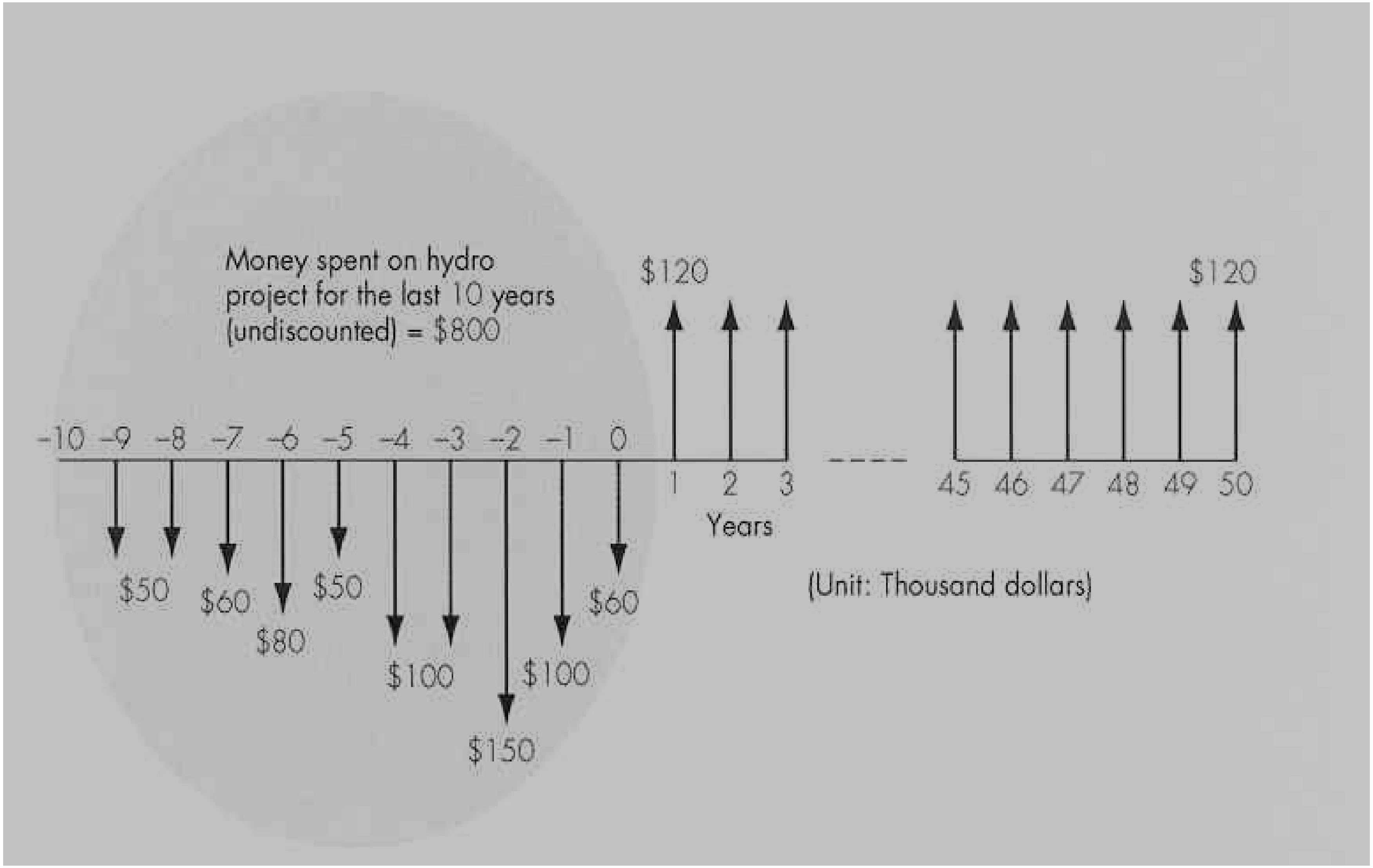
Example 7.9
Mr. Bracewell's Investment Problem

- Built a hydroelectric plant using his personal savings of $800,000
- Power generating capacity of 6 million kwhs
- Estimated annual power sales after taxes - $120,000
- Expected service life of 50 years

Was Bracewell's $800,000 investment a wise one?

How long does he have to wait to recover his initial investment, and will he ever make a profit?

Mr. Brcewell’s Hydro Project



Equivalent Worth at Plant Operation

- **Equivalent lump sum investment**

$$\begin{aligned} V_1 &= \$50\text{K}(F/P, 8\%, 9) + \$50\text{K}(F/P, 8\%, 8) + \\ &\quad \ldots + \$100\text{K}(F/P, 8\%, 1) + \$60\text{K} \\ &= \$1{,}101\text{K} \end{aligned}$$

- **Equivalent lump sum benefits**

$$\begin{aligned} V_2 &= \$120(P/A, 8\%, 50) \\ &= \$1{,}468\text{K} \end{aligned}$$

- **Equivalent net worth**

$$\begin{aligned} \text{FW}(8\%) &= V_1 - V_2 \\ &= \$367\text{K} > 0, \ \text{Good Investment} \end{aligned}$$

With an Infinite Project Life

- **Equivalent lump sum investment**

$$V_1 = \$50K(F/P, 8\%, 9) + \$50K(F/P, 8\%, 8) + \ldots + \$100K(F/P, 8\%, 1) + \$60K = \$1{,}101K$$

- **Equivalent lump sum benefits assuming *N* = ∞**

$$V_2 = \$120(P/A, 8\%, \infty) = \$120/0.08 = \$1{,}500K$$

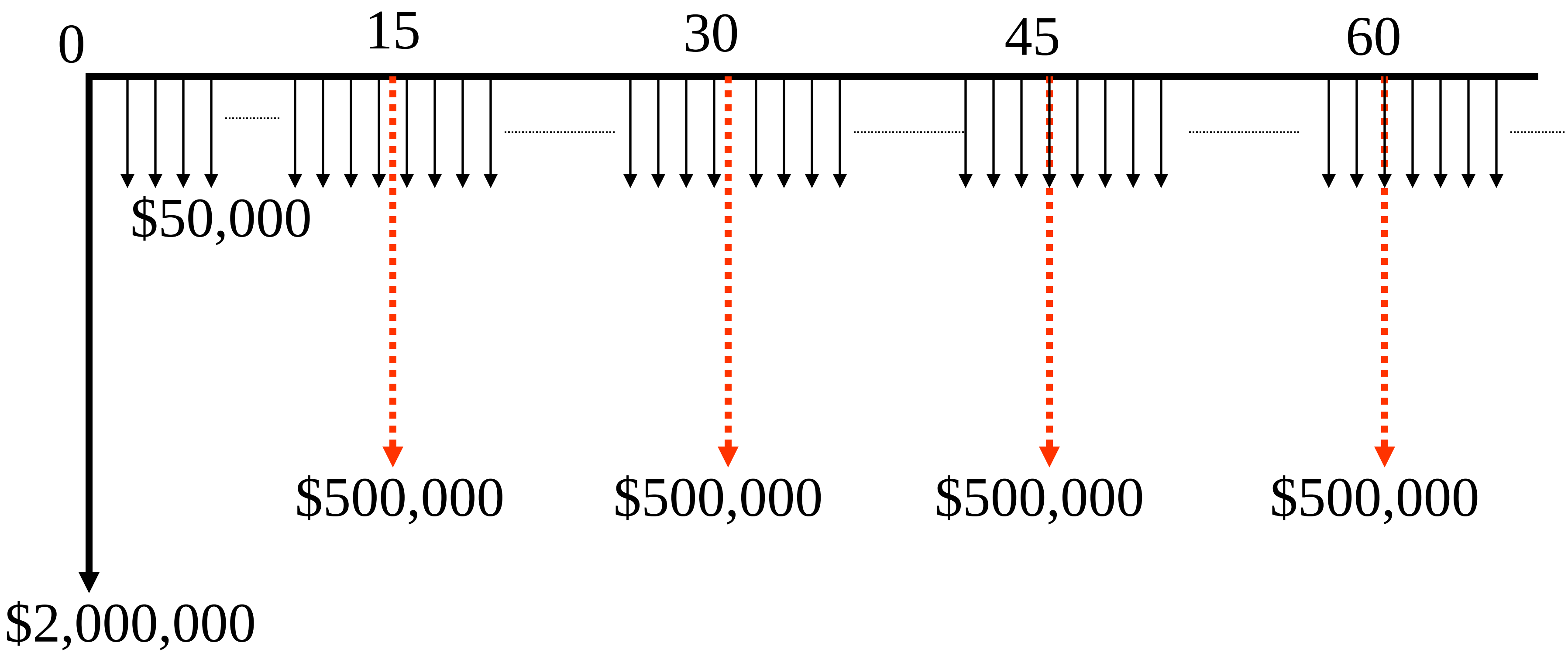
- **Equivalent net worth**

$$FW(8\%) = V_1 - V_2 = \$399K > 0$$

Difference = $32,000

Problem 7.27 - Bridge Construction

- Construction cost = $2,000,000
- Annual Maintenance cost = $50,000
- Renovation cost = $500,000 every 15 years
- Planning horizon = infinite period
- Interest rate = 5%


0
15
30
45
60
$50,000
$500,000
$500,000
$500,000
$500,000
$2,000,000

Solution:

- **Construction Cost**

  $P_1 = \$2,000,000$

- **Maintenance Costs**

  $P_2 = \$50,000/0.05 = \$1,000,000$

- **Renovation Costs**

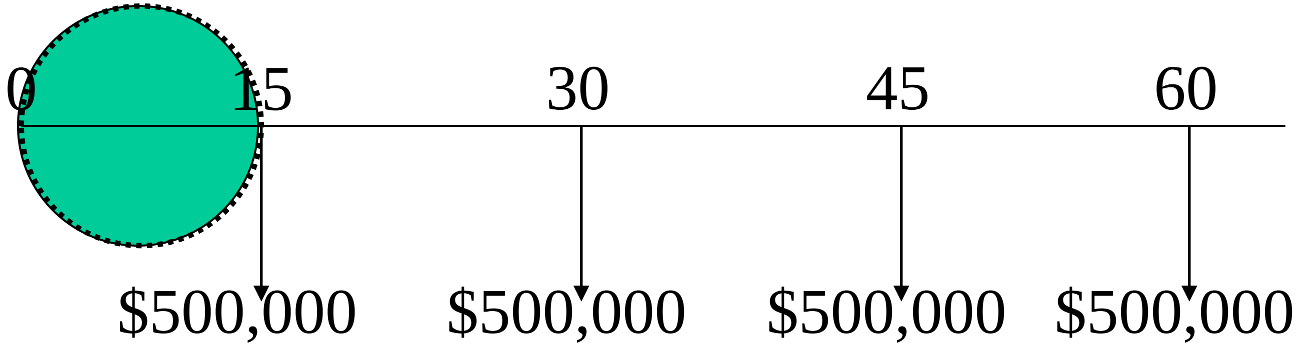
  $P_3 = \$500,000(P/F, 5\%, 15)$
  $+ \$500,000(P/F, 5\%, 30)$
  $+ \$500,000(P/F, 5\%, 45)$
  $+ \$500,000(P/F, 5\%, 60)$
  .
  $= \{\$500,000(A/F, 5\%, 15)\}/0.05$
  $= \$463,423$

- **Total Present Worth**

  $P = P_1 + P_2 + P_3 = \boxed{\$3,463,423}$

Alternate way to calculate P_3

- Concept: Find the effective interest rate per payment period



- Effective interest rate for a 15-year cycle

$$i = (1 + 0.05)^{15} - 1 = 107.893\%$$

- Capitalized equivalent worth

$$P_3 = \$500,000/1.07893$$
$$= \$463,423$$

Comparing Mutually Exclusive Projects

- **Mutually Exclusive Projects**
- **Alternative vs. Project**
- **Do-Nothing Alternative**

Revenue Projects

Projects whose revenues depend on the choice of alternatives

Service Projects

Projects whose revenues do not depend on the choice of alternative

Analysis Period

The time span over which the economic effects of an investment will be evaluated (study period or planning horizon).

Required Service Period

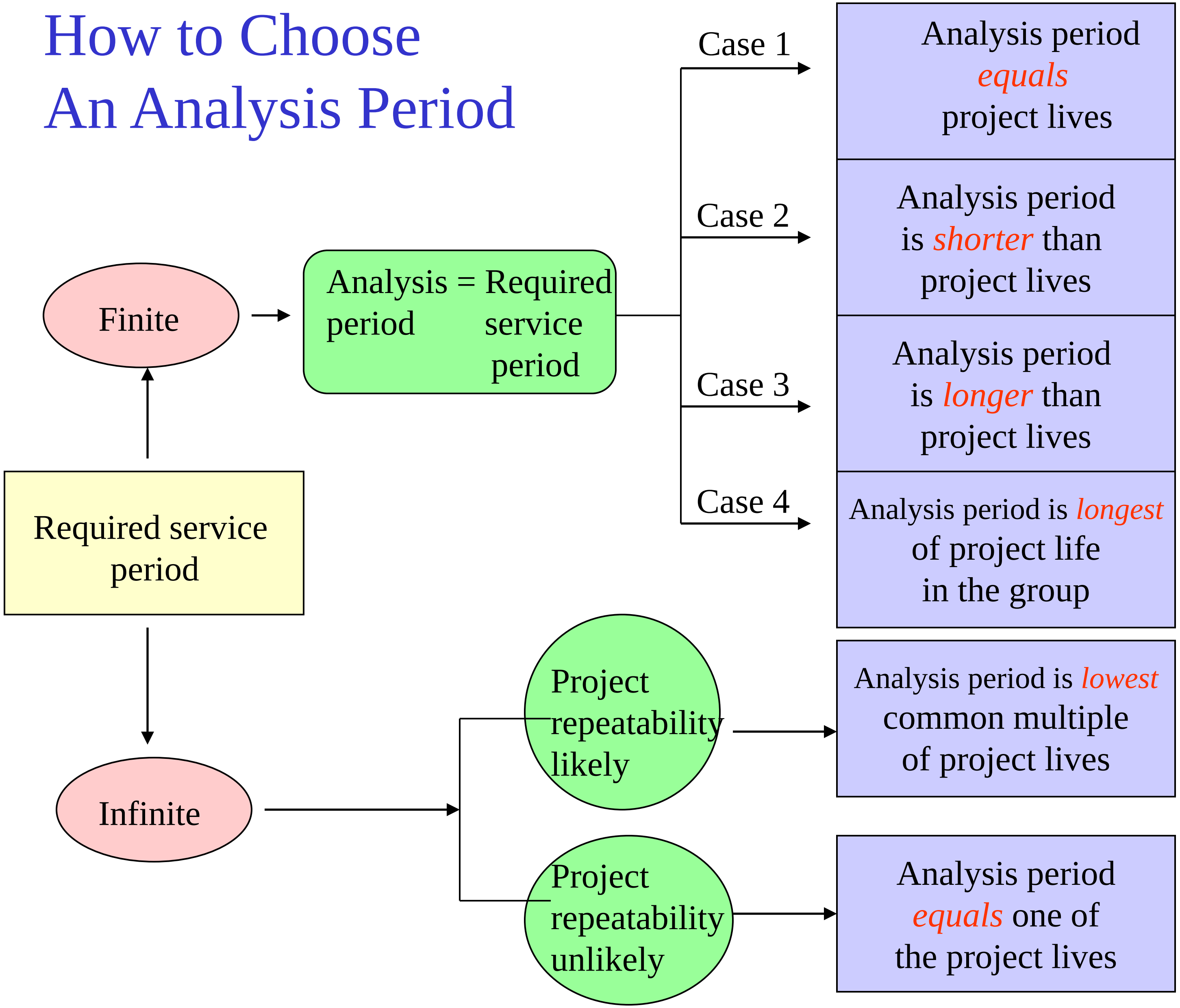
The time span over which the service of an equipment (or investment) will be needed.

Comparing Mutually Exclusive Projects

- **Principle**: Projects must be compared over an **equal time** span.

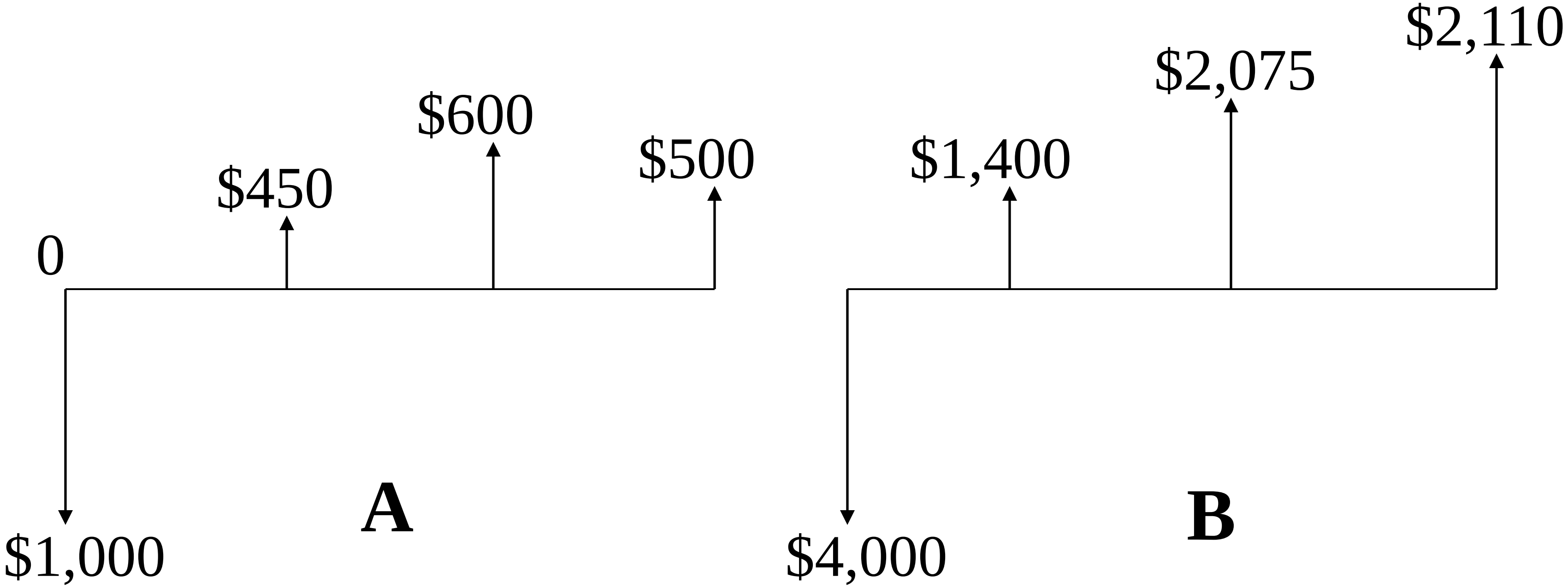
- **Rule of Thumb**: If the required service period is given, the analysis period should be the same as the required service period.

How to Choose
An Analysis Period



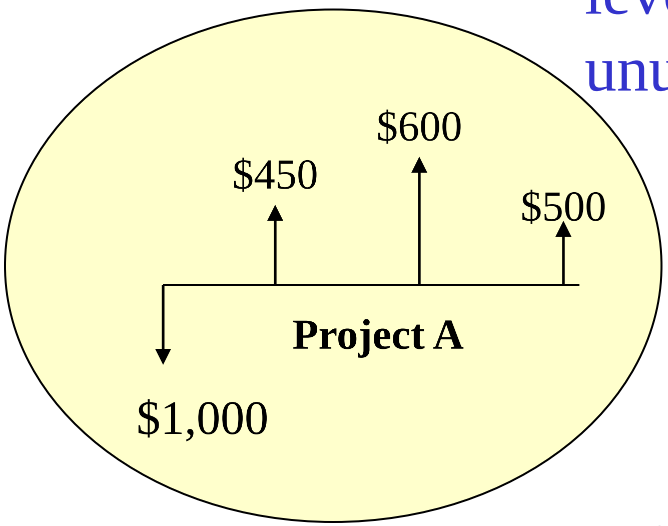
Case 1: Analysis Period Equals Project Lives

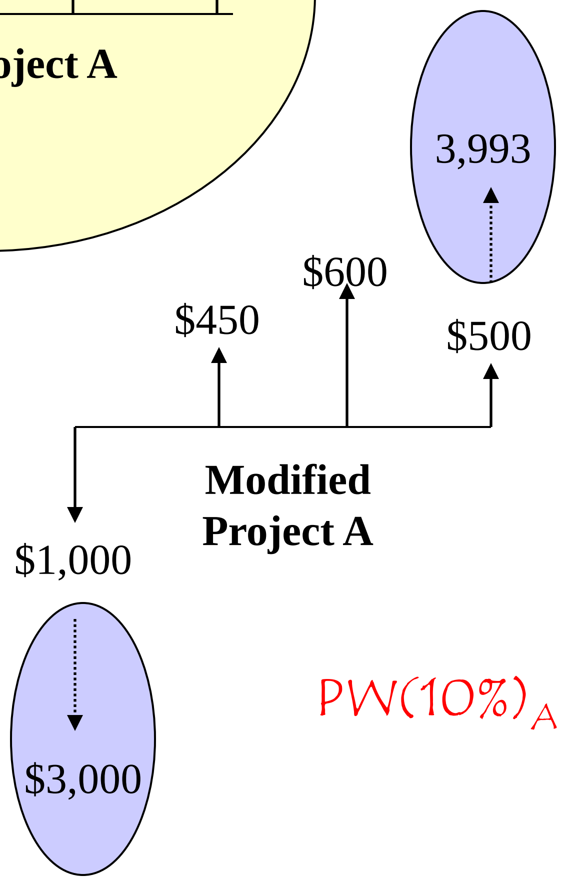
Compute the PW for each project over its life



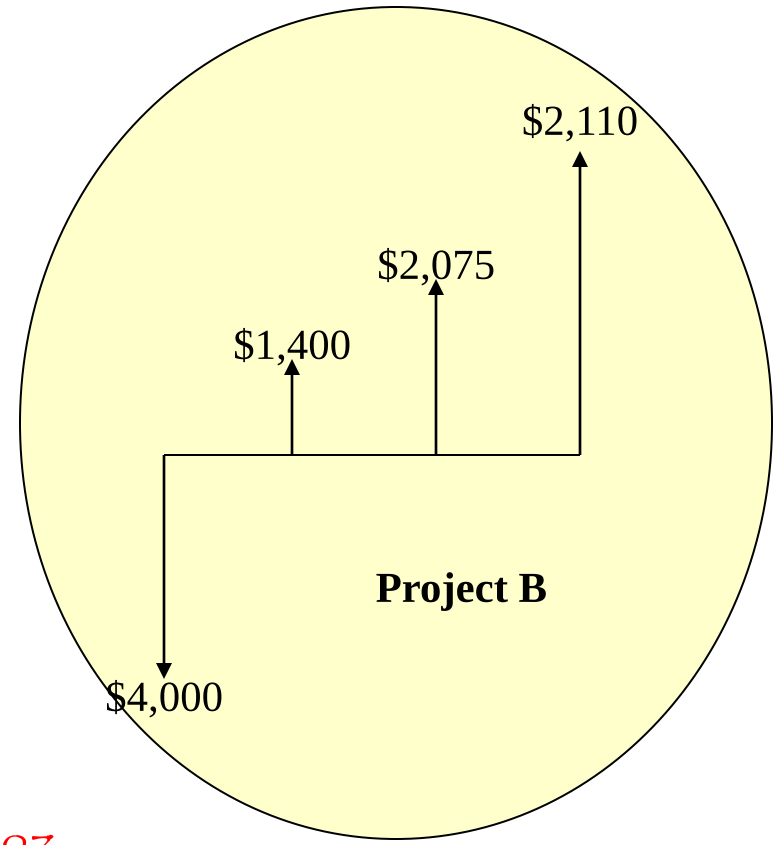
PW (10%)$_A$= $283
PW (10%)$_B$= $579

Comparing projects requiring different levels of investment – Assume that the unused funds will be invested at MARR.





This portion of investment will earn 10% return on investment.



$PW(10\%)_A = \$283$

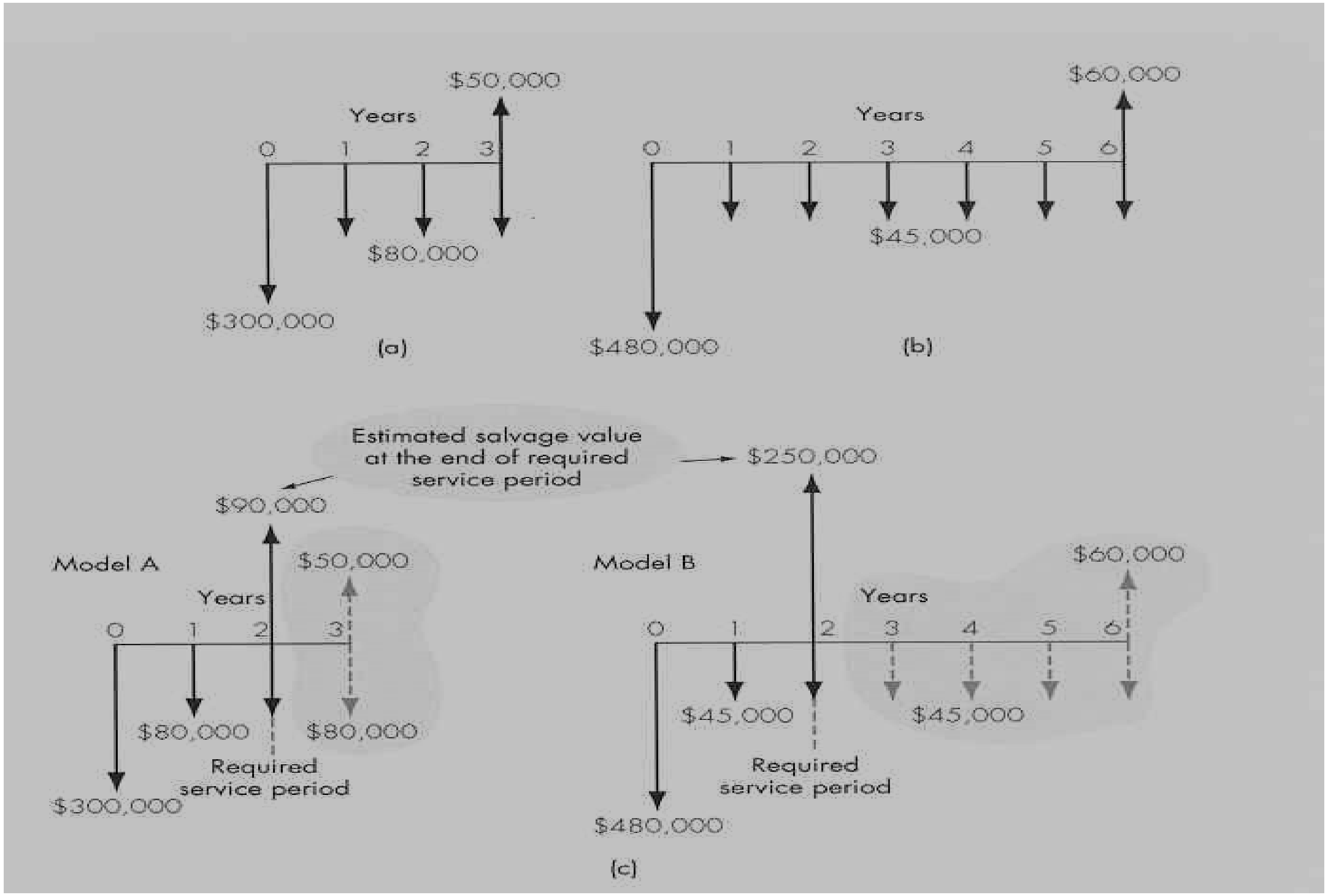
$PW(10\%)_B = \$579$

Case 2: Analysis Period Shorter than Project Lives

- Estimate the salvage value at the end of required service period.

- Compute the PW for each project over the required service period.

Comparison of unequal-lived service projects when the required service period is shorter than the individual project life

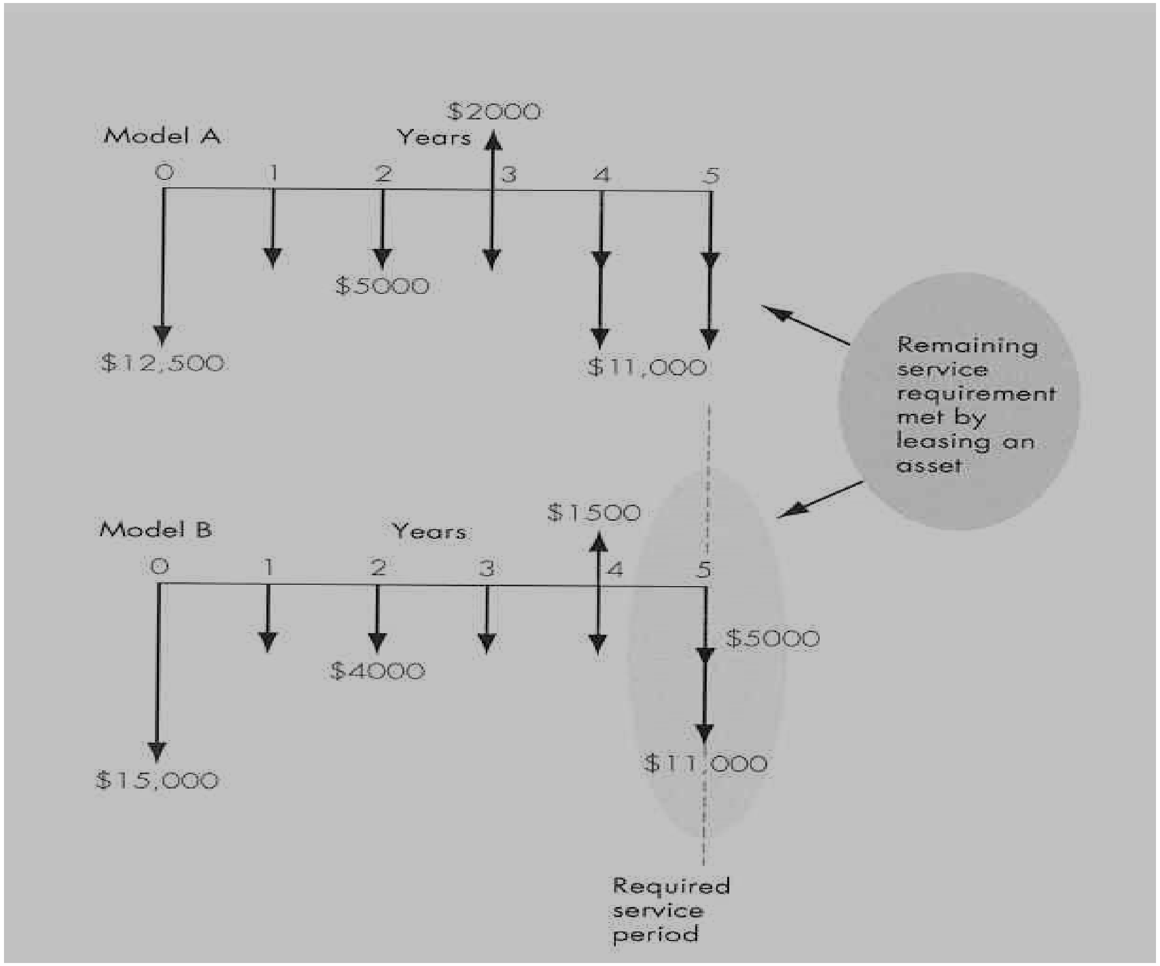


Case 3: Analysis Period Longer than Project Lives

- Come up with replacement projects that match or exceed the required service period.

- Compute the PW for each project over the required service period.

Comparison for Service Projects with Unequal Lives when the required service period is longer than the individual project life



Case 4: Analysis Period is Not Specified

- Project Repeatability Unlikely

  Use common service (revenue) period.

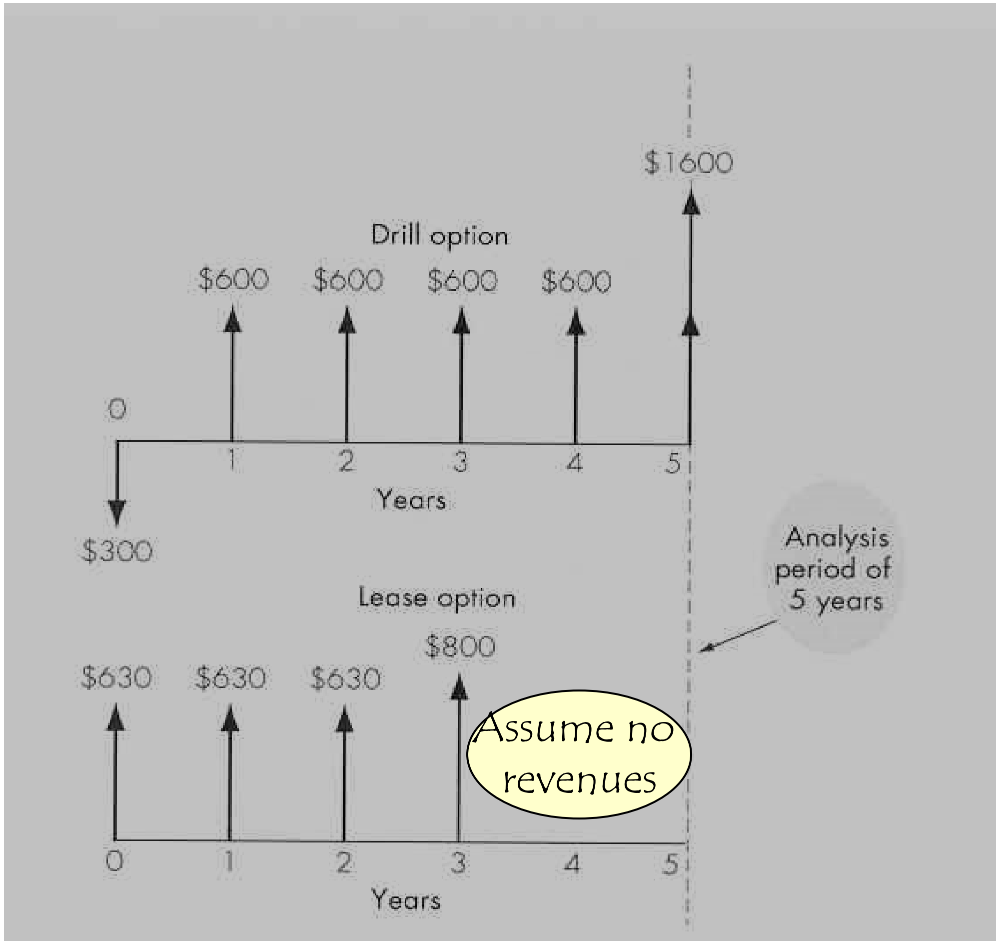
- Project Repeatability Likely

  Use the lowest common multiple of project lives.

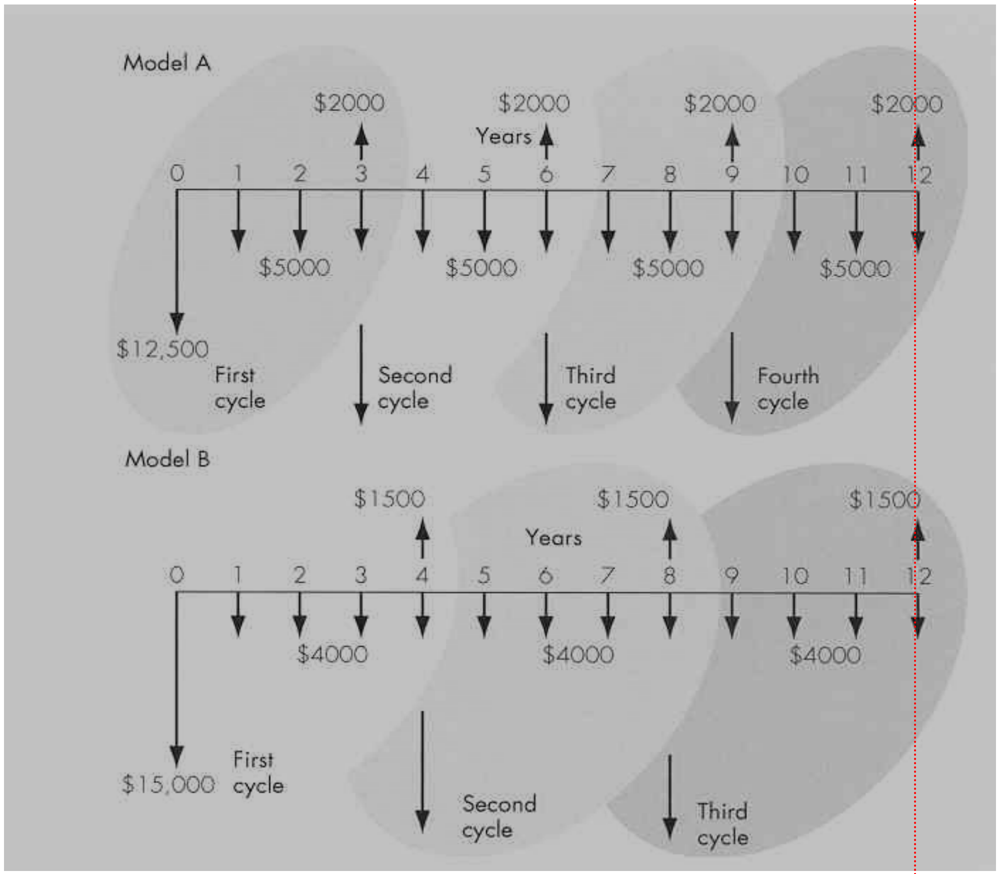
Project Repeatability Unlikely

$PW(15\%)_{drill} = \$2,208,470$

$PW(15\%)_{lease} = \$2,180,210$



Project Repeatability Likely



$PW(15\%)_A = -\$53,657$

Model A: 3 Years
Model B: 4 years
LCM (3,4) = 12 years

$PW(15\%)_B = -\$48,534$

Summary

- Present worth is an equivalence method of analysis in which a project's cash flows are discounted to a lump sum amount at present time.
- The MARR or minimum attractive rate of return is the interest rate at which a firm can always earn or borrow money.
- MARR is generally dictated by management and is the rate at which NPW analysis should be conducted.
- Two measures of investment, the net future worth and the capitalized equivalent worth, are variations to the NPW criterion.

- The term mutually exclusive means that, when one of several alternatives that meet the same need is selected, the others will be rejected.
- Revenue projects are those for which the income generated depends on the choice of project.
- Service projects are those for which income remains the same, regardless of which project is selected.
- The analysis period (study period) is the time span over which the economic effects of an investment will be evaluated.
- The required service period is the time span over which the service of an equipment (or investment) will be needed.

- The analysis period should be chosen to cover the required service period.
- When not specified by management or company policy, the analysis period to use in a comparison of mutually exclusive projects may be chosen by an individual analyst.

End of Lecture 5