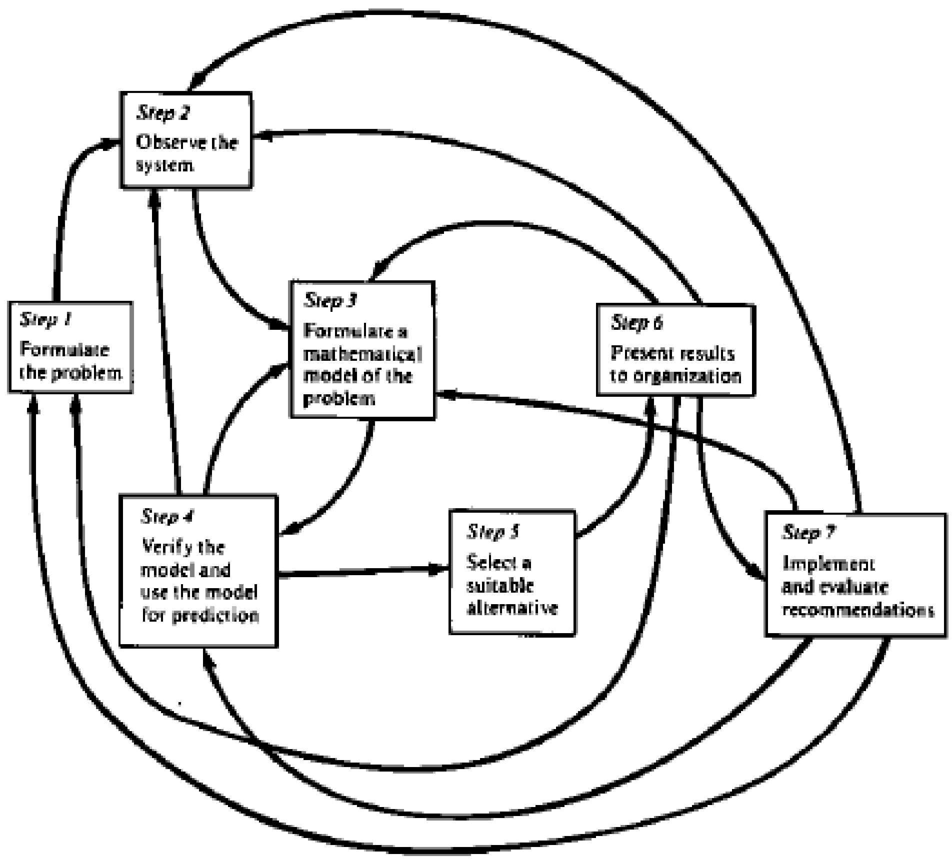
Chapter 1 Foundations of Engineering Economy

- **What is Engineering Economy?**
  - It involves estimating, formulating and evaluating the financial outcomes of alternatives
  - It is a collection of mathematical techniques that simplify economic comparison
  - It provides a criteria for decision making

- **Steps of a decision making process**

1. Understand the problem and define the objective
2. Collect relevant information
3. Define alternatives and estimate relevant costs
4. Identify the criteria
5. Evaluate each alternative
6. Select the best alternative
7. Implement the solution
8. Monitor the results
9. Refine the solution (go back to 3)

Use Eng. Econ. (steps 2–6)



- **Operations Research (OR) and Data Analytics**
  - OR is also concerned with scientific decision making.
  - It utilizes advanced math, stats, algorithms, software, and other tools, for rigorous analysis.
  - It is suited for complex systems and critical decisions.
  - Engineering economy concepts are at the heart of the OR analysis.
  - INDE 302, 303 and many of the INDE and ENMG courses fall under the wide umbrella of OR.

- A modern and highly popular paradigm data analytics or business analytics.
- Data analytics rely heavily on statistics and software, and interfaces with OR and engineering economy in what's called prescriptive analytics.
- Prescriptive analytics essentially utilizing big data sets to come-up (prescribe) with business solution.
- Two steps that come before are descriptive and predictive analytics. (look them-up if you are interested.)

- **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 execute from multiple alternatives
  - A proper economic analysis for selection and execution is a fundamental aspect of engineering

- **Examples of questions Engineering Economy can answer**
  - Take on a new project?
  - Which project(s) to bid for among many available?

- Replace an old equipment?
- Introduce a new product?
- Build a new plant?
- Invest in project A or in project B?
- What else? (Think of more decisions as you read this.)

- **Engineering Economy and Economic Feasibility Analysis**
  - When it comes to embarking on new business (e.g. opening-up a new restaurant or launching a start-up) the first step is to do an economic feasibility study justifying the profitability.
  - Engineering economy tools allow you to do full-blown economic feasibility for projects/endeavors at your company, your own business, and for personal matters
  - Examples of personal economic feasibility business this class can help you with include taking a loan, buying a car or an apartment, investing money, etc.
  - You need to connect the dots and keep what you learn in this course at the back of your mind when you face tough decisions with economic/financial implication.

- **Time Value of Money**
  - $1 today is not "equivalent" to $1 a year later. Worst alternative is to deposit (invest) the $1 in a bank and gain "interest" (or dividend)
  - *Money makes money* --
  - All firms make use of investment of funds
  - Investments are expected to earn a return
  - Investment involves money
  - Money possesses a "time value"

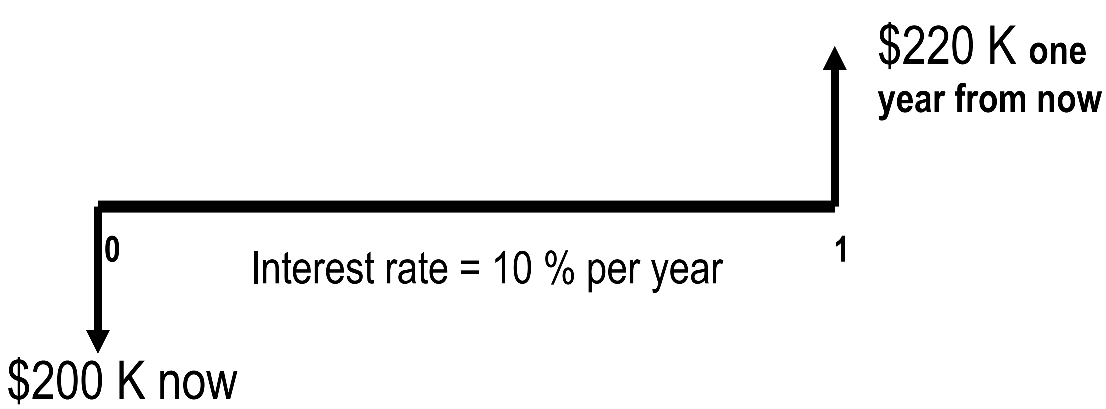
- **Interest**
  - Interest is the manifestation of the time value of money
  - Rental fee that one pays to use someone else's money
  - Difference between an ending amount of money and a beginning amount of money
  - Interest rate = (interest accrued per time unit) / (original amount)
  - From the lender perspective, the "earned" interest rate is a "rate of return" (ROR)
  - For a simple loan (investment) consisting of borrowing (lending) money now and returning (retrieving) it after one year, the annual interest rate (ROR) is given by

$$\text{Interest rate (\%)} = \frac{\text{Final loan amount} - \text{Original amount borrowed}}{\text{Original amount}} \times 100$$

$$\text{ROR (\%)} = \frac{\text{Final investment value} - \text{Original amount invested}}{\text{Original amount}} \times 100$$

- **Interest Examples**
  - ➢ The Oracle investment group invested $200,000 on May 1 and withdrew a total of $220,000 exactly one year later
    - Interest earned = $220,000 – $200, 000 = $20,000
    - ROR = ($20,000 / $200,000) × 100 = 10%
  - ➢ Another Oracle group borrowed $100,000 on May 1 and paid a total of $105,000 exactly one year later
    - Interest paid = $105,000 – $100, 000 = $5,000
    - Interest rate = ($5,000 / $100,000) × 100 = 5%

- **Equivalence**
  - ➢ Different sums of money at different times may be "equivalent" in economic value.
  - ➢ For the Oracle group doing the investment, $200 K now are *equivalent* to $220 K a year later



- **Equivalence Example**
  - You want to replace your study desk. The new desk is now $125 and estimated to be worth $135 for the next year.
  - Suppose you are going to finance the desk purchase from your saving account earning an annual interest rate of 12%.
  - Would you replace the desk now or next year?
  - $135 next year are equivalent to 135/1.12 = $120.54 < $125.
  - Then, it's better to buy the desk next year because this saves you around $5.
  - This is a "present worth" analysis.
  - Can you also think of a "future worth analysis?"

- **Simple and Compound Interest**
  - Interest can be either simple or compound.
  - With simple interest, in each period a borrower pays interest on the principal (the amount borrowed) itself only
  - With compound interest, in each period, a borrower pays interest on the principal and on the interest accumulated from previous periods.
  - That is, one pays "interest on interest."
  - Suppose you borrow an amount P and pay interest for n years at a rate of i per year.
  - Then, the amount, F, you pay back n years later is

- With simple interest, $F = P + iP + \ldots + iP = P + niP$. Then,

$$F = P(1+ni)$$

- With compound interest, $F = P(1+i)(1+i)\cdots(1+i)$. Then,

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

- Unless otherwise noted, we adopt compound interest in this class, which is the common case in practice.

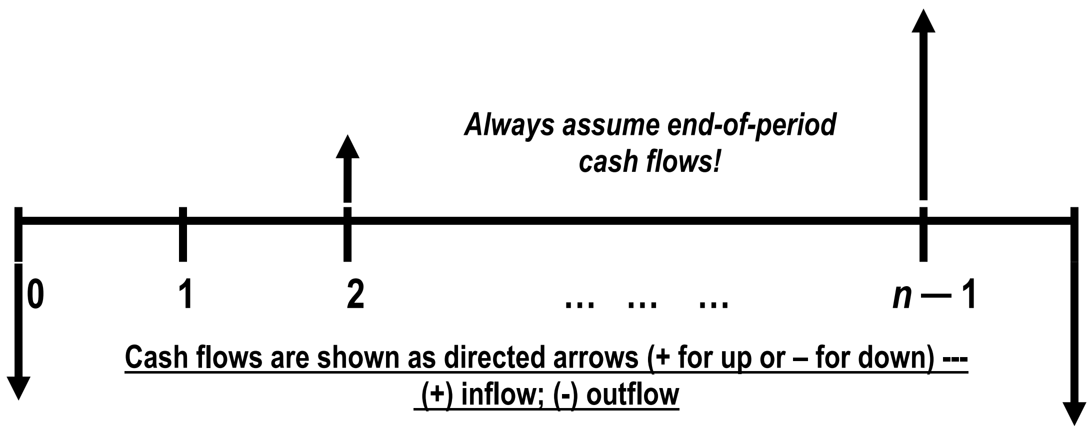
- **Rule of 72**
  - This rule (approximately) estimates the number of time periods (years), *n*, it takes for an amount of money to double under a ROR of *i* (%) under compound interest,

$$n \cong \frac{72}{i}.$$

  - So, money invested at 8% interest doubles (approximately) every 9 years. Money invested at 12% doubles every 6 years, etc.
  - This rule is useful for doing compounding "mentally," e.g. when negotiating or during a job interview, or when your phone battery dies and it becomes hard to calculate 1.12^6?

- **Cash Flows**
  - Cash Inflows - amount of funds flowing into the firm
  - Cash Outflows – amount of funds flowing out of the firm
  - Example of cash inflows
    - Sales Revenue
    - Asset salvage value
    - Borrowed money
    - Income tax savings
  - Example of cash outflows
    - Paybacks
    - Labor cost
    - Maintenance and operating costs
    - Loans (from the lender's perspective)
    - Income taxes
  - Past cash flows are summarized in an accounting statement called the "statement of cash flow." (More on this later.)
  - In this class, we are looking into the future, and we need to "project" (i.e. estimate or forecast) future cash flows.
  - Estimating future cash flows is an art (relying on experience) and a science (looking at past data such as those in the statement of cash flows. It is not definitely not easy!

➢ A cash flow diagram looks as follows. It is an essential tool in engineering economy



- **Minimum Attractive Rate of Return (MARR)**
  - ➢ Investors expect to earn a return on their investment (commitment of funds) over time
  - ➢ Economic projects should earn a reasonable return, which is termed "minimum attractive rate of return" (MARR)
  - ➢ The company management establishes the MARR
  - ➢ MARR is estimated based on the weighted average of the "cost of capital" (wacc) of sources of funding.
  - ➢ Sources of funding can be
    - o Equity financing – the firm uses its own assets to finance often through issuing stocks.
    - o Debt financing – the firm borrows money to finance often through issuing bonds.
  - ➢ MARR is set in such a way that MARR > cost of capital.

- ➢ A "risk" margin and a "profit" margin are added on top of the wacc to get the MARR.
- ➢ These margins depend on the economic environment, the type of business and market conditions (e.g. competition).
- ➢ To be considered financially viable, a project's expected ROR must meet or exceed the MARR. That is, a project should be undertaken if and only if its ROR ≥ MARR.
- ➢ More on this in Chapter 10.

- **Putting all the pieces together …**
  - ➢ By estimating future cash flows, the MARR, and utilizing equivalence (i.e, time value of money), one can do sound engineering economic analysis.