Industrial Management and Engineering Economics

Chapter Six

Investment Evaluation

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Engineering Economy

- Investment evaluation is conducted by the aid of Engineering Economy. Hence,
- Engineering economy is a collection of techniques that simplify comparisons of alternatives on an economic basis (or in relation to their costs).
- The alternatives usually involve such items as:
  - ✓ Purchase cost (first cost)
  - ✓ Anticipated useful life
  - ✓ Yearly costs of maintenance
  - ✓ Operating costs
  - ✓ Anticipated resale value (salvage value) and
  - ✓ The interest rate.

Cont.…

- After collecting all the facts and relevant estimates, an engineering economy analysis can be conducted to determine which is best alternative from an economic point of view.
- Engineering economy **is not** a method or process for determining what the alternatives are. On the contrary, engineering economy begins only after the alternatives have been identified.

Why Engineering Economy is Important to Engineers

- Often engineers must select and implement from multiple alternatives (e.g. Designing involves economic decisions).
  - To determine which engineering projects are worthwhile, engineers must be able to conduct a proper economic analysis for selection and execution of a fundamental task of engineering.

Concerns in Engineering Economics

(Investment evaluation techniques)

- ❖ Time value of money
- ❖ Cost comparison of alternation methods
- ❖ Depreciation
- ❖ Economic analysis of industrial operations

Finance Evaluation

1. 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).
- The time value of money is the most important concept in engineering economy.

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

Basic Concepts and Definitions

Money has the capacity to generate more money.

- ☑ If a given sum of money is deposited in a savings account; **it earns interest.**
- ☑ If it is used to start a business**, it earns profit**
- ☑ If it is used to purchase a share in a business, **it earns dividends**.
- ☑ If it is used to purchase an office building or apartment house, **it earns rent.**

- Thus, the original sum of money expands as time elapses through the accretion of these periodic earnings.

- **Interest –** the expression of the time value of money
  - The money earned by the original sum 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**: the time rate at which a sum of money earns interest (it is usually expressed in percentage form).

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

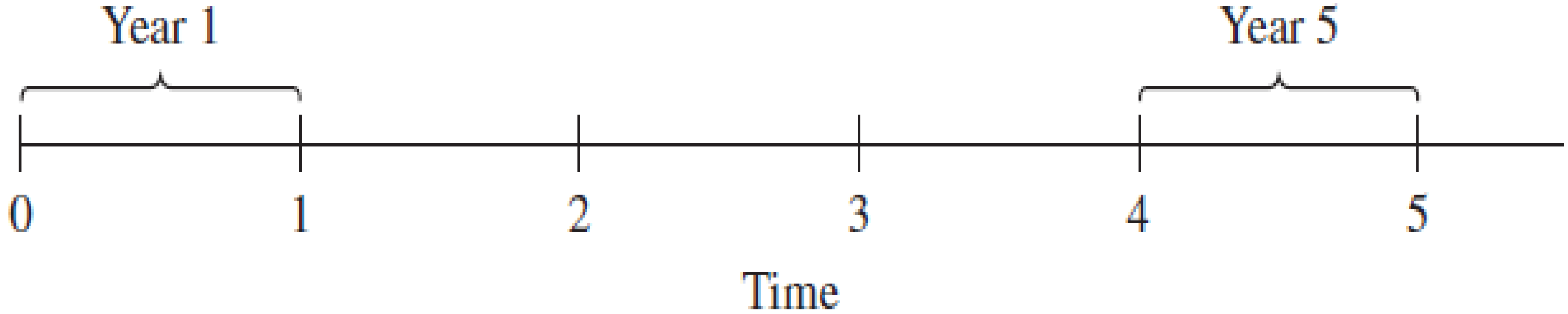
- ✓ **Investment**: the productive use of money to earn interest.
- ✓ **Capital**: the money that earns interest.
- ✓ **“”The interest earned by the original capital can itself be invested to earn interest, and this process can be continued indefinitely. “”**
- ✓ This capacity of money to enlarge itself with the passage of time is referred to as the time value of money.

Cash Flow and Cash-Flow Diagrams

- ✓ Cash flow is nothing but the set of payments associated with an investment; and cash flow diagram is a diagram that shows these payments.
- ✓ In the cash flow diagram:
  - Time is plotted on a horizontal axis
  - The payments are represented by vertical bars
  - The amount of each payment is recorded directly above or below the bar representing it.
  - The bars are generally not drawn to scale

Cash Flow diagrams (CFD)

- The costs and benefits of engineering projects over time are summarized on a cash flow diagram (CFD).
- 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.



E.g. assume that a project has the following cash flow:

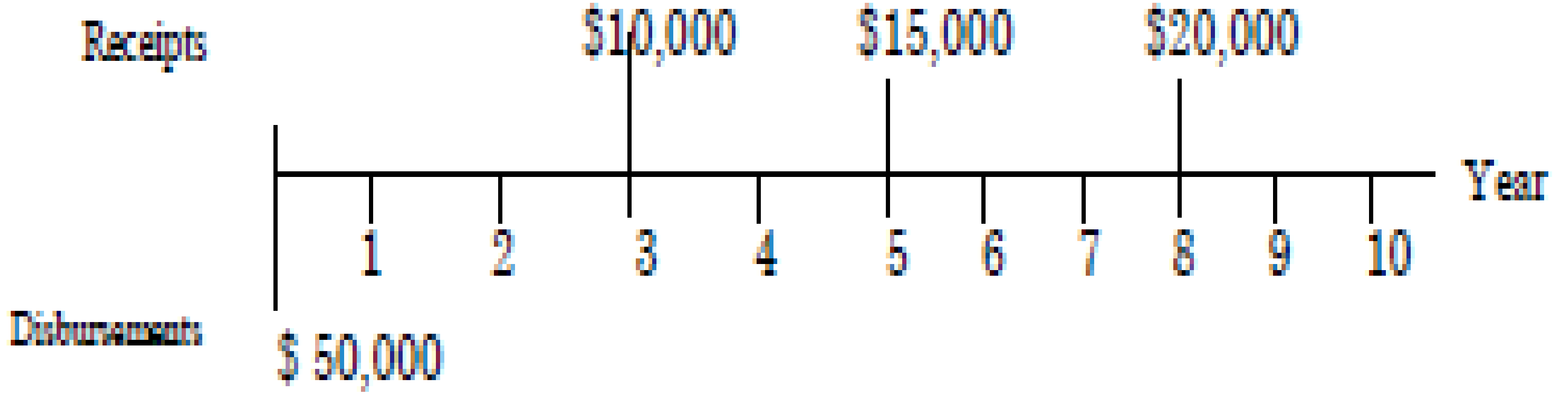
1) a disbursement of $ 50,000 now

2) a receipt of $ 10,000 after three years

3) a receipt of $ 15,000 after five years and

4) a receipt of $ 20,000 eight years hence

Taking the unit of time one year, the cash flow diagram is represented as in fig



Categories of Cash Flows

- The expenses and receipts due to engineering projects usually fall into one of the following categories:
  - **First 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 (can be a salvage cost)
  - **Revenues:** annual receipts due to sale of products or services

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:

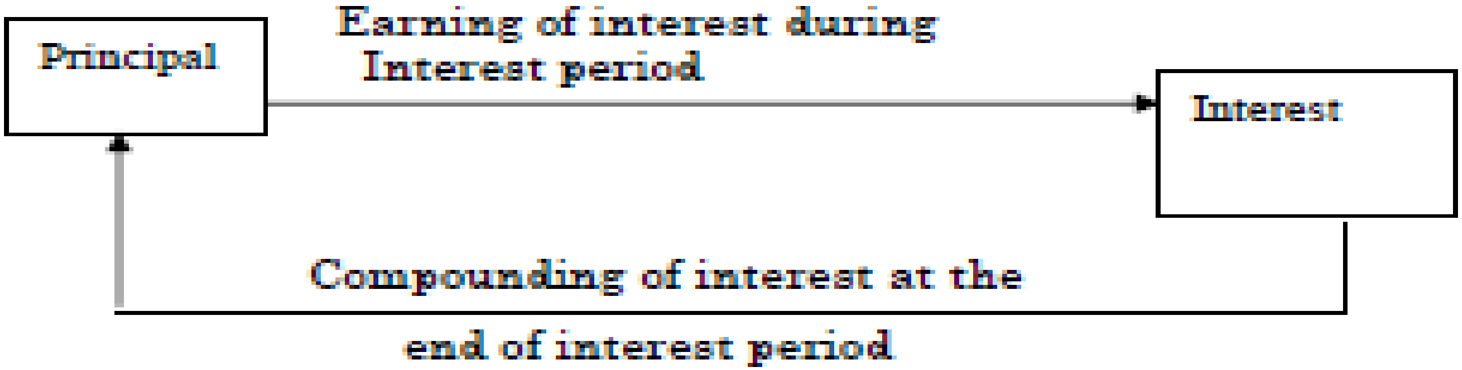
  NCF = cash inflows – cash outflows = R – D

- End-of-period assumption:

  Funds flow at the end of a given interest period

Basic Relationship between Money & Time

- The sum of money that is earning interest at a given instant is known as **the principal in the account**.
- The interest that has been earned up to date is converted to principal there by causing it to earn interest.
- This process of converting interest to principal is referred to as the **compounding of interest;** it represents an investment of the interest in the same investment.



E.g. At the beginning of a particular year, the sum of $10,000 was deposited in a savings account that earned interest of 10% per annum. The growth of this sum during a three-year period is explained as follows:

- During the first year, the principal is $10,000, and the interest earned by the end of that year is 10,000(0.10) = $1,000
- At that time, the interest is compounded, there by increasing the principal to 10,000 + 1,000 = $11,000.
- The interest earned by the end of the second year is 11,000(0.10) = $1,100
- At that time, this interest is compounded, there by increasing the principal to 11,000 + 1,100 = $12,100
- The interest earned by the end of the third year is 12,100(0.10) = $1,210
- At that time, this interest is compounded, there by increasing the principal to 12,100 + 1,210 = $13,310

In general, let

P = sum deposited in savings account at the beginning of an interest period

F = Principal in account at expiation of n interest periods

i = interest rate

The principal at the end of the first period is P + Pi = P (1+i)

The principal at the end of the 2^{nd} period is P (1+i) + P (1+i)

= P (1+i) (1+i) = P (1+i)^2

The principal at the end of the 3^{rd} period is

= P (1+i) (1+i) + P (1+i) (1+i) i

= P (1+i) (1+i) (1+i) = P(1+i)^3

From this we conclude that the principal is multiplied by the factor (1+i) during each period.

Therefore, the principal at the end of the n^{th} period is

$$\mathbf{F = P\,(1 + \boldsymbol{i})^{n}}$$

- Simple Interest

Interest is calculated using principal only

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

$I = P*n*i$

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

- **Example 1**: If \$ 5,000 is invested at an interest rate of 10% per annum, what will be the value of this sum of money at the end of 2 years?

Soln.

Given: P = \$5,000, n = 2, i = 0.10

$$\mathbf{F = P\,(1 + i)^n = 5000(1 + 0.1)^2}$$

$$\mathbf{= 5000\,(1.1)^2}$$

$$\mathbf{= \$6{,}050}$$

Hence, the value of money at the end of 2 years will be \$6,050.

- 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

$$\mathbf{I_t = \left(p + \sum_{j=1}^{j-t-1} I_j\right)(i)}$$

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

Notation for Compound Interest Factors

- We shall define and apply several compound-interest factors. Each factor will be represented symbolically in the following general format:
- (A/B, n, i)
  - A & B denoted two sums of money
  - A/B denotes the ratio of A to B
  - n denotes the number of interest periods
  - i denotes the interest rate
- For brevity the interest rate can be omitted, and the expression will be given simply as (A/B, n)

Calculations of Future Worth, Present Worth, Interest Rate, and Required Investment Duration

- $\mathbf{F = P\,(1+i)^n}$ ….. ……………………………………(A)
- P is referred to as the present worth of the given sum of money
- F is referred to as the future worth of the given sum of money
- The terms "present" and "future" are applied in a purely relative sense as a means of distinguishing between the beginning and end of the time interval consisting of n periods.
- The factor $\mathbf{(1+i)^n}$ is termed as the **single-payment future-worth** factor. Conventionally, we introduce the following notation.

  (F/P, n, i) = (1+i) n……………………………………………………(B)
- Thus, eqn (A) can be rewritten as

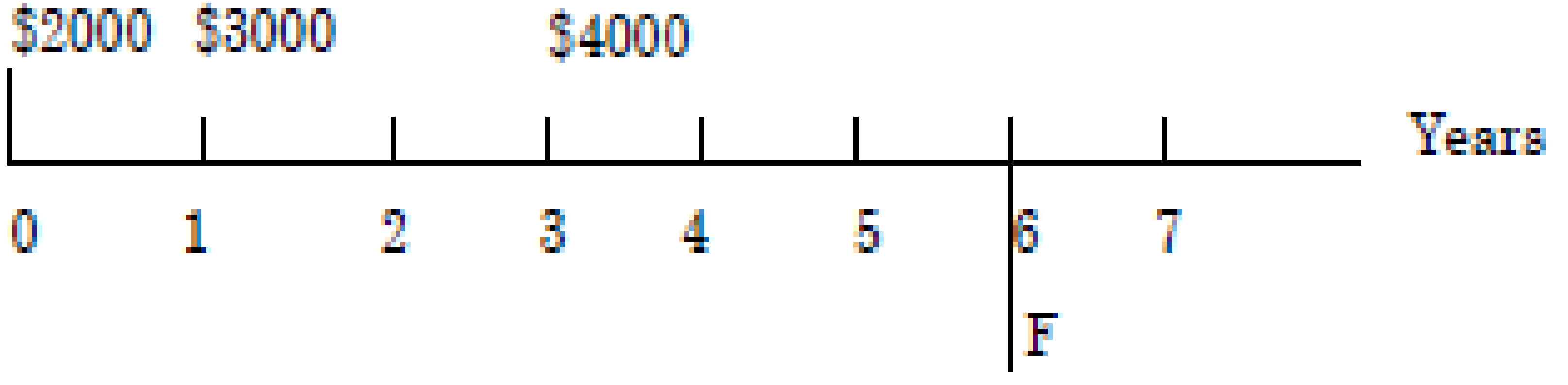
  F = P (F/P, n, i)………………………………………………………(C)

Similarly $P=F(1+i)^{-n}$

Example 2: Smith loaned for Jones, the sum of $2,000 at the beginning of year 1, $3,000 at the beginning of year 2 and $4,000 at the beginning of year 4. The loans are to be discharged by a single payment made at the end of year 6. If the interest rate of the loans is 6% per annum, what sum must Jones pay?

Soln:

- Refer to figure below. To maintain consistency and there by simplify the calculation of time intervals, convert the date of payment to the beginning of year 7.



Solution: by using the formula $F = P\,(F/P, n, i)$

$$F = 2000\,(F/P, 6, 6\%) + 3000\,(F/P, 5,6\%) + 4,000\,(F/P, 3, 6\%)$$

$$= 2000(1+0.06)^6 + 3000(1+0.06)^5 + 4000(1+0.06)^3$$

$$= 2000\,(1.41852) + 3000\,(1.33823) + 4000\,(1.19102)$$

= $**11,616**

Example 3: If $5000 is deposited in an account earning interest at 8% per year compound quarterly, what will be the principal at the end of 6 years?

Solution

$p = \$\,5000 \qquad n = 6 \times 4 = 24$

$$\text{True interest rate} = \frac{\text{nominal rate}}{\text{the no of interest periods contained 1 year}}$$

$$= 8\%/4 = 2\%$$

$$F = 5000\,(F/P, 24, 2\%)$$

$$= 5000\,(1.60844) = \$\,8,042$$

Economic Equivalence

- ✓ Economic equivalence means that different sums of money at different times would be equal in economic value.
- ✓ Relative attractiveness of different alternatives can be judged by using the technique of equivalence.
- ✓ For example, if the interest rate is 6% *per year*, $100 today (present time) is equivalent to $106 one year from today.

$$\text{Amount in one year} = 100 + 100(0.06) = 100(1 + 0.06) = \$106$$

Example of Equivalence

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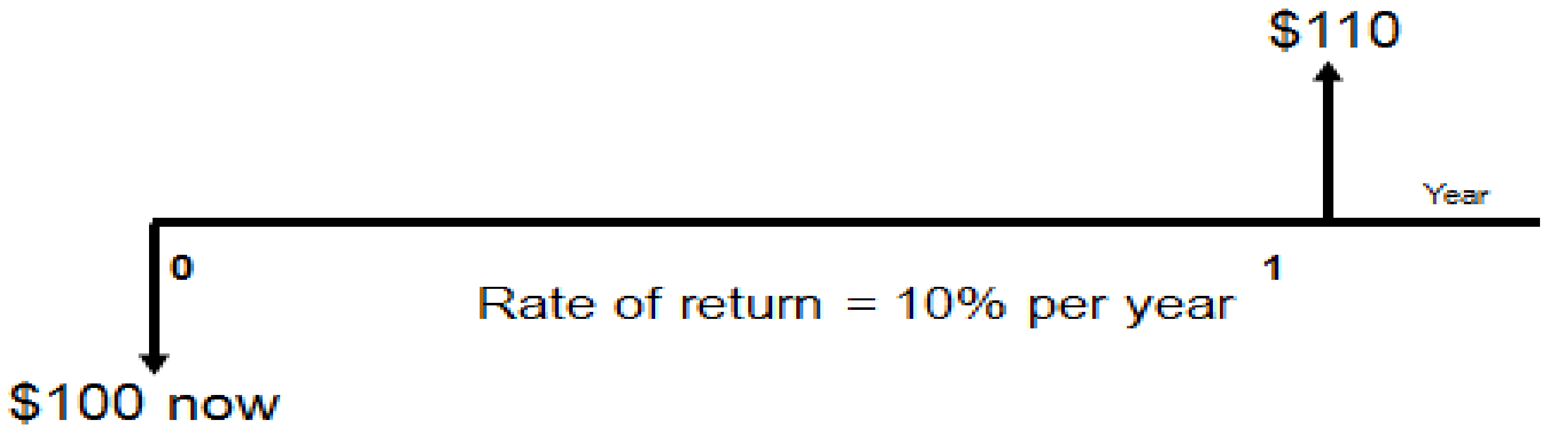


- **$100 now is economically equivalent to $110 one year from now, if the $100 is invested at a rate of 10% per year.**

Cost Comparison of Alternative Methods

- Every need that arises in our industrial society can be satisfied in multiple ways.
- For example, there are alternative manufacturing processes for producing a commodity.
- Consequently, the engineering economist has the task of identifying the most desirable way of satisfying each need that arises.
- As the name implied the alternative methods differ solely with respect to cost but are alike with respect to income, serviceability, general convenience, etc.

Selection of Interest Rate

- The first problem in a cost comparison of alternative methods is to select the interest rate on which the calculations are to be based.

- We assume that all savings that accrue from using one method in preference to the others are invested at the same interest rate, and it is the rate to be applied in the cost comparison.

Description of Simplified Model

- Our immediate objective is to formulate standard techniques of cost comparison.

- To avoid making our task prohibitively arduous, we shall construct a simplified model of the industrial world with the following characteristics:

All economical & technological conditions remain completely static, except where changes are expressly described.

As a result, interest rates and costs remain constant as time elapsed, and each asset is replaced with an exact duplicate when it is retired.

2) The future can be foreseen with certainty. Consequently, all forecasts and projections prove to be accurate in every respect.

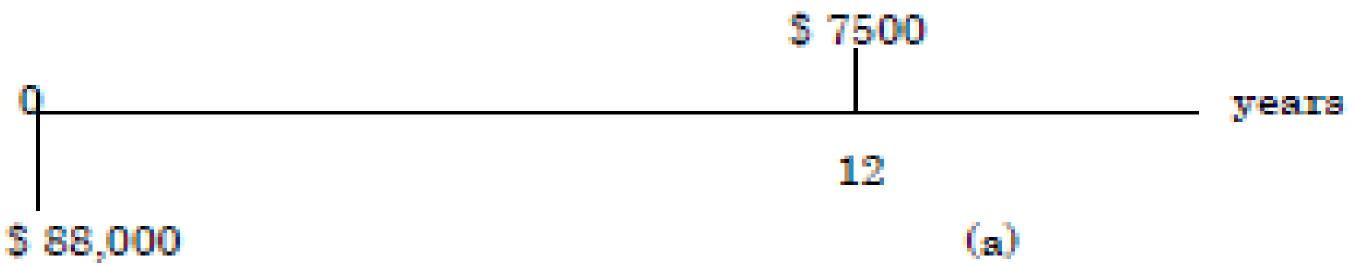
3) Interest is compounded annually

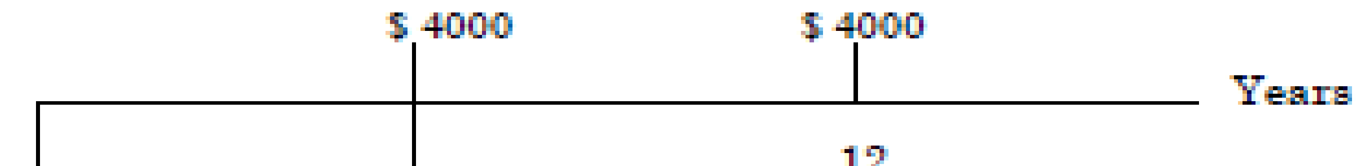
4) All disbursements and receipts associated with an asset occur at the beginning or end of a year.

There are several techniques of cost comparison, and we shall study each method in turn.

Example: Two types of equipment are available for performing a production process; the cost data associated with each type are recorded in the accompanying table. Applying an interest rate of 8%, determine which type is more economical.

	Type A	**Type B**
First cost, $	88,000	45,000
Salvage value, $	7,500	4,000
Annual maintenance, $	4,300	5,200
Life, years	12	6





This is because we take two lives of type B (we add another first cost@yr6 and salvage value @yr12) for 12yr evaluation date

PW_A = \$88,000+\$43,000(P_U/A,12)-\$75,000(P/F,12)

= \$88,000+\$43,000(7.53608)-\$75,000(0.39711)

= **\$117,430**

PW_B = \$45,000+(\$45,000-\$4,000)(P/F,6)+\$5,200(P_U/A,12)-\$4,000(P/F,12)

= \$45,000+\$41,000(0.63017)+\$5,200(7.53608)-\$4,000(0.39711)

= **\$108,440**

Hence, type B equipment is more economical.

Depreciation

Depreciation: the decline in the value of the asset.

Introductory points

- **Asset:** property that is acquired and exploited for monetary gain such as machines, vehicles, office building, planes, ships, boats, computers, etc.

- **First Cost of an Asset**: total expenditure required to place an asset in operating condition.
  - E.g. If an asset is purchased, it includes the purchase price related and all incidental expenses such as transportation, tax, telephone, assembly, expert advice, etc.

- **Salvage Value or Residual Value**: the price at which a fixed asset is expected to be sold at the end of its useful life.

- **Book Value**: the value of an asset displayed on the documents of the firm.
  - E.g. if the first cost of an asset is $20,000 and the depreciation charges to date total $14,000 the current book value is $6,000

Depreciation: the decline in the value of the asset.

As time elapses, every asset undergoes a progressive loss of value resulting from:

1) Physical factors: wear and tear, exposure to elements

2) Functional factors: technological change

In contrast to other business expenses, depreciations does not manifest itself in the form of cash transactions during the life of the asset, and consequently it is necessary to make an entry in the books of the firm at the close of each accounting period, for two reasons:

1) to record the depreciation that occurred during that period, and there by permit a true determination of the earnings for that period

2) to display the current value of the asset.

This entry is known as a depreciation charge, and the process of entering depreciation charges is known as writing-off the asset.

Tax Effects of Depreciation

- Since depreciation is a recognized business expense, it reduces the taxes the firm is required to pay.

- Thus, every depreciation charge creates a tax savings for that year, and amount of the savings is the function of the amount of the depreciation charge and the rate at which the firm's profits are taxed.

Depreciation Allocation Methods

The notational system for depreciation is as follows

- Bo = first cost of asset
- Br = book value of asset at the end of rth year
- L = estimated salvage value
- Dr = depreciation charge for rth year
- n = estimated life span of asset, years

Depreciation computation methods

i. Straight Line Method

- It is the simplest method of depreciation.
- It is almost rough estimate.
- It has the disadvantage of yielding a slow write-off of the asset.
- It assumes as the total depreciation cost to be assigned uniformly over the life of the asset.

$$Dc = \frac{B_o - L}{n}$$

Example 1: A machine costing $15,000 has an estimated life span of **8** years and an estimated salvage value of $3000. Compute the annual depreciation charge and the book value of the machine at the end of each year under the straight line depreciation method.

Given: Bo = $15,000, L = $3000 & n = 8 years

- Hence, $\mathbf{D} = \frac{B_o - L}{n} = \frac{\$15{,}000 - \$3{,}000}{8} = \$1500$, annual depreciation charge
- B1 = Bo - D

  = 15,000 – 1,500 = $13,500
- B2 = B1 –D = 15,000 – 1,500-1,500
- Bo –2D=$12,000

Bn = Bo - nD , book vale " at the end of each year"

- B3 = 15,000 – 3 x 1,500 = $10,500
- B4 = 15,000 – 4 x 1,500 = $9,000
- B5 = 15,000 – 5 x 1,500 = $7,500
- B6 = 15,000 – 6 x 1,500 = $6,000
- B7 = 15,000 – 7 x 1,500 = $4,500
- B8 = 15,000 – 8 x 1,500 = $3,000

ii. Accelerated-Cost-Recovery System (ACRS)

Ordinary Expenses: expense that has short-term effects such as wages paid to a machine operator, wages paid to laid off labourers.

Capital Expenses: expenses that has long-term effects such as the cost of purchasing land on which to build a new factory, etc.

The Characteristics of ACRS are as follows:

1. A newly acquired asset is assigned a cost-recovery period (as distinguished from an estimated service life), & the entire first cost of the asset can be written off during this period. Thus, salvage is ignored in calculating depreciation charges. The recovery period is 3, 5, 10, or 15 years, depending on the nature of the asset.
2. The firm is called to consider part of the first cost of a newly acquired asset as an ordinary expense incurred in the year of acquisition. This practice is known as first-year expensing (or simply expensing). Through first-year expensing, part of the cost of the asset is written off immediately.
3. The firm is granted an investment tax credit for a newly acquired asset.

Let,

Bo = first cost of the asset

E = amount of first-year expensing

I = Investment tax credit

M = depreciation basis of asset

The value of I is as follows:

- For an asset with a recovery period of 3 years 6 % (Bo –E)
- For an asset with a recovery period of 5 years or more, 10% (Bo – E)

- The tax credit is taken the year the asset is placed in service.
- However, if the credit exceeds a certain limit, the excess can be carried back to reduce the taxes for prior years or it can be carried forward to subsequent years.
- The depreciation basis of an asset is taken as:

$$M = Bo - E - 0.5I$$

- The depreciation charge for a given year is found by multiplying the depreciation basis by a prescribed factor.

Example 4: At the beginning of a certain year, a firm placed in service an asset having a first cost of $30,000 & recovery period of 5years. As this was the only asset acquired that year, the firm can assign the full expense allowance of $10,000 to this asset. Compute the deprecation charges using factors 0.15, 0.22, 0.21, 0.21, 0.21 for the 5 year period consecutively (a) with expensing (b) with out expensing.

- Solution Part a:

Given: Bo = $ 30,000, E = $10,000 & n = 5

For n = 5 years

I = 0.1 (Bo – E) = 0.1 (30,000 – 10,000) = $**2000**

M = Bo –E – 0.5I

M = 30,000 – 10,000 – 0.5 (2000) = **$19,000**

Cont…..

D1 = 19,000 (0.15) = $ 2850

D2 = 19,000 (0.22) = $ 4180

D3 = D4 = D5 = 19,000 (0.21) = $3950

Part b = I = 0.10 Bo = $3000

M = 30,000 – (0.5*3000) = **$28,500**

D1 = 28,500 (0.15) = $4275

D2 = 28,500 (0.22) = $6270

D3 = D4 = D5 = 28,500 (0.21) = $5985

iii. Units of Production Method

- If deterioration of an asset is primarily of exploitation rather than obsolescence, we have to use production volume as the base of depreciation charge.
- Moreover, if the asset is a machine that is used to produce a standard commodity, the magnitude of its use can be measured by the number of units it produces.
    - The depreciation charge/unit of production

$$Dc = \frac{Bo - L}{\text{Units produced by the asset}}$$

- Depreciation charges for consecutive years are allocated by multiplying the volume of production by this unit charge.

- N.B Depreciation can be allocated on the basis of profitability rather than production alone.
- Assume that the net profit per unit of production declines as the asset ages. Each unit can be assigned a weight proportional to its net profit, and the depreciation charges are then calculated on the basis of these weighted units, which are termed depreciation units.

Example: 5 A machine with a first cost of $76,000 will be used to produce 8000units of a standard commodity. Production will be distributed over a **6 year period**, and the number of units produced per year is expected to be as follows: 1st year, 1100; 2nd year, 2100; 3rd year, 1800; 4th year, 1200; 5th year, 1000; 6th year, 800. The machine will be scraped at the end of six years, and its salvage value is estimated to be $4,000. Depreciation will be allocated on the basis of profitability of production, and the units are considered to have the following relative values of profitability: first 2,000units, 1.20; next 2,000units, 1.15; next 3,000units, 1.10; last 1,000units, 1.00. Compute the depreciation charges.

- The depreciation charge/unit of production

$$D = \frac{Bo - L}{\text{Units produced by the asset}}$$

= 76000-4000/8000

= 9 depreciation charge /unit volume

D1=9 depreciation charge/unit volume * 1,100 unit volume

D1 = 9900

B1 = Bo-D1=76,000-9,900=66,100

D2 = 9*2,100=18,900

B2 = 66,100-18,900=47,200

D3 =

D4 =

D5 = 9*1,000=9,000

B5 = 20,200-9,000=11,200

D6 = 9*800=7200

B6 = 11,200-7,200=4,000

Thank you!!!