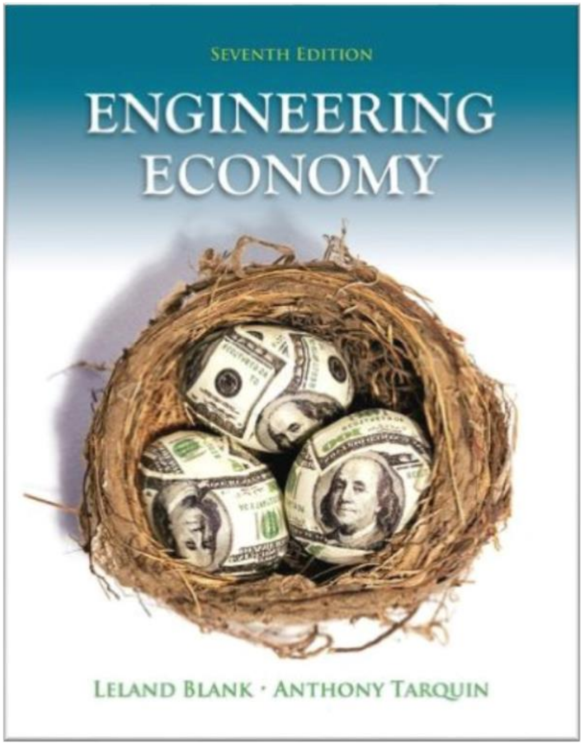
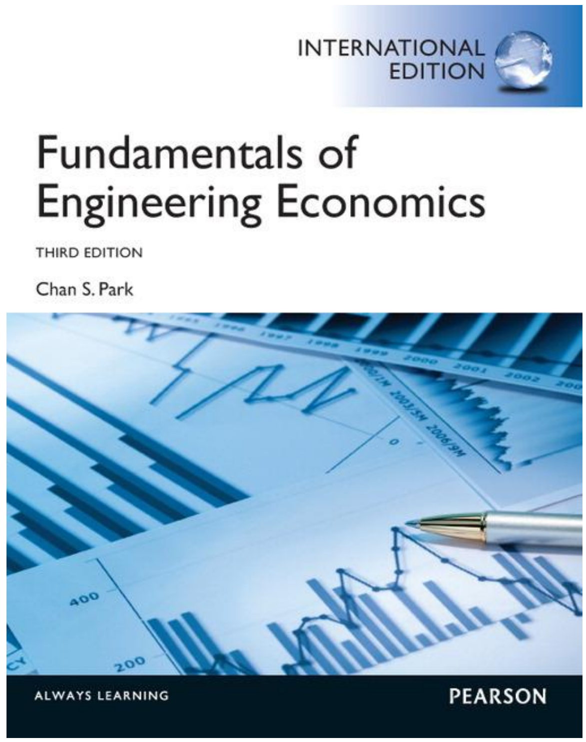
INTRODUCTION TO ENGINEERING ECONOMICS

1. BOOKS:



Engineering Economy by Leland Blank Anthony Tarquin, 7th edition



Fundamental of Engineering Economics by Chan S Park 3rd Edition

2. OBJECTIVES:

- Time value of money
- Use of interest calculations in equivalence calculations.
- Economic analysis of alternatives.
- The concept of cash flows
- Basic understanding of depreciation for engineering projects.

3. ENGINEERING:

Engineering is defined as;

"A profession in which a knowledge of mathematical and natural sciences gained by study, experience and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind."

Apart from everything else explained, a very important consideration is economy in this definition. Engineers use knowledge to find new ways of doing things economically.

4. IMPORTANCE OF ENGINEERING ECONOMY:

The following points emphasize the importance of studying engineering economy for the 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

5. WHAT IS ECONOMY?

- It is the study of choice and decision-making in world with limited resources.
- It is the study of how individuals, businesses and governments used their limited resources.

6. ENGINEERING ECONOMY

- Engineering Economy is about making decisions
  It is based on the systematic evaluation of the ***costs and benefits*** of proposed technical projects
- Successful design is the one that must sound technical and produces benefit.

In fact any engineering project must be physically and technically realizable but also it must be economically feasible, therefore economics weigh heavily in the design process.

7. NON-ECONOMIC FACTORS

The factors upon which a decision is based are commonly a combination of economic and noneconomic elements.

Non-Economic elements are:

- **Availability of certain resources,** e.g., skilled labor force, water, power, tax incentives.
- **Government laws that dictate safety,** environmental, legal, or other aspects.
- **Management's interest** in a particular alternative.

Engineering economics is a powerful tool for engineers in decision making and analysis of new and running projects. Sample question arising from various engineering related activities may be found in the following list. These questions may be solved only by learning *how to use engineering-economy*.

8. EXAMPLES

9. ENGINEERING ECONOMY FOR ENGINEERING ACTIVITIES

Should a highway bypass be constructed around a city of 25,000 people, or should the current roadway through the city be expanded?

10. ENGINEERING ECONOMY FOR GOVERNMENT

How much new tax revenue does the city need to generate to pay for an upgrade to the electric distribution system?

11. ENGINEERING ECONOMY FOR INDIVIDUALS

Should I buy or lease my next car, or keep the one I have now and pay off the loan?

12. ROLE OF 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

13. STEPS IN DECISION MAKING:

- Understand the problem – define objectives
- Collect relevant information
- Define the set of feasible alternatives
- Identify the criteria for decision making
- Evaluate the alternatives and apply sensitivity analysis
- Select the "best" alternative
- Implement the alternative and monitor results

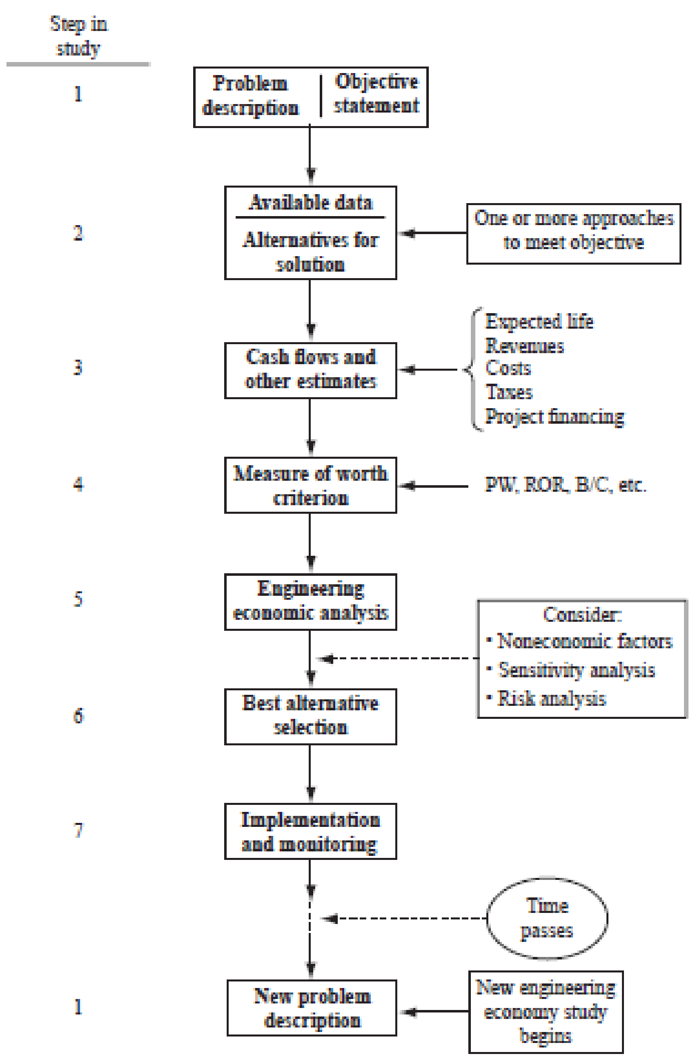


Figure 1–1
Steps in an engineering economy study.

14. TIME VALUE OF MONEY:

"TVM explains the change in the amount of money over time for funds owed by or owned by a corporation (or individual)"

It is often said that money makes money. The statement is indeed true, for if we invest money today, by tomorrow we will have accumulated more money than we have originally invested. This change in the amount of money over a given time period is called **the time value of money**; **it is the most important concept in engineering economy.** On the other hand, if a person or a company borrows money today, by tomorrow more money than the original loan will be owed. This fact is also explained by the time value of money.

15. MEANING OF INTEREST:

The appearance of the time value of money in actual life is termed **"interest" (I);** which is a measure of the increase between the original sum (borrowed or invested) and the final amount (owed or accrued). Thus, if money was borrowed at some time in the past, the interest would be:

I (interest) = present amount owed – original loan.

If money was invested at some time in the past, the interest would be.

I (interest) = total amount accumulated – original investment.

In either case, there is an increase in the amount of money that was originally invested or borrowed, and the increase over the original amount is the interest. **The original investment or loan is called "principal"** ***P*****.**

The interest is always defined as an "Interest rate" *i* (%). It expresses the interest per unit time as a percentage of the principal.

$$Interest\ rate\,(\%) = \frac{Interest\ accrued\ \ per\ unit\ time}{Original\ amout} \times 100\,\%$$

16. INTEREST PERIOD

The time unit which is most commonly (and unless otherwise stated) used to declare interest rates is one year (e.g. 10% per year, 10% per annum or just 10%). However, interest rates may sometimes be quoted over shorter periods of time (e.g. 1% per month). **The time unit used to express an interest rate is called an "interest period".**

17. INTEREST RATE (IR) AND RATE OF RETURN (ROR)

From a computational point of view, interest is the difference in money between what you end with and what you started with. Interest is paid when an entity borrows money and repays a larger amount; interest is earned when an entity save or invested money and obtained a return of a larger amount.

Interest = amount owed now – original amount or principal

$$\text{Interest rate, \%} = \frac{\text{interest accrued per time unit}}{\text{original amount}} \times 100\%$$

The time unit is called the interest period and is typically one year.

Interest paid over a specific period of time is expressed as a percentage of the original amount and is called the rate of return (ROR) or return on investment (ROI).

$$\text{Rate of Return, \%} = \frac{\text{interest accrued per time unit}}{\text{original amount}} \times 100\%$$

The equations are the same but interest rate paid is more appropriate from the borrower's perspective and the rate of return earned is better for the investor's perspective i.e.

IR – borrower and

ROR or ROI – investor.

18. INFLATION

- Inflation is the devaluation of a currency relative to a previous value.
- Country's currency becomes worth less over time, thus requiring more of the currency to purchase the same amount of goods or services in a time period
- From the borrower's perspective it is another interest rate; from the investor's perspective, inflation reduces the ROR.

Inflation impacts:

- Purchasing Power (reduces)
- Operating Costs (increases)
- Rate of Return on Investments (reduces)

19. CASH FLOW DIAGRAMS:

For any enterprise, firm or even a person there are cash receipts (income) and cash disbursements (costs) which occur over a certain time span. These are referred to as "cash flow". Positive cash flow represents inflow or receipt while negative cash flow indicates outflow or disbursement.

A "cash flow diagram" is a graphical representation of cash flows drawn on a time scale having the interest period as the unit or division. The length and direction of any cash flow arrow should indicate the amount of cash flow and whether it is a receipt or a disbursement. This is explained in the following figures.

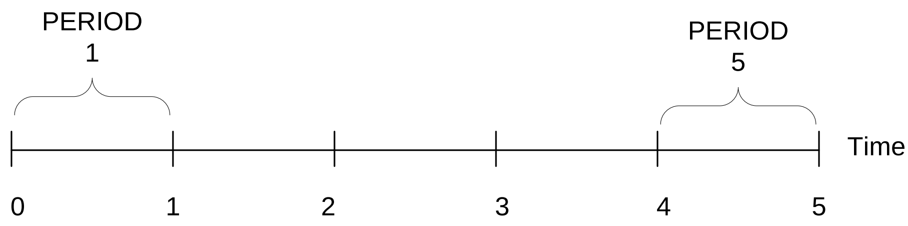


Figure: A typical cash flow time scale

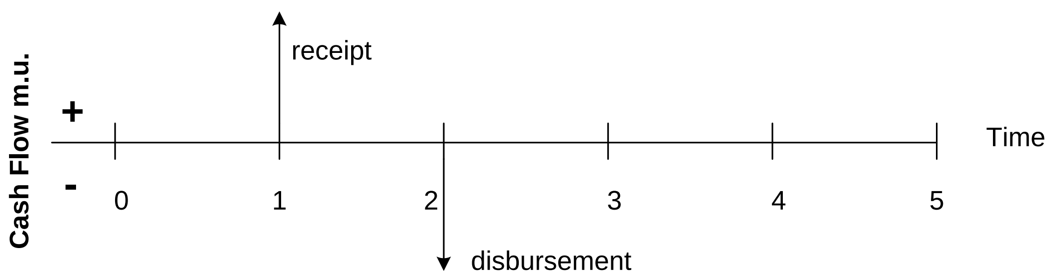
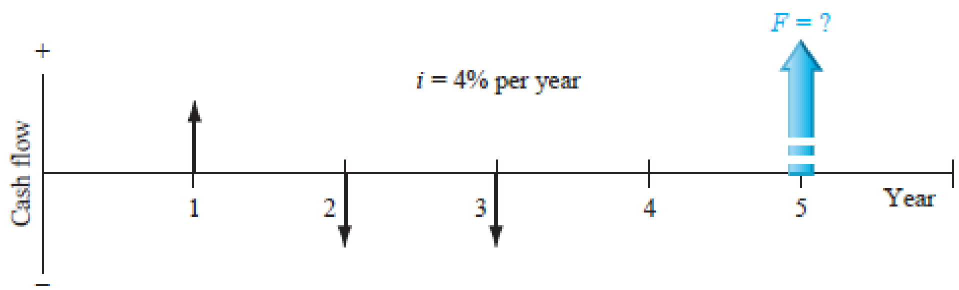


Figure: Representation of receipts and disbursements on a cash flow diagram



Example of Positive and Negative Cashflow

In practice, cash flow may occur at any time within an interest period. However, a simplifying assumption is made that all cash flow occurs at the end of the interest period. This is known as the "end-of-period convention". Accordingly, if several receipts and disbursements take place within the same interest period, the net cash flow (which is the algebraic sum) is assumed to occur, or to be concentrated, at the end of the interest period.

The cash flow diagram is a useful tool which gives a clear diagrammatic synoptic representation of the statement of any situation or problem. It may be marked to show what is known and what is to be found.

20. SIMPLE AND COMPOUND INTEREST

When more than one interest period is involved, the terms simple and compound interest must be considered.

21. SIMPLE INTEREST

Simple interest is calculated on the principal only, ignoring any interest that was accrued in preceding interest periods.

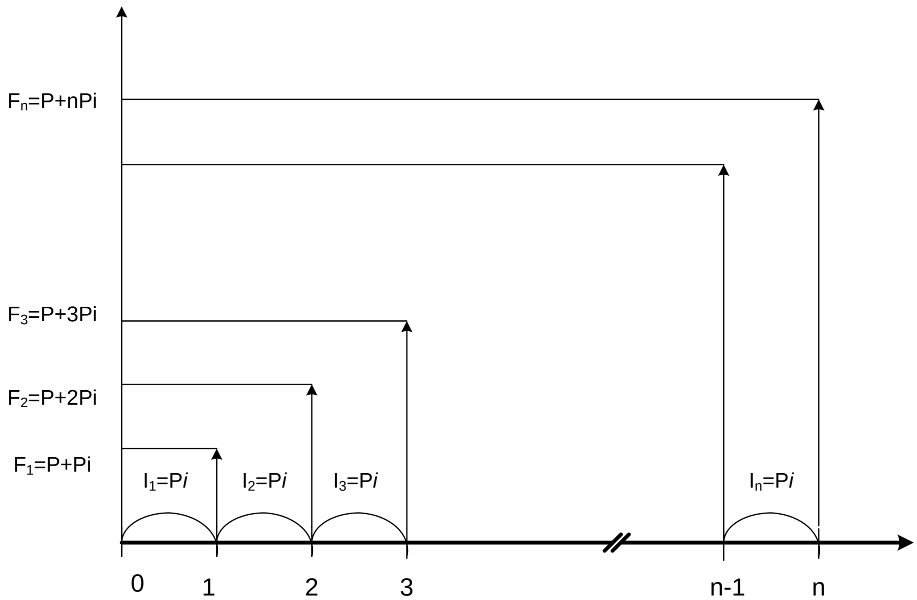


Figure: Diagram representing the accumulation of a principal based on simple interest

The total interest for (n) interest periods will be

$$I = P \times i \times n$$

And the future value F of the principal P after the (n) periods will be

$$F = P + P \times i \times n \ = P(1 + i \times n)$$

22. COMPOUND INTEREST

In calculation of compound interest, the interest for an interest period is calculated on the principal plus the total amount of interest accumulated in previous periods. Thus, compound interest means "interest on top of interest" (i.e., it reflects the effect of the time value of money).

The interest for any period (I_n) and the accumulated amount after that period (F) are consecutively given by

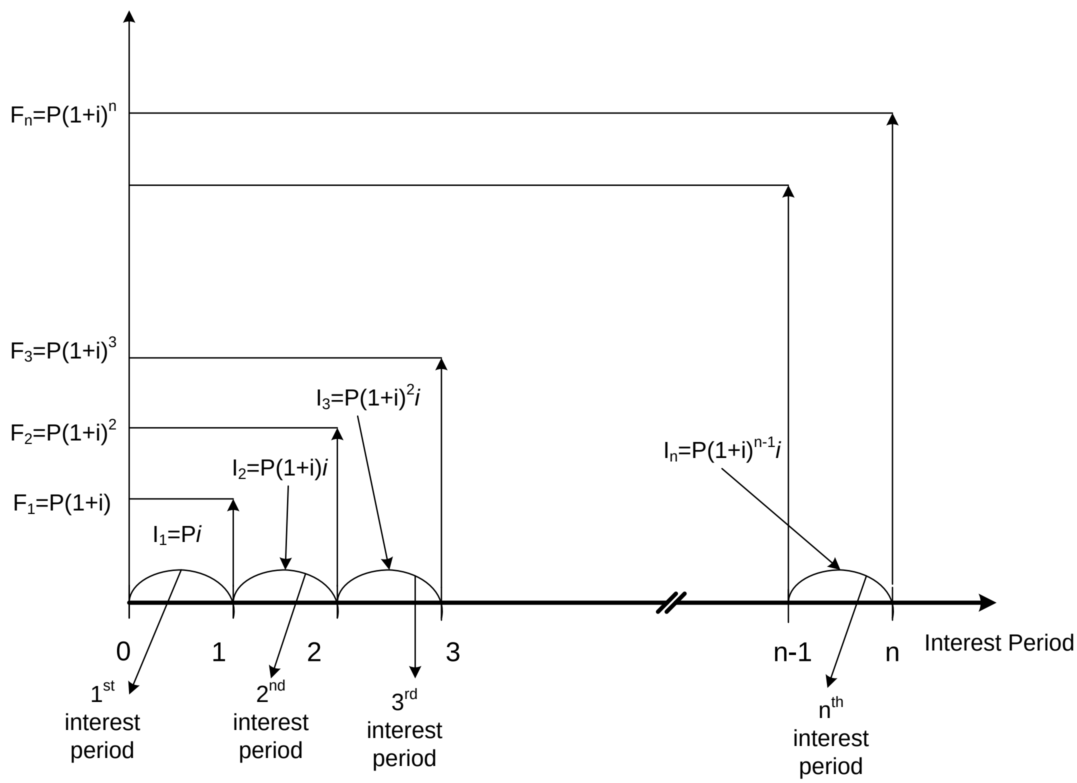


Figure: Diagram representing the accumulation of a principal based on compound interest

I_n = interest of interest period number n

$$I_n = P\left(1+i\right)^{n\text{-}1} i$$

F_n = accumulated amount after n interest periods

$$F_n = P\left(1+i\right)^n$$

23. ECONOMIC EQUIVALENCE

Economic Equivalence is the Equality in terms of Economic Value

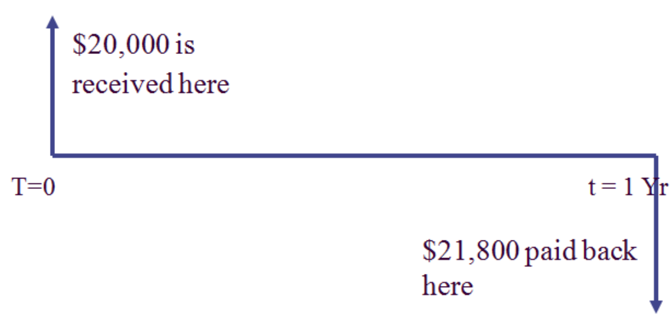
Two sums of money at two different points in time can be made economically equivalent if we consider an interest rate and No. of time periods between the two sums

The time value of money changes according to:

1. The interest rate,
2. The amount of money involved,
3. The timing of receipt or payment,
4. The manner in which interest is compounded

24. PRINCIPLES OF EQUIVALENCE

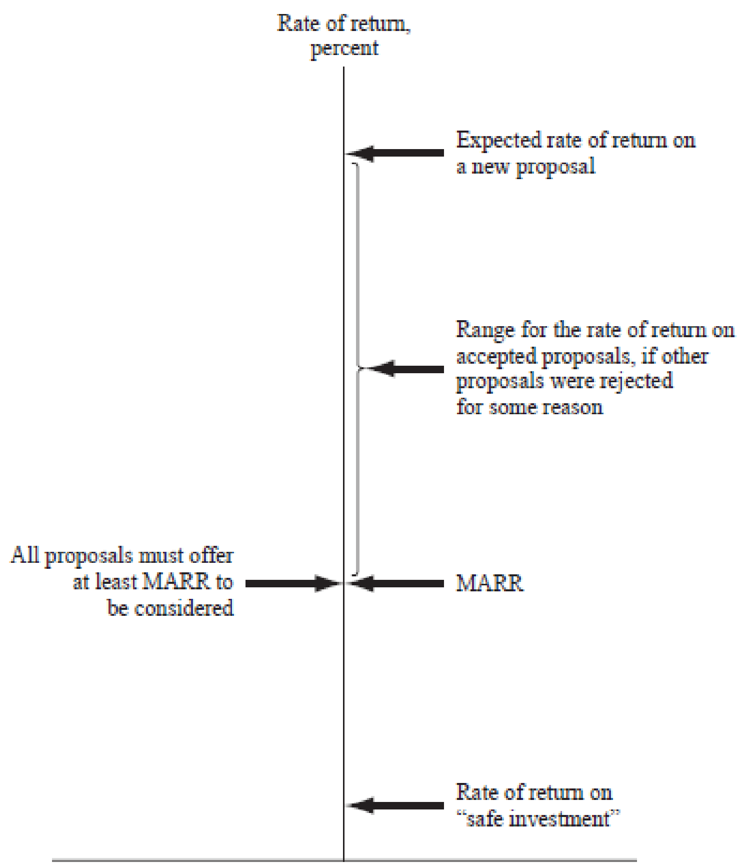
1. Equivalent cash flows have the same economic value at the same point in time.
2. Cash flows that are equivalent at one point in time are equivalent at any point in time.
3. Conversion of a cash flow to its equivalent, at another point in time must reflect the interest rate(s) in effect for each period between the equivalent cash flows.



$20,000 now is economically equivalent to $21,800 one year from now if the interest rate is set to equal 9%/year

25. MINIMUM ATTRACTIVE RATE OF RETURN (MARR)

The Minimum Attractive Rate of Return (MARR) is a reasonable rate of return established for the evaluation and selection of alternatives. A project is not economically viable unless it is expected to return at least the MARR. MARR is also referred to as the hurdle rate, cutoff rate, benchmark rate, and minimum acceptable rate of return.



- A firm's financial managers set a minimum interest rate that that all accepted projects must meet or exceed.
- The rate, once established by the firm is termed the Minimum Attractive Rate of Return (MARR).
- The MARR is used as a criterion against which an alternative's ROR is measured, when making the accept/reject investment decision.

It always costs money in the form of interest to raise capital. The interest, expressed as a percentage rate per year, is called the cost of capital. As an example on a personal level, if you want to purchase a new widescreen HDTV, but do not have sufficient money (capital), you could obtain a bank loan for, say, a cost of capital of 9% per year and pay for the TV in cash now. Alternatively, you might choose to use your credit card and pay off the balance on a monthly basis. This approach will probably cost you at least 15% per year. Or, you could use funds from your savings account that earns 5% per year and pay cash. This approach means that you also forgo future returns from these funds. The 9%, 15%, and 5% rates are your cost of capital estimates to raise the capital for the system by different methods of capital financing. In analogous ways, corporations estimate the cost of capital from different sources to raise funds for engineering projects and other types of projects.

In general, capital is developed in two ways—equity financing and debt financing. A combination of these two is very common for most projects.

Equity financing: The corporation uses its own funds from cash on hand, stock sales, or retained earnings. Individuals can use their own cash, savings, or investments.

Debt financing: The corporation borrows from outside sources and repays the principal and interest according to some schedule. Sources of debt capital may be bonds, loans, mortgages, venture capital pools, and many others. Individuals, too, can utilize debt sources, such as the credit card and bank option.

Combinations of debt-equity financing mean that a weighted **average cost of capital (WACC)** results. If the HDTV is purchased with 40% credit card money at 15% per year and 60% savings account funds earning 5% per year, the weighted average cost of capital is

$0.4(15) + 0.6(5) = 9\%$ per year.

For a corporation, the established MARR used as a criterion to accept or reject an investment alternative will usually be equal to or higher than the WACC that the corporation must bear to obtain the necessary capital funds.

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

The above inequality must be correct for an accepted project. Exceptions may be government-regulated requirements (safety, security, environmental, legal, etc.), economically lucrative ventures expected to lead to other opportunities, etc.