Engineering Economic Analysis

- **Engineering Economy deals with the concepts and techniques for evaluating the worth of systems, products, and services in relation to their costs.**

Engineering Economic Analysis

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- It is used to answer many different questions
  - Which engineering projects are worthwhile?
    - Has the design engineer shown that the solar tracker project he designed is worth developing?
  - Which engineering projects should have a higher priority?
    - Has the construction engineer shown which road improvement projects should be funded with the available dollars?
  - How should the engineering project be designed?
    - Has the electronics engineer chosen the best material for fiber optic insulation?

Outline

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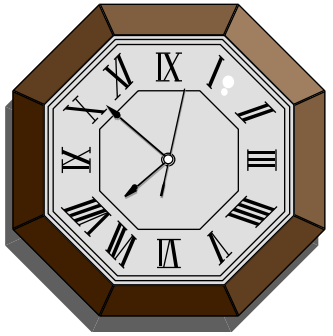
- Time Value of Money
- Interest
- Cash Flow Diagrams
- Evaluating Economic Alternatives
- Present Worth Analysis
- Annual Equivalent Worth
- Breakeven Analysis

Elements of a Transaction 4

- P = Principal (Amount of money invested)
- P can also be the Present Worth of an investment
- i = Interest rate (The cost of money)
- N= Duration of the transaction
- A= Amount in a regular series of payments
- A can also be an annual cost or revenue
- F= Future amount

Time Value of Money



- **Money has value**
  - **Money can be leased or rented**
  - **The payment is called interest**
  - **If you put $1,000 in a bank at 10% interest for one time period you will receive back your original $1,000 plus $100**

Original amount to be returned = $1000
Interest gained = $1,000 x .1 = $100

For simplicity, **interest** will be considered **inflation-adjusted**

Compound Interest

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- Interest that is computed on the principal (original unpaid debt) and the unpaid interest
- Compound interest is most commonly used in practice
- Total interest earned = $I_N = P\,(1+i)^N - P$
  - Where,
    - P – present sum of money
    - i – interest rate
    - N – number of periods (years)

Cash Flow

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- **Engineering projects generally have economic consequences that occur over an extended period of time**
  - **For example, if an expensive piece of machinery is installed in a plant were bought on credit, the simple process of paying for it may take several years**

- **Each project is described as cash receipts or disbursements (expenses) at different points in time.**

Categories of Cash Flows

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- **The expenses and receipts due to engineering projects usually fall into one of the following categories:**
  - Initial cost [-]: expense to build or to buy and install
  - Operations and Maintenance (O&M) [-]: annual expense, such as electricity, labor, and minor repairs
  - Salvage Value [+]: receipt at project termination for sale or transfer of the equipment
  - Revenues [+]: annual receipts due to sale of products or services
  - Overhaul [-]: major capital expenditure that occurs during the asset's life

Cash Flow Diagram (CFD)

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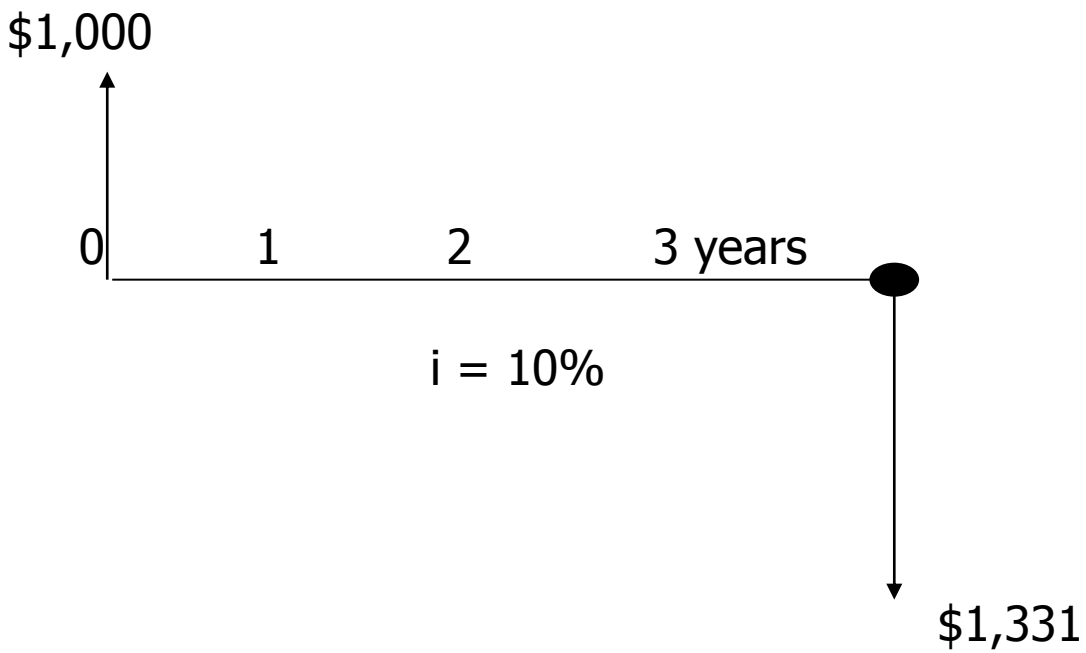
- A CFD is created by first drawing a segmented time-based horizontal line, divided into appropriate time unit. Each time when there is a cash flow, a vertical arrow is added – pointing down for **costs** [-] and up for revenues or **benefits** [+]. The cost flows are drawn to relative scale

An example of a Cash Flow Diagram



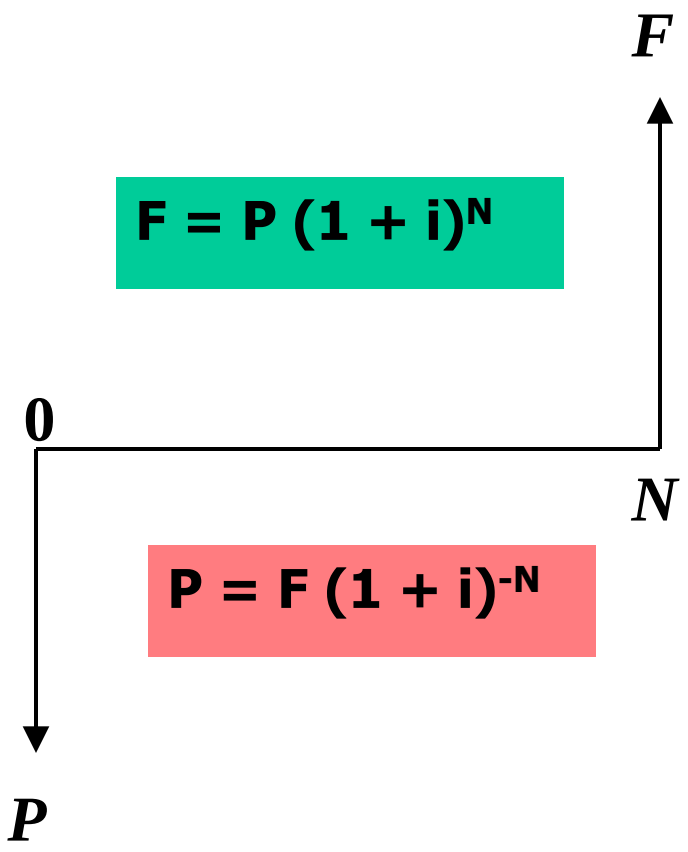
$1000 $(1+0.10)^3$ = $1,331

Borrower's Perspective

Future Worth and Present Worth

- Future Worth (F)
- If you deposit *P* dollars today for *N* periods at *i*, you will have *F* dollars at the end of period *N*.

- Present Worth (P)
- *F* dollars at the end of period *N* is equal to a single sum *P* dollars now, if your earning power is measured in terms of interest rate *i*.



Measures of Investment Worth

Annual Equivalent Worth (AE) Analysis

Net Present Worth (NPW) Analysis

Breakeven Analysis

Annual Equivalent Analysis

Annual Equivalent Worth (AEW)

AEW = Annual Equivalent Benefits – Annual Equivalent Costs

For a project to be economically feasible,

Revenues must exceed costs.

Two main kinds of costs:

Operating costs and capital costs

Choosing alternatives using Present Worth

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Which of these two alternatives would you choose if the interest rate is 8%?

Year	Plan 1	Plan 2
0		$5,000
1		
2		
3		
4		
5	$5,000	
Total	$5,000	$5,000

To make a choice the cash flows must be altered so a comparison may be made.

An example of Net Present Worth Calculation

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- It has been projected that a design project for a garage door remote sensor will yield a revenue of $60,000 after 5 years. If initial costs total $15,000, compute its net present worth at an interest rate of 10%.

- **Solution:**
- **The Net Present Worth = Present equivalent of revenue (benefit) – Initial cost**
- **Find Peq; Given F= $60,000, N = 5, I = 10%**
- **$Peq = F(1+i)^{-N} = 60{,}000\ (1.1)^{-5} = 37{,}255$**
- **NPW = 37,255 – 15,000 = $22,255**

Breakeven Analysis

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- Breakeven analysis is commonly used to study relationships among costs, revenue, and volume:
  - Define cost and revenue functions
  - Linear (or non-linear) functions of volume, price, etc.
- Objective: Find the value (volume, price, etc.) that maximizes profits

Fixed Costs (FC)

- Do not vary with production or activity levels, price, etc.
- Examples:
  - Buildings
  - Insurance
  - Fixed overhead
  - Equipment
  - etc.

Variable Costs (VC)

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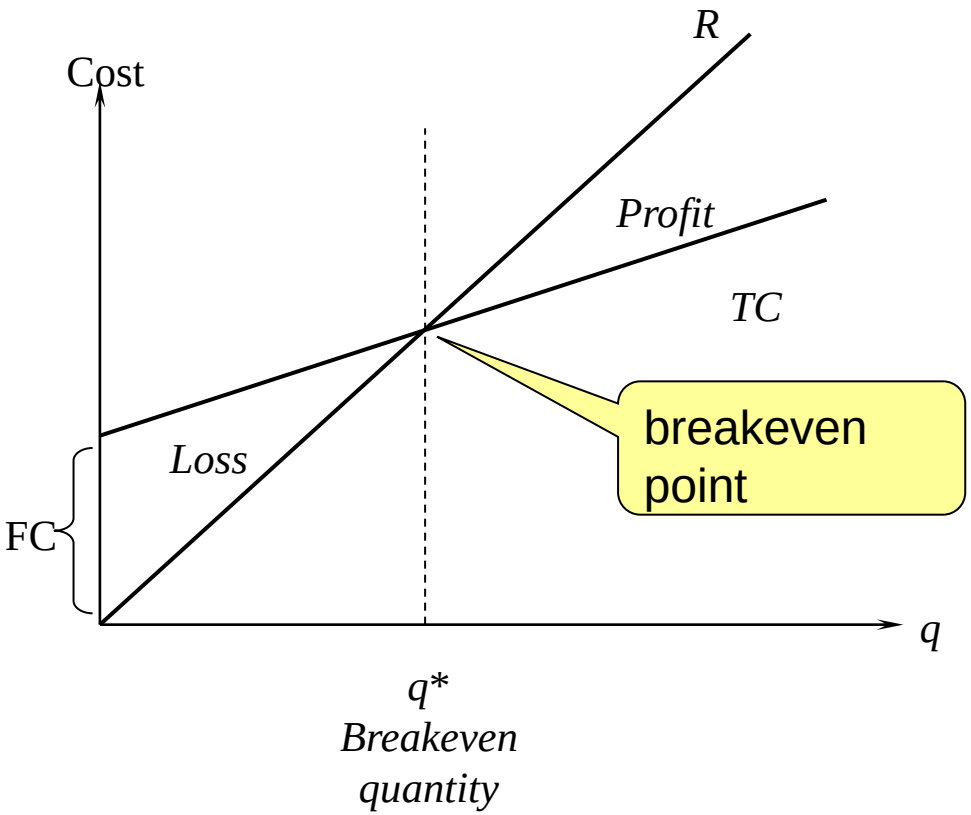
- Vary with the level of activity
- Examples:
  - Direct labor (wages)
  - Materials
  - Indirect costs (e.g., fringe benefits)
  - Marketing
  - Advertising
  - Warranty
  - etc.

Breakeven Analysis



- **Revenue (R)**
- **Total Cost (TC):**
  - **Fixed Cost (FC)**
  - **Variable Cost (VC)**

    TC = FC + VC
- **At the breakeven point:**

  R = TC
- **Profit:**
  - **Revenue minus total cost**

    Profit = R - TC

In per unit terms, the breakeven quantity of units

$$q^* = \frac{FC}{r - v}$$

r is the revenue per unit, v is the variable cost per unit

Practice Problem: Breakeven Analysis

Star Design Group invested $4,000,000 as fixed cost in a project. The variable cost was $2,000,000 per year. If the total revenue is at a rate of $3,000,000 per year. Calculate the breakeven point, in years.

Summary

- Engineering economic analysis should consider the time value of money
- The Present Worth method can be used to evaluate alternatives having different lives
- The Annual Equivalent method has the advantage of not requiring the use of the least common multiple.
- The breakeven point is the level of production (and sales) that results in a zero profit