Faculty of Applied Science and Engineering

The Department of Electrical
and Computer Engineering

ECE 472F

Engineering Economic Analysis & Entrepreneurship

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Introduction

Each engineering project should be evaluated along two dimensions:

- Does it meet the required technical specifications?
  - Will it work?
  - Will it achieve service level objectives?

- Is it economically viable?
  - Private sector/regulated utilities
    - Will it make a profit?
    - Will it increase the wealth of the shareholders?

  - Public sector
    - Are the benefits of the project to society greater than the costs to society (i.e., the taxpayer)?

Introduction

Each technically acceptable alternative presents a different set of economic consequences.

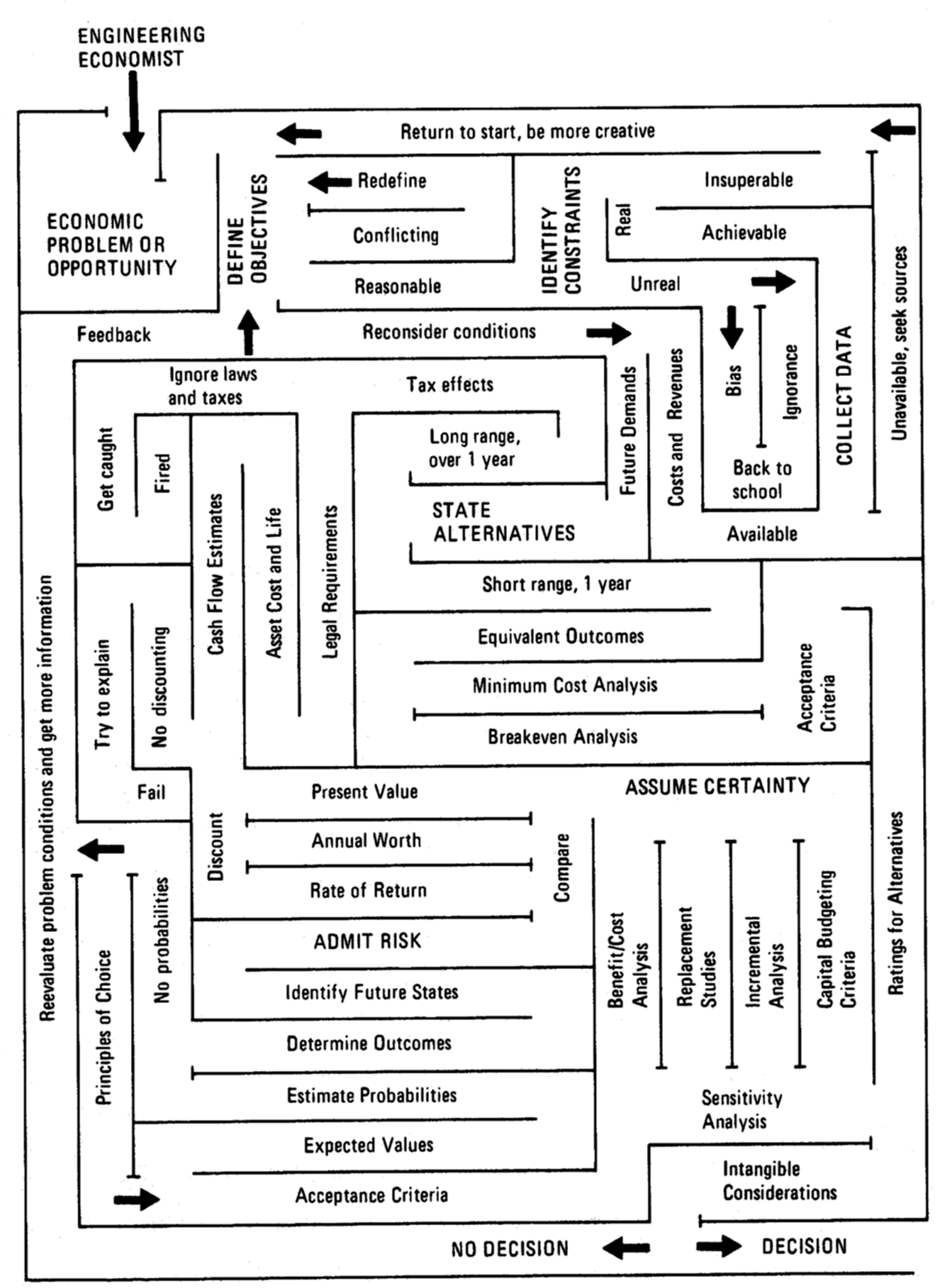
- Consider all of the costs and all of the benefits over the life cycle of the project.
- The best engineering design is of little value to the company if it can't be sold to management.

Engineering Economics

- techniques to assist engineers in presenting the economics of technical alternatives
- techniques to evaluate projects involving long-term investments in capital equipment from a financial point of view
- maximize a joint achievement function
  - performance objectives and costs

- $$$ MONEY
- presenting the economics of technical alternatives

Engineering Economics Decision Maze



Engineering Economics Course Outline

1. Introduction
    - Engineering economics definition
    - Time value of money
    - Cash flow approach
2. Cost Concepts
    - Life-cycle costs
    - Direct, indirect and overhead costs
    - Average and marginal costs
3. Basic accounting principles
    - Income Statement
    - Balance Sheet
    - Financial ratios/indicators
4. Time Value of Money Operations
    - Interest rates
    - Present/future value calculations
    - Series of cash flows
    - Equivalence
5. Comparison of Alternatives I
    - no taxes - perfect certainty
    - project evaluation on a cash-flow basis
    - financial comparison of technical alternatives

Engineering Economic Course Outline

6. Income Tax & Engineering Projects
    - Personal/corporate income tax
    - Depreciation
    - Capital Cost Allowance
    - Income tax incentives
7. Comparison of Alternatives II - Private Sector
    - Tax impact
    - Operating cash flow statements
    - Project evaluation on an after-tax basis
8. Comparison of Alternatives III - Public Sector Projects
    - Cost-benefit analysis of government projects
9. Decisions Under Conditions of Uncertainty
    - Account for the element of risk in projects
    - Descriptive models
        - Break-even and sensitivity analysis
    - Prescriptive/normative models
        - Decision trees

Time Value of Money

- The value of a given sum of money depends on when that money is received
  - Which would you prefer, $1 000 today or $X one year from now? Assume the payment one year from now is guaranteed.

Alternative	$X
1	1 000
2	1 050
3	1 100
4	1 250
5	2 000
6	10 000

- If one is indifferent between receiving $1 000 today and $X one year from now, then $X has a **present worth** or **present value** of $1 000 for that particular individual.

Cash Flow Approach

- Occurs when money actually changes hands
- Ask how much money is received and spent each time period during the life of a project for each alternative
- Concentrate on the differences in the alternatives

Alternative A:

- Workstation for computerized design
- If successful, competition will develop very quickly
- Expect declining revenue profile

Alternative B:

- Coal-mining venture
- Coal is anticipated to increase in value
- Expect increasing revenue profile

There is enough funding available to accept only one alternative.

- Which alternative is better?
- Should that alternative be funded?

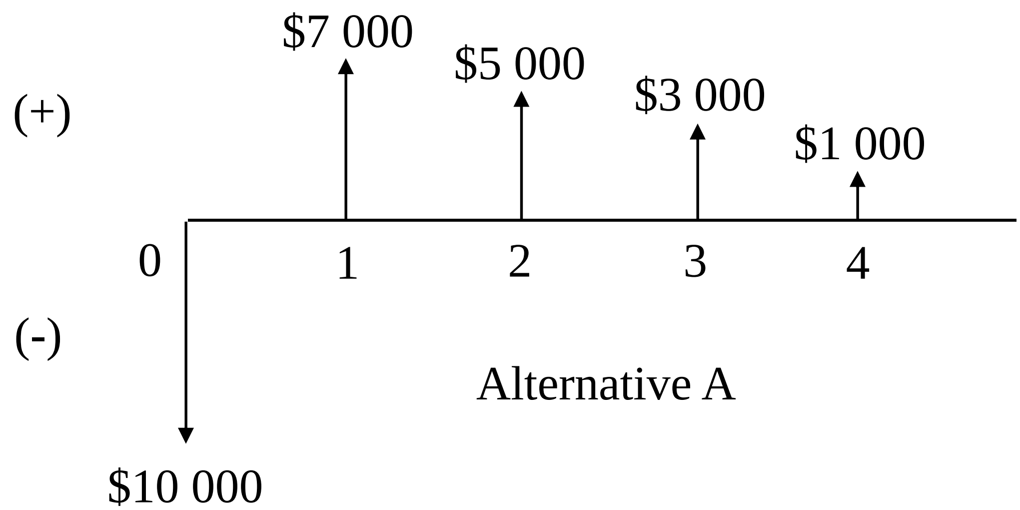
Cash Flow Approach

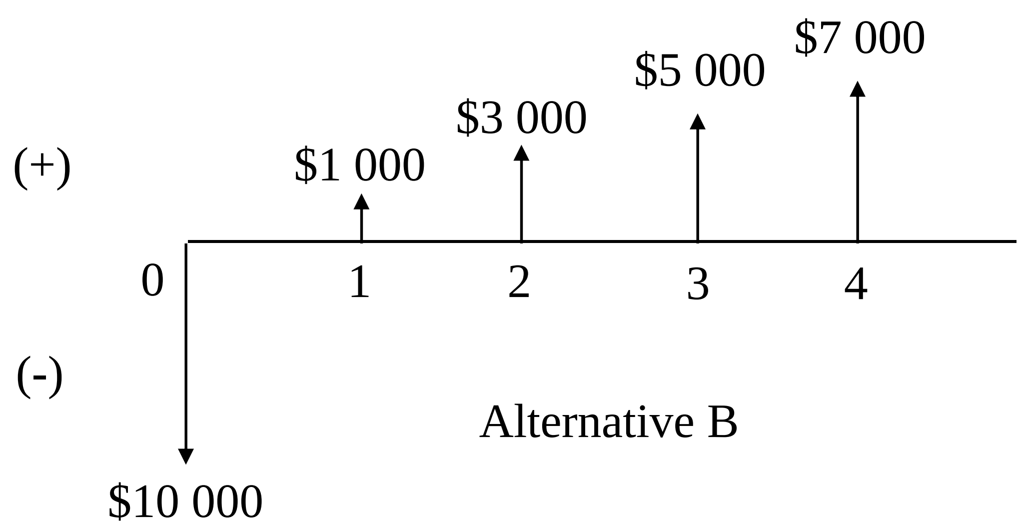
Cash Flow Profile

End of Year	Alternative A	Alternative B
0	– 10 000	– 10 000
1	+ 7 000	+ 1 000
2	+ 5 000	+ 3 000
3	+ 3 000	+ 5 000
4	+ 1 000	+ 7 000

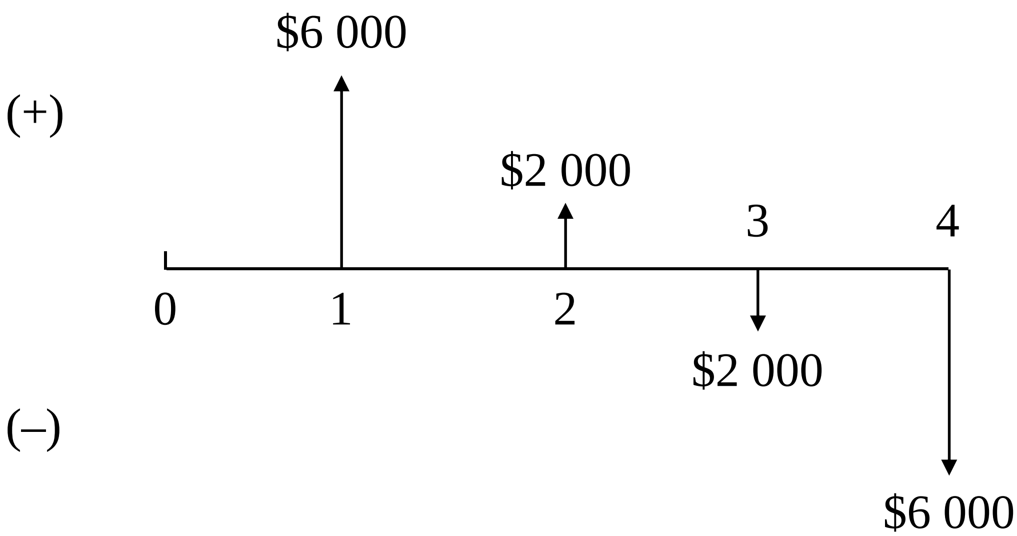
Is one alternative preferable over the other since both return $16 000 over the four year period?

Cash Flow Diagrams for Alternatives A and B





Cash Flow Diagram for Alternatives A and B

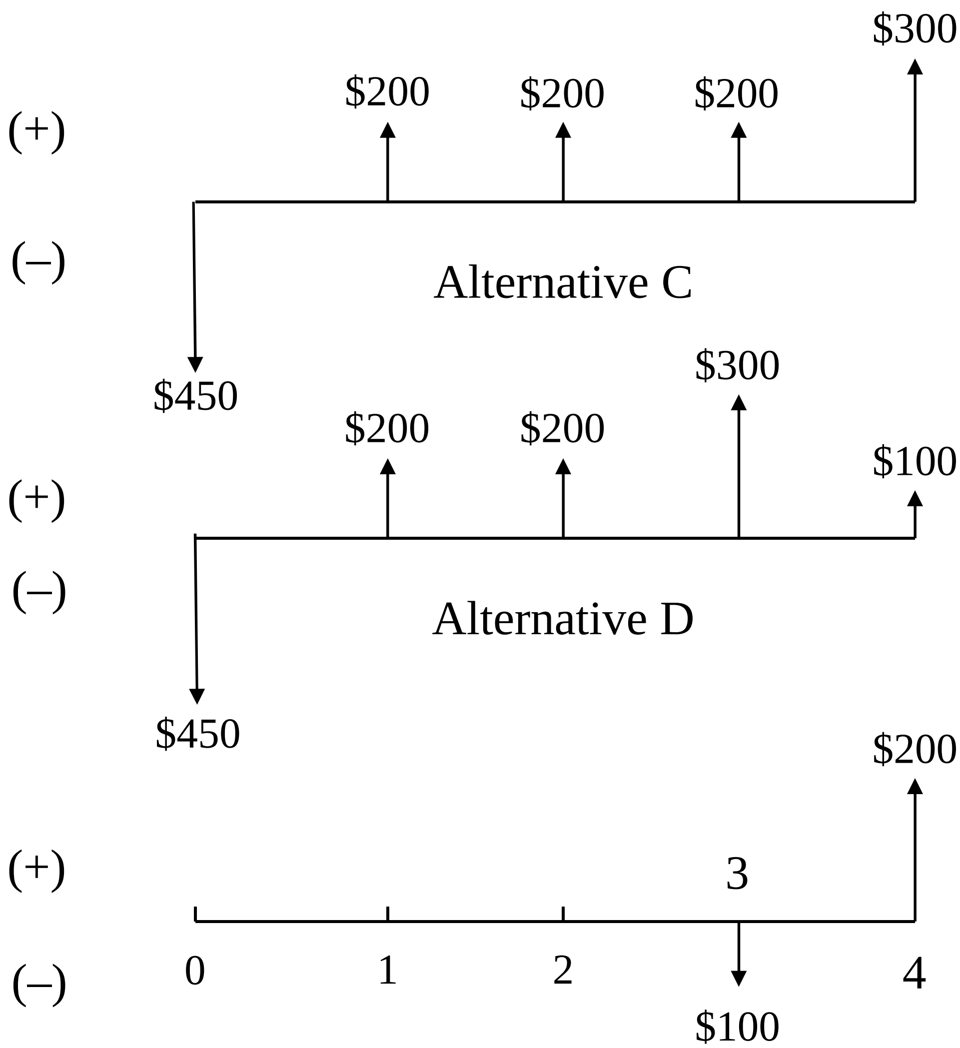


Difference between alternatives
(A – B)

+ cash flows – benefits of choosing Alternative A
– cash flows – things given up when choosing Alternative A

A dollar at some future time has less value than a dollar today.

Cash Flow Diagrams for Alternatives C and D



Difference between alternatives

(C – D)

What if the EOY 4 Alternative C cash flow is $205?

The Time Value of Money and Tuition Fees

1. U of T tuition fees invoice sent in July.
2. U of T recommends early payment.
   – at least first installment by August 15
3. Payment by installments allowed.
   – Total Fee $13 620
   – Minimum First Installment $8 853
   – Balance $4 767
4. First installment due before the first day of class.
5. Remainder of tuition fees due January 15.
6. Service charge (i.e., interest) charged on the balance outstanding from October 15.
   – Interest rate charged – 1.5% per month compounded
     => 19.56% per annum!

What payment strategy is consistent with money having a "time value?"

What payment strategy has the lowest present value cost?

2015-2016
Fee schedule

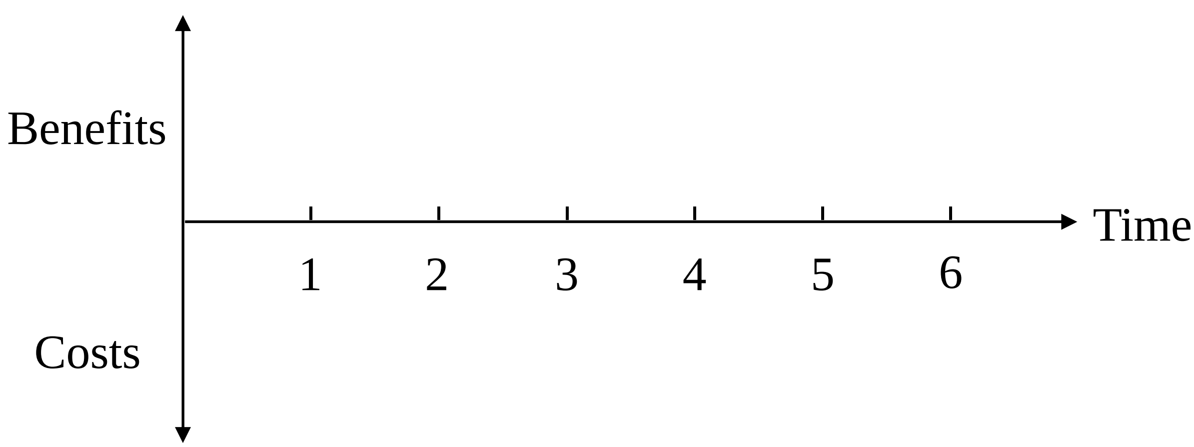
Engineering Project Cash Flows

COSTS

The price, or amount paid, for anything required by the project.

BENEFITS

Revenues, or cost savings, resulting from undertaking the project.



Because of the time value of money, always consider costs and benefits in terms of their associated cash flows.

Cost Terminology

Compare engineering project alternatives on the basis of an economic measure of effectiveness.

Which costs should be considered?

Life Cycle Costs

- The sum of all expenditures associated with the project during its entire service life

  = Acquisition (first) costs

    - purchase price of item
    - shipping and installation
    - training costs
    - supporting equipment costs

  + Operating and Maintenance Costs

    - labour, material and overhead items
    - recurring costs

  + Disposal Costs

- At disposal, the item will have a market or trade-in value

  Salvage Value = Market Value – Disposal Costs

Cost Terminology

To fairly compare alternatives, one must consider all the costs over the life of each alternative.

Often there is a trade-off between First Cost and Operating & Maintenance costs.

Which time period does one use for the length of the life cycle?

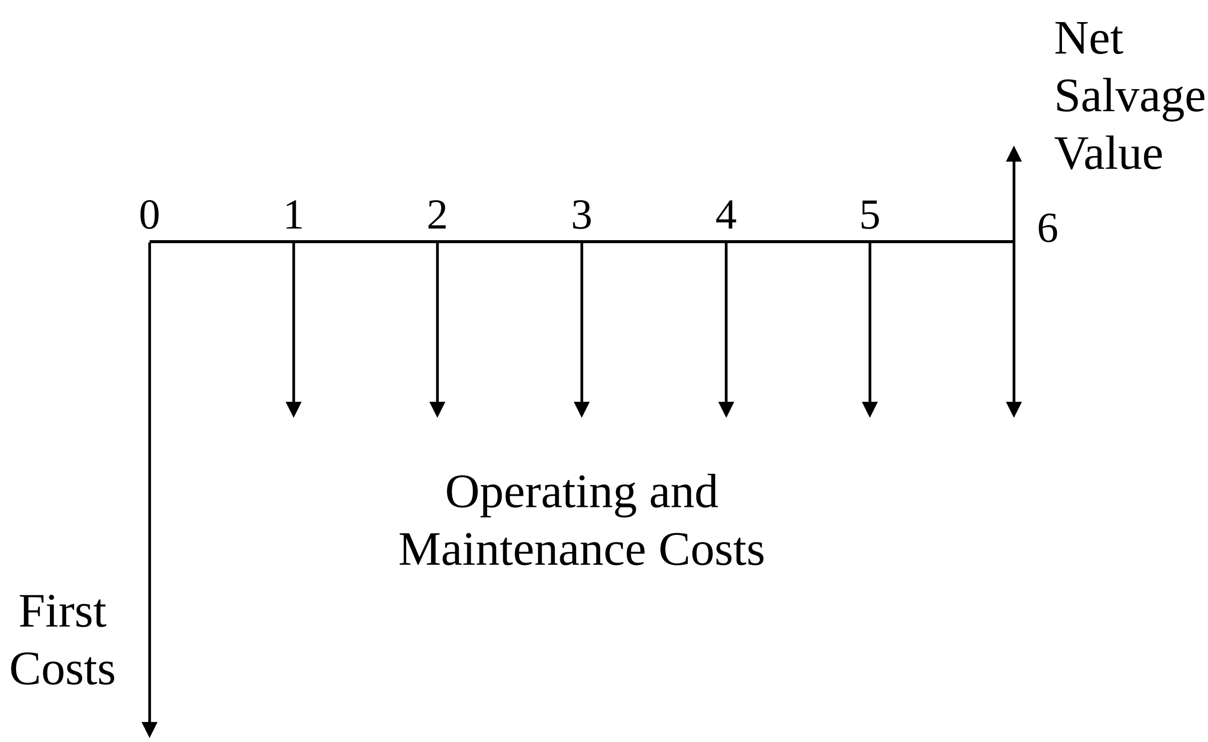
- functional life
- economic life

Example: A solid-state telephone switch may be functionally useful for 10 years. But due to technological improvements, it may only have an economic life of 6 years.

Economic Life < Functional Life

Always use the estimated economically useful life for engineering analysis.

Engineering Project Life Cycle Costs



Six-Year Economic Life

Depreciation

- assets decrease in value over their lifetime
- physical deterioration and obsolescence result in a loss of value
- this must be included when determining operating costs
- allocate a portion of the lifetime loss value to annual operating costs
- yearly depreciation charge

Example:	Network Server Purchase Price	\$40 000
	Estimated Salvage Value	\$10 000
	Economic Life (Years)	5

Yearly Depreciation Charge: $\dfrac{(40\ 000\ -\ 10\ 000)}{5} = \$6\ 000$

The price of the service provided by the server is set to include the depreciation charge. Therefore, over the 5 years of useful life, the sales will recover the \$30 000 capital cost of the network server.

Note that the \$6 000 depreciation is **not** an annual cash flow.

Historical Costs

Cost Terminology

Past Costs – Historical costs that have occurred

Sunk Costs – Past Costs that are unrecoverable

Example: The salvage value for the server was estimated to be $10 000 at the end of 5 years. However, at that time, it turned out to be worth only $2 000.

Original Depreciation Charge $\dfrac{(40\ 000\ -\ 10\ 000)}{5} = \$6\ 000$

Should have been $\dfrac{(40\ 000\ -\ 2\ 000)}{5} = \$7\ 600$

Annual difference $= \$1\ 600$

This extra $1 600 was not recovered when the service was sold. It can no longer be recovered and therefore is lost.

Sunk Cost = 5 × 1 600 = $8 000

Surplus Datasets

A telephone company has 1 000 obsolete datasets that cost $800 each when new. These datasets can be upgraded to the current release level for $300 each and then sold for $650 each. The other alternative is to sell them as is to a local electronics hobby store for $100 each. What would your decision be?

Surplus Datasets

	Alternative A	Alternative B	A-B
Benefits	1 000 × 650=650K	1 000 × 100=100K	550K
Costs	1 000 × 300=300K	0	300K
	350K	100K	250K

Therefore, the datasets should be rebuilt.

Note that:

The original cost of $800 is irrelevant in this decision.

The unrecoverable $450 (800 – 350) per modem is a sunk cost.

- Sunk costs are irrelevant in decisions affecting the future.
- You can't "unspend" money!

COST TERMINOLOGY

Future Costs

- future costs must be estimated over the project planning period
- estimates of future costs are uncertain and subject to error
- uncertainty introduces risk into the project
- assume for now future costs are known with certainty

Opportunity Costs

- the cost of foregoing the opportunity to earn a return on investment funds

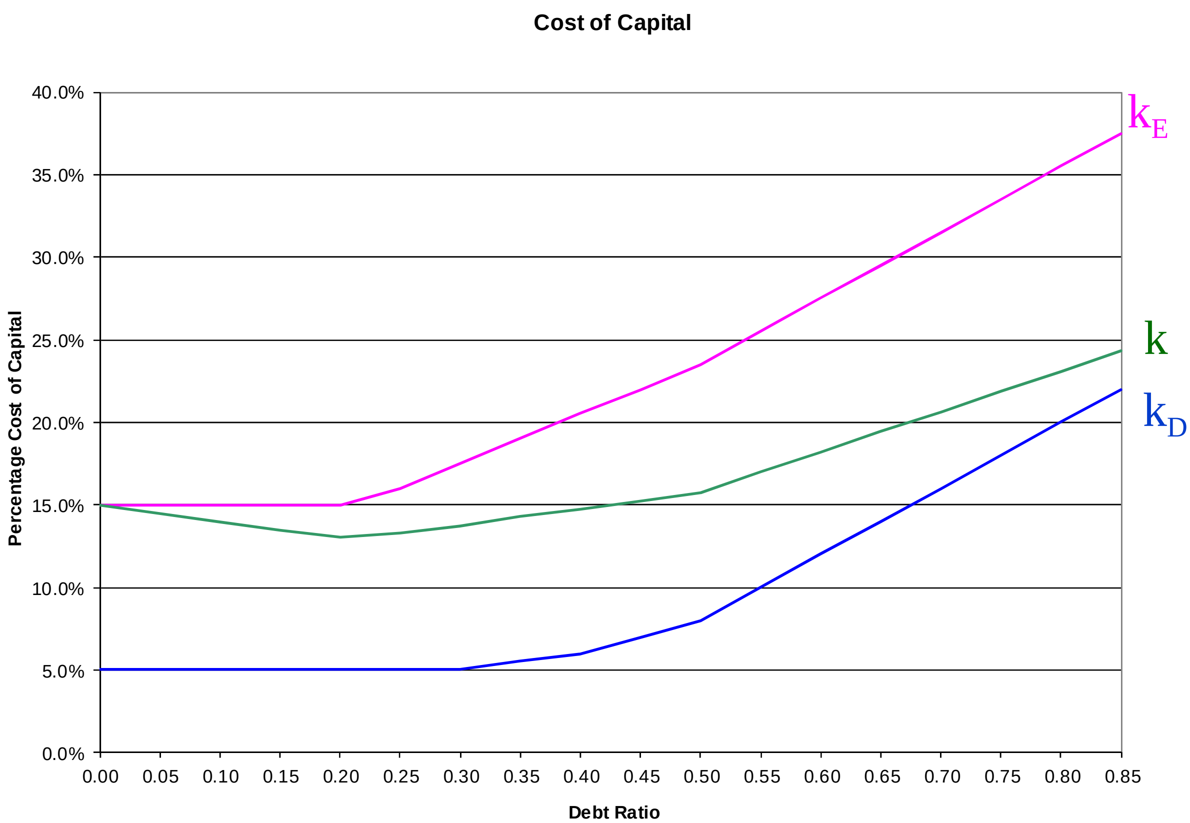
Cost of Capital

- the cost of obtaining funds for financing engineering projects
- MARR – minimum attractive rate of return

Sources of Capital

- bonds (DEBT FINANCING)
- shares (EQUITY FINANCING)
- what is the optimal debt ratio?
- risk-return relationship

Corporate Financing: The Cost of Capital



D – \$ Value of Debt; E – \$ Value of Equity; V – \$ Raised
V = D + E; Debt Ratio = D / V; Debt-Equity Ratio = D / E

k_D – Cost of debt financing (%)
k_E – Cost of equity financing (%)
k – Cost of capital (weighted average percentage cost)
– Used as the Minimum Attractive Rate of Return (MARR) in engineering projects

$$k = \frac{D}{V} k_D + \frac{E}{V} k_E$$