Engineering Economy
Chapter 1 - Introduction

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Decision Making and Problem Solving

1. **Simple Problems:**
   - can generally be worked in one's head without extensive analysis.
2. **Intermediate Problems:**
   - primarily economic and the principal subject of this course.
   - They are sufficiently important to justify serious thought and action.
   - They can't be worked in one's head; must be organized.

Intermediate Problems (cont'd)

- The economic aspects are a significant component in the analysis leading to a decision.
- Examples: buy or lease a car, investment management, managing projects

Complex Problems

- Such problems represent a mixture of economic, political and humanistic elements. They are beyond the scope of this course from a decision making criteria point of view, but the economic aspects of complex problems will be discussed.
- Example: New Mercedes plant in Alabama, Intel plant in Costa Rica.

The Decision Making Process

- **1. Recognition of the Problem**
  - Some systems (example SPC) can be set up to help do this.
- **2. Definition of the Goal or Objective**
  - Goal or objective often ill-defined.
- **3. Assembly of Relevant Data on Costs and Benefits**
  - **Example: Manufacturing (Product) Costs**: The following cost categories are included in the estimation of manufacturing costs for a production facility. When deciding whether to accomplish a task "in house" or whether to "contract out", for example, failure to account for these categories for both alternatives can bias the decision.

Manufacturing (Product) Costs

1. Direct Labor and Salary Costs: Estimated labor hours times hourly wage for each worker. Generally this is a variable cost if the work force can be adjusted to meet volume requirements.
2. Direct Materials and Supplies: A variable cost with overhead and profit added for each handler: jobber, wholesaler, distributor, sub-contractor, etc.
3. Manufacturing Overhead Costs: All costs of manufacturing a product other than Direct Materials and Direct Labor. These costs include Indirect Materials, Indirect Labor (including design and engineering costs), Utility Costs, and Depreciation.

Cost-Volume Considerations

- 1. Fixed costs: Costs unaffected by production volume: Property taxes, interest on borrowed capital, insurance, rent, and many overhead costs.
- 2. Variable costs: Groups of costs that vary proportionately to changes in production volume, including direct labor, materials, direct utilities, sales commissions, shipping costs, etc.

Chapters 1/3 - 7

Other Cost Categories

- 1. Sunk costs: Past expenditures and investments which cannot be recovered. Sunk costs should usually be ignored.
- 2. (Lost) Opportunity costs: The cost of revenue forgone by failing to use available investment capital to pursue the best rejected project.
- 3. With and Without costs: Compare what will happen *with and without* the new investment from various viewpoints.

Chapters 1/3 - 8

Availability of Data

- *A primary problem in any engineering project is making good cost estimates in the absence of a readily available cost model and cost database for various system costs.*
- *Inaccurate and inadequate data - big problem.*

Chapters 1/3 - 9

Decision Making Process (Cont'd)

- **4. Identification of Feasible Alternatives** for accomplishing the goals and objectives.
  - Important stage
  - Can include "do nothing"
  - Can use brainstorming

Chapters 1/3 - 10

Decision Making Process (Cont'd)

- **5.Selection of the Criteria for Judging which is the Best Alternative**: Many different criteria are possible. Use of a single criterion vs a weighted average of several criteria.
- Examples:
  - 1. Initial Cost per unit
  - 2. "Life Cycle Cost" per unit is a reasonable criteria when data is available to calculate Equivalent Uniform Annual Cost (EUAC) or Net Present Worth (NPW).
  - 3. Total cost of satisfying mission requirements.
  - 4. Spread the work around to various contractors.
  - 5. Accomplish the mission as soon as possible regardless of cost.

Chapters 1/3 - 11

Decision Making Process (Cont'd)

- **6. Constructing the Model**
  - Need to develop some mathematical model
- **7. Prediction of the Outcome for each Alternative**
  - Estimate the future
  - Usually uncertain

Chapters 1/3 - 12

Decision Making Process (Cont'd)

- **8. Choice of the Best Alternative**
  - Can be swayed by person doing the analysis
  - See Example p13 where Liz discards one alternative
- 9. **Post Audit of Results**: Evaluate the analysis model in terms of actual performance.
  - Often not done

Example Decision Making

- Example 1-2
  - Note assumption that each supplier can meet demand
- Example 1-3
  - Note sunk cost
  - Ignores time delay for new tooling
  - Other costs are not well explained
- Example 1-4
  - Note use of engineering equation

Engineering Costs and Costs Estimating -- Chapter 2

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Engineering Costs

- Fixed costs
- Variable costs - vary with some input, output or other variable
- Marginal cost - variable cost per unit
- Average cost - total cost per unit

Breakeven Point

- Example 2-1

  Note costs are both fixed (bus $80, gas $75, fuel $20, driver $50 with total $225) and variable (event $12.50, refreshments $7.50 with total $20)

  Variable costs are per person.

  [What is the marginal cost?]

  Total costs = 225 + 20 x

  x is the number of paying customers on trip

  Revenue = 35 x

  At breakeven point costs = revenue

  35 x = 225 +20 x

  Breakeven point x = 15

Engineering Costs

- Sunk costs - already committed or spent
  - Can do nothing about them
  - Should be ignored in evaluation
  - However, decision makers often influenced
- Opportunity Costs - costs associated with using resources in one activity rather than another
  - Example company keeps $30 million in inventory, rather than buying new equipment

Engineering Costs

- Example 2-3
  - Shows sunk costs
- Recurring Costs - occur at intervals
- Incremental costs - concentrates on difference in costs
  - See example 2-4

Engineering Costs

- Cash Costs Vs Book Costs
  - Assets are on a companies books at some value.
  - book value = cost - cumulative depreciation
- Life Cycle costs - costs for the whole life cycle of a product.

Cost Estimation

- Types of Estimates
  - Rough Estimates
  - Semi- Detailed
  - Detailed
- Note trade-off between accuracy of estimates and cost of obtaining estimate (and time taken).
- Data often unknown
- Typical project (senior design)
  - Data not available - how much time and effort do you spend to obtain data?

Estimation Models

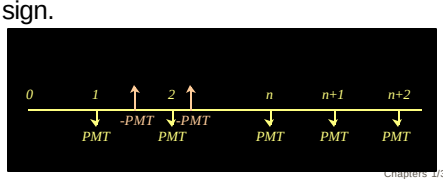
- Per Unit - example: cost of a house is $200 per sq. ft.
  - Gives rough estimate
- Segmented Model
  - Estimates are made of components and total estimate then calculated
- Use of Cost Indexes - use of cost index to project costs (example CPI)

  Cost at time A/cost at time B =

  Index value at time A/Index value at time B

Cash Flow Diagrams

- Shows the size, sign and timing of individual cash flows.
- Sign convention - Revenues are generally positive and costs are generally negative in sign.



Chapter 3
INTEREST AND EQUIVALENCE

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Equivalence and time value of money

- Engineering decision making requires a common language to compare alternatives
- First step is to translate into $
- Second step is to consider time value of $ (equivalence)
- Equivalence provides a common language to consider current and future sums of money
- **Equivalence depends on interest rate assumption**

Chapters 1/3 - 25

Simple interest

- Interest earned= P x i x n
- **P**= (P)resent sum of money
- **i**= (i)nterest per time period (usually years)
- **n**= (n)umber of time periods (usually years)
- Example: investing $100 for 4 years gives $40 interest.
- What is wrong with this?

Chapters 1/3 - 26

Single Payment COMPOUND Interest

- **P**= (P)resent sum of money
- **i**= (i)nterest per time period (usually years)
- **n**= (n)umber of time periods (usually years)
- **F**= (F)uture sum of money that is equivalent to **P** given an interest rate **i** for **n** periods

  $F=P(1+i)^n$ $P=F(1+i)^{-n}$
- Often use economic shorthand form:

  $F=P(F/P,i,n)$ $P=F(P/F,i,n)$
  - Can also use tables, financial calculator, spreadsheet

Chapters 1/3 - 27

Example 1 - Retirement Planning

- You invest $10,000 in a tax deferred retirement plan [401(k) or 403(b) or IRA]. What is the expected balance after a) 20 years b) 40 years with annual return of
  - i) 5% fixed rate interest and
  - ii) 12% return from stocks (equities)?
- What would be the balance with a taxable account for 40 years with 7% net return from stocks?

Chapters 1/3 - 28

Example 2

- Peter Minuet, the first director general of New Netherlands province, purchased Manhattan Island from the local Canarsee Indians for approximately $24 in 1626.
- What is the worth of the 1626 $24 today if invested in a conservative project that earned 8% per year?
- $F = 24(1.08)^{375}$ =

Chapters 1/3 - 29

Example 3 - Compounding Frequency

- You deposit $1000
- 12% per year
- 5 years
- How much do you have at end if compounded yearly?
- compounded monthly (interest = 12/12%, = 1% per month for 60 months)?

Chapters 1/3 - 30

Steps to solution

- Step 1: Identify cash flow (P and F)
- Step 2: Identify interest rate (i) and number of periods
- Step 3: Select appropriate table or formula
  - $F=P(1+i)^n$ $P=F(1+i)^{-n}$
  - $F=P(F/P,i,n)$ $P=F(P/F,i,n)$
- Step 4: Perform calculation
- All four steps are a small part of an actual engineering decision

Chapters 1/3 - 31

Interest

Interest is paid to the supplier of capital for the use of money.

- The interest rate, i, is established based on the risk the supplier takes in making an investment.

Simple Interest can be used for investments where the interest is paid out and not reinvested at the end of each payment period.

Compound Interest is used for most other investments than those listed in B.

Any interest not paid out at the end of a payment period is added to the capital investment (principal) to earn interest during the succeeding period.

Chapters 1/3 - 32