Chapter 1

Foundations Of Engineering Economy

LEARNING OUTCOMES

1. Role in decision making
2. Study approach
3. Ethics and economics
4. Interest rate
5. Terms and symbols
6. Cash flows
7. Economic equivalence
8. Simple and compound interest
9. Minimum attractive rate of return
10. 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
- Often engineers must select and implement from multiple alternatives
- Understanding and applying time value of money, economic equivalence, and cost estimation are vital for engineers
- A proper economic analysis for selection and execution is a fundamental task of engineering

Time Value of Money (TVM)

Description: TVM 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 involves money
- Money has a ‘time value’

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

Engineering Economy

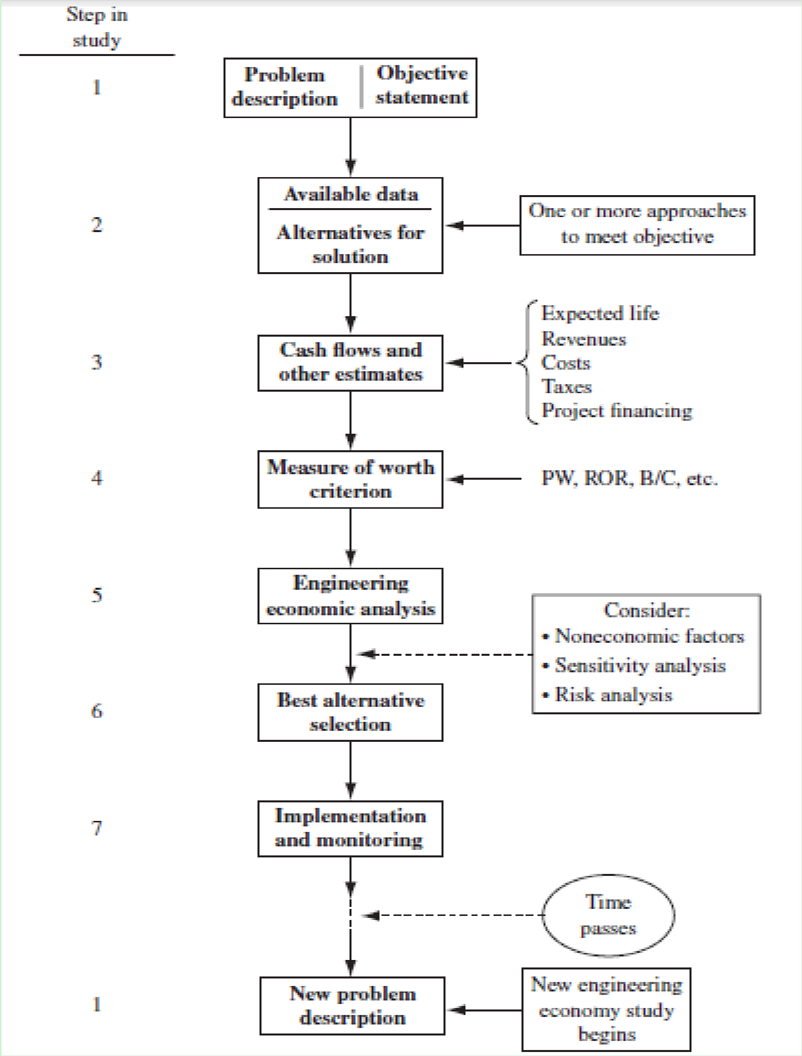
- Engineering Economy involves
  - Formulating
  - Estimating, and
  - Evaluating

  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
3. Define the set of feasible alternatives
4. Identify the criteria for decision making
5. Evaluate the alternatives and apply sensitivity analysis
6. Select the “best” alternative
7. Implement the alternative and monitor results

Steps in an Engineering Economy Study



Ethics – Different Levels

- **Universal morals or ethics** – Fundamental beliefs: stealing, lying, harming or murdering another are wrong
- **Personal morals or ethics** – Beliefs that an individual has and maintains over time; how a universal moral is interpreted and used by each person
- **Professional or engineering ethics** – Formal standard or code that guides a person in work activities and decision making

Code of Ethics for Engineers

All disciplines have a formal code of ethics. National Society of Professional Engineers (NSPE) maintains a code specifically for engineers; many engineering professional societies have their own code

National Society of Professional Engineers®

Code of Ethics for Engineers

Preamble

Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct.

I. Fundamental Canons

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

II. Rules of Practice

1. Engineers shall hold paramount the safety, health, and welfare of the public.

4. Engineers shall act for each employer or client as faithful agents or trustees.
   a. Engineers shall disclose all known or potential conflicts of interest that could influence or appear to influence their judgment or the quality of their services.
   b. Engineers shall not accept compensation, financial or otherwise, from more than one party for services on the same project, or for services pertaining to the same project, unless the circumstances are fully disclosed and agreed to by all interested parties.
   c. Engineers shall not solicit or accept financial or other valuable consideration, directly or indirectly, from outside agents in connection with the work for which they are responsible.
   d. Engineers in public service as members, advisors, or employees of a governmental or quasi-governmental body or department shall not participate in decisions with respect to services solicited or provided by them or their organizations in private or public engineering practice.
   e. Engineers shall not solicit or accept a contract from a governmental body on which a principal or officer of their organization serves as a member.
5. Engineers shall avoid deceptive acts.
   a. Engineers shall not falsify their qualifications or permit misrepresentation of their or their associates' qualifications. They shall not misrepresent or exaggerate their responsibility in or for the

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

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

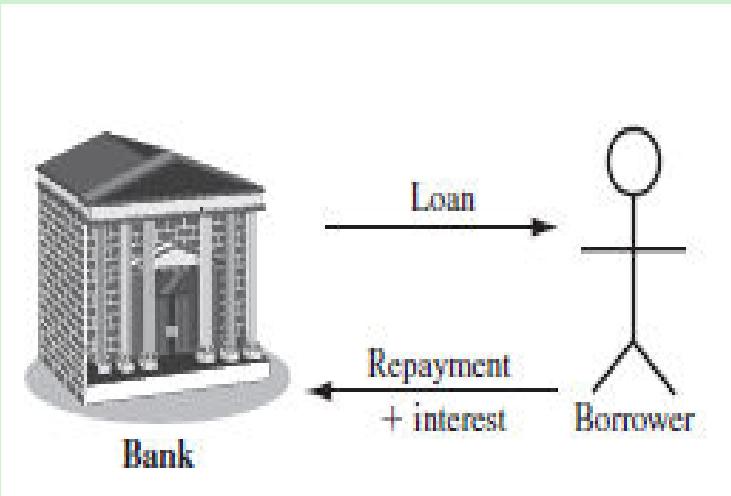
Rate of Return

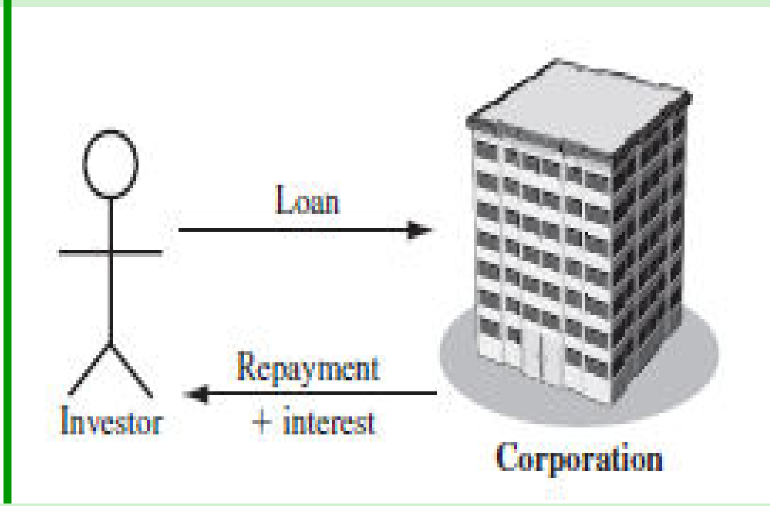
- **Interest earned over a period of time is expressed as a percentage of the original amount (principal)**

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

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

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 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**

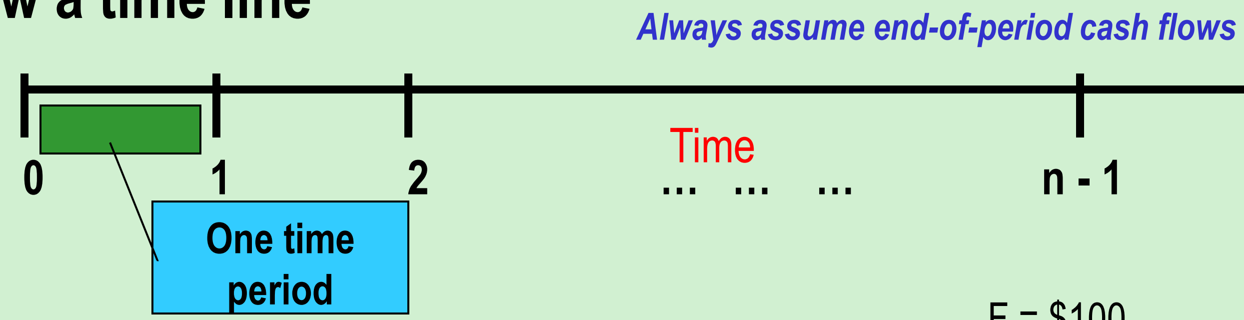
  Cash outflow: Cost is between $2.5 M and $3.2 M

Point estimates are commonly used; however, range estimates with probabilities attached provide a better understanding of variability of economic parameters used to make decisions

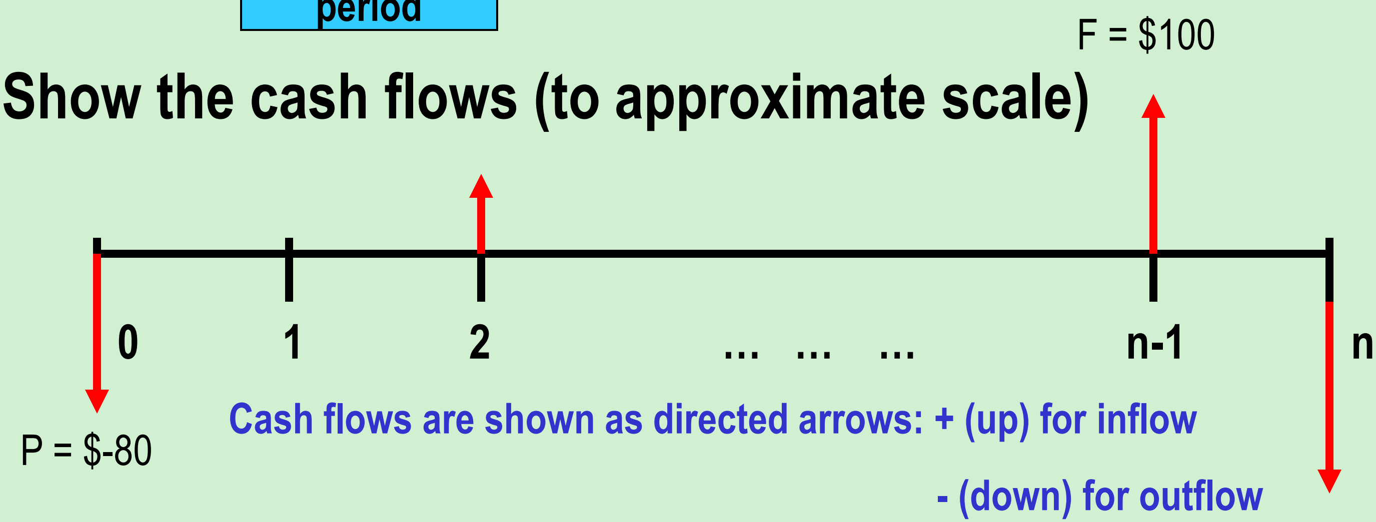
Cash Flow Diagrams

What a typical cash flow diagram might look like

Draw a time line



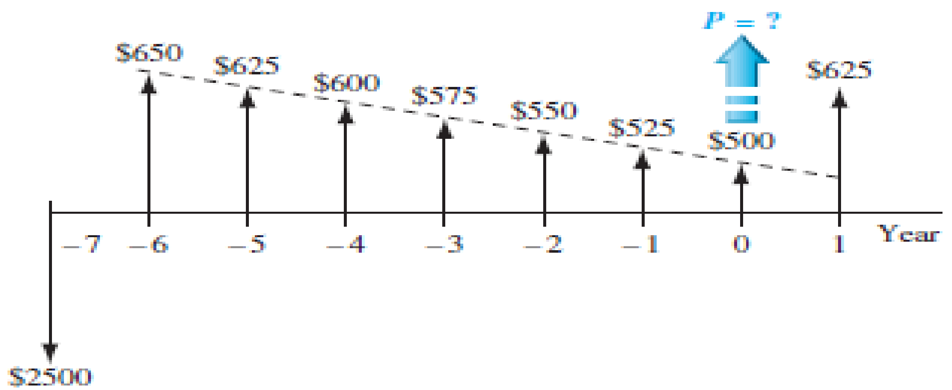
Show the cash flows (to approximate scale)



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



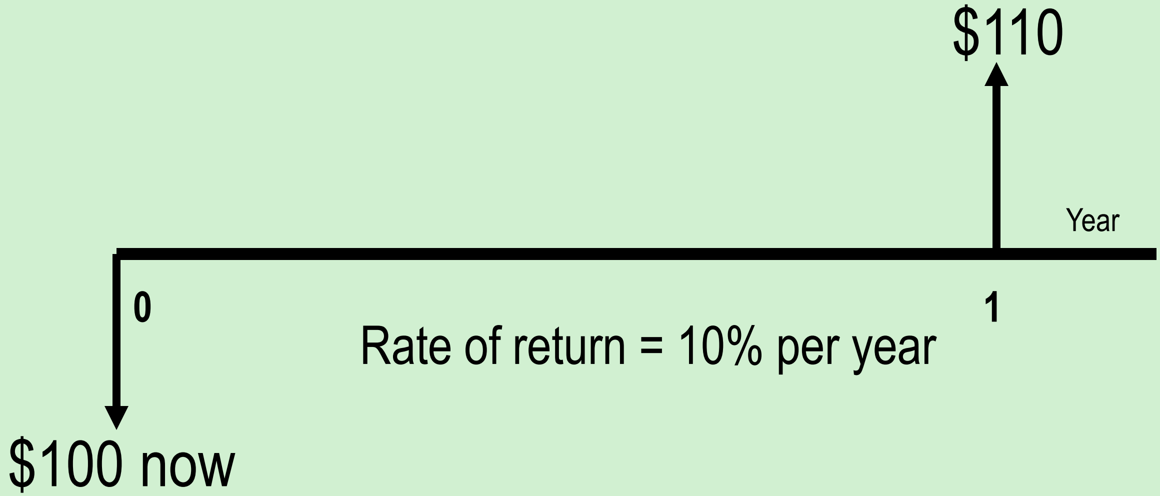
Economic Equivalence

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 rate *i* and time *t* in upcoming relations to move money (values of P, F and A) between time points *t* = 0, 1, …, 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

- Simple Interest

Interest is calculated using principal only

Interest = (principal)(number of periods)(interest rate)

$I = Pni$

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

Interest = 100,000(3)(0.10) = $30,000

Total due = 100,000 + 30,000 = $130,000

Simple and Compound Interest

- Compound Interest

Interest is based on principal plus all accrued interest

That is, interest compounds over time

Interest = (principal + all accrued interest) (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: $T_2 = 110{,}000 + 11{,}000 = \$121{,}000$

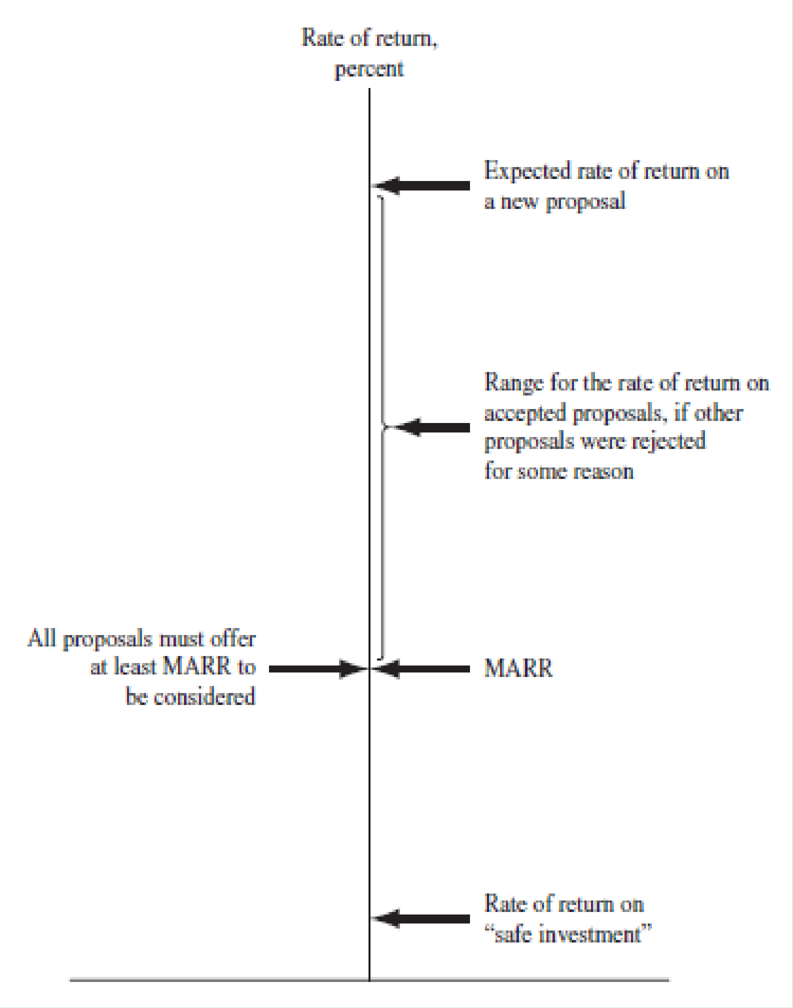
Interest, year 3: $I_3 = 121{,}000(0.10) = \$12{,}100$

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

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

Minimum Attractive Rate of Return

- 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

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. Interest is paid to the lender on these funds

For an economically justified project

$$ROR \geq MARR > WACC$$

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 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

- **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
- **Ethics**
  - Universal morals and personal morals
  - Professional and engineering ethics (Code of Ethics)