In the name of Allah

Industrial Engineering Department

Course Title: Engineering Economics

1. Foundations of Engineering Economy

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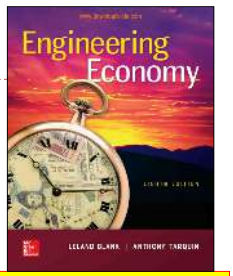
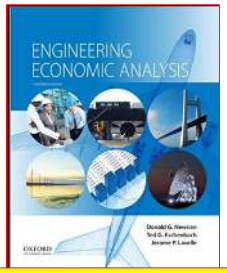
Learning Stage 1: The Fundamentals

- Chapter 1
  - Foundations of Engineering Economy
- Chapter 2
  - Factors: How Time and Interest Affect Money
- Chapter 3
  - Combining Factors and Spreadsheet Functions
- Chapter 4
  - Nominal and Effective Interest Rates



Chapter 1 of EE (BT) book 8th edition



Chapter 1 of EEA (NELL) book 13th edition

LEARNING OUTCOMES

- Purpose:
  - Understand and apply fundamental concepts and use the terminology of engineering economics.

1. Economics role in decision making
2. Economic Study approach
3. Interest rate
4. Terms and symbols
5. Cash flows
6. Economic equivalence
7. Simple and compound interest
8. Minimum attractive rate of return (MARR)
9. Spreadsheet functions

Why Engineering Economy is Important to Engineers

- Engineers design and create
- Designing involves economic decisions
- Engineers must be able to incorporate economic analysis into their creative efforts
- Understanding and applying time value of money, economic equivalence, and cost estimation are vital for engineers
- Project decisions are made more on the return on investment or payback than on technology
- You must communicate the basics of economy for your proposals to get funding

Time Value of Money (TVM)

- Description of TVM
  - It explains the change in the amount of money over time for funds owed by or owned by a corporation or individual
    - Corporate investments are expected to earn a return
    - Investment always involves money
    - Money has a 'time value'

The time value of money is the most important concept in engineering economics

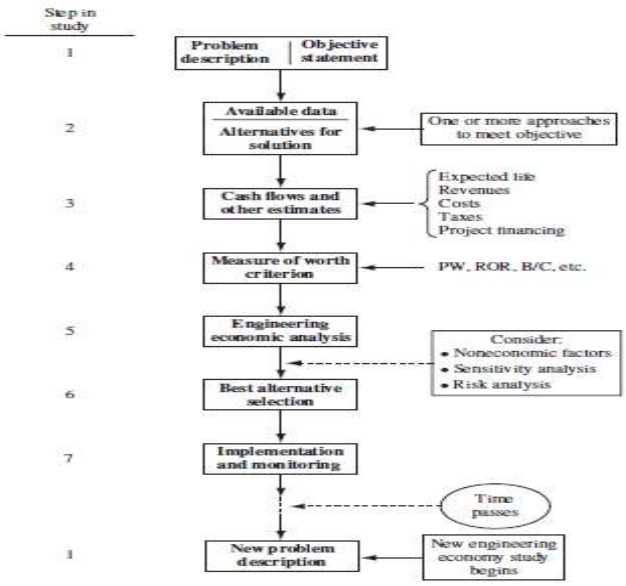
Engineering Economy

- Engineering Economy involves
  - Formulating
  - Estimating
  - Evaluating
    - Evaluating expected economic outcomes of alternatives designed to accomplish a defined purpose
- Easy-to-use math techniques simplify the evaluation
- Estimates of economic outcomes can be
  - deterministic or stochastic in nature

General Steps for Decision Making Processes

1. Understand the problem – define objectives
2. Collect relevant information – e.g. cash flows, interest rate, estimated life.
3. Define the set of feasible alternatives
4. Define the criteria for decision making
5. Evaluate the alternatives and explore sensitivity analysis
6. Select the best alternative (typically measured by dollars)
7. Implement the alternative and monitor the results.

Steps in an Engineering Economy Study



Interest and Interest Rate

- Interest – the manifestation of the time value of money
  - Fee that one pays to use someone else's money
  - Difference between an ending amount of money and a beginning amount of money
    - Interest = amount owed now − principal
- Interest rate – Interest paid over a time period expressed as a percentage of principal

$$\text{Interest rate}(\%) = \frac{\text{interest accrued per time unit}}{\text{principal}} \times 100\%$$

Rate of Return

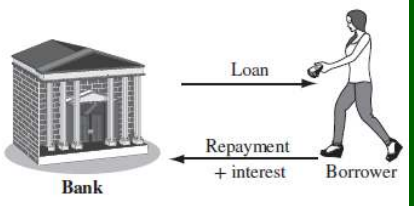
- Interest earned over a period of time is expressed as a percentage of the original amount (principal)

$$\text{Rate of return}(\%) = \frac{\text{interest accrued per time unit}}{\text{original amount}} \times 100\%$$

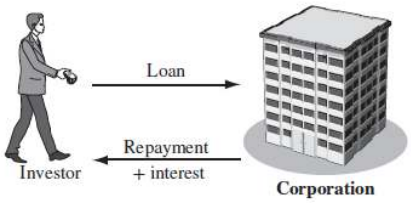
- Borrower's perspective: interest rate paid
- Lender's or investor's perspective: rate of return earned

Depends on your point of view

Interest paid



Interest earned



Interest rate | **Rate of return**

Commonly used Symbols

- t = time, usually in periods such as years or months
- P = value or amount of money at present (a time *t)*
  - designated as present or time 0
- F = value or amount of money at some future time, such as at $t = n$ periods in the future
- A = series of consecutive, equal, end-of-period amounts of money
- n = number of interest periods; years, months
- i = interest rate or rate of return per time period; percent per year or month

Cash Flows: Terms

- Cash Inflows
  - Revenues (R), receipts, incomes, savings generated by projects and activities that flow in.
    - Plus sign (+) used
- Cash Outflows
  - Disbursements (D), costs, expenses, taxes caused by projects and activities that flow out.
    - Minus sign(-) used
- Net Cash Flow (NCF) for each time period:
  - NCF = cash inflows − cash outflows = R − D
- End-of-period assumption:
  - Funds flow at the end of a given interest period

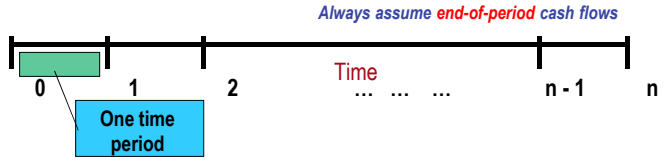
Cash Flows: Estimating

- Point estimate: A single-value estimate of a cash flow element of an alternative
  - Cash inflow: Income = $150,000 per month
- Range estimate: Min and max values that estimate the cash flow
  - Cash outflow: Cost is between $2.5 M and $3.2 M

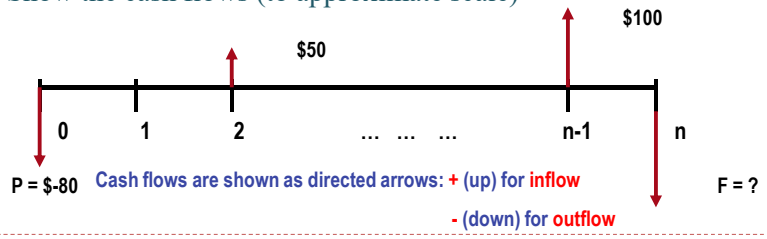
Point estimates (a constant) are commonly used; however, range estimates with probabilities assigned provide a better understanding of the variability and sensitivity of economic parameters used to make decisions.

Cash Flow Diagrams

- What a typical cash flow diagram might look like
  - Draw a time line



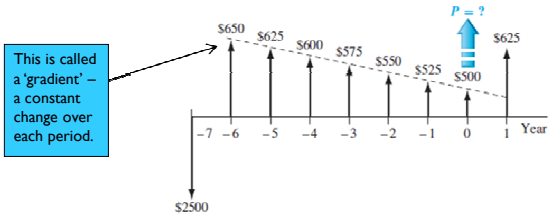
  - Show the cash flows (to approximate scale)



Cash Flow Diagram Example

- Plot observed cash flows over last 8 years and estimated sale next year for $150. Show present worth (P) arrow at present time, $t = 0$

End of Year	Income	Cost	Net Cash Flow
−7	$ 0	$2500	$−2500
−6	750	100	650
−5	750	125	625
−4	750	150	600
−3	750	175	575
−2	750	200	550
−1	750	225	525
0	750	250	500
1	750 + 150	275	625

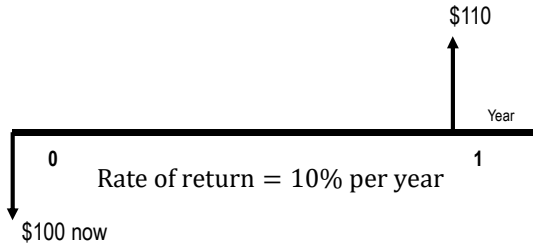


Economic Equivalence

- Definition:
  - Combination of interest rate (rate of return) and time value of money to determine different amounts of money at different points in time that are economically equivalent
- How it works:
  - Use interest rate *i* and time *t* in upcoming relations to move money (values of P, F and A) between time points $t = 0, 1, \ldots, n$ to make them equivalent (not equal) at the rate *i*

Example of Equivalence

- Different sums of money at different times may be equal in economic value at a given rate



$100 now is economically equivalent to $110 one year from now, if the $100 is invested at a rate of 10% per year.

Simple and Compound Interest (1)

- Simple Interest
  - Interest is calculated using principal only

$$\text{Interest} = (\text{principal})(\text{number of periods})(\text{interest rate})$$
$$I = Pni$$

- Example: $100,000 lent for 3 years at simple i = 10% per year. What is repayment after 3 years?

$$\text{Interest} = 100{,}000(3)(0.10) = \$30{,}000$$
$$\text{Total due} = 100{,}000 + 30{,}000 = \$130{,}000$$

Simple and Compound Interest (2)

- Compound Interest
  - Interest is based on principal plus all accrued interest
    - That means interest earns interest and compounds over time

$$\text{Interest} = (\text{principal} + \text{all accrued interest})\ (\text{interest rate})$$

  - Interest for time period t is

$$I_t = \left(P + \sum_{j=1}^{j=t-1} I_J \right)(i)$$

Compound Interest Example

- Example: \$100,000 lent for 3 years at $i = 10\%$ per year compounded. What is repayment after 3 years?

Interest, year 1: $I_1 = 100{,}000(0.10) = \$10{,}000$

Total due, year 1: $T_1 = 100{,}000 + 10{,}000 = \$110{,}000$

Interest, year 2: $I_2 = 110{,}000(0.10) = \$11{,}000$

Total due, year 2: $T_2 = 110{,}000 + 11{,}000 = \$121{,}000$

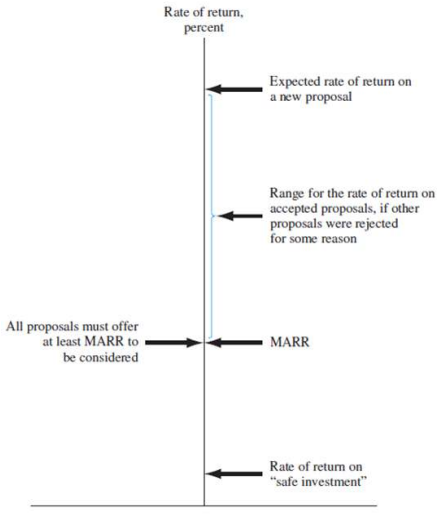
Interest, year 3: $I_3 = 121{,}000(0.10 = \$12{,}100$

Total due, year 3: $T_3 = 121{,}000 + 12{,}100 = \$\mathbf{133{,}100}$

Compounded: \$133,100 Simple: \$130,000

Minimum Attractive Rate of Return (MARR)

- MARR is a reasonable rate of return (percent) established for evaluating and selecting alternatives.
- An investment is justified economically if it is expected to return at least the MARR.
- Also termed hurdle rate, benchmark rate and cutoff rate



MARR Characteristics

- MARR is established by the financial managers of the firm
- MARR is fundamentally connected to the cost of capital
- Both types of capital financing are used to determine the weighted average cost of capital (WACC) and the MARR
- MARR usually considers the risk inherent to a project
  - the higher the risk means the higher the MARR.

Types of Financing

- Equity Financing
  - Funds either from retained earnings, new stock issues, or owner's infusion of money.
- Debt Financing
  - Borrowed funds from outside sources – loans, bonds, mortgages, venture capital pools, etc.
  - nterest is paid to the lender on these funds
- For an economically justified project

$$\mathbf{ROR} \geq \mathbf{MARR} > \mathbf{WACC}$$

Opportunity Cost

- Definition: Largest rate of return of all projects not accepted (forgone) due to a lack of capital funds
  - If no MARR is set, the ROR of the first project not undertaken establishes the opportunity cost.

- Example: Assume MARR = 10%. Project A, not funded due to lack of sufficient funds, is projected to have $ROR_A = 13\%$. Project B has $ROR_B = 15\%$ and is funded because it costs less than A
- Opportunity cost is 13%, i.e., the opportunity to make an additional 13% is forgone by not funding project A.

Introduction to Spreadsheet Functions

- Excel financial functions

Present Value, P: = PV(i%,n,A,F)
Future Value, F: = FV(i%,n,A,P)
Equal, periodic value, A: = PMT(i%,n,P,F)
Number of periods, n: = NPER((i%,A,P,F)
Compound interest rate, i: = RATE(n,A,P,F)
Compound interest rate, i: = IRR(first_cell:last_cell)
Present value, any series, P: = NPV(i%,second_cell:last_cell) + first_cell

Example: Estimates are P = $5000 n = 5 years i = 5% per year
Find A in $ per year
Function and display: = PMT(5%, 5, 5000) displays A = $1154.87

Chapter Summary (1)

- Engineering Economy fundamentals
  - Time value of money
  - Economic equivalence
  - Introduction to capital funding and MARR
  - Spreadsheet functions
- Interest rate and rate of return
  - Simple and compound interest
- Cash flow estimation
  - Cash flow diagrams
  - End-of-period assumption
  - Net cash flow
  - Perspectives taken for cash flow estimation

Chapter Summary (2)

- Economic Equivalence
  - Combination of interest rate and time value of money
- Simple and Compound Interest
  - Simple interest is Pni (Principal, #periods, and interest rate)
  - Compound interest is where interest is earned/paid on interest
- MARR and Opportunity Cost
  - Debt or equity capital financing
  - Impact of not selecting an project opportunity