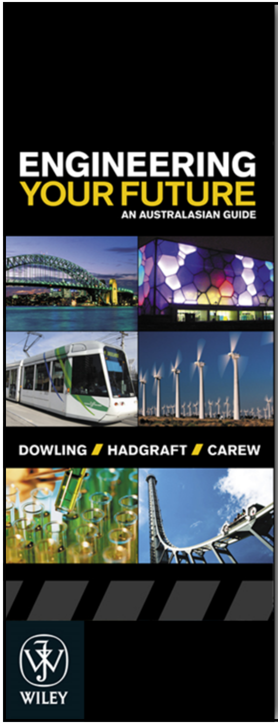
All ENGG105 materials are adapted versions from originals of Dr. Justine Calleja, Dr. Brad Stappenbelt,Dr. David Hastie, Dr. Faisal Hai, Dr. Jeff Moscrop, Dr. Neaz Sheikh, Dr. Tom Goldfinch, Dr. Vinod Jayan Sylaja



Engineering Economics: Cost Benefit Analysis

This presentation is mainly based on the material prepared by

Prof. Peter Wypych, University of Wollongong

Pre-Reading

- Dowling, Carew & Hadgraft, (2013). Engineering your Future :An Australasian Guide, 2nd Edition, John Wiley & Sons Australia Ltd, Chapter 10.
- Eide, Jenison, Northup, Mickelson (2008), Engineering Fundamentals and Problem Solving, (3rd edition) McGraw Hill New York, Chapter 13.

Learning objectives

- Understand the value of money changes with time
- Prepare a cash-flow diagram
- Compute present worth and future worth of multiple sum of money
- Recognize and solve problems involving installment loans

Introduction

- Engineers often serve as manager/executive officers of business and therefore are required to make financial and technical decision
- The amount of capital investment in many industries represents a significant part of the cost of doing business
- Thus estimates of the cost of new equipment, facilities, software and processes must be carefully done if the business is to be successful.

Economically sustainable engineering

- The costs and benefits of a development for all stakeholders must be evaluated.
- **Cost Benefit Analysis (CBA)** assigns values to all direct and indirect outcomes of a project with future costs discounted (Net Present Value, NPV).
- If the sum of all these values is positive, then it is assumed the project should proceed. If it is negative, then the costs outweigh the benefits, so the project should nor proceed.

Economic Evaluation

An important part of design evaluation

- Three terms:
  - *Cost*
  - *Price*
  - *Value*

Do these terms mean the same thing?

Cost

- Summation of all expenditures incurred on a product
- Depends on:
  - ***Design***
  - ***Efficiency of manufacture***
  - ***Local economic conditions***
  - ***Availability of raw materials***

Price

- Price = Actual money involved with final buying or selling of product
- Price is set by vendor or producer
- If the selling price < cost of production?
    - *Activity is unprofitable*
    - *"Economic failure"*

Types of Price

- **Two types:**

- Asking price - amount for which the product is advertised
- Selling price - price at which the commodity is actually sold

Value

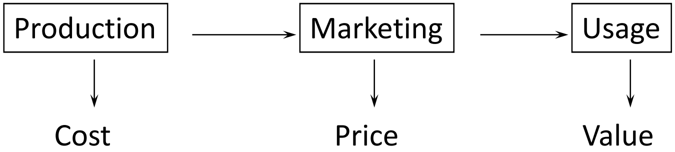
- Value = Worth attached to product or service
- Depends on utility of product
- Difficult to assign an absolute number

Value is determined by User

Types of Value

- “Market” value - economical value of product
- “Use” or “Usage” value – value where market price cannot be assigned (e.g. comfort)

Often Usage Value > Market Value



Example 1: Computer manufacture...

Cost

- Cost of raw materials
- Cost of manufacture (labour + machinery + energy + …)
- Say…$4,500/unit

Price

- Cost of production $4,500
- Manufacturer’s profit
- Dealer’s profit
- Govt taxes
- Transportation costs
- Packaging costs

$2,000

Asking price = $6,500
Selling price = $6,000 (discount of $500)

Value

- Actual worth to owner
- Market value:

• Develop a computer package	$3,000
• Private typing & word processing	$3,000
• Private drafting and presentation	$1,000
• **Total**	**$7,000**

Total Value

- Usage value:
  - Includes some human factors: comfort, ease of use, ease of communication, etc.

- Total Value = Market value + Usage value

Economical Evaluation

- Cost
- Price
- Value

Which one should be used for economic evaluation?

Economical Evaluation

- Total Cost (or Total Value) is used
- Total Cost can be computed as:
  - Capital costs
  - Operating & Maintenance (O&M) costs
  - Returns

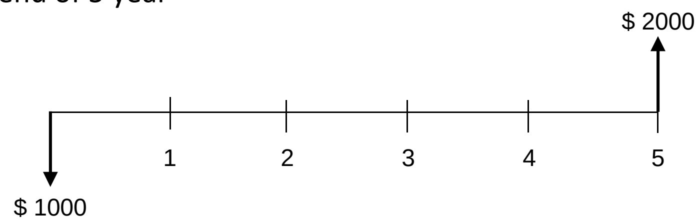
Total Cost

- Hence $\rightarrow$ Total Cost should include:
  - Capital (one-off)
  - O&M costs (recurring)
  - Returns (recurring)

Cash Flow Diagram

- A time interval divided into an appropriate number of equal periods
- All cash flow (deposits, expenditure, etc) in each period. **A downward arrow means money out, an upward arrow means money in.**
- The diagram is dependent on the point of view from which it is constructed-that is on whether it is lenders or borrows point of view.

Example: A cash flow diagram showing an outflow or disbursement of $1,000 at the beginning of year 1 and inflow or return of $2,000 at the end of 5 year



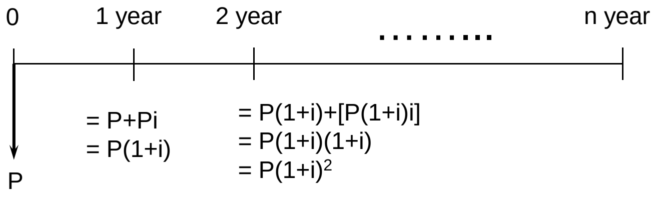
Present Worth

- Where “Time value” of money should be taken into account
- This is done by considering “Present Worth” of money

  Present worth: is the worth of a monetary transaction at the current time. It is the amount of money that must be invested now in order to produce a prescribed sum at another date.
- Two types of calculations:
  - Single payment
  - Uniform series of payments (annuity)

Present Worth for *Single* Payment

Interest rate = i (percentage per year)



After 1st year:

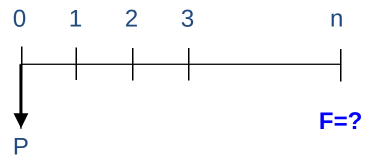
$= P + Pi$
$= P(1+i)$

After 2nd year:

$= P(1+i)+[P(1+i)i]$
$= P(1+i)(1+i)$
$= P(1+i)^2$

After 3rd year:
$= P(1+i)^2 + [P(1+i)^2\ i]$
$= P(1+i)^2\ (1+i)$
$= P(1+i)^3$

Present Worth for *Single* Payment



- Future sum of money at the end of n^{th} year:

$$F = P\,(1+i)^n$$

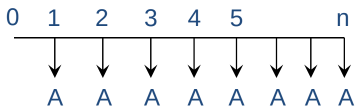
P = present sum of money
F = future sum of money
n = number of interest periods
i = interest rate per period

- Present worth of future cost:

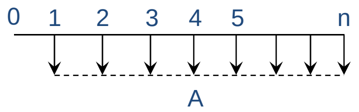
$$P = \frac{F}{(1+i)^n}$$

- Present worth factor (p.w.f) = $1/(1+i)^n$

Uniform Series of Payments

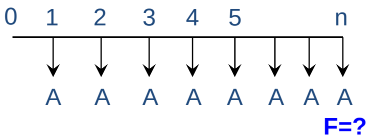


OR



A - uniform series end of year payments (annuity)

Consider future cost (F) at end of year n for following:



$$F = A(1)+A(1+i)+A(1+i)^2+A(1+i)^3+\ldots+A(1+i)^{n-1} \qquad (1)$$

Multiply this equation by (1+i):

$$F(1+i) = A(1+i)+A(1+i)^2+A(1+i)^3+\ldots+A(1+i)^{n-1}+A(1+i)^n \qquad (2)$$

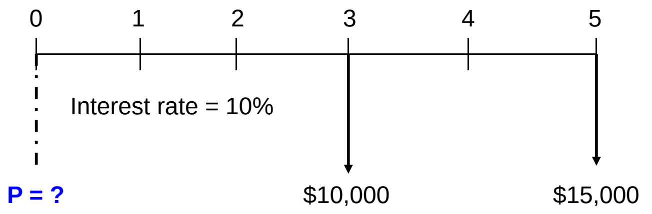
After substitutions and noting $F=P(1+i)^n$:

$$P(1+i)^n = A\frac{(1+i)^n - 1}{i}$$

Therefore the present worth cost (P) is:

$$\mathbf{P} = \frac{(1+i)^n - 1}{i\,(1+i)^n}\,\mathbf{A}$$

Example:



$$\text{Present worth} = P = \frac{F}{(1+i)^n}$$

$$\text{Present worth} = \frac{10{,}000}{(1.1)^3} + \frac{15{,}000}{(1.1)^5} = \$16{,}827$$

Triple Bottom Line: Real life complexity

- In many real life situations, there is no single straightforward criteria for judging a “good” solution. There are often multiple parties with different vested interests.
- Economic, social and environmental aspects of a problem form the so-called **triple bottom line**.
- The TBL is a set of design criteria that sits alongside technical measures, and is used in the engineering method to inform decisions.

TBL constraints of sustainable engineering practice

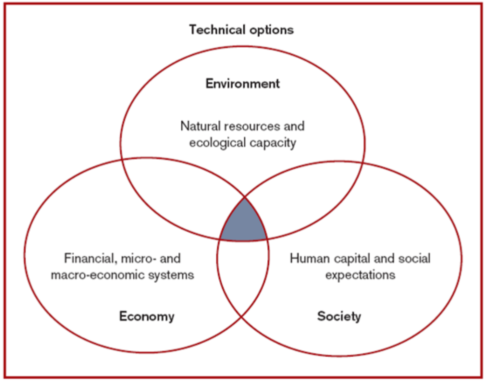


Figure 8.3 Dimensions of sustainability with technical options as the foundational constraint

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Triple bottom line analysis (TBLA)

- **Triple bottom line analysis (TBLA)**
  - An approach to cost-benefit analysis commonly used for evaluating the sustainability of corporate or industry operations, or for evaluating a range of options.
- Indicators of environmental, social and economic sustainability can be either **qualitative** or **quantitative**. They should aim to be reliable, useful, consistently presented, reproducible, auditable and demonstrate full disclosure.

Typical indicators of TBLA

- **Environmental:**
  - Amount of energy consumed and its origin.
  - Volume or mass of material resource use.
  - Solid waste management.
  - Emissions to air.
  - Quantity and quality of effluents released.

Typical indicators of TBLA

- **Social:**
  - Health and safety of workers or community members.
  - Extent of community involvement.
- **Economic:**
  - Taxes paid.
  - Estimates of wealth created.