

Engineering Economics:

Comparing Financial Characteristics of Design Options

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Engineering Economic Analysis: Slide 1

Engineering Economy

- Objective – Evaluation
 - How to compare the economic value of alternative design options?

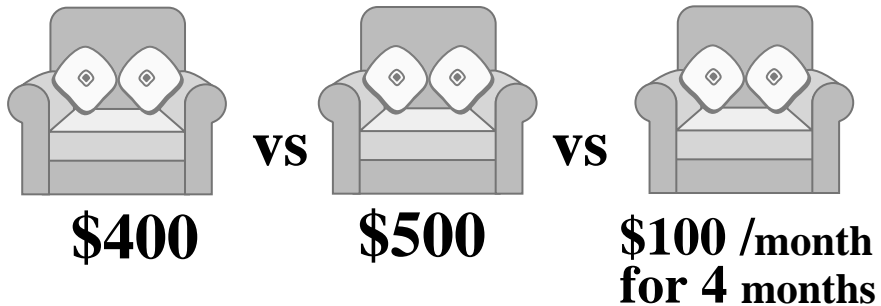


Figure by MIT OCW.

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Engineering Economy

- **Objective – Evaluation**
 - How to compare the economic value of alternative design options?
- **Basis – Cash Flow Analysis**
 - One is indifferent between investments with equivalent cash flows
- **Key issues**
 - Time value of money
 - Cash flows occurring at different times
 - “Designs” with different durations

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Determining Equivalence: Issue - Value over time

- **Money now has a different value than the same amount at a different date**
 - Would you prefer \$75 today or \$80 in one year?
 - It depends – Rate of return on investment
- **Proper name: Discount Rate, r**
 - Future benefits / costs are reduced (ie, “discounted”) to compare with present
- **Compare options via**
 - Net Present Value =
Sum of present value of all cash flows
 - Annualized equivalent =
Set of equal payments with present value = NPV

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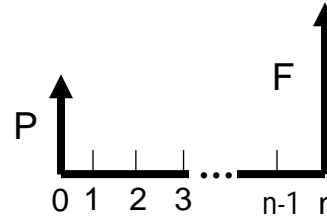
Formulae for N Periods – Single Payments

a) Future Amount =

$$P (1 + r)^N =$$

$$P (\text{caf})$$

**caf = Compound
Amount Factor**



b) Present Amount =

$$F/\text{caf}$$

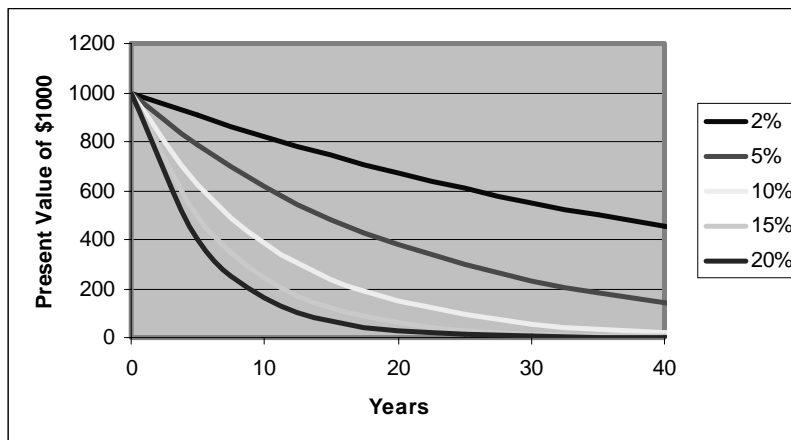
**1/caf = Present Worth
Factor**

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Graphical view of Effect of Different Discount Rates and Lengths of Time

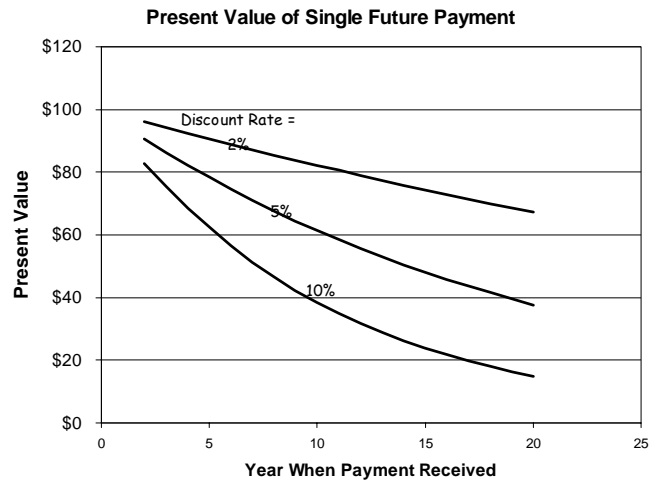


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How Do Specific Parameters Effect the Result?



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Formulas for N Periods Finite Series of Equal Payments

a) **Future Value (F)**

$$= \sum_i A (1 + r)^i$$

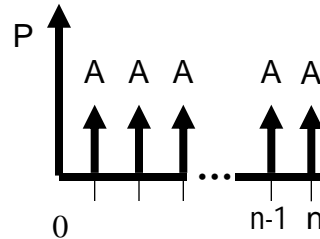
$$= A [(1 + r)^N - 1] / r$$

b) **Payment (A)**

$$= P \times r \frac{[(1+r)^N]}{[(1+r)^N - 1]}$$

$$= P (\text{crf})$$

**crf = Capital Recovery
Factor**



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Formulas for N Periods

Series of Payments (continued)

- **Infinite Series**

$$\lim_{N \rightarrow \infty} \frac{[(1+r)^N]}{[(1+r)^N - 1]} \rightarrow 1$$

$$\lim_{N \rightarrow \infty} r \frac{[(1+r)^N]}{[(1+r)^N - 1]} \rightarrow r$$

- **Small Periods**

$$(1+r)^N \rightarrow e^{rN}$$

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Discount Rate Approximation

- **To appreciate effect of discounting:**

“Rule of 72” or “Rule of 70”

$e^{rN} = 2.0$ when $rN = 0.72$ (actually = 0.693)
with r expressed in percent

- **Examples**

– When would \$1000 invested at 10% double?

Rule → 7.2 years Actual → 7.273

– What is, at 9%, the value of \$1000 in 8 years?

Rule → \$2,000 Actual → \$1,993

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Cash Flow Analysis

- What expense today is equivalent to the following set of payments over time?
- Interest 12%
- Compute present values –
Net Present Value (NPV)

Time	Expense
0	\$5,000
Year 1	\$800
Year 2	\$800
Year 3	\$900
Year 4	\$1,000
Year 5	\$1,100
Year 6	\$1,200
Year 7	\$1,300
Year 8	\$1,400

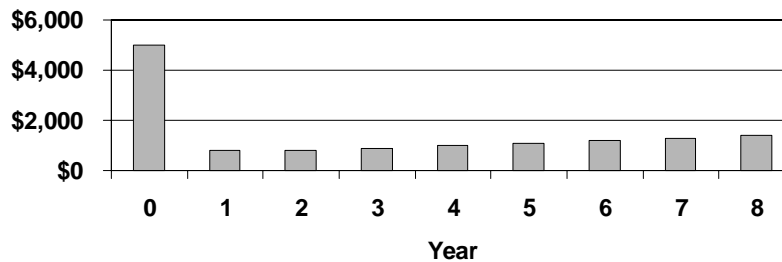
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NPV Example

- What expense today is equivalent to the below set of cash flows?
– Assume discount rate of 12%/year
- Compute Net Present Value

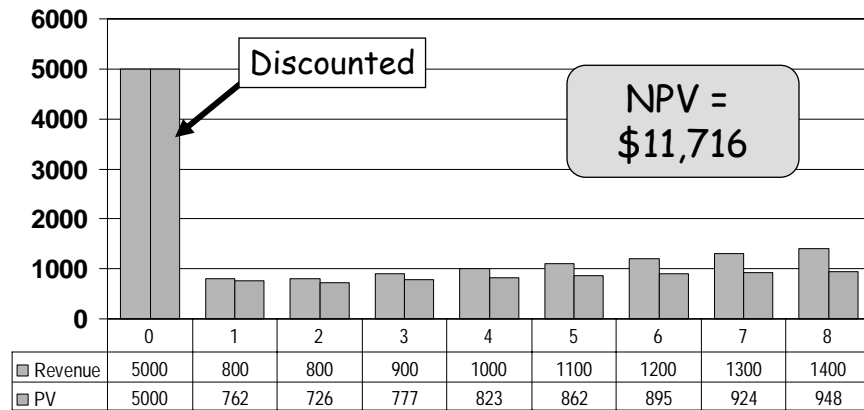


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NPV Example (continued)



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Comparing Two Technology Option

- Key parameters

- Furnace life
6yrs
- Discount rate
10%

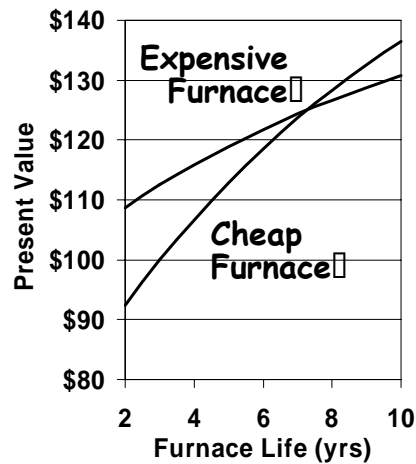
	Cheap Furnace High Maint.	Expensive Furnace Cheap Maint.
Purchase Price	\$75 k	\$100 k
Maintenance	\$10 k	\$ 5 k
Nominal Cost	\$135 k	\$130 k
NPV	\$118 k	\$122 k
Annualized Equivalent	\$27.2 k	\$28 k

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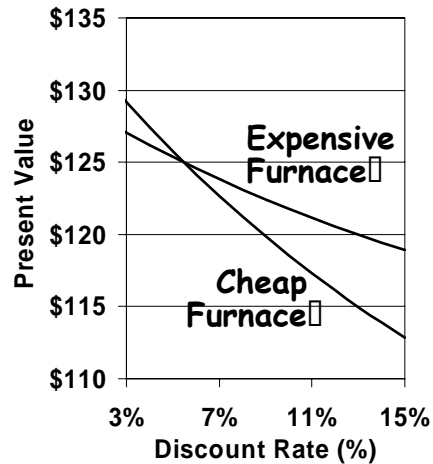
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Effect of Parameters on NPV



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Effect of Different Discount Rates

- Higher Discount rates =>
 - smaller value of future benefits
 - discourages projects with long pay back periods
 - project advocates try to minimize discount rate
 - Examples: Concrete vs. Asphalt roads
- Argument over Discount rates
 - Technically, simply opportunity cost ...
 - Often very difficult politically

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Effect of Different Time Horizons

- **Longer Periods of Benefits**
 - Increase Present Values
 - Increment depends on discount rate
- **What length of time matters?**
 - For US Government Rate, not much over 30 years
 - For Rates commonly used in business (15 to 20%), anything over 20 years has little value
 - Exception: Future benefits grow exponentially

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Summary

- **Formulas Simple**
- **Especially by Spreadsheets**

- **Discount rate is key issue**
- **Longer term benefits not large**

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