Department of Humanities

Sub: Engineering Economics and Costing (BHU1302) (4-0-0)

Syllabus

Module I   **(10 Hours)**
Time value of money : Simple and compound interest, Time value equivalence, Compound interest factors, Cash flow diagrams, Calculation, Calculation of time óvalue equivalences.
Present worth comparisons, Comparisons of assets with equal, unequal and infite lives, comparison of deferred investments, Future worth comparison, pay back period comparison.

Module II   **(10 Hours)**
Use and situations for equivalent annual worth comparison, Comparison of assets of equal and unequal life. Rate of return, Internal rate of return, comparison of IIR with other methods, IRR misconceptions. Analysis of public Projects: Benefit/ Cost analysis, quantification of project, cost and benefits, benefit/ cost applications, Cost óeffectiveness analysis.

Module III   **(10 Hours)**
Depreciation, Computing depreciation charges, after tax economic comparison, Break-even analysis; linear and non-linear models. Sensitivity analysis: single and multiple parameter sensitivity.

Module IV   **(12 Hours)**
Fixed and variable cost, Product and Process Costing, Standard Costing, Cost estimation, Relevant Cost for decision making, Cost estimation, Cost control and Cost reduction techniques.

Text Book
1. Horn green, C.T., Cost Accounting, Prentice Hall of India
2. Riggs, J.L ., Dedworth, Bedworth, D.B, Randhawa, S.U. Engineering Economics, McGraw Hill International Edition, 1996 (Chapter 2,3,4,5,7,8,9,11,12)

Disclaimer

This document does not claim any originality and cannot be used as a substitute of textbooks. This is just to help students to go through in advance of their lecture class.

Module-I

1 Defining Time Value of Money

It is a mechanics which involve the *compound interest factors* to express cash flows (payments) occurring at different times to a single equivalent payment. Let's understand interest rates and its types which would be helpful in understanding compound interest factors.

1.1 Interest rate and types of interest rate

Interest rate is said to be the earning power of money. Because of interest rate and time factor, the numerical value of money (not purchasing power) multiplies over a period of time. Interest is the cost of using capital as well as the reward of parting with one's liquidity (saved money).

We are acquainted with two types of interest rates so far, i.e., simple interest rate[1] and compound interest rate. Apart from these two interest rates, some other interest rates which are used in economic evaluation of projects are: nominal interest rate, effective interest rate, and continuous effective interest rate.

When we are asked with interest rate, it is generally understood that these interest rates are charged annually. But sometimes, interest rates are charged periodically, and then it becomes a case of nominal interest rate.

Nominal interest rate is an annual interest rate which is a product of interest rate per period and number of periods in a year.

Effective interest rate (i_{eff}) is the ratio of interest to principal amount. It is used to have comparison between investments.

$$i_{eff} = F\text{-}P/P = I/P$$

When interest rate is nominal one, then $i_{eff} = \left(1 + \frac{r}{m}\right)^m - 1$

When m $\to \infty$, this effective interest rate becomes a continuous one.

$$\text{Lim}_{m \to \infty} i_{eff} = \lim_{m \to \infty} \left(1 + \frac{r}{m}\right)^m - 1$$

$$= e^r - 1 \text{ is known as continuous effective interest rate}$$

Compound interest factors are the use of different compound interests, when multiplied by a single sum or multiple series to produce an equivalent sum or series.

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[1] Simple interest rate may be exact or ordinary. In Exact simple interest, time period is based on calendar dates, whereas in ordinary simple interest general time period is taken into account.

2 Cash Flow Diagrams

Cash flow diagrams are graphical representation of cash flows (inflows and out flows) along a time line. Individual inflows or outflows are designated by vertical lines and relative magnitude can be represented by the heights of lines. Cash inflows are designated by vertical lines above the axis and cash outflows below the time line axis. Inflows take a positive sign whereas outflows take negative sign. Cash flow diagrams involve magnitude and direction fulfilling the properties of flow.

2.1 Cash flow transactions

Cash flow transactions are of five types, Viz.
 i) Single cash flow
 ii) Uniform series
 iii) Linear Gradient series
 iv) Geometric gradient series
 v) Irregular series
Letøs discuss each of the above cash flow transactions.

Single payment cash flow: It involves a single present or future cash flow. The diagram of this is given below.

$$\text{F (inflow)}$$

$$0 \quad \text{time line} \quad \longrightarrow \quad n$$
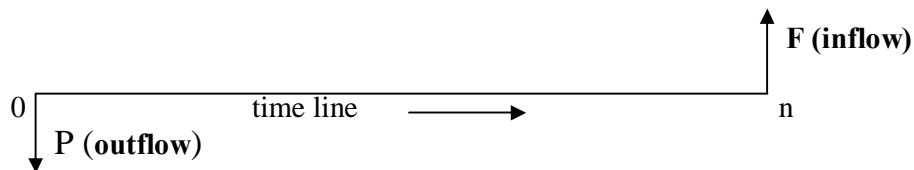
$$P \text{ (outflow)}$$

In this diagram there is single cash out flow (P) which occurs at ÷0ø time and Cash inflow of (F), which occurs at n^{th} time.

*Uniform series:* Here cash flows involve a series of equal amounts occurring at equal interval of time. It is also known as annuity.

Annuity cash flow

$$0 \quad 1 \quad 2 \quad 3 \quad 4 \quad n$$

Time line $\longrightarrow$
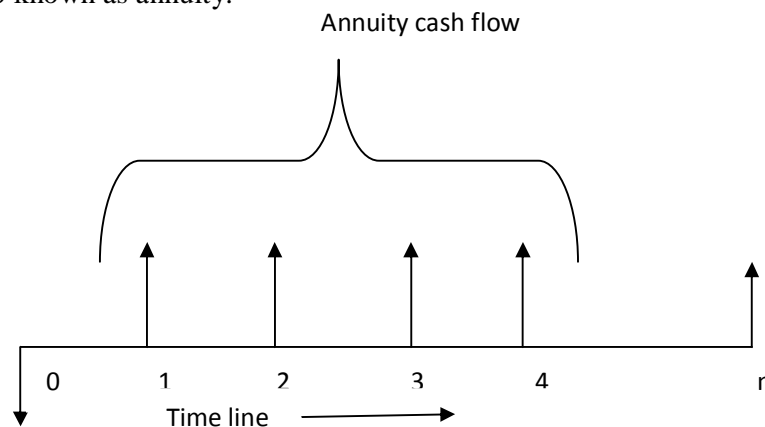
Linear Gradient series: It is a series of cash flows displaying properties of arithmetic progression series. So the cash flow increases or decreases by a fixed amount.

A+ (n-1) G

A+3G

A+2G

A+G

A

0   1   2   3   4   n
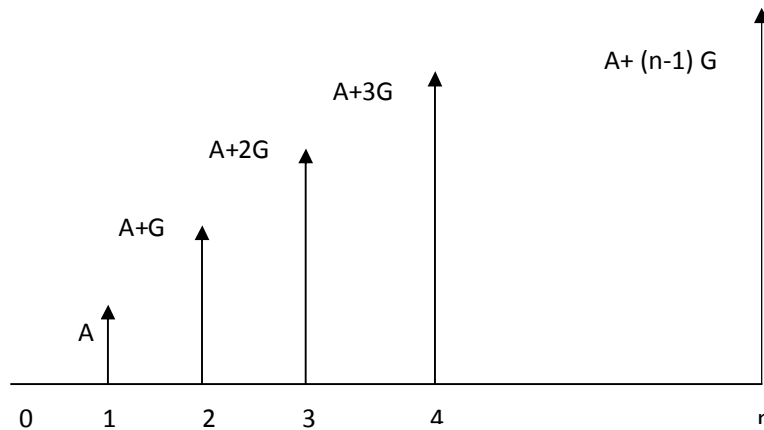
Geometric Gradient series: It is a series of cash flows displaying properties of geometric progression series. So the cash flow increases or decreases by a fixed ratio (or percentage).

Ag^{n-1}

Ag^3

Ag^2

Ag

A

0
1   2   3   4   n
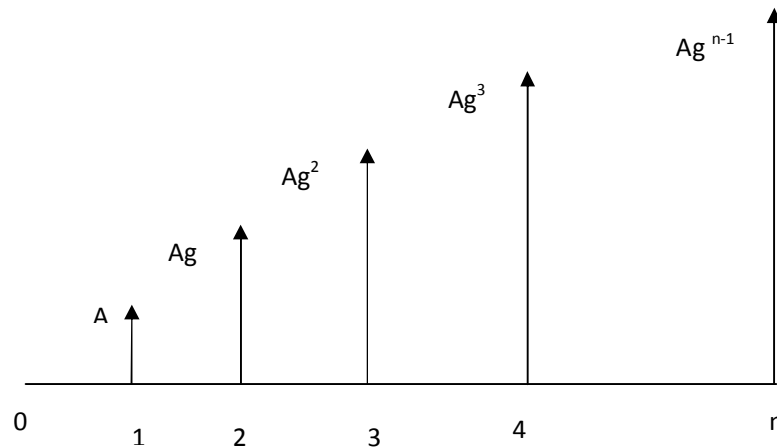
Irregular payment series: When the cash flows do not display any regular overall pattern over time, the series is known as Irregular payment series.

2.2   Compound Interest Factors

Compound interest factor is that factor when multiplied by a single amount or uniform series gives an equivalent amount at compound interest. There are eight types of compound interest factors. Let's discuss one by one.

a) *Single payment compound amount factor*: Here given Future amount 'F', it is needed to find out 'P' amount. It means F is converted to P amount by help of rate of interest 'i' and time period 'n'. The notation used for this conversion is (F/P,i,n)

$$F = P \ (F/P, i, n) = P \ (1+i)^n$$

b) *Single payment present worth factor*: To find the present worth of a future amount, this factor is used. The notation for this is (P/F, i, n)

$$P = F \ (P/F, i, n) = F \ (1+i)^{-n}$$

C) *Equal payment series compound amount factor*: Given annuity amount, it is needed to find out F amount.

$$F= A (F/A, i, n) = A [(1+i)^n-1]/i$$

d) *Equal payment series sinking fund factor:* In this case given a fund F which needs to be filled up (sank) in terms of annuity (A) amount.

$$A= F (A/F, i, n) = F [i/ (1+i)^n-1]$$

e) *Equal payment series present worth factor*: Given A, i, n, we need to find P amount.
$$P= A (P/A, i, n) = A [(1+i)^n-1]/[i(1+i)^n]$$

f) *Equal payment series capital recovery factor*: Given P, i, n, we need to find equivalent annual amount A.
$$A= P (A/P, i, n) = P [i(1+i)^n]/ [(1+i)^n-1]$$

g) *Linear gradient series annual equivalent amount factor*: If the first amount is A_1 at the end of the first year and the gradient amount is G (equal increment), then annual equivalent amount will be found out.
$$A= A_1 + G (A/G, i, n)$$
$$A_1 + G [(1+i)^n-in-1]/ [i (1+i)^n-i]$$

h) *Geometric gradient series Present amount factor*:
If the first amount is A_1 at the end of the first year, and the geometric gradient g, i, n are given, then we can find out the present worth of these cash flows.
$$P= \{A_1 (P/ A_1, g, i, n)\}$$
$$= A_1 \{1-(1+g)^n (1+i)^{-n}\} \qquad [\text{if } i\pm g]$$
$$= n A_1/ (1+i) \qquad [\text{if } i=g]$$

2.3   Time-Value equivalence

Time value equivalence is based on equivalent numerical value not equivalent purchasing power. If two cash flows can produce same effects, then it is said that there is an equivalence existing between these two cash flows. For example, we can say that INR 1000 is equivalent to INR 1210 after two years at a rate of interest 10% per annum.

2.4   Calculation of Time Value equivalence

The objective of equivalence calculation is given below:

  i) To compare among alternatives and chose the best one.

  ii) To find out the equivalent amount of any single as well as cash flow series.

  iii) For economic evaluation of projects.

Equivalence calculation may be of two types. Viz.

  a) Involving a single factor

  b) Involving cash flow series

3.   Present worth comparisons

3.1 Why present worth comparisons?

Comparisons of assets or investment projects are necessary in order to select the best among the alternatives, i.e., to accept one and reject others. When these alternatives are mutually

exclusive in nature, comparisons need to be taken into account a particular point of time, i.e., at current or base period as the reference year. Moreover, as the value of any currency keeps on changing over time, comparisons cannot be made across time unless the value of the projects is transferred into a particular time. Letøs take an example: An invested amount of INR 10, 00000 in the year 2014 cannot be compared with 10, 00000 in the year 2011 as both the investment occurred in two different times. These two amounts need to be transferred to the same time for comparison purpose.

3.2   What is present worth method?

In present worth method, cash flows of each of the projects occurring in different time are converted to ÷zero timeø (base period), by the help of rate of interest and time factor, which is known as ÷discount rateø The best alternative project is selected by comparing the present worth amounts of alternatives. Two deciding factors govern in choosing alternatives, viz. minimisation of cost (use of least present worth) and maximisation of profit (maximum present value).

For present worth comparison method, the following *assumptions*[2] need to be taken. Viz.,
   a) All cash flows (inflows as well as out flows should be known
   b) Time and rate of interest is to be given
   c) Constant time value of money
   d) Before tax cash flows are to be taken for comparison
   e) No intangible factors are to be taken
   f) Comparisons should not include considerations of the availability of funds to implement projects or engineering alternatives

3.2.1 Basis of cash flows and calculation of Present worth method

Present worth calculation depend on the nature of cash flows, i.e., whether the cash flows are cost-dominated cash flow stream or revenue-dominated cash flows stream. If majority of cash flows from a project are inflows, then the said cash flow stream is known to be revenue-dominated and if majority of cash flows are costs, then cash flow stream is known to be cost-dominated cash flow. In case of revenue ódominated cash flows, all the inflows take a positive sign and all the out flows take a negative sign. But the reverse happens in case of cost- dominated cash flow stream.

Letøs take that the cash flows of X project are given, P is the initial investment, R1, R2, R3, R4, R6 are the cash inflows for respective years and C5 is the additional investment amount in year 5. Now letøs find the present worth amount of project X

Year ➙ Project ↓	0	1	2	3	4	5	6
X	P	R1	R2	R3	R4	C5	R6

The above cash flows are an example of revenue- dominated cash flow. Therefore,

$Pw (X)_i = -P + R_1/(1+i)^1 + R_2/(1+i)^2 + R_3/(1+i)^3 + R_4/(1+i)^4 ó C_5/(1+i)^5 + R_6/(1+i)^6$

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[2] See Riggs, Bedworth and Randhawa (2004), p. 80-81.

3.3 Applications of Present worth Comparison Method

Present worth method can be applicable to the following four different cases. Viz.

Case: 1   Comparison of assets/projects that have equal lives (Co-terminated assets)
If the projects are having equal lives, the best alternative can be chosen by the help of Present worth method. Letøs take there are two alternative projects X and Y and both can continue for 4 years having different cash flows. In this case equal payment series present worth factor (P/A, i, n) can be applied. If Pw(X)> Pw (Y), then X project should be preferred.

Case: 2   Comparison of assets/projects that have unequal lives
In case of projects having unequal lives, two techniques can be applied, i.e., Common multiple method and a definite Study- period method. In case of common-multiple method, LCM of unequal lives of the projects are taken and it is tried to find how many times a particular project can repeat (replace) itself. The number o f times a particular project can replace itself is calculated by the ratio of LCM and the individual life of projects. That is why this method is also known as Repeated project method. After finding out the repetition times of projects, then only present worth method can be applied. Whereas in case of a Study period method, a definite period of analysis is taken into account irrespective of the individual longevity of the alternative projects. Therefore, in a study period method, projects always have salvage value[3].

Case: 3   Comparison of assets/projects that have infinite lives
Generally we doubt on the infiniteness longevity of project, but this infinite lives is only meant for long-lived assets like dams, fly-overs, tunnels, railway tracks etc. which can continue to render service beyond generations (that means here lives of projects (n) tend to infinite). For these examples Capitalised cost is calculated for comparisons of alternatives. According to Riggs, Bedworth and Randhawa (2004:90), Capitalised cost is õthe sum of the first cost and the present worth of (*mine: annual*) disbursements assumed to last foreverí ö In capitalised cost we try to reduce each of the cash flows, initial cost as well as other cash flows to zero time.
Now capitalised cost can be derived from equal payment series present worth factor.

$$(P/A, i, n) = [(1+i)^n - 1]/ i(1+i)^n$$

When $n \to \infty$, then $\lim (P/A, in, n)$

$$\lim_{n \to \infty} (P/A, i, n) = \lim_{n \to \infty} [(1+i)^n - 1]/ i(1+i)^n$$

Dividing $(1+i)^n$ in both the numerator and denominator of RHS of the above equation,

We get $\lim_{n \to \infty} (P/A, i, n) = 1/i$

Case: 4   Comparison of deferred investments
In case of deferred investment projects (to arrange for something to happen at a later time than you had planned), present worth comparison method can also be applicable to judge whether the deferred on e is better than the current one.

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[3] See, ibid, p.90.

4 Future worth comparisons

When each of the cash flows of projects is expressed in terms of future time by the help of discounting factor is known as the future worth method[4]. We are able to get the future value of each of the projects and compare whose worth is the maximum and accordingly the project with the highest future value is preferred.

$$Fw = Pw \ (F/P, \ i, \ n)$$
$$= Pw \ (1+i)^n$$

5 Payback Period (Payout) Method

Payback period method finds out how quickly the investment amounts of a project get recovered. Therefore this method tries to find the minimum time period required to get back the invested amount of a project. This period is known as payback period of a concerned project. This method emphasises on the riskiness of the project and is indifferent to profitability. So this method ignores the cash flows happening beyond payback period. Although this method of comparison is not equivalent to present worth (or future method) as the former does not entertain the discounted cash flows, but this method is the simplest one. It is particularly applicable to small investment projects.

Letøs calculate payback period (PBP) of a project given below:
If the initial cost of a project is ₹6000 and the cash inflows are ₹2000, ₹ 3000, ₹ 1000, and ₹2000 (all in INR) respectively for the yearly 1, 2, 3, and 4. The PBP will be the 3rd year.

But the above technique does not satisfy the basic criteria of time value of money. Therefore discounted payback period method is said to be a better method over PBP method by applying discounting factor to the cash flows.

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[4] FW method is also based on the same conditions on which present worth method is based.

Module II

1   Equivalent annual worth comparisons

Equivalent Annual Worth[5] (EAW) method is a measure of cash flows in terms of equivalent equal payment occurring on a yearly amount.

EAW is based on the following conditions. Viz.

a) All cash flows (inflows as well as out flows should be known
b) Time and rate of interest is to be given
c) Constant time value of money
d) Before tax cash flows are to be taken for comparison
e) No intangible factors are to be taken
f) Comparisons should not include considerations of the availability of funds to implement projects or engineering alternatives

1.1   Steps in annual equivalent worth method

a) Compute the NPW (i.e., PW of inflows- PW of outflows) of the cash flow stream
b) Multiply the amount of NPW by the capital recovery factor
$$AEW_{(i)} = NPW [A/P, i, n]$$
$$= NPW [i (1+i)^n]/ [(1+i)^n-1]$$
c) The decision rule

If $AEW_{(i)}$ is > 0, accept the project
If $AEW_{(i)}$ is < 0, reject the project
If $AEW_{(i)}$ is $= 0$, remain indifferent

1.2   Use of EAW comparison method

The EAW method is used in the following cases. Viz.
a) Cost accounting procedure
b) Depreciation expenses
c) Tax calculations
d) Basic present worth comparisons

1.3   Application of AEW

AEW can be applied to three different cases based on lives of assets. Life of the assets defined as the number of compounding periods appropriate for the analysis of cash flows of the projects. Asset life may be described by three concepts: Ownership/ service life, accounting life and economic life/ optimal replacement interval. Letøs understand these concepts.

i) Ownership life: This is also known as service life of the project. It is defined as the duration of time an asset/project is kept in service by the owners.

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[5] Equivalent annual cost is used to designate the comparisons involving only costs, whereas EAW is used when both cost as well as income is present.

ii) Accounting life: It is the life expectancy which is taken into account for tax considerations and maintaining book keeping.

iii) Economic life: It is the life time of the asset which finds the appropriate time for replacement. Within this time period the asset's total equivalent annual cost is minimised and the net annual income is maximised.

1.3.1 Comparison of assets with equal lives

For comparing assets having equal lives, the cash flows may be converted to equivalent annual costs. If initial cost and salvage value is involved, then annual equivalent worth can be derived as

Equivalent annual cost (EAC) = P (A/P, i, n) - S (A/F, i, n)

We know that $(A/P, i, n) = i (1+i)^n / (1+i)^n - 1$

$[i (1+i)^n / (1+i)^n - 1] - i = i / (1+i)^n - 1$

$(A/P, i, n) - i = (A/F, i, n)$

Replacing the value of the above equation in

EAC = P (A/P, i, n) - S (A/F, i, n)

EAC = P (A/P, i, n) - S {(A/P, i, n) - i}

$\qquad$ = (P-S) (A/P, i, n) + Si

1.3.2 Comparison of assets with unequal lives

In case of assets having unequal lives, each of the cash flows are converted in terms equivalent annual amount. If this annual amount is the cost, then assets having least annual equivalent cost are preferred.

1.3.3 Comparison of assets with infinite lives

In case of assets having infinite lives, we are using A= P (A/P, i, n)

$(A/P, i, n) = i (1+i)^n / (1+i)^n - 1$

$\lim_{n \to \infty} (A/P, i, n) = \lim_{n \to \infty} [i (1+i)^n / (1+i)^n - 1]$

$\qquad\qquad = i$

A = Pi

2   Rate of Return

Rate of return is a percentage that indicates the relative yield on different uses of capital. In engineering economic evaluation studies, there are 3 types of rate of used, viz., Minimum acceptable rate of return (MARR), Internal rate of return (IRR) and External rate of return (ERR). Let's describe each of the aforesaid rates of return.

MARR: It is the lowest level of return which makes allows investment and makes an investment possible.

IRR: It is the discount rate at which net present worth is zero. i.e.,
If B and C are the benefits and costs respectively with respect to different years, then IRR is calculated as $B_1 - C_1 / (1+i)^1 = 0$

ERR: It is the rate of return that is possible under current economic conditions.
However, our topic of discussion is IRR and its application.

2.1   Calculations of IRR

Let's suppose that there are 2 mutually exclusive projects ó A & B and B is more costly.
We can say that B= A+ (B-A)
(B-A) is known as incremental cash flow. Now the steps to find the IRR are as follows:

   a) Calculate (B-A)
   b) Compute IRR on this incremental cash flow
   c) Decision rule is:
      IF IRR $_{(B-A)}$ > MARR, then select B project
      If IRR $_{(B-A)}$ < MARR, then select A project
      IRR $_{(B-A)}$ = MARR, indifferent to take either A or B
IRR is calculated by the following three methods. Viz.,
      i)   Direct solution method
      ii)   Trial and error method
      iii)   Computer solution method
Let's take an example.
The cash flows for two mutually exclusive alternatives of projects A and B are given. If MARR is 10% which alternative is to be chosen?

End of year	A Project (INR)	B Project (INR)
0	-3000	-12,000
1	1350	4200
2	1800	6225
3	1500	6330

Between these two projects, B project is the costlier one. Therefore it is needed to find out the incremental cash flow (B-A).

The PW of the incremental cash flow stream is

PW (i*) = -9000+2850(P/F, i*, 1) + 4425 (P/F, i*, 2) +4830 (P/F, i*, 3)

By Direct method the PW (i*) is to be equated with zero.

After solving it, i*= IRR $_{(B-A)}$ =15.01%

Now the decision rule is that since IRR $_{(B-A)}$ >MARR, i.e., 15.01% > 10%, B project need to be chosen.

This example can also be solved by Trial *and error method*.

We know that PW (i*) = -9000+2850(P/F, i*, 1) + 4425 (P/F, i*, 2) +4830 (P/F, i*, 3)
Since MARR is 10%, we will start our trial and process from i= 10%
If i*=10%,
PW (10%) = -9000+2850(P/F, 10%, 1) + 4425 (P/F, 10%, 2) +4830 (P/F, 10%, 3) =876.78

We know that there exists an inverse relationship between i and pw.
So in order make the PW zero, i* needs to be raised
If i*= 14%,   PW= 165
If i*= 16%,   PW= -160.23

The i* at which PW would be zero can be found out by the method of interpolation

i*= 14%+ $(165 − 0)/[165 − (−10.23)]$× (16%-14%)

$\qquad$ = 15.01%

As this i* > MARR, B is to be preferred.

3   Analysis of Public Projects

For evaluating projects on the basis of national point of view, two most appropriate methods are used, Viz., Benefit-cost (B-C) analysis and Cost-effectiveness (C-E) analysis. Apart from these two techniques environmental impact analysis (EIA) complements in evaluating public projects. Recently National Green Tribunal (NGT) is regarded as an improved criterion in public undertaking projects. However our discussion is limited to B-C and C-E analysis only.

3.1   Benefit-Cost Analysis

Cost- benefit analysis helps the planning authority in making correct investment decisions to achieve optimum resource allocation by maximising net present value of benefits and costs of a project. B-C analysis displays following *characteristics*.
   i)   It involves enumeration, comparison and evaluation of benefits and costs of a project.
   ii) Its primary objective is based on achieving net social benefit.
   iii) Each of the costs and benefits are expressed in terms of common monetary units.

This analysis rests on following *assumptions*.
   a) The money value of costs and benefits represent the real values in the market economy.
   b) There exists full employment in the economy.

3.1.1   Steps of B-C analysis

   i)   Prepare the blue print of the project
   ii) Identify the scope of costs and benefits
   iii) Consideration of appropriate rate of interest for discounting and time taken for analysis
   iv) Appropriate criteria for investment comparability
   v)   Projection of constraints and limitations

3.1.2   Quantification and valuation of costs and benefits

In case of quantification of costs and benefits, all the relevant items are weighed in terms of a *common denominator* like in terms of any national currency. Use of opportunity costs and prices is also adopted for putting a price (valuating) on each of the costs and benefits. However, every costs and benefits do not have a market price. In these cases we face some issues regarding valuation. Some of these issues are noted here:

a) When costs and benefits do not have market value
b) Market imperfections
c) Changes in price level
d) Incorporation of political and social judgement

After carefully going through some of the cases as above indirect method are used.

B-C (i) = Equivalent benefit/Equivalent cost

= B/I+C

Where, B= total benefits from a project

I= equivalent capital invested by the government

C= net equivalent cost to the government

The decision criteria is if B/ I+C > 1, then the project gets accepted

< 1, then it gets rejected

= 1, the there is indifference between acceptance and rejection

For equivalent of benefits and costs, PW, FW or AEW method can be used.

If expressed in PW method B-C (i) = $B_p/I+C_p$

In terms of FW method $= B_F/I_F+C_F$

In case of AEW method $= B_A/I_A+C$

3.1.3 Factors influencing costs and benefits

a) Tax
b) Unemployment
c) Collective goods
d) Intangibles

3.1.4 Critical appraisal of C-B analysis

Although this analysis helps in rejecting inferior projects by emphasising quantitative figures, still it succumbs to some limitations. These limitations are related to assessment of costs and benefits, uncertainty, problem of opportunity case, non-market economy, legal constraints, administrative constraints etc. The biggest limitation of this method is overemphasis of quantifying costs and benefits and ignorance of non-monetary effectiveness.

3.2 Cost-Effectiveness Analysis

In case of C-E analysis, it gives emphasis both on quantification as well as non-monetary effectiveness measures. It is having its back ground from b-c analysis. This method had its origin in the economic evaluation of defence and space systems.

3.2.1 Assumptions

i) The system under consideration must have common goal
ii) Existence of alternative means to meet the common goal

3.2.2 Steps of C-E analysis

a) Determine the goal
b) Specifying the constraints
c) Identifying all feasible alternatives
d) Appropriate social rate of discount

e) Determine the equivalent life-cycle cost of the project
f) Determine the basis of cost-effectiveness index, i.e., whether *fixed- cost approach* Or *fixed-effectiveness approach*
g) Finding cost-effectiveness ratio
h) Select the alternative with highest cost-effectiveness index

Bibliography

Riggs, J. L., Bedworth David D., & Randhawa, S. U. (2004). *Engineering economics*. New Delhi: TMH Education Private Ltd.

Whitman, D. L. & Terry, R.E. (2012). *Fundamentals of engineering economics and decision analysis.* University of Wyoming: Morgan & Claypool publishers.

Model short type questions (Module-I&II)

Answer the following questions.

a) What is the need of common multiple method?

b) Write two shortcomings of B- C analysis in evaluating engineering alternatives.

c) What is an external rate of return?

d) Define 'compound amount factor'

e) Differentiate between 'annuity 'and 'capitalised cost'

f) Define taxable income and income tax rate.

g) Write any two objectives behind the cost-effectiveness analysis.

h) Define continuous effective interest rate with a suitable example?

i) Differentiate between IRR and interest rate.

j) What is the importance of 'time value of money' in evaluating engineering projects?

k) Differentiate between 'sinking fund' and 'capital recovery' factor.

l) Draw a very brief differentiation between linear gradient and geometric gradient?

m) What is an analysis period and why is it taken?

n) Define the 'discounting factor' and state why is it used?

o) Differentiate between salvage value and book value.

p) What do you mean by 'time value of money'?

q) What is IRR method for evaluation of alternative engineering projects?

r) Why do we prefer 'present time' to 'future time'?

s) Find the continuous compounding rate of interest for $ 1000 with an interest of 2% for 1 year.

Module-III

1 What is depreciation?

It is the loss of value of the physical assets used in production. It also reduces efficiency as well as value of assets. When depreciation is measured in terms of monetary units, it is generally calculated on yearly basis. The monetary value which is deducted yearly from the assets is called Depreciation charge. Depreciation is permanent, continuing and gradual shrinkage in the book value of a fixed asset.

It can be understood in 3 senses.

In physical sense depreciation is a decline in the physical ability of equipment in the process of production. In economic sense, it is a decline in the worth of an asset due to outdated technology and due to changes in psychological factors like tastes and preferences. Likewise, in accounting sense, depreciation is estimated value of fall in the worth of asset, which is generally treated as an implicit cost.

1.1 Causes of Depreciation

Depreciation may occur due to following few causes.

i)   Physical depreciation
ii)   Time factors
iii)   Accidental factors
iv)   Depletion
v)   Deferred maintenance
vi)   Inadequacy or functional depreciation
vii)   Obsolescence

1.2 Assumptions of depreciation

Depreciation of an asset is calculated under the following conditions.

a) Asset should be used in business or in production of further income
b) It should have definite life time
c) It should be subject to wear, tear, decay and obsoletion from natural causes.

1.3 Method of Calculating Depreciation

Generally four basic methods are used for calculation of depreciation and discussed as follows.

i)   Straight line method
ii)   Declining Balance method
iii)   Double declining balance method
iv)   Modified accelerated cost recovery system method

Straight line method: This method is also known as fixed instalment method. Here rate of depreciation is constant over time. In depreciation calculation we calculate book value of the asset. Book value is defined as the difference between original cost of the asset and accumulated depreciation amount.

Where amount of depreciation (d) = [Original cost of the asset (P) - Salvage value (S)] ÷ life time of the asset (n)

Rate of Depreciation (D) = d/P×100

Book Value= P- [n/N (P-S)], where n= No. of years of use and N= Total longevity of the asset

Declining Balance Method: This method is also known as Written down method. It is assumed that the value of an asset declines at a decreasing rate. So, more depreciation is charged during the beginning of the life time and less is charged during the end. Under this method depreciation is calculated as

$$D_n = R/N \; [BV_{n-1}]$$

Where R= depreciation rate= $1-(S/I)^{1/N}$

$$BV_n = I \, (1-R)^n$$

$$= I(S/I)^{n/N}$$

One of the limitations of this method is that the book value at the end of the life of the asset may not be exactly equal to the salvage value.

Double-Declining Balance Method:

In case of double declining balance method, the rate of depreciation(R) is 200%/N or 2/N. The depreciation amount is calculated as

$$D_n = R \; [BV_{n-1}]$$

$$BV_n = I \, (1-R)^n$$

But in case of this method book value may not be equal to the salvage value at the end of its life time. Therefore, in order to equate BV with S, it is suggested to shift to straight line method.

But the question is that in which year this shifting is to be done?

This shifting should be done in that year when the following condition is satisfied.

The straight line depreciation charge on the undepreciated portion of the asset's value is greater than the double declining allowance.

We can find out SL (D) on the undepreciated portion by the following formula

SL (D) = [BV (n) - S]/N-n

Modified Accelerated Cost Recovery System Method:

In this method we determine the depreciation charge on the basis of the longevity of the assets. For example, if an asset has a life of 5 years, it is named as 5-years property.

The criteria for determining depreciation charge is

If NÖl0 years, then depreciation charge is 200% and if N×10 years. Depreciation charge is 150%.

Steps of MARCRs:

- Divide the appropriate % by the number of years of theirs longevity
- Determine the annual MACRs by rounding the result up to two decimal points
- Divide the result by 2 to convert the % to the half year convention for the first year of service
- The percentage for second year service is calculated by multiplying the current book value by the base rate
- This procedure is continued until a switch to straight line method is allowed to reach the terminal salvage value. This switch is possible when SL depreciation is greater than double declining balance depreciation. Straight line depreciation can be calculated by

$$DC_k = BV_k/ [N-k+0.5]$$

2   After Tax Economic Comparison

Economic comparison is preferred after tax because of three reasons. Viz.

- Differences in depreciation schedules
- Deductions for interest payments
- Special tax regulations

After tax evaluations can be made by any of the comparison methods- EAW, PW or IRR.

If IRR is applied, then $IRR_{after\ tax} = IRR_{before\ tax}$ (1- effective income tax rate)

3   Break-Even Analysis

Break-even analysis finds a point at which TR=TC. It is a point of output at which there is no profit and no loss. This analysis can be of 2 types.

Linear Break-even analysis

Non-linear break-even analysis

When TR and VC are directly proportional to output, then it is called linear break-even analysis. If this condition is not satisfied, the concerned break-even analysis is known as non-linear break-even analysis.

Methods of finding break-even point:

Letøs find break-even point by *algebraic method*.

We know that, C= FC+VC

So, selling price= FC+VC+ selling price

TC= FC+ VC

n×p= FC+ VC

np-nv-FC=0

n(p-v)-F=0

n=break-even quantity= F/[p-v]= TFC/[p-AVC]

Break-even sales= np = p [F/ [p-v]

= F/ [1-v/p]

Break-even sales can be found out by the difference between actual sales and break-even sales or [profit×sales]/ [sales-vc]

Margin of safety is an important concept in B-E analysis. It is defined as the sales over and above the break-even sales. It represents the strength of an investment situation.

Margin of safety= actual sales-break even sales

Linear break-even point by graphic method:

This can be done by using break-even chart.
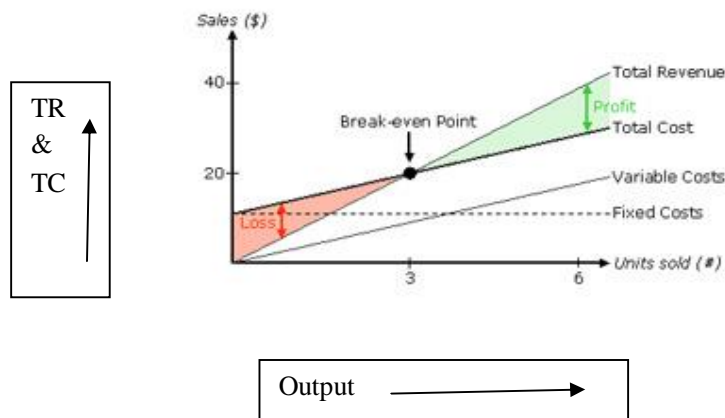
Fixed Costs are those costs which remain unchanged irrespective of number of outputs, whereas *Variable costs* are those costs which change with respect to number of outputs.

Non-linear Break-even analysis:

Non-linear break-even analysis can happen in three cases.

    a) Non-linear TR and linear TC
    b) Linear TR and non-linear TC
    c) Non-linear TR and TC

Non-linear TR and linear TC cost function
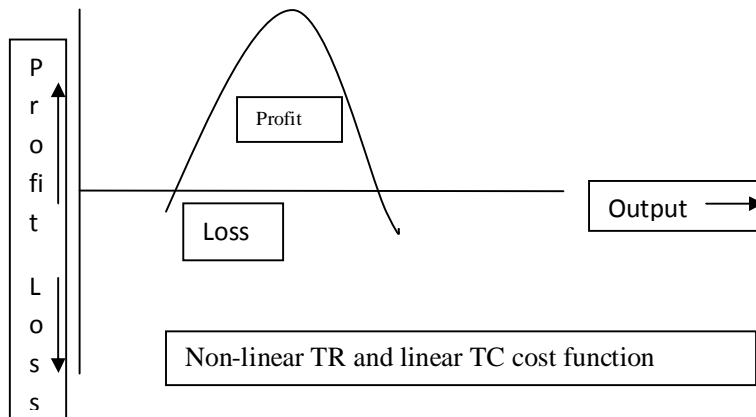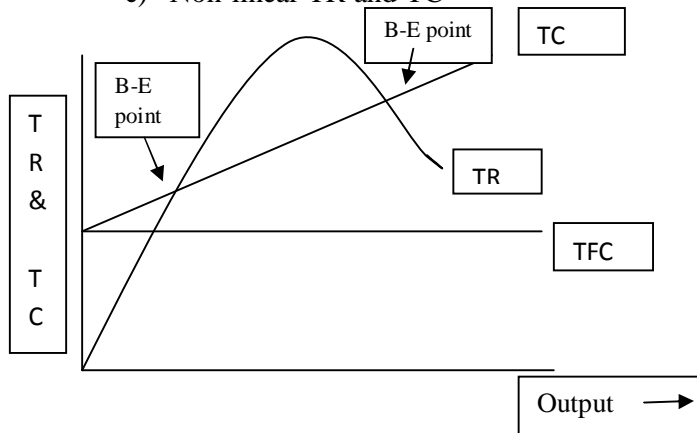
We know that profit= = TR-TC

        For maximisation of profit,

        Max   = —   – —   = 0

        And, —   – —   < 0

Likewise we can also find the break even points given Linear TR and non-linear TC

and non-linear TR and TC function.

4 Sensitivity Analysis (SA)

What is sensitivity?

If a small change in an element leads to a proportionately greater change in the results, then the situation is said to be sensitive to that variable and concerned analysis is called as *Sensitivity analysis*.

Objectives of SA

a) To know the change in net present value (NPV) if some parameters change.
b) To identify the highly sensitive variable.

For this analysis, following *assumptions* are taken.

i) Only one variable changes at a time, others remaining constant
ii) There exists no correlation between any two variables under consideration

We can use methods like PW, AEW or IRR.

Sensitivity analysis is of two types, i.e., *Single-parameter sensitivity analysis* and *Multiple-parameter sensitivity analysis*. Both the types can be applicable to single proposal case as well as to alternatives.

In *Single-parameter sensitivity analysis,* only one variable can be changed, keeping others constant, whereas is in Multiple-parameter sensitivity analysis, more than one variable can be changed at a time.

It is important to find the *critical point* in sensitivity analysis. It is defined as the point at which the decision for the project changes from acceptable to non-acceptable.

In case of multiple-parameter SA, we need to go for scenario generation approach finding the PW of optimistic, pessimistic and most-likely estimates. If both extreme estimates (PW of optimistic and pessimistic estimates) are negative, then the proposal should be rejected, and if both are positive then, the proposal should be accepted. But in case of the alternatives of scenario generation approach, majority is taken into account.

Module-IV

1   Costing

Costing is a technique and process of ascertaining the cost of activities of processes, products or services. *Product costing* technique covers all the processes of production- manufacturing and other costs and subsequently assigning them to work-in-process, finished goods and so on. It is the process of determining costs on the basis of actual data.

1.1   Steps of Product Costing

Product costing involves following four steps.

Collection and classification of costs:

We need to collect three elements of costs, i.e., material, labour and other expenditure and their classification can be shown as follows.
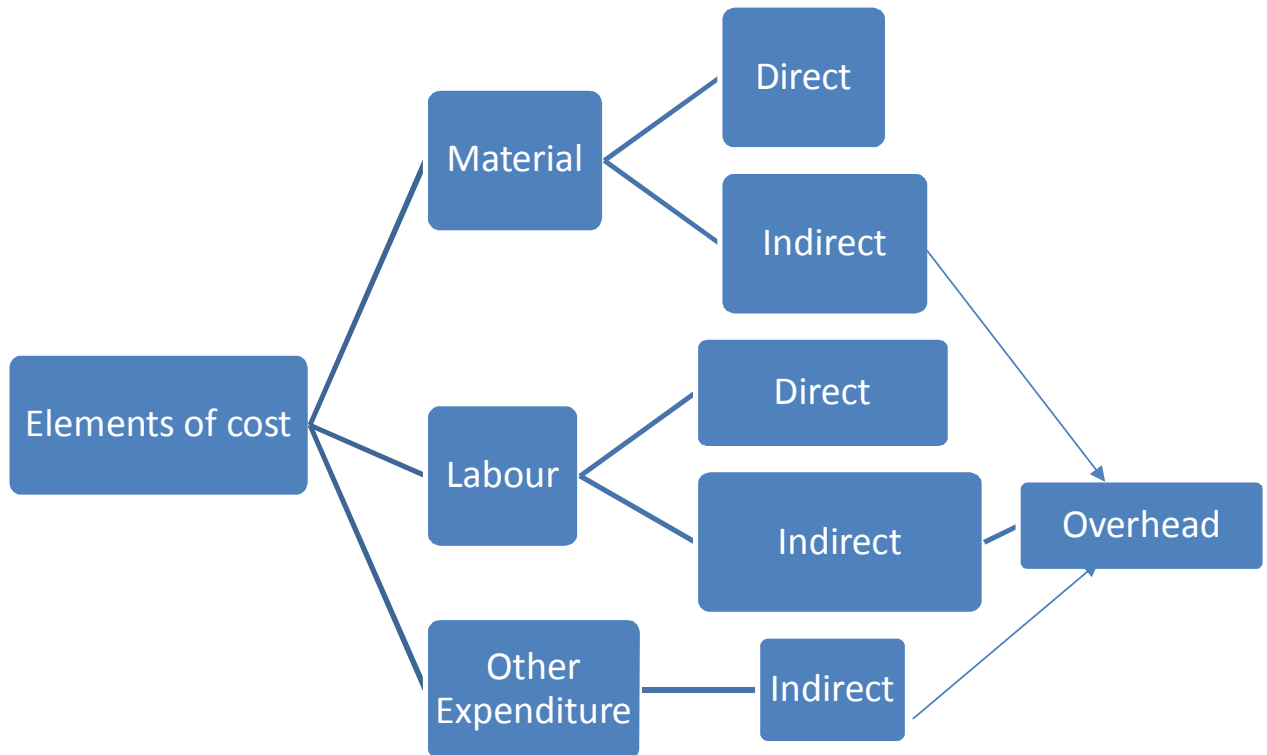
Moreover, Overheads is of three types, viz., functional, element-wise and behavioural. Functional overhead is of four types, Viz. production/work overhead, administrative overhead, selling and distribution overhead. Element- wise, it is divided into indirect material cost, indirect labour cost and indirect expenditure (like rents, insurance, taxes). Behavioural overhead is divided into fixed overhead, variable overhead and semi-variable overhead.

Apportionment of cost:

Cost Sheet   Unit=1000

Particulars	Total cost (INR)	Cost per unit (CPU) (INR)
Direct Material	30,000	30
+ Direct Labour	15,000	15
Prime cost	45,000	45
+Production overhead	18,000	18
Factory cost	63,000	63
+Administrative overhead	5,000	05
Cost of production	68,000	68
+Selling and distribution overhead	06,000	06
Total cost or cost of sales	74,000	74
+Profit	9,000	09
Revenue or Sales	83,000	83

Choice of appropriate methods of costing:

Generally two types of methods are taken into account, i.e., job costing and process costing.

Job costing is that system of costing in which costs are ascertained in terms of specific job or order which are not comparable with each other. Whereas, *process costing* refers to the procedure of determining the average unit cost in situations in which the product passes through more than one stage of production processes.

Selection of appropriate methods of costing:

It refers to the manner of ascertaining cost for the purposes of cost control and decision-making. Costing techniques include the following techniques.

- Uniform costing
- Marginal costing
- Direct costing
- Absorption costing
- Historical costing
- Standard costing

1.2   Process Costing

Process costing refers to the procedure of determining the average unit cost in situations in which the product passes through more than one stages of production processes. In this method, we need to find out average unit cost in each of the processes. Thus, it is easier to

find out the wastes, loss or gain happening in each process and accordingly control costs in respective processes.

Process costing can be applied to the following cases.

    I.   Process costing without out loss or gain

   II.   Process costing with abnormal loss or gain

What is Normal Loss?

It is what arises under efficient operating conditions. It is normal and beyond management's control in the short run. The cost of normal loss is regarded as part of the cost of production of the processes.

Abnormal Loss

Abnormal loss means the loss in excess of normal loss. It is also known as unplanned costs.

2   Cost Control (CC)

It is the regulation on costs by executive action of operating and undertaking of costs particularly where such action is guided by cost accounting.

Characteristics of Cost Control

- It needs a system of cost accounting
- It requires fixation of attainable targets of performance, which are scientifically set, taking into account practical applications of production and costs under normal conditions.

Techniques of cost control

Budgetary control   Standard costing
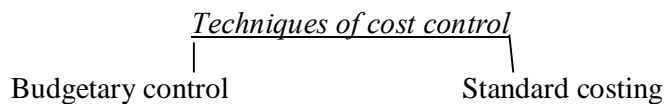
Budgetary Control: It can be defined as the establishment of budgets relating the responsibilities of executives to the requirements of a policy and the continuous comparison of actual budgeted results, either to secure the objectives of that policy by individual action or to provide a basis for revision.

Steps in process of Budgetary Control:

- Defining objectives
- Formulating necessary plans to achieve these objectives
- Transforming plans into budgets
- Linking the responsibilities of executives to the budgets
- Continuous comparison of actual results to the budgets
- Finding the causes of deviation (if any) between budgets and actual results.

- Presentation of information to management relating the variances to individual responsibility.
- Corrective action of management to prevent recurrence of variances.

Standard Costing:

It is the technique whereby standard costs are pre-determined and subsequently compared with the recorded actual costs. It is a technique of cost ascertainment and cost control.

A standard is a predetermined measure of material, labour and overheads. It can be of three types.

> Current standard
> Basic standard
> Normal standard

Current standard is defined for use over a short-period of time and is related to current condition. It is ideal or expected standard.

Basic standard is defined for long run.

Normal standard is average standard which is anticipated and can be attained over a long future time to cover one trade cycle.

Steps of Standard Costing:

- Defining the standards of performance
- Measuring the actual performance against the standards mentioned
- Computing the variances, finding causes of variances with analysis and localizing them, presenting timely reports.
- Enforcing accountability of the executives concerned
- Taking corrective action to eliminate /squeeze the variances
- Reviewing periodically the standards in the light of changed situation.

3   Standard Costing and Variance Analysis

Variance is the difference between the standards and the actual performance. It may be of two types, i.e., favorable variance and adverse variance.

Favorable variance is one when actual results are better than the expected results; whereas *adverse variance* happens when actual is worse than the expected.

3.1   Types of Variance Analysis

```
                                                    ┌─────────────────────┐
                                                    │   Profit Variance   │
                                             ┌──────┴─────────────────────┘
┌──────────────────────────┐                 │
│ Types of Variance        │────────────────→┤  ┌─────────────────────┐
│       Analysis           │                 ├──│    Cost Variance    │
└──────────────────────────┘                 │  └─────────────────────┘
                                             │
                                             │  ┌─────────────────────┐
                                             └──│    Sales Variance   │
                                                └─────────────────────┘
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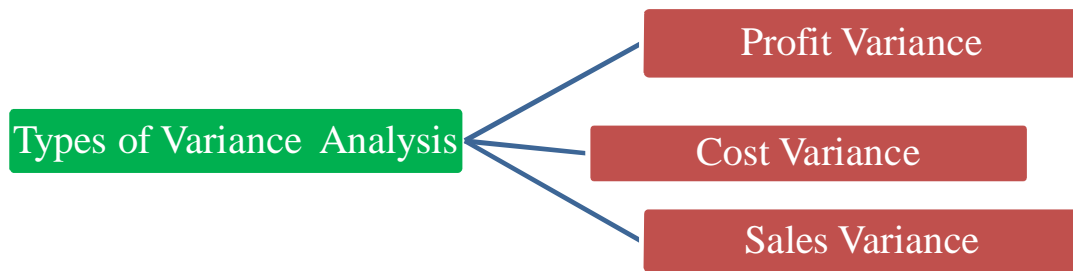
Letøs discuss each of the above categories of variances.

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                              ┌──────────────────────┐
                              │   Profit Variance    │
        ┌─────────────────────┼──────────────────────┬─────────────────────────┐
┌───────────────────┐  ┌────────────────┐                          ┌────────────────────┐
│ Selling and       │  │ Total          │                          │ Total sales margin │
│ administrative    │  │ production     │                          │      variance      │
│ variance          │  │ cost variance  │                          └────────────────────┘
└───────────────────┘  └────────────────┘                            │            │
       ┌───────────┬──────────┬──────────┐                  ┌──────────────┐ ┌──────────────┐
┌───────────┐ ┌──────────┐ ┌──────────┐ ┌──────────┐        │ Sales margin │ │ Sales margin │
│ Material  │ │ Labour   │ │ Variable │ │ Fixed    │        │ price        │ │ volume       │
│ cost      │ │ cost     │ │ overhead │ │ overhead │        │ variance     │ │ variance     │
│ variance  │ │ variance │ │ variance │ │ variance │        └──────────────┘ └──────────────┘
└───────────┘ └──────────┘ └──────────┘ └──────────┘
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```
                                              ┌──────────────────────────┐
                                              │ Material price variance  │
                     ┌─────────────────────┐  └──────────────────────────┘
                     │ Material cost       │──
                     │ variance            │  ┌──────────────────────────┐
                     └─────────────────────┘  │ Material usage variance  │
                   ──                          └──────────────────────────┘
                                              ┌──────────────────────────┐
┌────────────────┐                            │ Labour rate variance     │
│ Cost variance  │── ┌─────────────────────┐  └──────────────────────────┘
└────────────────┘   │ Labour cost variance│──
                     └─────────────────────┘  ┌──────────────────────────┐
                   ──                          │ Labour efficiency        │
                                              │ variance                 │
                                              └──────────────────────────┘
                     ┌─────────────────────┐  ┌──────────────────────────┐
                     │ Variable overhead   │  │ Expenditure variance     │
                     │ variance            │──└──────────────────────────┘
                     └─────────────────────┘  ┌──────────────────────────┐
                                              │ Efficiency variance      │
                                              └──────────────────────────┘
```

```
                                    ┌─────────────────────┐
                                    │  Total sales margin │
                                    │      variance       │
                                    └─────────────────────┘
┌──────────────────┐                ┌─────────────────────┐
│  SalesVariance   │                │ Sales margin variance│
│  (Profit Method) │                │  due to selling price│
└──────────────────┘                └─────────────────────┘    ┌─────────────────────┐
                                                               │ Due to sales mixture│
                                    ┌─────────────────────┐    └─────────────────────┘
                                    │ Sales  margin variance│
                                    │                       │   ┌─────────────────────┐
                                    └─────────────────────┘    │  Sales quantities   │
                                                               └─────────────────────┘
```

```
                        ┌──────────────────────────┐
                        │      Sales Variance      │
                        │     (Value Method)       │
                        └──────────────────────────┘
            ┌───────────────────┐  ┌───────────────────┐  ┌───────────────────┐
            │ Sales value variance│ │ Sales price variance│ │Sales volume variance│
            └───────────────────┘  └───────────────────┘  └───────────────────┘
                                           ┌───────────────────┐  ┌───────────────────┐
                                           │ Sales mix variance│  │Sales quantity variance│
                                           └───────────────────┘  └───────────────────┘
```

4   Cost Reduction

It may be defined as the achievement of actual and permanent reduction in the unit cost of the goods produced.

Features of cost reduction

- Cost reduction is real. Cost is brought down by changes in methods of production, research etc.
- It is permanent.
- But this cost reduction should not impair the suitability of goods and services for which it is meant.

Reduction in cost per unit of production may happen by two means. Viz.,

- By reducing expenditure, but volume of output remains constant
- By increasing production, but level of expenditure remains constant

Cost Reduction is generally applicable in the following fields. Viz.,

Production design

Organization

Factory layout and equipment

Administration

Marketing

Production plan, program and methods

Material control

Financial Management