



JANAK EXERCISE BOOK

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Name: Surendra Sharma

Class: BCE III/II Roll No.: 078BCE178 Sec: GH

Subject: Engineering Economics

School/College: Pulchowk Campus, Lalitpur

Chapter: 2

Interest and Time value of Money

- * Time value of money is defined as the time dependent value of money because of changes in purchasing power (inflation or deflation) and real earning capacity of capital with time.
- * Interest → दर : It is the price of money services or it is the fee that is charged for the use of money

Simple Interest



$$I = \frac{PTR}{100} = PNi$$

where, $\frac{R}{100} = i = \text{interest ratio}$

$$A = P + I$$

A = future amount

T = no. of years

Compound Interest

$$A = P \left(1 + \frac{R}{100}\right)^T$$

* Why interest?

- ① Inflation adjustment
- ② Compensate lost opportunity
- ③ To compensate risk of not getting money back.

* Types of Bank Account:

- (i) Fixed Deposit → 'मुदती'
- (ii) Current Deposit → 'चलती'
- (iii) Saving Deposit → 'बचत'

• Simple interest

$$I = \frac{PTR}{100} = PNi$$

$$A = P + I$$

$$\Rightarrow F = P + PNi \\ = P(1 + Ni)$$

• Compound Interest

$$A = P \left(1 + \frac{R}{100}\right)^T$$

$$\Rightarrow F = P(1+i)^N$$

$$\therefore I = F - P = P[(1+i)^N - 1]$$

(8) Deposit Rs. 1000 in a bank now. What will be the amount after 5 years if interest rate is 10% per year. Use simple & compound interest.

→ Solⁿ:

$$P = \text{Rs. } 1000$$

$$N = 5 \text{ years}$$

$$i = 10\% \text{ per year} = 0.1$$

Now

$$\text{SI: } F = P + I = P + PNi = 1000 + 1000 \times 5 \times 0.1 \\ = 1500$$

$$\text{CI: } F = P(1+i)^N = 1000(1+0.1)^5 \\ = 1610.51$$

(9) Deposit Rs. 10,000 now. Draw Rs. 6000 at the end of 3 years. What will be the amount remain in bank after 5 years? $i = 10\%$ per year.

→ Solⁿ:

$$P = \text{Rs. } 10,000$$

At the end of 3 years,

$$F = 10000(1+0.1)^3 = 13310$$

After 6000 is drawn,

$$\text{Amount remain, } F = 13310 - 6000 = 7310$$

After 2 more years,

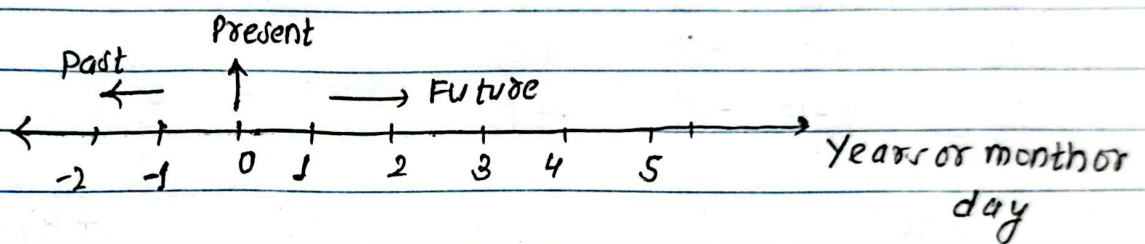
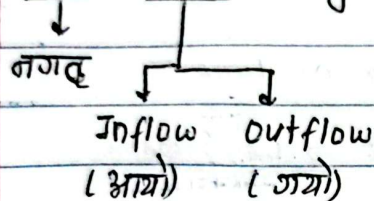
$$F = 7310 (1 + 0.1)^2 = 8845.10$$

(OR)

$$F = [10000(1 + 0.1)^3 - 6000](1 + 0.1)^2$$

$$= 10000(1 + 0.1)^5 - 6000(1 + 0.1)^2$$

• Cash Flow Diagram (CFD)

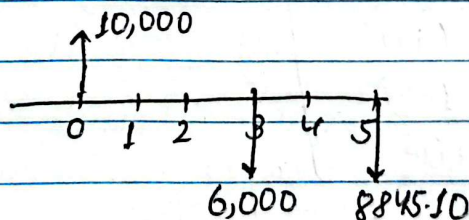


① → End of year 1 'or' Start of year 2

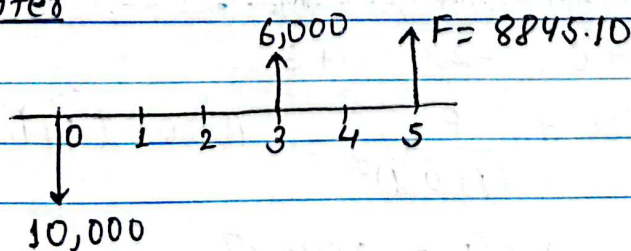
↑ Inflow (upward arrow)

↓ Outflow (downward arrow)

CFD for bank



CFD for Depositor



Note: For ideal condition i.e. no interest

$$\Sigma \text{inflow} = \Sigma \text{outflow}$$

$$\text{or, } 6000 + F = 10,000$$

$$[F = 4,000]$$

$$\bullet \quad \Sigma \text{inflow} = \Sigma \text{outflow}$$

$$\text{or, } 6000 + F = 10000$$

$$\begin{array}{ccc} \downarrow & \downarrow & \downarrow \\ \textcircled{3} & \textcircled{5} & \textcircled{0} \end{array} \quad] \rightarrow \text{Different time}$$

★ Make all same time either at 3 or 5 or 0

$$\text{For 3: } +\textcircled{1} \quad -\textcircled{2} \quad +\textcircled{3}$$

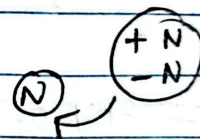
$$\text{For 5: } +\textcircled{2} \quad +\textcircled{1} \quad +\textcircled{5}$$

$$\text{For 0: } -\textcircled{3} \quad -\textcircled{5} \quad +\textcircled{0}$$

Note:

+ $\rightarrow$ Multiply by $(1+i)^N$

- $\rightarrow$ divide by $(1+i)^N$



For eg:

$$+3 \rightarrow \times (1+i)^3$$

$$-3 \rightarrow \frac{1}{(1+i)^3}$$

$$+5 \rightarrow \times (1+i)^5$$

$$-5 \rightarrow \frac{1}{(1+i)^5}$$

i is given

$$\underline{\text{So}} \quad 6000 + F = 10000$$

$$\begin{array}{ccc} \downarrow & \downarrow & \downarrow \\ \textcircled{3} & \textcircled{5} & \textcircled{0} \\ +0 & -2 & +3 \end{array}$$

taking
all time to
3

$$\Rightarrow 6000 + \frac{F}{(1+0.1)^2} = 10000 (1+0.1)^3$$

$$\Rightarrow [F = 8845.1]$$

taking
all time to
5

'OP'

$$\left\{ \begin{array}{l} 6000(1+0.1)^2 + F = 10000(1+0.1)^5 \\ \therefore F = 8845.1 \end{array} \right.$$

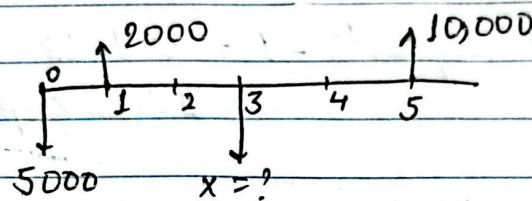
'OP'

$$\frac{6000}{(1+0.1)^3} + \frac{F}{(1+0.1)^5} = 10000$$

$$\Rightarrow [F = 8845.1]$$

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Eg:



($i=10\%$)

$$2000 + 10000 = 5000 + X \quad \left\{ \sum \text{inflow} = \sum \text{outflow} \right\}$$

$$\begin{array}{cccc} \textcircled{1} & \textcircled{5} & \textcircled{0} & \textcircled{3} \\ +2 & -3 & +3 & +0 \end{array}$$

Making it
③

$$2000(1+0.1)^2 + \frac{10000}{(1+0.1)^3} = 5000(1+0.1)^3 + X$$

$$\Rightarrow [X = 4029.463]$$

Nominal and Effective interest rates:

→ Basic annual interest rate calculated using the concept of simple interest is nominal interest rate (r)

If $i = 1\%$ per month, $r = 12\%$ per year (annual)

If $i = 2\%$ in 3 month, $r = 2\% \times \frac{12}{3} = 8\%$

⇒ But, due to compounding effect, the actual interest rate is higher than nominal. This actual interest rate is known as effective interest rate - $I_{\text{eff}}(i)$

Formula,

$$I_{eff} = \left(1 + \frac{r}{m}\right)^m - 1$$

r = nominal interest rate

m = number of compounding each year.

→ If $i = 1\%$ per month, $r = 12\%$, $m = 12$

$$i_{eff} = \left(1 + \frac{0.12}{12}\right)^{12} - 1 = 0.1268$$

= 12.68% per year

So

1% per month = 12.68% per year

→ If $i = 2\%$ in 3 months, $r = 8\%$, $m = 4$ (1 year = 4 × 3 months)

$$i_{eff} = \left(1 + \frac{0.08}{4}\right)^4 - 1 = 0.0824$$

= 8.24% per year.

$$i = \left(1 + \frac{r}{m}\right)^m - 1$$

$$i_{yr} = \left(1 + \frac{12\%}{12}\right)^{12} - 1$$

$$i_{yr} = (1 + 1\%)^{12} - 1$$

Thus,
$$\left\{ \begin{array}{l} i_{yr} = (1 + i_{month})^{12} - 1 \\ i_{6month} = (1 + i_{month})^6 - 1 \\ i_{6month} = (1 + i_{3mo})^2 - 1 \\ i_{mo} = (1 + i_{year})^{1/12} - 1 \\ i_{3mo} = (1 + i_{year})^{1/4} - 1 \end{array} \right.$$

Q Calculate effective interest rate i_{eff} if nominal interest rate $r = 6\%$ compounded

- a. Yearly b. Semiannually c. Quarterly
d. Monthly e. Daily f. Continuously

→ Soln:-

(a) $m = 1$

$$i_{eff} = \left(1 + \frac{6\%}{1}\right)^1 - 1 = 6\% \quad \left\{ \begin{array}{l} 6\% \text{ वर्षको एक पटक } \\ \text{दिने आनेको } 3\% \text{ in } \\ 6 \text{ month} \end{array} \right\}$$

(b) $m = 2$

$$i_{eff} = \left(1 + \frac{6\%}{2}\right)^2 - 1 = 6.09\%$$

(c) $m = 4$

$$i_{eff} = \left(1 + \frac{6\%}{4}\right)^4 - 1 = 6.136\%$$

(d) $m = 12$; $i_{eff} = \left(1 + \frac{6\%}{12}\right)^{12} - 1 = 6.168\%$

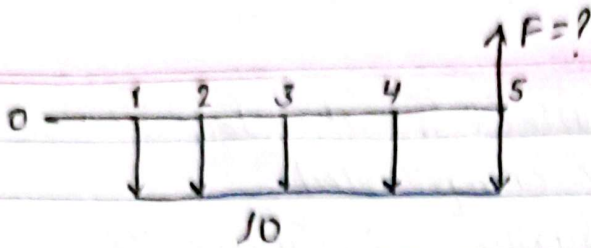
(e) $m = 365$; $i_{eff} = \left(1 + \frac{6\%}{365}\right)^{365} - 1 = 6.183\%$

(f) Continuously, $m \rightarrow \infty$ do

$$i_{eff} = \lim_{m \rightarrow \infty} \left(1 + \frac{6\%}{m}\right)^m - 1 = e^{6\%} - 1 = 0.06184 = 6.184\%$$

(Q) Bank ले आज दिने

- (a) $i_{eff} = 6.5\%$ yearly
 (a) 6.5% yearly (b) $i_{eff} = 6.4\%$ semi-annually
 (b) 6.4% semi-annually $i_{yr} = \left(1 + \frac{6.4\%}{2}\right)^2 - 1 = 6.502\%$
 (c) 6.3% quarterly (c) $i_{eff} = 6.3\%$ quat.
 (d) 6.2% monthly $i_{yr} = 6.450\%$
 (e) 6.1% daily (d) $i_{eff} = 6.2\%$ monthly
 $i_{yr} = 6.379\%$
 (e) 6.1% daily
 $i_{yr} = 6.289\%$



$$\Rightarrow F = 10 \times 1.1^4 + 10 \times 1.1^3 + 10 \times 1.1^2 + 10 \times 1.1^1 + 10 \times 1.1^0$$

$$= 61.05$$

⑩ → Equal cash flow at equal interval of time
 ↳ Also known as ANNUITY 'A'

$$\Rightarrow \text{Geometric series} \rightarrow CF = \frac{1}{1.1}$$

$$\text{First term, } a = 10 \times 1.1^4$$

$$N = 5$$

$$r = \frac{10 \times 1.1^3 (b)}{10 \times 1.1^4 (a)} = \frac{1}{1.1}$$

$$\text{Sum} = \frac{a(r^n - 1)}{r - 1} = \frac{10 \times 1.1^4 \left(\frac{1}{1.1}^5 - 1 \right)}{\frac{1}{1.1} - 1}$$

$$= 61.051$$

$$F = 10 \times 1.1^4 + 10 \times 1.1^3 + 10 \times 1.1^2 + 10 \times 1.1 + 10 \quad \text{--- (I)}$$

Multiply both sides by 1.1 i.e. (1+i)

$$1.1F = 10 \times 1.1^5 + 10 \times 1.1^4 + 10 \times 1.1^3 + 10 \times 1.1^2 + 10 \times 1.1 \quad \text{--- (II)}$$

$$\text{--- (II) - (I)}$$

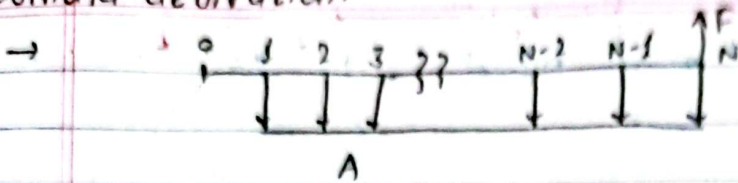
$$(1.1 - 1)F = 10 \times 1.1^5 - 10$$

$$F = \frac{10 [1.1^5 - 1]}{1.1 - 1} = \frac{10 [1.1^5 - 1]}{0.1}$$

$$\approx \frac{A [(1+i)^N - 1]}{i}$$

$$= 61.051$$

Formula derivation:



$$F = \underset{\textcircled{N}}{A} + \underset{\textcircled{N-1}}{A} + \underset{\textcircled{N-2}}{A} + \dots + \underset{\textcircled{N-1}}{A} + \underset{\textcircled{N}}{A}$$

$$+0 \quad +N-1 \quad +N-2 \quad +N-3 \quad \dots \quad +1 \quad +0$$

So,

$$F = A(1+i)^{N-1} + A(1+i)^{N-2} + A(1+i)^{N-3} + \dots + A(1+i)^1 + A(1+i)^0 \quad \text{--- (I)}$$

Multiply both sides by $(1+i)$

$$F(1+i) = A(1+i)^N + (1+i)^{N-1} + A(1+i)^{N-2} + \dots + A(1+i)^2 + A(1+i)^1 \quad \text{--- (II)}$$

$$\textcircled{II} - \textcircled{I}$$

$$(1+i)F - F = A(1+i)^N - A$$

$$\text{or, } F = A \frac{[(1+i)^N - 1]}{i} \quad \text{--- (a)}$$

$$A = F \left[\frac{i}{(1+i)^N - 1} \right] \quad \text{--- (b)}$$

OR' From (I),

$$a = A$$

$$r = (1+i)$$

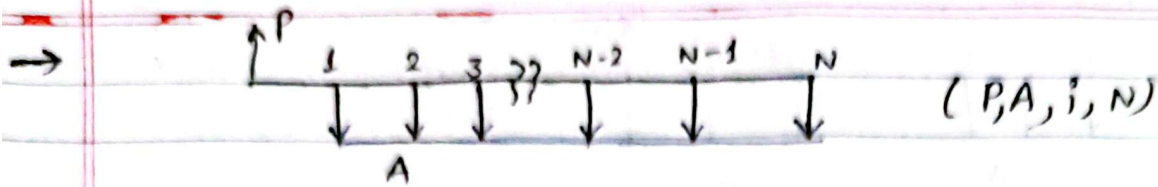
$$n = N$$

$$F = S_n = \frac{A [(1+i)^N - 1]}{(1+i) - 1} = A \left[\frac{(1+i)^N - 1}{i} \right]$$

Eqⁿ (a) & (b) applicable for,

$F \rightarrow N^{\text{th}}$ year म

$A \rightarrow N^{\text{th}}$ year देखी N^{th} year सम्म N वटा (arrow ↓)



$$P = A + A + A + \dots + A + A$$

①	①	②	③		(N-1)	(N)
+	+	+	+		+	+
N	N-1	N-2	N-3		1	0

So,

$$P(1+i)^N = A(1+i)^{N-1} + A(1+i)^{N-2} + A(1+i)^{N-3} + \dots + A(1+i)^1 + A(1+i)^0$$

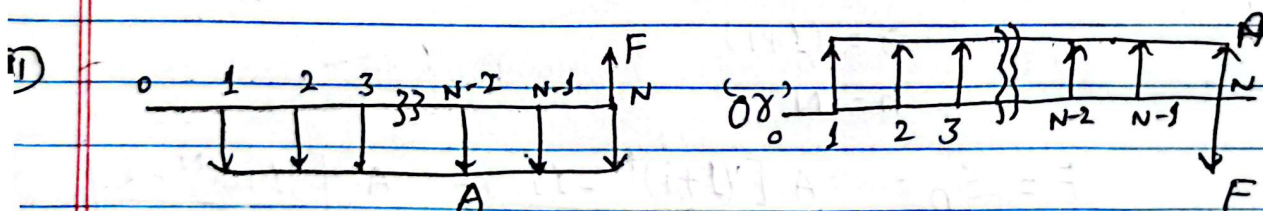
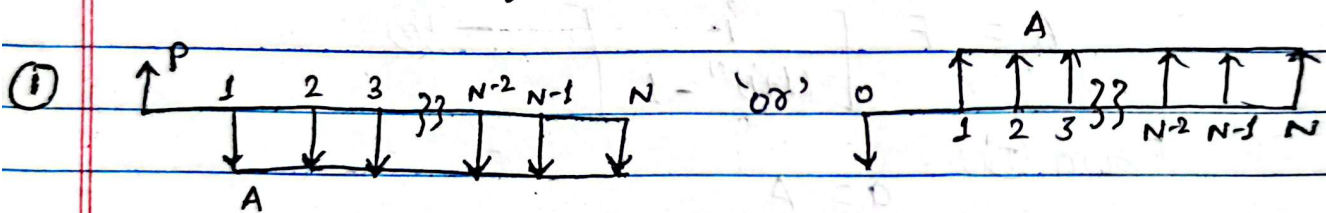
$$a = A(1+i)^0 = A$$

$$r = (1+i)$$

$$n = N$$

$$P = S_n = \frac{A [(1+i)^N - 1]}{(1+i) - 1} \times \frac{1}{(1+i)^N}$$

$$\left\{ P = \frac{A [(1+i)^N - 1]}{i (1+i)^N} \right\} \text{ (Ans)}$$



$$\left\{ \begin{array}{l} P \rightarrow 0 \text{ या } A \rightarrow 1 \text{ to } N \\ F \rightarrow N \text{ या } A \rightarrow 1 \text{ to } N \end{array} \right\}$$

same formula for both i.e. 1 या अर्को both condⁿ

formula same & 2 या अर्को both condⁿ formula same

Q Mr. Thapa took 10 lakh loan He wish to repay the loan after 3 years from now for 5 more years on a monthly basis. How much Rs is his EMI if interest rate is

(a) 1% per month

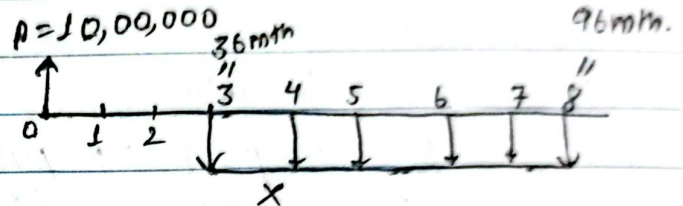
(b) 10% compounded semi-annually.

→ Solⁿ:

$$P = 10,00,000$$

(a) 1% per month.

$$1\% = 12\% \text{ p.a.}$$



$$10,00,000 = X \left[\frac{(1+0.01)^{60} - 1}{0.01} \right] \times (1.01)^{96}$$

$$\Rightarrow [X = 31826.66]$$

(b) 10% compounded semi-annually.

$$\Rightarrow \frac{10\%}{2} = 5\% \text{ per 6 month}$$

$$i_{mo} = (1 + 5\%)^{1/6} - 1 = 0.816\%$$

So,

$$10,00,000 \times (1.00816)^{96} = X \left[\frac{(1.00816)^{60} - 1}{0.01} \right]$$

$$\Rightarrow [X = 28331.2115]$$

• 55-60 yrs. work

60 → retire

Deposit certain Rs. x /month from your salary till retirement.

Retire 60 $\xrightarrow{20 \times 12 = 240 \text{ mth}}$ 80
draw Rs. 50,000/month.

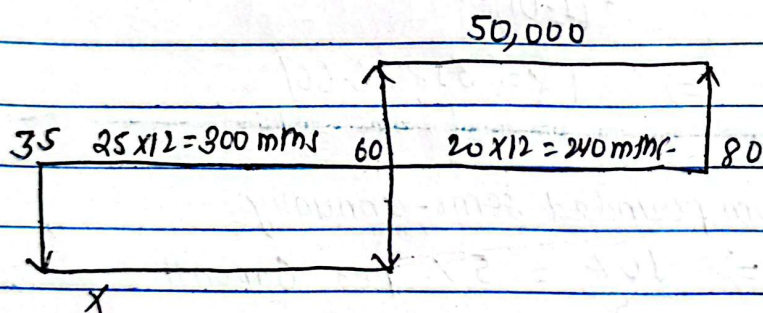
Find x .

(i) $i = 0.8\%$ /month

ii) $i = 6\%$ compounded quarterly
 $= \frac{6\%}{4} = 1.5\%$ per 3 month

$$[i_{mo} = (1 + 1.5\%)^{1/3} - 1 = 0.498\% \text{ per month}]$$

→ Solⁿ:-



$$x \left[\frac{(1.008)^{300} - 1}{0.008} \right] * (1.008)^{240} = 50000 \left[\frac{(1.008)^{240} - 1}{0.008} \right]$$

(60) + (20) 80

$$\Rightarrow [x = 4296.4]$$

$$x \left[\frac{(1.00498)^{300} - 1}{0.00498} \right] * (1.00498)^{240} = 50000 \left[\frac{(1.00498)^{240} - 1}{0.00498} \right]$$

$$\Rightarrow [x = 10127.66]$$

(8) ① $P \rightarrow$ Fixed deposit for 20 yrs.

$P = 20$ yrs.

12% rate

② After 10 yrs, 40,00,000 loan, 14% interest rate.

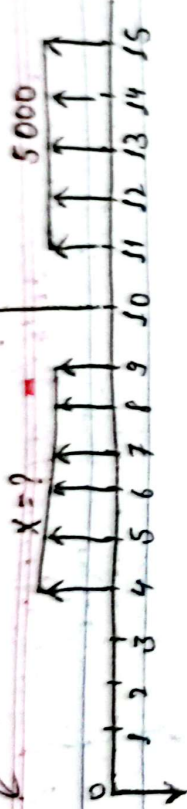
③ After 15 yrs, monthly x deposit, 10% compounded annually for next 5 years.

④ After 20 yrs, monthly 25,000 pension for next 10 yrs.
 $x = ?$

After 20 yrs, 10% annual interest.

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8% per year. 10% per year

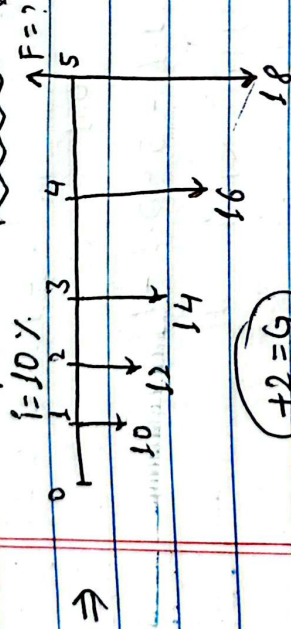


10,000,000

$$10,000,000 \times 1.08^{10} = X \left[\frac{1.08^6 - 1}{0.08} \right] \times 1.08 + 5000 \left[\frac{1.15 - 1}{0.1} \right] \times \frac{1}{1.15}$$

$$\Rightarrow [X = 270102.767]$$

Cash flow increase by certain amount Q



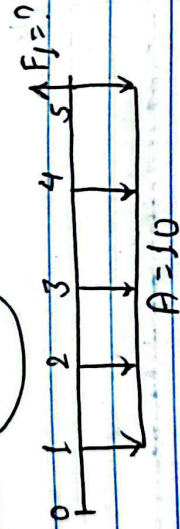
$i = 10\%$

$F = ?$

$$F = 10 \times 1.1^4 + 12 \times 1.1^3 + 14 \times 1.1^2 + 16 \times 1.1 + 18$$

$$= 83.153$$

$$+2 = G$$



$F = ?$

$$F_1 = 10 \left[\frac{1.15 - 1}{0.1} \right]$$

$$= 61.051$$

$$G = 2, N = 4 + 1 = 5$$

$$F_2 = G \left[\frac{(1+i)^N - N i - 1}{i^2} \right]$$

$$= 2 \left[\frac{1.15 - 5 \times 0.1 - 1}{0.1^2} \right] = 22.102$$

$$F = F_1 + F_2$$

$$= 61.051 + 22.102$$

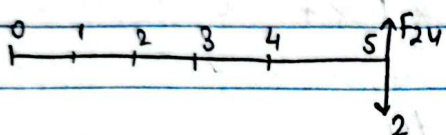
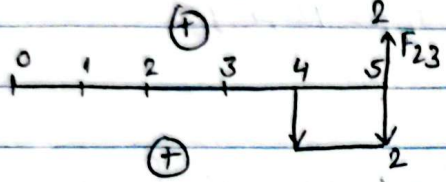
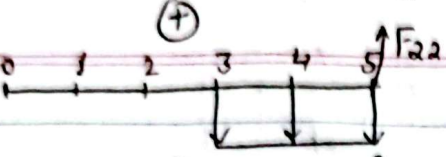
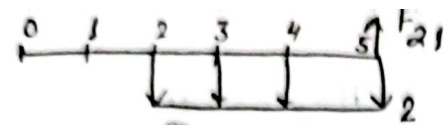
$$= 83.153$$

OR check

$$F_2 = 2 \times 1.1^3 + 4 \times 1.1^2 + 6 \times 1.1 + 8$$

$$= 22.102$$

Q1, (2)



$$F_2 = F_{21} + F_{22} + F_{23} + F_{24}$$

$$= 2 \left[\frac{1 \cdot 1^4 - 1}{0.1} \right] + 2 \left[\frac{1 \cdot 1^3 - 1}{0.1} \right] + 2 \left[\frac{1 \cdot 1^2 - 1}{0.1} \right] + 2 \left[\frac{1 \cdot 1^1 - 1}{0.1} \right]$$

$$= 22.102$$

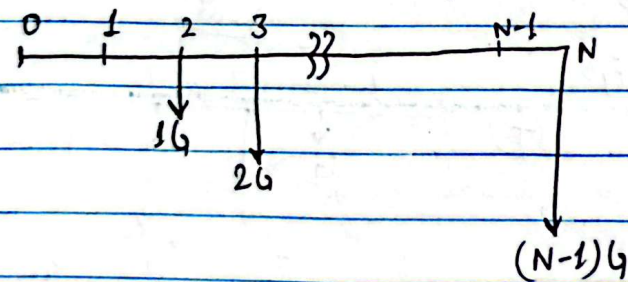
Formula

$$F_2 = \frac{2}{0.1} [1 \cdot 1^4 + 1 \cdot 1^3 + 1 \cdot 1^2 + 1 \cdot 1 - 1 - 1 - 1 - 1]$$

$$= \frac{2}{0.1} \left[\frac{1 \cdot 1 [1 \cdot 1^4 - 1]}{0.1} - 4 \right] = \frac{2}{0.1^2} [1 \cdot 1^5 - 1 \cdot 1 - 4 \times 0.1]$$

$$= \frac{2}{0.1^2} [1 \cdot 1^5 - \underbrace{5 \times 0.1}_{N \times i} - 1]$$

Q2



$$F = G \left[\frac{(1+i)^{N-1} - 1}{i} \right] + G \left[\frac{(1+i)^{N-2} - 1}{i} \right] + G \left[\frac{(1+i)^{N-3} - 1}{i} \right]$$

$$+ \dots + G \left[\frac{(1+i)^2 - 1}{i} \right] + G \left[\frac{(1+i) - 1}{i} \right]$$

$$= \frac{G}{i} [(1+i)^{N-1} + (1+i)^{N-2} + \dots + (1+i)^2 + (1+i)^1 - (N-1)1]$$

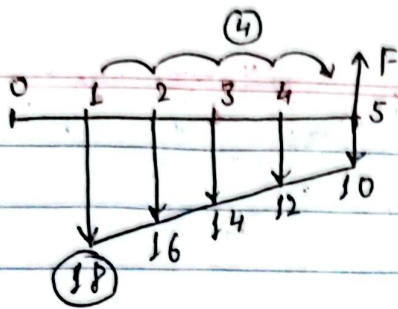
$$= \frac{G}{i} \left[\frac{(1+i) [(1+i)^{N-1} - 1]}{(1+i) - 1} - 1(N-1) \right]$$

$$= \frac{G}{i^2} [(1+i)^N - (1+i) - Ni + i]$$

$$F = \frac{G}{i^2} [(1+i)^N - Ni - 1] \quad \text{Ans}$$

★ [Here, decreasing, but we have formula only for decreasing increasing amount]

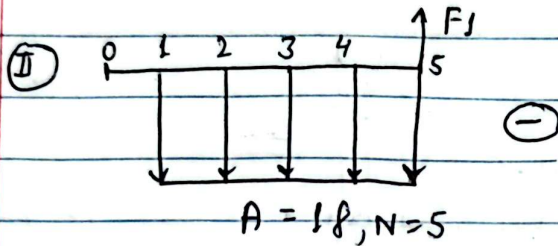
Q.



$$i = 10\%$$

Use A & G Formula.

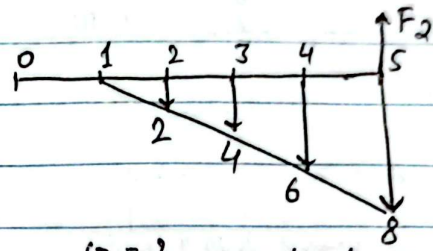
$$(I) \quad F = 18 \times 1.1^4 + 16 \times 1.1^3 + 14 \times 1.1^2 + 12 \times 1.1 + 10 = 87.790$$



$$F_1 = A \left[\frac{(1+i)^N - 1}{i} \right]$$

$$= 18 \left[\frac{(1+0.1)^5 - 1}{0.1} \right]$$

$$= 109.89$$



$$G = 2, N = 4 + 1 = 5$$

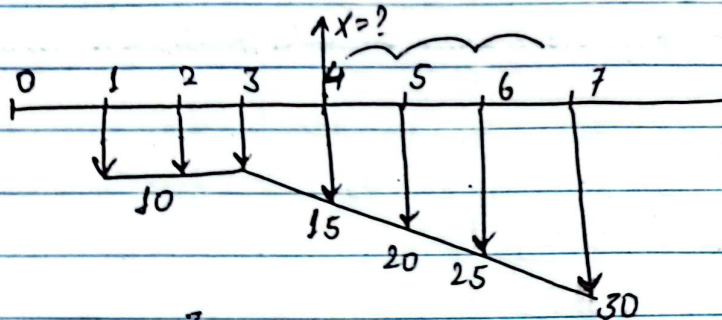
$$F_2 = \frac{G}{i^2} \left[(1+i)^N - Ni - 1 \right]$$

$$= \frac{2}{0.1^2} \left[1.1^5 - 5 \times 0.1 - 1 \right]$$

$$= 22.102$$

$$\Rightarrow F = F_1 - F_2 = 109.89 - 22.102 = 87.789$$

(Q)



$$i = 10\%$$

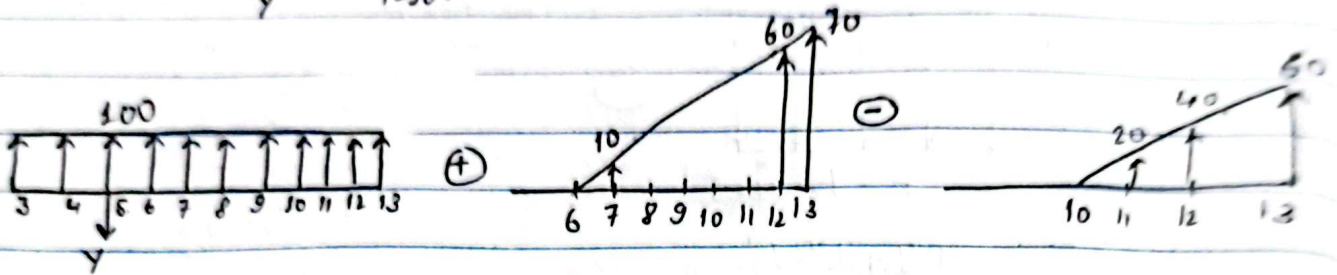
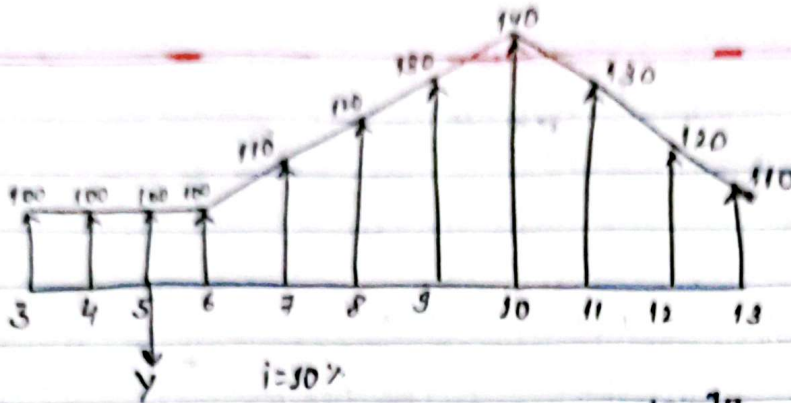
$$10 \left[\frac{1.1^7 - 1}{0.1} \right] + \frac{5}{0.1^2} \left[1.1^5 - 5 \times 0.1 - 1 \right] = X (1.1)^3$$

(7)

(7)

(4)

$$\Rightarrow [X = 112.792]$$



$$100 \left[\frac{1.1^{10} - 1}{0.1} \right] + \frac{10}{0.1^2} [1.1^8 - 8 \times 0.1 - 1] - \frac{20}{0.1^2} [1.1^4 - 4 \times 0.1 - 1]$$

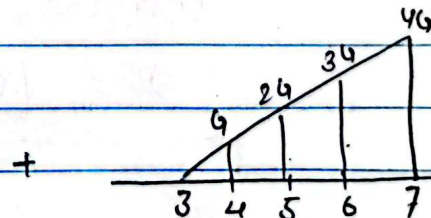
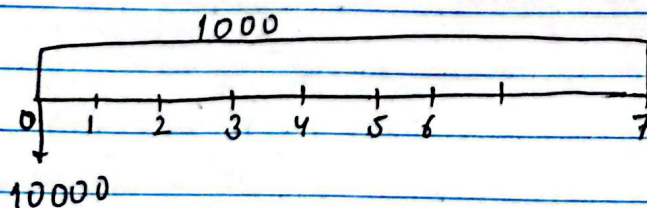
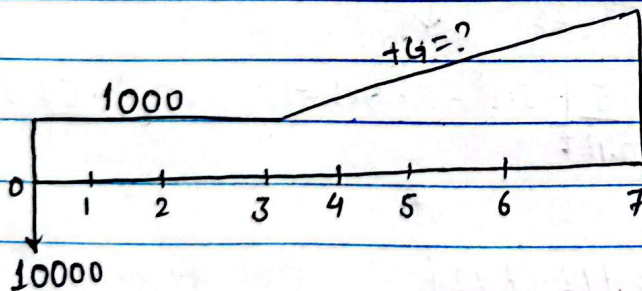
(13) (13) (13)

$$= Y \times (1.1)^8$$

$$(5) + (8)$$

$$\Rightarrow [Y = 964.973]$$

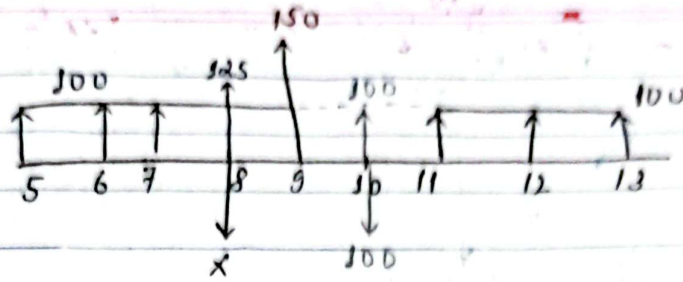
Q.



$$128.55 \left\{ 1000 \times \left[\frac{1.1^8 - 1}{0.1} \right] + \frac{46}{0.1^2} [1.1^5 - 5 \times 0.1 - 1] \right\} = 10000 \times 1.1^7$$

(6) (7) (6) + (7)

Q.



$$100 \left[\frac{1.1^9 - 1}{0.1} \right] \times \frac{1}{1.1^5} + \frac{25 \left[1.1^3 - 3 \times 0.1 - 1 \right] \times \frac{1}{1.1}}{0.1^2} - 100 \times \frac{1}{1.1^2}$$

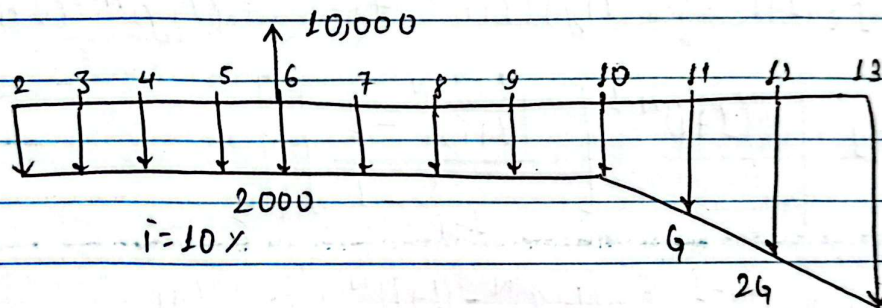
(13) - (5) (9) - (1) (10) - (2)

$$= x$$

(8)

$$\Rightarrow [x = 830.99]$$

(9)

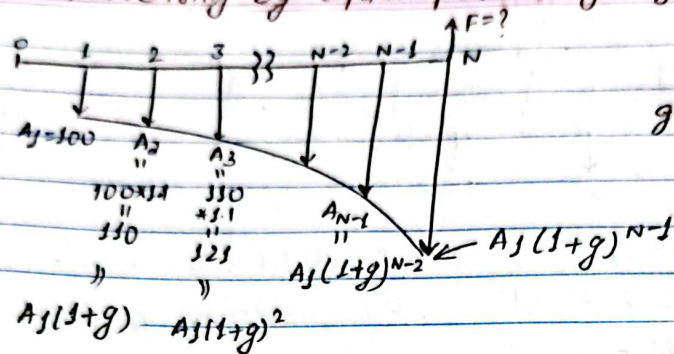


$$2000 \times \left[\frac{1.1^{12} - 1}{0.1} \right] + \frac{6 \left[1.1^4 - 4 \times 0.1 - 1 \right]}{0.1^2} = 10000 \times 1.1^7$$

(13) (13) (6) + (7)

$$\Rightarrow [G = 928.137]$$

- Cashflow increasing by equal percentage 'g'



i = interest rate
 g = % increase of cashflow.

$$F = A_1(1+i)^{N-1} + A_1(1+g)(1+i)^{N-2} + \dots + A_1(1+g)^{N-1}(1+i)^0$$

$$= A_1[(1+i)^{N-1} + (1+g)(1+i)^{N-2} + \dots + (1+g)^{N-2}(1+i) + (1+g)^{N-1}]$$

$$= A_1 \left[(1+i)^{N-1} \left[\frac{\left(\frac{1+g}{1+i}\right)^N - 1}{\frac{1+g}{1+i} - 1} \right] \right]$$

$$= A_1(1+i)^{N-1} \left[\frac{(1+g)^N - (1+i)^N}{1+g-1-i} \right] \times \frac{1+i}{(1+i)^N}$$

$$F = A_1 \left[\frac{(1+g)^N - (1+i)^N}{g-i} \right]$$

- If $i=g$,

$$F = A_1(1+i)^{N-1} + A_1(1+i)^{N-1} + \dots + A_1(1+i)^{N-1}$$

$$F = NA_1(1+i)^{N-1}$$

Q. Mr. R. wants to deposit Rs. 10,000 per month & start depositing from next month. He wish to continue for 20 yrs. Bank interest rate is 8% per year. He thought, he will increase deposit by

i. Rs. 50 per month

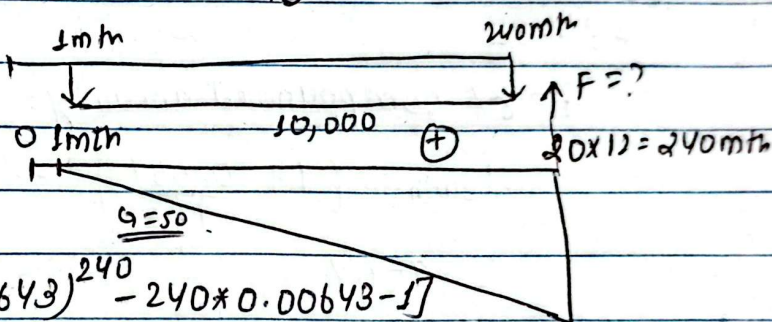
ii. 1% per month.

→ Solⁿ:-

$$i_{\text{month}} = \left(1 + \frac{8}{100}\right)^{1/12} - 1 = 0.643\%$$

i. $G = \text{Rs. } 50$

$i = 0.643\%$



$$F = \frac{50}{(0.00643)^2} \left[(1.00643)^{240} - 240 \times 0.00643 - 1 \right]$$

$$+ 10000 \left[\frac{(1.00643)^{240} - 1}{0.00643} \right]$$

$$= 8242265.752.$$

ii. $i = 0.643\%$

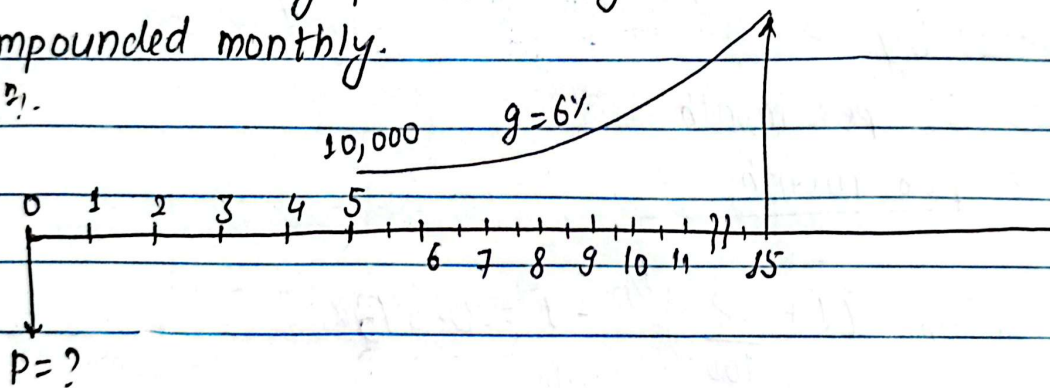
$g = 1\%$

$$F = A_1 \left[\frac{(1+g)^N - (1+i)^N}{g-i} \right] = 10,000 \left[\frac{(1.01)^{240} - (1.00643)^{240}}{0.01 - 0.00643} \right]$$

$$= 17467993.69.$$

Q. How much Rs. should you deposit now if so that you can get Rs. 10,000 at the end of 5 years & increasing by 6% per six month semi-annually for 10 more years. Bank interest rate = 8% compounded monthly.

→ Solⁿ.



$i = 8\%$ compounded annually $= 0.667\%$ per month

$$i_{6\text{mth}} = \left(1 + \frac{0.667}{100}\right)^6 - 1 = 4.07\%$$

$g = 6\%$

$$\underbrace{P}_{\text{①}} \times \underbrace{1.0407}_{\text{③}}^{30} = 10000 \left[\frac{(1.06)^{30} - (1.0407)^{20}}{0.06 - 0.0407} \right]$$

$(15 \times 2) = 30^{\text{th}}$ semi-annuals

$$\Rightarrow [P = 1544176.747]$$

Chapter 3:-

Basic Methodology of Engineering Economic Studies

→ TO decide whether project is feasible (to invest) or not

1. Payback period method
2. Equivalent worth method
3. Rate of Return method
4. Benefit cost Ratio (BCR, B/C) methods

• Payback Period (PBP) - method

No. of years required to recover invested capital in PB period.

+ Time required to recover principle only is simple PB period

+ Time required to recover both principle & interest is Discounted PB period.

+ Disc. PB period > Simple PB period.

1 Initial Investment, $I = 50,000$

Annual Income, $(B) = 12,500$

$$\text{Simple PB period} = \frac{I}{B} = \frac{50,000}{12,500} = 4 \text{ years}$$

(OR) Alternatively.

→ For suspension bridge, FB from HPL = 5m

Year cash flow cumulative cash flow

0	-50,000/-	-50,000/-
1	12,500	-50,000 + 12,500 = -37,500/-
2	12,500	-37,500 + 12,500 = -25,000/-
3	12,500	-12,500
4	12,500	0 → Cutoff
5	12,500	12,500
6	12,500	25,000

86000

#	Year	0	1	2	3	4	5
	Cash flow	-50	+10	12	15	20	25
	Cum. cash flow	-50	-40	-28	-13	7	32

PB period > 3 years & < 4 years.

By interpolation,

$$[PB \text{ period} = 3.65 \text{ years}]$$

$$\left(\frac{-13 - 7}{0 - 7} = \frac{3 - 4}{2 - 4} \right)$$

∴ Project is feasible or not?

→ PB period < expected → Feasible.

(standard

PB period)

Calculate simple and Discounted PB period.

$$i = \text{MARR} = 10\%$$

Year	0	1	2	3	4	5
Cash flow	-40	-60	20	30	40	50

Soln.

i. Simple payback period calculation.

Year	0	1	2	3	4	5
Cash flow	-40	-60	20	30	40	50
Cumulative cash flow	-40	-100	-80	-50	-10	40

$$\text{Simple PB period} = 4 + \frac{10}{50} \times 1 = 4.2 \text{ years}$$

Year	0	1	2	3	4	5
Cash flow	-40	-60	20	30	40	50
Discounted cash flow	-40	$\frac{-60}{(1+i)^1}$	$\frac{20}{1.1^2}$	$\frac{30}{1.1^3}$	$\frac{40}{1.1^4}$	$\frac{50}{1.1^5}$
$P = \frac{F}{(1+i)^N}$		$= \frac{-60}{1.1}$	$= 16.529$	$= 22.539$	$= 27.321$	$= 31.046$
		$= -54.545$				
Cumulative discounted cash flow	-40	-94.545	-78.016	-55.477	-28.156	2.890

$$\text{Discounted PB period} = 4 + \frac{28.156}{31.046} \times 1$$

$$= 4.907 \text{ years}$$

Electricity rate (buying rate for M)
 4.80 → rainy season (also produce E)
 8.40 → dry season (also " " ")

Q. A hydropower project 1MW costs Rs. 20 crore. Study period (life) = 30 years - salvage value (sv) = 5 cr.

Annual income

$$= 1000\text{kw} \times 1\text{hr} \times 24 \times (365.5) \text{ unit/year}$$

$$\times 0.55 \times 6 \text{ Rs/unit}$$

50 to 60% of
 max. electricity
 in dry period

(weighed mean
 rate of buying)

$$= 2851200 \text{ Rs/year}$$

Annual Operation & Maintenance (O&M) cost:

$$= 2\% \text{ of initial cost}$$

$$= 2\% \text{ of } 20 \text{ crore}$$

$$= 40 \text{ lakh/year}$$

Calculate both simple & discounted PB period.

→ Solⁿ:

$$\bullet \text{ Simple PB period} = \frac{\text{Initial investment}}{\text{Net annual income}}$$

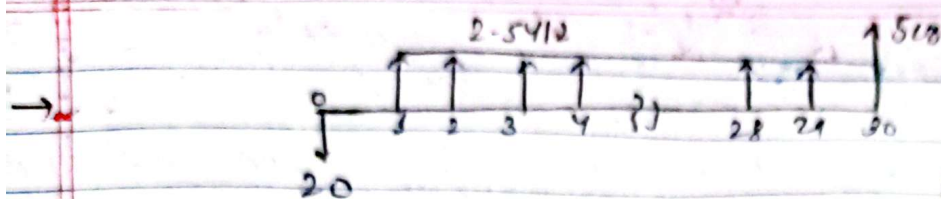
$$= \frac{20,00,00,000}{28512000 - 40,00,000}$$

$$= 8.159 \text{ years}$$

• Discounted PB period

Year	Cost (cr)	Discounted cashflow, $P = \frac{F}{(1+i)^N}$	Cum. dis. value
0	-2000	-20	-20
1	2.4512	2.2283	-17.772
2	2.4512	2.026	-15.746
3	2.4512	1.842	-13.904
4	2.4512	1.675	-12.229
5	2.4512	1.522	-10.707
6	"	1.384	-9.323
7	"	1.258	-8.065
8	"	1.144	-6.921
9	"	1.040	-5.881
10	"	0.945	-4.936
11	"	0.859	-4.077
12	"	0.781	-3.296
13	"	0.710	-2.588
14	"	0.646	-1.940
15	"	0.584	-1.356
16	"	0.534	-0.822
17	"	0.485	-0.337
18	"	0.441	0.104
19	"		

$$\text{Discounted PB value} = 17 + \frac{0.337}{0.441} = 17.764 \text{ yrs.}$$



$$-20 + \underbrace{2.5412}_A \left[\frac{(1+0.1)^N - 1}{0.1 \times (1+0.1)^N} \right] + \text{Lignee at first} = 0$$

assuming $N < 29$

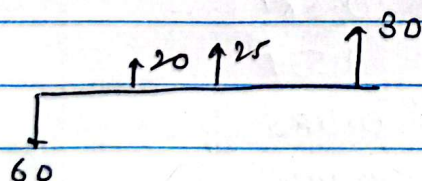
$$\Rightarrow [N = 17.76 \text{ years}]$$

If $29 < N \leq 30$, include salvage value and recalc new N

#	Year	Cashflow	Dis. cashflow	Cum. Cashflow
	0	-60	-60	-60
	1	20	18.182	-41.818
	2	25	20.661	-21.157
	3	30	22.539	1.382

$i = 10\%$

$$2 + \frac{\cancel{1.382} + 21.157}{(1.382 + 21.157)} \times 1 = 2$$



$$\frac{[61.382 - 60]}{2} = 1.382$$

6 years]

include salvage value and recalculation

Cash flow Cum. Cash flow

60 -60

82 -41.818

661 -21.157

539 1.382

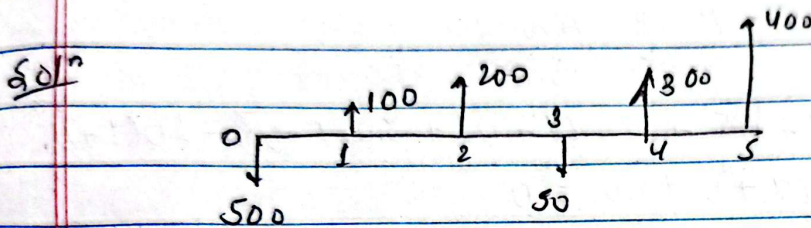
$$2 + \frac{\cancel{1.382} 21.157 \times 1}{(1.382 + 21.157)} = 2.938$$

$$\frac{382 - 60}{\cancel{60}} = 1.382$$

Find Net present value (NPV) = Present worth (PW) & Net Future value (NFV) = Future worth (FW) to decide its feasibility.

Year	0	1	2	3	4	5
CF	-500	100	200	-50	300	400

$$i = \text{MARR} = 15\%$$



$$\begin{aligned} \text{Present worth (PW)} &= -500 + \frac{100}{1.15} + \frac{200}{1.15^2} - \frac{50}{1.15^3} + \frac{300}{1.15^4} + \frac{400}{1.15^5} \\ &= 75.71 \end{aligned}$$

$$\begin{aligned} \text{Future worth (FW)} &= -500 \times 1.15^5 + 100 \times 1.15^4 + 200 \times 1.15^3 - 50 \times 1.15^2 \\ &\quad + 300 \times 1.15 + 400 \\ &\quad \text{or} \\ &\quad \text{PW} \times 1.15^N \\ &= 152.28 \end{aligned}$$

$$PW > 0 \text{ \& } FW > 0$$

So, Feasible to invest (Profitable)

check

$$FW = PW(1+i)^N = 75.71 \times 1.15^5 = 152.28$$

$$\text{or, } NFV = NPW(1+i)^N$$

IRR → लगानी गर्दा आउने ब्याज

Find IRR Determine its Feasibility & Draw Investment balance (TIB) diagram.

Years	0	1	2	3	4	5
Cashflow	-100	20	30	-10	40	50

MARR = 10%

Solution:-

TO find IRR,

Make $PW = 0$ or $FW = 0$ or $AW = 0$

Now,

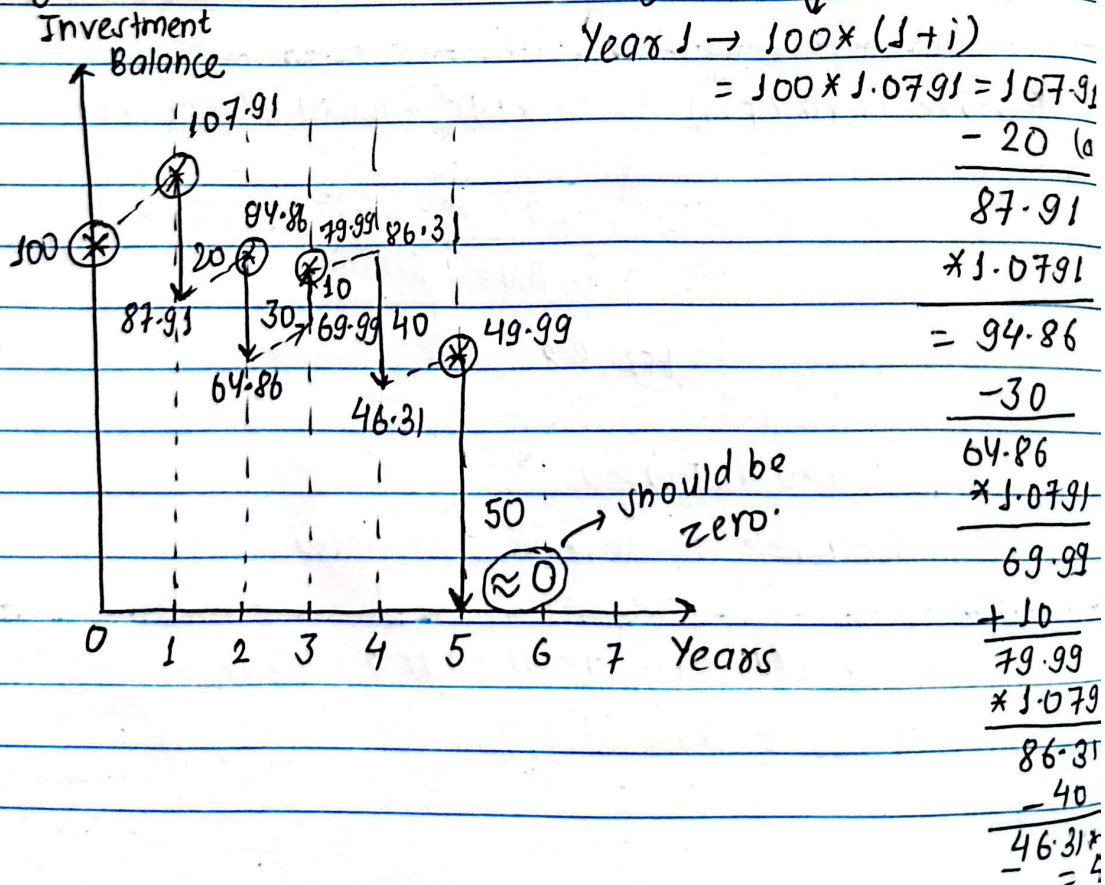
$$FW = -100(1+i)^5 + 20(1+i)^4 + 30(1+i)^3 - 10(1+i)^2 + 40(1+i) + 50 = 0$$

Solving,

$$[i = IRR = 7.91\%] < \text{MARR}$$

⇒ Unfeasible

Figure: Investment Balance Diagram. ^{initial withdr}



$$45 = 100(1 + 0.075) + 20(1 + 0.075) + 40(1 + 0.075) + 50 = 0$$

Dividing

$$j = 7.5\% \rightarrow \text{unfeasible}$$

initial withdrawal

Borrow Diagram

$$\text{Year 1} \rightarrow 100 \times (1 + i)$$

$$= 100 \times 1.0791 = 107.91$$

$$- 20 \text{ (initial)}$$

$$87.91$$

$$\times 1.0791$$

$$= 94.86$$

$$- 30$$

$$64.86$$

$$\times 1.0791$$

$$69.99$$

$$+ 10$$

$$79.99$$

$$\times 1.0791$$

$$86.31$$

$$- 40$$

$$46.31 \times 1.0791$$

$$= 49.99$$

$$- 50$$

40

49.99

50

20

should be zero

6 7 Years

TANK configuration,

$$d_e = 1.5 \text{ m}$$

$$\text{Area, } A = \frac{V}{d_e} = \frac{29.6875}{1.5} = 19.792 \text{ m}^2$$

$$\text{Assume, } L/B = 3$$

$$\Rightarrow B = 2.568 \text{ m} \approx 2.6 \text{ m}$$

$$L = 3B = 7.705 \text{ m} \approx 7.75 \text{ m}$$

$$\text{Total depth, } D = 1.5 + \underbrace{0.5}_{\substack{\uparrow \\ \text{FB}}} = \underline{\underline{2 \text{ m}}}$$

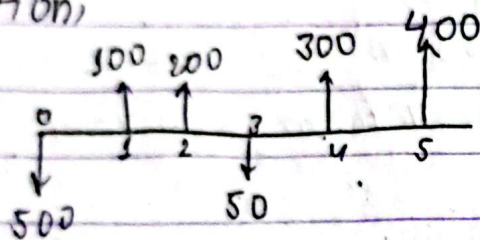
SURENDRA SHARMA

Find net present value (NPV) = Present worth (PW)
& Net Future Value (NFV) = Future worth (FW)
to decide on its feasibility.

Year	0	1	2	3	4	5
Cashflow	-500	100	200	-50	300	400

$i = \text{MARR} = 15\%$

→ Solution,



प्रति लाभ
0 का
लाभ

$$PW = -500 + \frac{100}{1.15} + \frac{200}{1.15^2} - \frac{50}{1.15^3} + \frac{300}{1.15^4} + \frac{400}{1.15^5}$$

$$= 75.71$$

लाभ
का
ने

$$FW = -500 \times 1.15^5 + 100 \times 1.15^4 + 200 \times 1.15^3 - 50 \times 1.15^2 + 300 \times 1.15 + 400$$

$$= 152.27$$

'or'

$$\Rightarrow 75.71 \times 1.15^5 = 152.27$$

check

$$FW = PW(1+i)^N$$

'or'

$$NFW = NPW(1+i)^N$$

Find Net present value (NPV) : Present worth (PW)
 & Net Future Value (NFV) : Future worth (FW)
 to decide on its feasibility.

① Initial investment $I = 100,000$

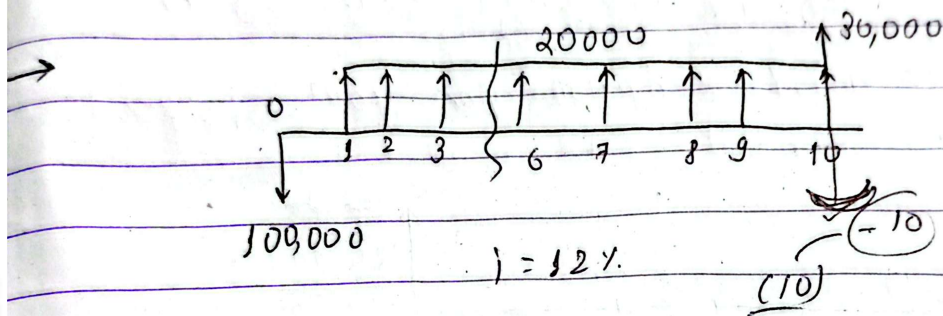
Net annual income = 25000

Annual cost (O&M) = 5000

Useful life (yr) = 10

Salvage Value (S_v) = 30,000

MARR (i) = 12%



$$PW = -100000 + 20000 \left[\frac{1.12^{10} - 1}{0.12} \right] \times \frac{1}{1.12^{10}} + \frac{30000}{1.12^{10}}$$

$$= 22663.657$$

$$(10) \quad FW = -100000 \times 1.12^{10} + (25000 - 5000) \left[\frac{1.12^{10} - 1}{0.12} \right] + 30000$$

$$= 70389.88$$

(check)

$$FW = \underbrace{PW}_{22663.657} \times 1.12^{10} = 70389.88$$

$PW > 0$ & $FW > 0 \rightarrow$ Feasible to invest.

Q An equipment cost Rs. 1,00,000 now. Its life = 5 years. Salvage value expected is Rs. 20,000.

Opt 1 Buy now @ Rs. 1,00,000

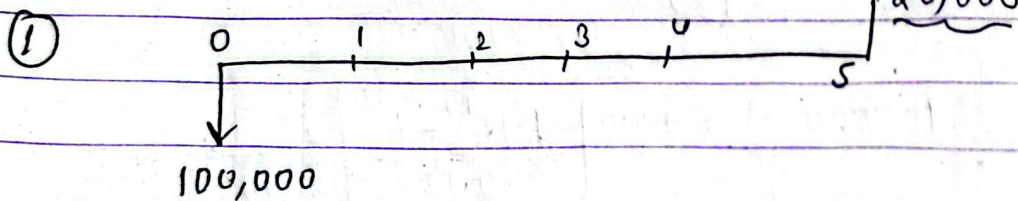
Use for 5 years & sell at 20,000 after 5 years.

Opt 2. Rent it at Rs. 24,000/yr for 5 years at paid the end of each year.

Opt 3 → Use it for 5 years pay Rs. 10,000 now & pay Rs. 1,30,000 after 5 years

which is best option for you? ($i = 8\%$)

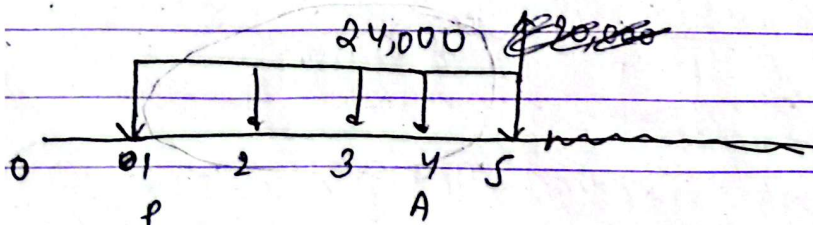
→ Solⁿ:



$$PW = \begin{matrix} (P) & (F) \\ -100000 & + \frac{20000}{1.08^5} \end{matrix} = -86388.34$$

$$= -72776.67$$

$$FW = PW \times (1.08)^5 = -106932.81$$



$$PW = -24000 \left[\frac{1.08^5 - 1}{0.08} \right] \times \frac{1}{1.08^5} + \frac{20000}{1.08^5} = -95825.04$$



$$PW = -10,000 - \frac{1,30,000}{1.08^5} = -38475.21$$

Since,

PW of opt. (1) is minimum best.

(u)

PW $\Rightarrow$ convert to P

$\Rightarrow$ funcⁿ (P, F, A)

AW $\Rightarrow$ funcⁿ (P, F, A)

$$\left\{ \begin{array}{l} A = P \left[\frac{i(1+i)^N}{(1+i)^N - 1} \right] \\ A = F \left[\frac{i}{(1+i)^N - 1} \right] \end{array} \right.$$

For 1,

$$AW = -100,000 \left[\frac{0.08 \times 1.08^5}{1.08^5 - 1} \right] + 20000 \left[\frac{0.08}{1.08^5 - 1} \right]$$

$$= -21636.51$$

For 2, AW = -24000

$$\text{For 3, } AW = -10,000 \left[\frac{0.08 \times 1.08^5}{1.08^5 - 1} \right] - 1,30,000 \left[\frac{0.08}{1.08^5 - 1} \right]$$

$$= -24663.90$$

Mr. Suhant sah → Parent 10 yrs → 1 cr → Bkr → घर

Yesterday → 2 cr → घर बिक्री

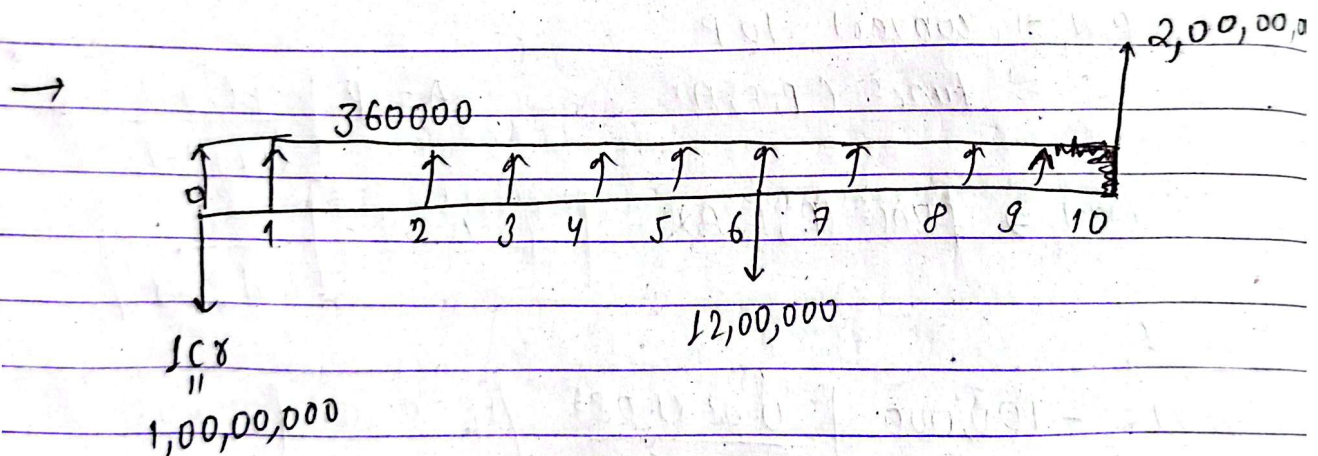
घर बिक्री Bank तब 10% per year interest मिल
गरी 1 cr loan लिया।

→ घर भासा लया @ Rs 360,000/year paid
of the basis of each year.

→ 4 year ago he spend Rs. 12 lakh to repair
Roof & other.

Was he able to pay all loan & interest

Yesterday? ⇒ Did he make any profit
or did he incur loss?



$$PW = -10000000 + 360,000 \left[\frac{1.1^{10} - 1}{0.1} \right] \times \frac{1}{1.1^9}$$

$$= \frac{12,00,000}{1.1^6} + \frac{20000000}{1.1^{10}}$$

$$= -533254.3536 \%$$

$$FW = \downarrow \times 1.1^{10}$$

$$= -1383124.456$$

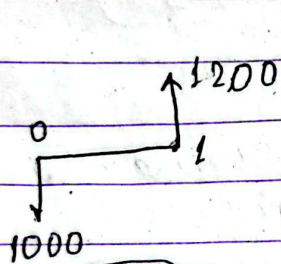
Rate of Return (ROR) methods:-

Interest Rate of Return (IRR)

External Rate of Return (ERR)

IRR $\rightarrow$ It is the interest rate earned by investing in a project. or anywhere including Bank deposit

To find IRR make $PW=0$ or $FW=0$ or $AW=0$.
Find $i = IRR$.



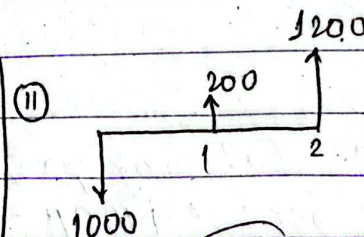
$$1000 + \frac{1200}{(1+i)^1} = 0$$

$$\Rightarrow [i = 0.2 = 20\%]$$

100 - 1 yr - 200

100 - 1 - 20

$$[i = 20\%]$$



$$-1000 + \frac{200}{(1+i)^1} + \frac{1200}{(1+i)^2} = 0$$

$$\Rightarrow i = 0.2$$

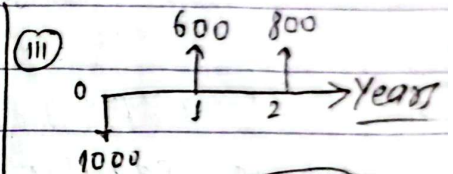
$$[i = 20\%]$$

or
Year 1 @ 20% $\rightarrow -200$

Year 2 $\rightarrow 200 + 1000$

$\downarrow \quad \downarrow$
I P

$$[i = 20\%]$$



$$-1000 + \frac{600}{(1+i)^1} + \frac{800}{(1+i)^2} = 0$$

$$i = 0.2434$$

$$\Rightarrow [i = 24.34\%]$$

What investment rate are you offering $\rightarrow$ IRR

Deposit \$1,000 in a bank now

$$i = 8\%$$

\$50 in 5 years

T

$$F = 1000 \times 1.06^5 = 13382.26$$

$$13382.26$$



10000

For, IRR

$$FW = -10000 * (1+i)^5 + 13382.26 = 0$$

$$Y \text{ [IRR} = i = 0.06 = 6\%]$$

Find IRR of the following project. Decide whether it is feasible or not? (MARR = 10%)

Year	0	1	2	3	4	5
Cashflow	-100	20	20	30	40	50

PW=0

$$-100 + \frac{20}{(1+i)^1} + \frac{20}{(1+i)^2} + \frac{30}{(1+i)^3} + \frac{40}{(1+i)^4} + \frac{50}{(1+i)^5} = 0$$

$$\Rightarrow [i = 0.1634 = 16.34\%]$$

Since, IRR > MARR $\rightarrow$ feasible to invest.

MARR $\Rightarrow$ Minimum Attractive Rate of Return (?)

< Layman concept >

↳ company ले Bank एर loan लिखे project मा invest जेने,

* Bank लाई तिने ख्याज = MARR

* Project एर कमाउने ख्याज = IRR

सो, If IRR (पाउने ख्याज) > MARR (तिने ख्याज)

Project is Profitable or Feasible

SURENDRA SHARMA

$< \text{MARR} \Rightarrow$ bank offer $\frac{\text{Interest}}{\text{Cost}} + \text{Risk factor}$

$< \text{MARR} \Rightarrow ??$ How to decide?

① Opportunity cost?

- $\rightarrow$ cost of opportunity foregone
- $\rightarrow$ cost of best rejected alternative.

2. Type of organizations involved.

3. The amt. of perceived risk associated with investment

4. No. of good project available.

5. Amt. of money available for investment

Drawbacks of IRR

① Possibility of multiple value of IRR.

$$\begin{aligned} a^2 + b &= c & \left\{ \begin{array}{l} a^2 + b^2 + c = 0, a \Rightarrow 2 \text{ values} \\ a^3 + b^2 + c^2 + d = 0, a \Rightarrow 3 \text{ values} \end{array} \right. \\ a = \frac{c-b}{a} \rightarrow 1 & \left\{ \begin{array}{l} \text{and so on.} \end{array} \right. \end{aligned}$$

② Results from IRR & PW may be different.

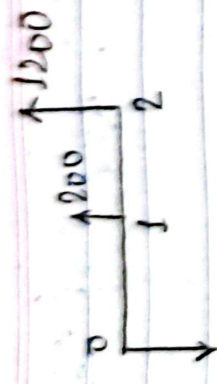
Year	A	B
0	-100	-500
1	+200	+700
IRR	100%	40%
PW	100%	more

$i = \text{MARR} = 10\%$

select A

select B

③ Ignores re-investment possibility & overall internal Rate of Return after reinvestment.

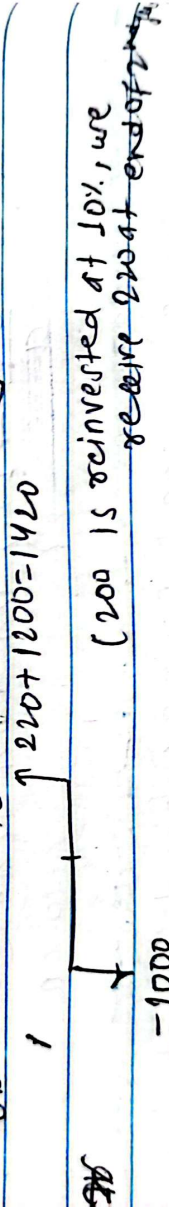

 From first investment,
 $IRR \Rightarrow FW = -1000(1+i)^2 + 200(1+i) + 1200 = 0$
 $\Rightarrow [i = IRR = 20\% \cdot (0.2)]$

But if we reinvest Rs. 200 at 10% interest per year $i = 10\%$. [External rate of investment] Overall IRR will be

(a) 20% (b) $< 20\%$ (c) $> 20\%$ (d) All

$\Rightarrow -1000(1+i)^2 + 200(1.1) + 1200 = 0$

'6R' $\Rightarrow [i = 19.164\% \cdot (20\%)]$


 (200 is reinvested at 10%, we receive 220 at end of year 1)

New IRR (After Reinvestment)

$-1000(1+i)^2 + 1420 = 0$

$\Rightarrow [i = 19.16\% \cdot (20\%)]$

पहिलो ठाउँ वाट (लगानी गरेको) भएको व्याज
 $= IRR$

EIRR (modified IRR) $\rightarrow$ पहिलो वाट भएको
 पैसा लाई Reinvest गर्ने भएको overall
 व्याज $= EIRR$ (modified IRR)

How to calculate IRR

Make $PW = 0$ or $FW = 0$ or $AW = 0$

Find $i = IRR$

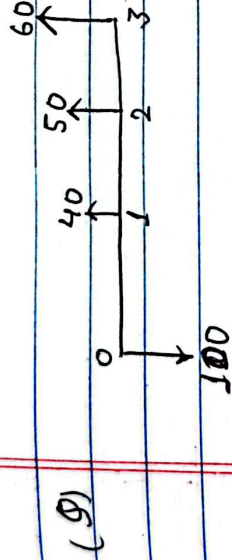
How to calculate $ERR(MIRR)$

Always make $FW = 0$

Put ϵ instead of i for +ve cashflow

Put i for -ve cashflow (conditions Apply)

Find $i = ERR$



Find IRR & ERR when

$\epsilon = MARR = 12\%$

• $IRR \Rightarrow FW = -100(1+i)^3 + 40(1+i)^2 + 50(1+i) + 60 = 0$

$\Rightarrow i = IRR = 21.65\%$

• ERR } $FW = -100(1+i)^3 + 40(1+\epsilon)^2 + 50(1+\epsilon) + 60 = 0$
(MIRR) } $-100(1+i)^3 + 40 \times 1.12^2 + 50 \times 1.12 + 60 = 0$

$\Rightarrow i = ERR(MIRR) = 18.45\%$

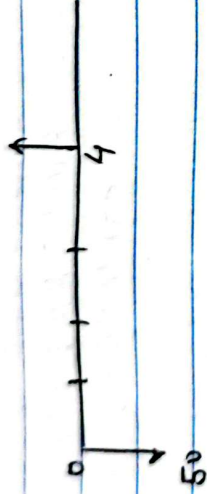
$[\epsilon < ERR < IRR \text{ 'OR' } \epsilon > ERR > IRR]$

9. Find ERR. MARR = $\epsilon = 12\%$

Year	0	1	2	3	4
Cashflow	-50	10	15	20	25

$$\rightarrow FW = -50(1+i)^4 + 10x(1+i)^3 + 15x(1+i)^2 + 20(1+i) + 25 = 0$$

$$\Rightarrow i = 12\%$$



$$\text{OK } FW = -50(1+i)^4 + 10 \times 1.12^3 + 15 \times 1.12^2 + 20 \times 1.12 + 25 = 0$$

$$\Rightarrow (i = 12.56\%)$$

$$(10 \times 1.12^3 + 15 \times 1.12^2 + 20 \times 1.12 + 25)$$

ERR > MARR $\rightarrow$ Feasible.

Test

Find both IRR & ERR. MARR = 12% . $\epsilon = 15\%$.

Year	0	1	2	3	4	5
Cashflow	-100	20	30	-10	40	50

For IRR

$$-100(1+i)^5 + 20(1+i)^4 + 30(1+i)^3 - 10(1+i)^2 + 40(1+i) + 50 = 0$$

$$\Rightarrow [i = \text{IRR} = 10.01\%]$$

IRR

For EAP,

$$-100(1+i)^5 + 20(1+i)^4 + 30(1+i)^3 - 10(1+i)^2 + 40(1+i) + 60 = 0$$

$$\Rightarrow i = \text{EAP} = 11.43\%$$

Since,

$\text{EAP} > \text{MARR}$

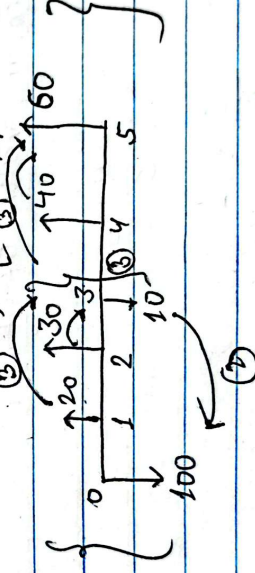
(not feasible)

$\text{EAP} < \text{MARR}$

↳ Unfeasible

$$-100(1+i)^5 + 20(1+i)^4 + 30(1+i)^3 - 10(1+i)^2 + 3 + 40(1+i) + 60$$

$$\Rightarrow i = \text{EAP} = 11.85\%$$



$$20 \times 1.15^2 + 30 \times 1.15 - 10 = \frac{50.95}{1.15^2} + 40 \times 1.15$$

$$\frac{+60}{173.381}$$

$$100 \times (1+i)^5 = 173.381$$

$$\Rightarrow i = 11.635\%$$

Benefit cost Ratio (BCR)

↳ Benefit (B) → Income from the project (आय)
Cost (C) → Expenditure (खर्च)

→ For any project to be feasible,
Benefit (B) > cost (C)
i.e. $\left[\frac{B}{C} > 1\right]$

Criteria

- $\frac{B}{C} > 1 \rightarrow$ Feasible or $\frac{C}{B} < 1$
- $\frac{B}{C} < 1 \rightarrow$ Unfeasible or $\frac{C}{B} > 1$
- $\frac{B}{C} = \frac{C}{B} = 1 \rightarrow$ critical.

Q. For feasible project

(a) ~~By~~ Minimum value of $\frac{B}{C} = 0$

1) Max^m value of $\frac{B}{C} = 0$

2) Min^m value of $\frac{C}{B} = 1$

Max^m value of $\frac{C}{B} = 1$

* Find $\frac{B}{C}$ of the following project.

Initial investment, $I = 100 \Rightarrow$ Present value (P)

Annual benefit (B) = 30 $\Rightarrow$ A (Annuity)

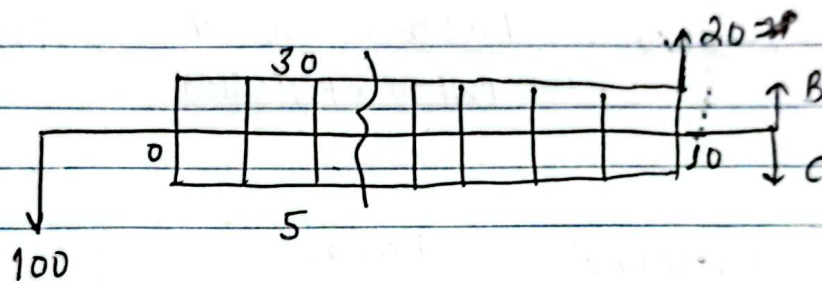
Annual cost ($O\&M$) = 5 $\Rightarrow$ A (Annuity)

Useful life (N) = 10 yrs

Salvage value (S_v) = 20 $\Rightarrow$ Future value (F)

MARR = 10%

$\rightarrow$



$$\left\{ \frac{B}{C} = \frac{30 \times 10 + 20}{100 + 5 \times 10} = \frac{320}{150} = 2.13 \right.$$

Correct only if $i = 0\%$.

(No time value of money considered)

* Convert all the cashflow into Either Pos or For A

$$\frac{B}{C} = \frac{30 \left[\frac{1.1^{10} - 1}{0.1} \right] + 20}{5 \left[\frac{1.1^{10} - 1}{0.1} \right] + 100 \times 1.1^{10}} = \frac{498.12}{339.66} = 1.469$$

Converting to

(P) $\rightarrow$ PW

(F) $\rightarrow$ FW

(A) $\rightarrow$ AW

(I) $\rightarrow$ 100

(B) $\rightarrow 30 \left[\frac{1.1^{10} - 1}{0.1 \times 1.1^{10}} \right] = 184.34$

(O&M) $\rightarrow 5 \left[\frac{1.1^{10} - 1}{0.1 \times 1.1^{10}} \right] = 30.72$

(Sv) $\rightarrow \frac{20}{1.1^{10}} = 7.71$

$\rightarrow 100 \times 1.1^{10} = 259.37$

$\rightarrow 30 \left[\frac{1.1^{10} - 1}{0.1} \right] = 478.13$

$\rightarrow 5 \left[\frac{1.1^{10} - 1}{0.1} \right] = 79.68$

$\rightarrow 20$

$\rightarrow 100 \left[\frac{0.1 \times 1.1^{10}}{1.1^{10} - 1} \right] = 16.2$

$\rightarrow 30$

$\rightarrow 5$

$\rightarrow 20 \left[\frac{0.1}{1.1^{10} - 1} \right] = 1.2$

Thur

(P)

Cost = 130.72

Benefit = 192.05

$B/C = 1.469$

(F)

C = 339.064

B = 498.12

$B/C = 1.469$

(P)

C = 21.274

B = 31.25

$B/C = 1.469$

Ans :-

$$\# \quad \frac{B}{C} (\text{conventional}) = \frac{PW(B) + PW(SV)}{PW(I) + PW(D\&M)} \quad \left. \vphantom{\frac{B}{C}} \right\} P/F/A$$

$$\propto \frac{B}{C} (\text{conventional}) = \frac{PW(I) + PW(D\&M) - PW(SV)}{PW(I) + PW(D\&M) - PW(SV)}$$

$$\propto \frac{B}{C} (\text{modified}) = \frac{PW(B) - PW(D\&M)}{PW(I) - PW(SV)} \quad (\text{आमदानी - खर्च})$$

$\propto$ Exam $\rightarrow$ in Both types of B/C ratios are
 $\rightarrow$ conventional
 $\rightarrow$ Modified.

$$\text{Since, } FW = PW(1+i)^N = AW \left[\frac{(1+i)^N - 1}{i} \right]$$

$$PW = \frac{FW}{(1+i)^N} = AW \left[\frac{(1+i)^N - 1}{i (1+i)^N} \right]$$

Ans.

Since, multiplying factor same.

P/F/A $\rightarrow$ एका ही रहे बि सम B/C

Cost (P)

(P)

$$\frac{B}{C} \text{ (normal)} = 1.469$$

P

$$1.469 \text{ (feasible)}$$

$$\frac{B}{C} \text{ (conventional)} = \frac{184.34}{100+30.72-7.71}$$

$$1.498 \text{ (feasible)}$$

$$= 1.498$$

$$\frac{B}{C} \text{ (modified)} = \frac{184.34 - 30.72}{100 - 7.71} = 1.66$$

$$1.66$$

(Q)

$$\left(\frac{B}{C}\right) \text{ modified} > \left(\frac{B}{C}\right) \text{ conventional}$$

$$\text{if } \frac{B}{C} > 1 \text{ - Feasible}$$

$$\left(\frac{B}{C}\right) \text{ modified} < \left(\frac{B}{C}\right) \text{ conventional}$$

$$\text{if } \frac{B}{C} < 1 \rightarrow \text{unfeasible}$$

$$\left(\frac{B}{C}\right) \text{ modified} = \left(\frac{B}{C}\right) \text{ conventional}$$

$$\text{if } \frac{B}{C} = 1$$

$$\frac{B}{C} > 1$$

$$B + S_V = A$$

$$I + O + M = B + D$$

$$\frac{A}{B} = \frac{B}{C}$$

$$\Rightarrow \left(\frac{B}{C}\right) \text{ modified} =$$

$$\text{det, } \pi = 107p$$

$$I = 10$$

$$O + M = 1$$

$$B = 2$$

$$S_V = 1$$

$$\frac{B}{C} \geq 1 \left\{ \frac{B}{C} \text{ (normal)} = \frac{2}{1+7.71} > 1 \right\} \frac{B}{C} \text{ (modified)} = 1.66$$

$$\frac{B}{I+O-S_v}$$

$$\frac{B+J_v}{I+O} > 1 \quad \frac{B}{I+O-S_v} > \frac{B-b}{I-S_v}$$

$$B+J_v > I+O$$

$$\frac{B}{I+O-S_v} > 1$$

$$\left. \begin{array}{l} B=3 \\ S_v=4 \\ I=11 \\ O=2 \end{array} \right\}$$

$$\Rightarrow \left(\frac{B}{C} \right)_{\text{mod}} > \left(\frac{B}{C} \right)_{\text{conv.}}$$

$$PW(B) - PW$$

B

$$\left(\frac{B}{C} \text{ mod } = \right) \frac{PW(B) - PW(O \& M)}{PW(I) - PW(S_v)} > \frac{PW(B)}{PW(I) + PW(O \& M) - PW(ZA)} \quad \left(= \frac{B}{C} \right)$$

$$\text{or } B \neq 0^2 \neq 00.$$

$$\text{or } BI + BO - BS - OI - O^2 + OS > BI - BS$$

$$\text{or } B \times 0 - 0 \times I - 0^2 + 0 \times S > 0$$

$$\text{or } \frac{B+S}{I+O} > 0$$

$$\text{i.e. } \left(\frac{B}{C} \right) > 1_{\text{normal}}$$

which is true

Thus,

$$\left(\frac{B}{C} \right)_{\text{modified}} > \left(\frac{B}{C} \right)_{\text{conv.}} \quad \text{if } \frac{B}{C} > 1$$

(8) Find B/C - (B&R) of the following project using FW formulation.

Initial investment = 100

Annual benefit = Rs. 20 in year 1 & increases by +2 each year.

Annual benefit (flood control) $\Rightarrow$ Rs. 5 in each year

Annual Benefit (Recreational) $\Rightarrow$ Rs. 2 in year 1 and increases by 5% each year.

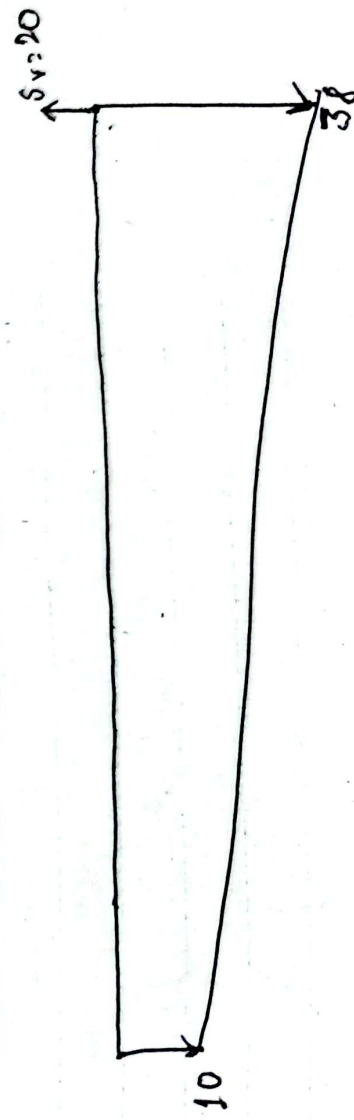
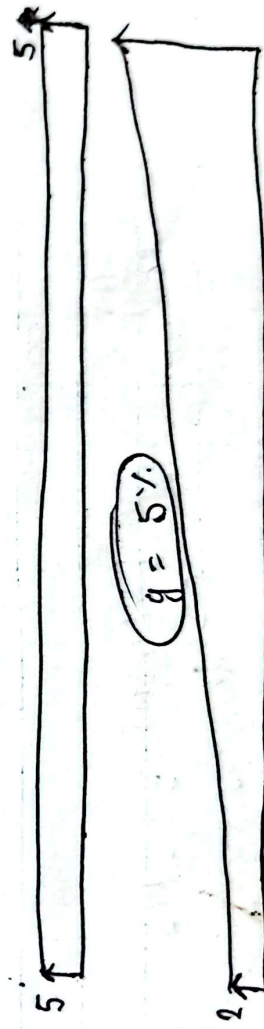
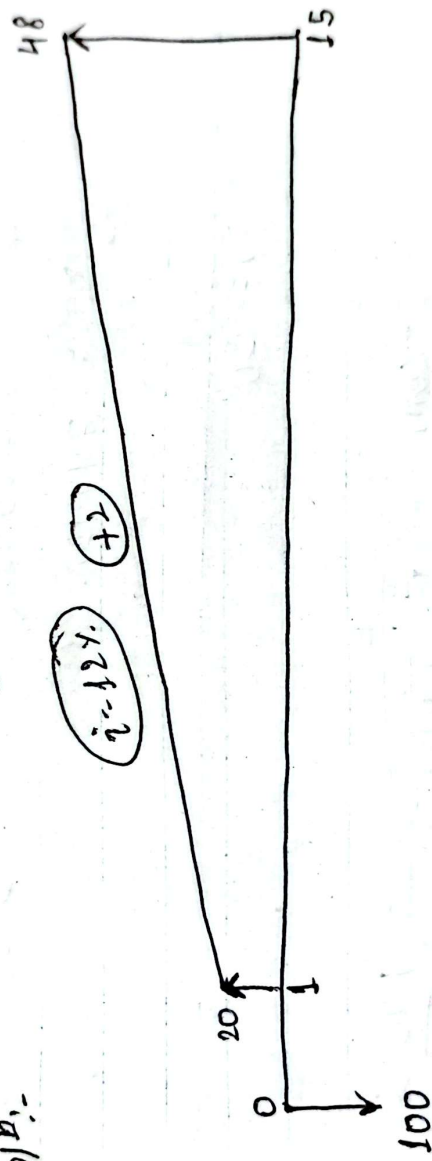
Annual cost (O & M) = Rs. 10 in year 1 & increases by Rs. 2 each year.

Useful life (N) = 15 years

Salvage value = 20% of Initial cost.

MARK = 12% each year.

$\rightarrow$ Soln:-



178

(FN)

$$I = 547.36$$

$$\text{Annual benefit} = \left\{ 20 \left[\frac{1.12^{15} - 1}{0.12} \right] + 2 \left[\frac{1.12^{15} - 18 \times 0.12 - 1}{0.12^2} \right] \right\}$$

$$= 1116.923$$

$$AB(FC) = 5 \left[\frac{1.12^{15} - 1}{0.12} \right] = 186.388$$

B

1400.306

$$AB(FV) = 2 \left[\frac{(1 + 0.05)^{15} - (1 + 0.12)^{15}}{(0.05) - (0.12)} \right] = 96.384$$

$$\text{cost}_{CC} = 10 \left[\frac{1.12^{15} - 1}{0.12} \right] + 2 \left[\frac{1.12^{15} - 15 \times 0.12 - 1}{0.12^2} \right]$$

$$(0.12) = 744.125$$

$$S_v = 20$$

$$\left(\frac{B}{C} \right)_{\text{conv}} = \frac{B}{I + (0.08M) - S_v} = 1.1013$$

$$\left(\frac{B}{C} \right)_{\text{mod}} = \frac{B - (0.08M)}{I - S_v} = 1.2443$$

Theory

- ① Opportunity cost
- ② Sunk cost
- ③ Capital Recovery cost
- ④ Sinking Fund
- ⑤ Marginal cost
- ⑥ Financial & Economic Analysis.

□ Financial & Economic Analysis

⇒ Project मा पैसा Invest गर्दा Investor को बर्च कति हुन्छ?
उसलाई आम्दानी कति हुन्छ? उसको perspective मा Analysis
भयो भने FINANCIAL ANALYSIS.

→ Financial Analysis वा भएको IRR ⇒ FIRR

(Financial Internal Rate of Return)

• Project मा Invest गर्दा, Investor लाई मात्र छोड्न, देश
अ जम्तालाई कति फाइदा वा घाटा हुन्छ भन्ने हेरियो
भने ECONOMIC ANALYSIS

→ Economic Analysis वा भएको IRR is Economic
Internal Rate of Return (EIRR)

Budhi Gandaki → Storage Hydro project 1200 MW
installed capacity

	Rate
FIRR = 8.9% ⇒ के कम्ती?	11 Rs/unit
EIRR = 13% ⇒ के कम्ती?	20 Rs/unit

- In Financial Analysis,
→ Direct cost & Direct Benefit of Investor
- In Economic Analysis
→ Benefit & cost of society, people & country.

□ Private Investors Focus on Financial Analysis
& Public project focus on
Both Financial & Economic Analysis.

- # Sunk Cost:-
- (a) Part Cost $\Rightarrow$ 'Part' (Advance)
 - (b) which cannot be recovered
 - (c) Not used for future Analysis
- and) All of the above

$\Rightarrow$ Capital Recovery Cost [CR-cost]
Annual Income required to recover invested capital
over the period of project life.

$$CR = I \left[\frac{i[(1+i)^N]}{(1+i)^N - 1} \right] - S_v \left[\frac{i}{(1+i)^N - 1} \right]$$

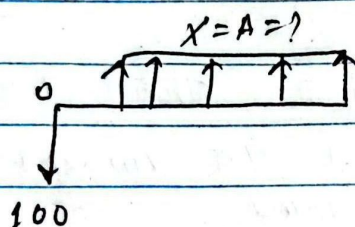
$\uparrow$ Capital Recovery Factor (CRF) $\uparrow$ Sinking Fund Factor (SFF)

- 1 सेप्ली = 16 आना = ₹ 2000
- अठन्नी = $1/2$ Rs = 50 पैसे
- चवन्नी = $1/4$ Rs = 25 पैसे

eg: Machine cost = 100 Rs
 Life = 5 years (say)
 $S_v = 0$ (say)

→ Each year =) कति रकम? ($i=0\%$)
 कमाइनु पर्दै =) to Recover Rs. 100
 $= \frac{100}{5} = 20$ [CCR-cost]

→ But, if $i=10\%$



$$X = I \left[\frac{i(1+i)^N}{(1+i)^N - 1} \right] \quad \text{CRF}$$

$$= 100 \left[\frac{0.1 \times 1.1^5}{1.1^5 - 1} \right]$$

$$= 26.38 \text{ Rs}$$

CRF

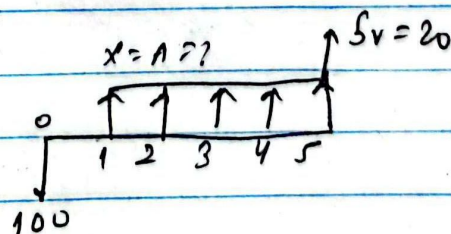
Ignoring salvage value

→ say, $S_v = 20$ & $i=0\%$

$$CR = \frac{100 - 20}{5} = 16$$

$$= \frac{I - S_v}{N}$$

→ say, $S_v = 20$ & $i=10\%$



$$CR = 100 \left[\frac{0.1 \times 1.1^5}{1.1^5 - 1} \right] - 20 \left[\frac{0.1}{1.1^5 - 1} \right] = \underline{\underline{23.10}}$$

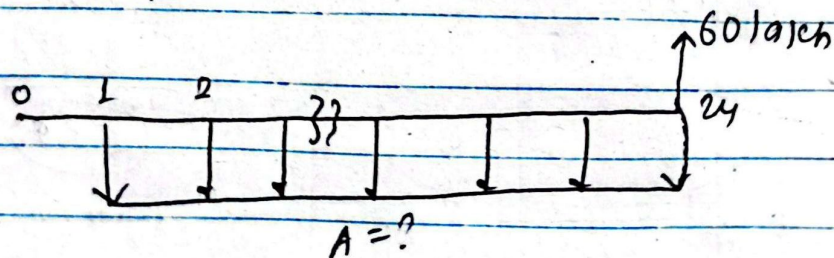
Marginal cost

Sinking Fund

↳ Future में किसी काम के लिए चाहिए पैसे आज से
continuously जमा करें पैसे amount.

↳ eg: premium paid in insurance

eg:



$i = 0.5\%$ per month $\approx 6\%$ p.a.

$$A = F \left[\frac{i}{(1+i)^N - 1} \right]$$

Sinking fund factor

#

Chapter 4:-

Comparative Analysis

4.1 Comparing alternatives having same useful life.(a) Select best project using simple & Discounted PB period methods. $MARR = 10\%$

Year	0	1	2	3	4	5
Cashflow A	-50	10	15	20	25	30
B	-80	15	20	25	30	40

Hint:

Find PB period both. Select the project with minimum PB period.

→ Year:	0	1	2	(3)	4	5
ACF	-50	10	15	20	25	30
Cum-CF	-50	-40	-25	(-5)	+20	50

$$\text{Simple PB period} = 3 + \frac{5}{25} = 3.2 \text{ years}$$

Year:	0	1	2	(3)	4	5
B CF	-80	15	20	25	30	40
Cum-CF	-80	-65	-45	-20	+10	+50

$$\text{Simple PB period} = 3 + \frac{20}{30} = 3.67 \text{ years}$$

Simple PB period of $A < B \Rightarrow A$ is better

Similarly, find discounted PB period of both.

Discounted PB period calculation. MARR = 10% (i)

Year	0	1	2	(3)	4	5
A	-50	10	15	20	25	30
Discounted C.F.	-50	$\frac{10}{1.1}$	$\frac{15}{1.1^2}$	$\frac{20}{1.1^3}$	$\frac{25}{1.1^4}$	$\frac{30}{1.1^5}$
"	-50	9.09	12.4	15.03	17.07	18.63
Cum. Disc. CF	-50	-40.91	-28.51	-13.48	3.59	22.22

$$\text{Discounted PB period} = 3 + \frac{13.48}{17.07} = 3.79 \text{ years}$$

Year	0	1	2	(3)	(4)	5
B. CF	-80	15	20	25	30	40
Discounted C.F.	-80	$\frac{15}{1.1} = 13.64$	$\frac{20}{1.1^2} = 16.53$	$\frac{25}{1.1^3} = 18.78$	$\frac{30}{1.1^4} = 20.49$	$\frac{40}{1.1^5} = 26.69$
Cumulative Disc. C.F.	-80	-66.36	-49.83	-31.05	-10.56	10.28

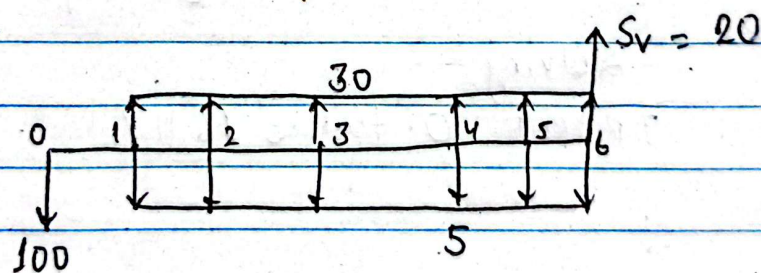
$$\text{Discounted PB period} = 4 + \frac{10.56}{20.49} = 4.51$$

Since, PB period of B > A $\Rightarrow$ A is better.

(8) Select the best using PW/FW/NAV/PB period/IRR/ERR & BCR. MARR = 10%

Item	A	B	C	
Initial cost (C_i)	100	140	200	
Annual income (A)	30	40	50	
(cost) Annual cost (B)	5	8	10	
Useful life (T)	6	6	6	
Salvage value (S_v)	20	30	40	
NPV	20.17	16.3	-3.21	] select A
NFV	35.73	28.88	-5.69	
NAV	4.63	3.74	-0.73	
PB Simple Dir.	5.36 yr.	5.09 yr.	> 6 year.	] select B
PB Disimple	4 yr.	4.88 yr.	5 year	] select A
IRR	16.11%	13.54	9.5%	
ERR				
BCR				

For A.



PW method,

$$PW = -100 + (30 - 5) \left[\frac{1.1^6 - 1}{1.1^6 \times 0.1} \right] + \frac{20}{1.1^6}$$

$$= 20.17$$

'OP' $PW \times 1.16$

$$FW = -100 \times 1.16 + 25 \times \left[\frac{1.16 - 1}{0.1} \right] + 20 = 35.73$$

$$AW = -100 \left[\frac{0.1 \times 1.16}{1.16 - 1} \right] + 25 + 20 \left[\frac{0.1}{1.16 - 1} \right]$$
$$= 4.63$$

$$PB \text{ Simple} = \frac{100}{25} = 4$$

PB Discounted (N)

$$-100 + 25 \left[\frac{1.1^N - 1}{0.1 \times 1.1^N} \right] = 0$$

$$\Rightarrow [N = 5.36 \text{ years}]$$

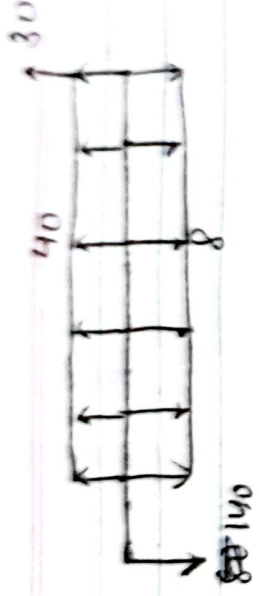
$$IRR(A) \quad FW = -100(1+i)^6 + 25 \left[\frac{(1+i)^6 - 1}{i} \right] + 20 = 0$$

(FW=0)

Solving,

$$IRR(A) = 0.1611 \approx 16.11\%$$

Payk



$$PW = -\frac{140}{1.16} + 32 \left[\frac{1.16^6 - 1}{0.1 \times 1.16} \right] + \frac{30}{1.16} = 16.302$$

$$FW = -140 \times 1.16 + 32 \left[\frac{1.16^6 - 1}{0.1} \right] + 30 = 28.88$$

$$AW = \frac{-140 \times \left[\frac{0.1 \times 1.16^6}{1.16 - 1} \right] + 32 + 30 \left[\frac{0.1}{1.16 - 1} \right]}{0.1} = 3.74$$

$$PB \text{ Simple} = \frac{140}{32} = 4.38$$

→ PB Discounted :

$$\text{First NPV} : -140 + 32 \left[\frac{1.1^N - 1}{0.1 \times 1.1} \right] = 0$$

(Ignoring PV)

$$N = 6.036 \text{ yrs}$$

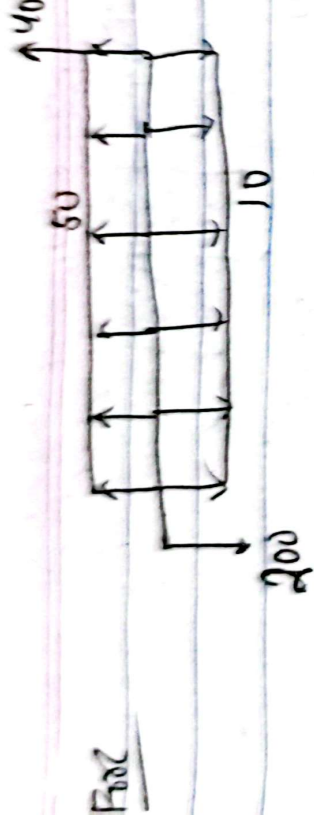
(But 6 yrs for calculation is taken)

$$-140 + 32 \left[\frac{1.1^6 - 1}{0.1 \times 1.1} \right] + \frac{30}{1.16} = 0 \Rightarrow [N = 5.09 \text{ years}]$$

→ IRR (B) : $-140(1+i)^6 + 32 \left[\frac{(1+i)^6 - 1}{i} \right] + 30 = 0$

→ project is profitable (B)

$$\Rightarrow [i = 13.54\%]$$



$$P_w = -200 + 40 \left[\frac{1.16 - 1}{0.1 \times 1.16} \right] + \frac{40}{1.16} = -3.21$$

$$FW = -200 \times 1.16 + 40 \left[\frac{1.16 - 1}{0.1} \right] + 40 = -5.69.$$

$$AW = -200 \left[\frac{0.1 \times 1.16}{1.16 - 1} \right] + 40 \times \left[\frac{0.1}{1.16 - 1} \right] = -0.73$$

$$\text{PBlim p10} = \frac{200}{40} = 5$$

PB Discounted $\rightarrow$ लगानी जग complete 6 year सग
 , एक लगानी उठुवेन 50, It is > 6 year
लगानी
+ आयदनी

IRCC (C) $F = M = 0$

$$-200(1+j)^6 + 40 \left[\frac{(1+j)^6 - 1}{j} \right] + 40 = 0$$

$$1 = 722(1) = 9.5\%$$

(λ_{MAR}) $\leftarrow$ not feasible

⇒ IRR/ERR & BCR वाट Best project select गर्नुपर्छ।
Incremental Analysis गर्नुपर्छ। ठूलो project को cashflow
वाट सानो project को cashflow घटाए साना project
बनाउँछे।

(ठूलो project → Initial cost बढी गर्छे)

[But, unfeasible projects छन्लाई out गर्ने, here]

→ $IRR < MARR$

ठूलो - सानो ⇒ नयाँ project

(In general, सर्वश्रेष्ठ) सानोलाई अन्तिमति ठूलो
project वाट घटाउँछे)

↳ only cashflow
(not year)

Then, New project को IRR निकाल्ने

Say $(B-A) \rightarrow$ New project

If

$IRR_{New(B-A)} > MARR \rightarrow$ select B

$< MARR \rightarrow$ select A

SURENDRA SHARMA

unfeasible
to out

Just for
check
↓

Item	A	B	C	B-A	B-A	C-A
C_i	100	140	200		40	100
A_i	30	40	50		10	20
O&M	5	8	10		3	5
Useful life	6	6	6		36	6
S_v	20	30	40		10	20
$PW \leftarrow NPV$						
$FW \leftarrow NFV$						
$AW \leftarrow NAV$						
PB simple						
PB discounted						

(Incremental Analysis) $\rightarrow$ ERR of B-A

For ERR of B-A,

$$\Rightarrow \text{ERR}_{(B-A)} = 40 \frac{(1+i)^6 - 1}{i} + 7 \left[\frac{(1+i)^6 - 1}{i} \right] + 10 = 0$$

$$i = (\text{ERR})_{B-A} = 7.0\% < \text{MARR}$$

Select A (B is knocked out)

For check (C-A) (not for check)

$$\Rightarrow \text{ERR}_{(C-A)} = -100 \frac{(1+i)^6 - 1}{i} + 15 \left[\frac{(1+i)^6 - 1}{i} \right] + 20 = 0$$

$$\text{ERR}_{(C-A)} = 2.46\% < \text{MARR}$$

Select A (C is out)

For ERR,

For A

$$FW = 0$$

$$\text{or } -100 \frac{(1+i)^6 - 1}{0.1} + 25 \times \frac{1.1^6 - 1}{0.1} + 20 = 0$$

$$\text{ERR}(A) = i = 13.42\%$$

For B,

$$-140 \frac{(1+i)^6 - 1}{0.1} + 32 \times \frac{1.1^6 - 1}{0.1} + 30 = 0$$

$$\text{ERR}(B) = i = 12.04\%$$

For C

$$-200 \frac{(1+i)^6 - 1}{0.1} + 40 \times \frac{1.1^6 - 1}{0.1} + 40 = 0$$

$$\text{ERR}(C) = i = 9.70\%$$

So, C is unfeasible.

For ERR (B-A)

$$FW = 0$$

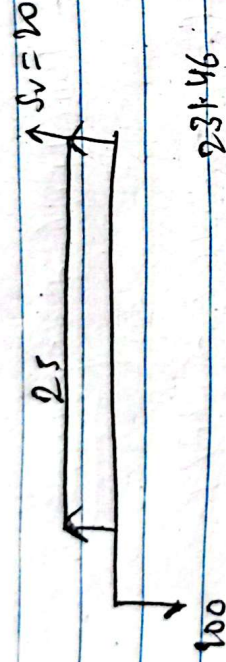
$$-40 \frac{(1+i)^6 - 1}{0.1} + 10 \times \frac{1.1^6 - 1}{0.1}$$

$$-3 \times \frac{(1+i)^6 - 1}{1} + 10 = 0$$

$$\therefore \text{ERR}(B-A) = 8.15\% < \text{MARR}$$

So, select A (not B)

Item	A	B	C
C	100	140	200
AT	30	40	50
ODM	5	8	10
life	6	6	6
Sv	20	30	40



231.46

$$\text{Benefit}(B) = 130.65 / 231.46 \text{ (PW)}$$

$$\text{Cost}(CC) = 177.16 \text{ (PW)}$$

$$Sv = 11.2920 \text{ (PW)}$$

$$ODM = 88.51$$

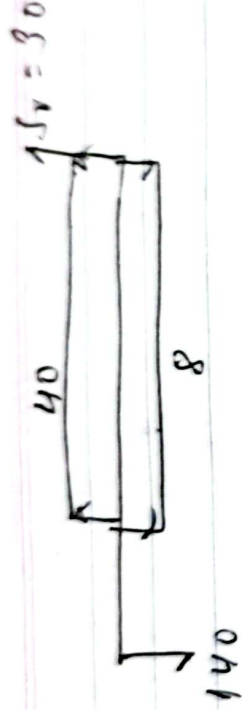
$$(BCL)_{\text{conv}} = \frac{8}{I + ODM - Sv} = \frac{130.65}{177.16 + 38.58 - 11.29} = \frac{231.46}{184.45} = 1.25$$

(A)

$$\frac{ERR}{-100(1+ERR)^6 + 20 \left[\frac{(1+ERR)^6 - 1}{ERR} \right] + 2000 - 5 \left[\frac{(1+ERR)^6 - 1}{ERR} \right] = 0}$$

$$\Rightarrow ERR = 13.42\%$$

⑧



$$\text{Benefit}(B) = 40 \left[\frac{1.16 - 1}{6.1} \right] = 308.62$$

$$\text{Cost}(I) = 140 \times 1.16$$

$$\text{O\&M: } 61.72$$

$$S_V = 16.99 \quad 30$$

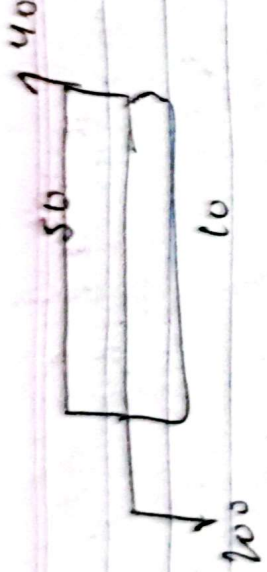
$$(BCR)_{\text{conv}} = \frac{308.62}{\left(\frac{140(1.16) + 61.72 - 16.99}{30} \right)} = 1.10$$

ERR

$$= 140(1 + x)^6 + 40(1.1)$$

$$\Rightarrow (ERR = 12.73\%)$$

c)



$$B = 315.78$$

$$T = 354.31$$

$$OAM = 77.16$$

$$SV = 40$$

$$BCL_M = \frac{385.78}{354.31 + 77.16 - 40} = 0.98$$

ELP

⇒ For BCL,

$$\left(\frac{B}{C}\right)_{mod} = \frac{FW(B) - FW(OAM)}{FW(T) - FW(SV)}$$

For A,

$$\left[\left(\frac{B}{C}\right)_{mod}\right]_A = \frac{30 \times \frac{1.16-1}{0.1} - 5 \times \frac{1.16-1}{0.1}}{100 \times \frac{1.16-1}{0.1}} = 1.23$$

$$\left[\left(\frac{B}{C}\right)_{mod}\right]_B = \frac{40 \times \frac{1.16-1}{0.1} - 8 \times \frac{1.16-1}{0.1}}{140 \times \frac{1.16-1}{0.1}} = 1.13$$

$$\left[\left(\frac{B}{C}\right)_{mod}\right]_C = \frac{50 \times \frac{1.16-1}{0.1} - 10 \times \frac{1.16-1}{0.1}}{200 \times \frac{1.16-1}{0.1}} = 0.98$$

$$\text{For } B-A, \left[\left(\frac{B}{C}\right)_{mod}(B-A)\right] = \frac{10 \times \frac{1.16-1}{0.1} - 3 \times \frac{1.16-1}{0.1}}{40 \times \frac{1.16-1}{0.1}} = 0.89$$

So, select A.

→ Find IRR/ERR of both A & B

→ Perform incremental analysis if both are feasible or both are unfeasible

B-A

Q. Select the best project using IRR method & ERR.

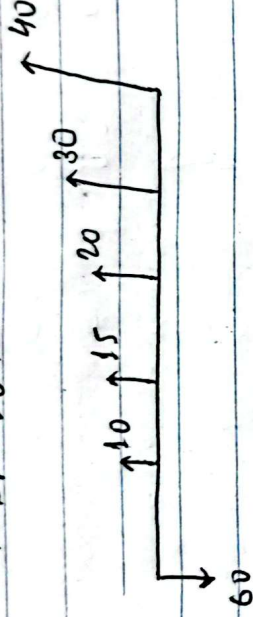
Year	0	1	2	3	4	5
A	-60	10	15	20	30	40
B	-80	15	20	25	30	35

MARR = 10%

$\begin{cases} IRR_{(B-A)} > MARR \\ \text{Select B} \end{cases}$
 $\begin{cases} ERR_{(B-A)} > MARR \\ \text{Select B} \end{cases}$

→ Solⁿ:

For A,



FW = 0

$$-60(1+i)^5 + 10(1+i)^4 + (15)(1+i)^3 + 20(1+i)^2 + 30(1+i) + 40 = 0$$

$$\Rightarrow i = 20.52\%$$

$$\Rightarrow IRR = 20.52\%$$

For ERR,

$$-60(1+i)^5 + 10(1+i)^4 + 15(1+i)^3 + 20(1+i)^2 + 30(1+i) + 40 = 0$$

$$E = 10\%$$

$$\Rightarrow i = ERR = 17.05\% > MARR \text{ unfeasible.}$$

For B,

$$-80(1+i)^5 + 15(1+i)^4 + 20(1+i)^3 + 25(1+i)^2 + 30(1+i) + 35 = 0$$

$$\Rightarrow i = IRR = 14.61\%$$

For ERR,

$$-80(1+i)^5 + 15(1+i)^4 + 20(1+i)^3 + 25(1+i)^2 + 30(1+i) + 35 = 0$$

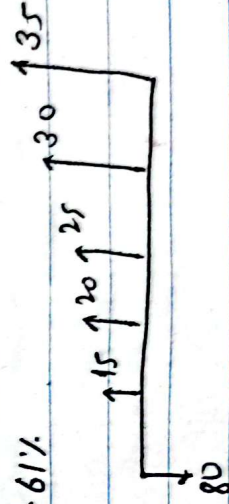
$$+ 35 = 0$$

$$E = 10\%$$

$$\Rightarrow i = ERR = 12.91\% < MARR \text{ unfeasible.}$$

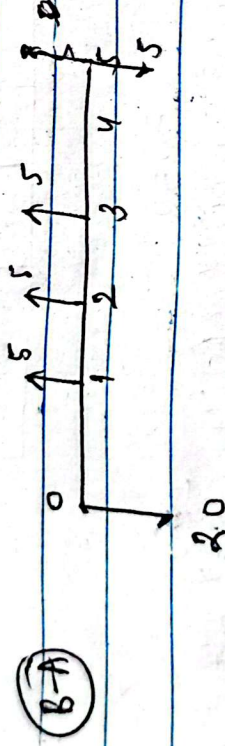
Both unfeasible

Incremental Analysis required.



Both unfeasible $\rightarrow$ so, incremental analysis required.

Year	A	B	B-A
0	-60	-80	-20
1	10	15	5
2	15	20	5
3	20	25	5
4	30	30	0
5	40	35	5



$$FW=0$$

For IRR

$$-20(1+i)^5 + 5(1+i)^4 + 5(1+i)^3 + 5(1+i)^2 + 0 - 5 = 0$$

$$\Rightarrow 1+i = -0.69$$

$$[i = IRR = -0.69 = -69\%]$$

select A, < MARR

For ERR

$$-20(1+i)^5 + 5(1+i)^4 + 5(1+i)^3 + 5(1+i)^2 + 0 - 5 = 0$$

$$[i = ERR = 94.44\%]$$

$$\Rightarrow i = ERR = 94.44\% < MARR$$

select A

For better project check just $IRR(A)$ check is enough
 But if need feasibility check of each project then
 $IRR(A)/ERR_A, IRR_B/ERR_B, IRR_{(B-A)}/ERR_{(B-A)}$ should
 be computed

Q	A ₁	A ₂	A ₃	A ₄	A ₅
Initial Investment	+100	+200	140	350	300
Net Annual Income	30	50	40	90	75
Useful life	5	5	5	5	5
Salvage value.	20%	of initial investment			
Sv	20	40	28	70	60

Select best project using IRR. $MARR = 12\%$

(A₁)

$$-100 + 30 \left[\frac{(1+i)^5 - 1}{i} \right] + 20 = 0$$

$$i = IRR = 32\%$$

(A₂)

$$-200 + 50 \left[\frac{(1+i)^5 - 1}{i} \right] + 40 = 0$$

$$i = IRR = 22\%$$

(A₃)

$$-140 + 40 \left[\frac{(1+i)^5 - 1}{i} \right] + 28 = 0$$

$$i = IRR = 29.49\%$$

(A₄)

$$-350 + 90 \left[\frac{(1+i)^5 - 1}{i} \right] + 70 = 0$$

$$i = IRR = 28.88\%$$

(A₅)

$$-300 + 75 \left[\frac{(1+i)^5 - 1}{i} \right] + 60 = 0$$

$$i = IRR = 26.53\%$$

Now

(A1 & A2) A2 - A1

$$-100 + 20 \left[\frac{(1+i)^5 - 1}{i} \right] + 20 = 0$$

$$\Rightarrow i = IRR(A2 - A1) = 5.73\% < MARR$$

knockout A2
select A1

(A3 & A1)

A3 - A1

$$-40 + 10 \left[\frac{(1+i)^5 - 1}{i} \right] + 8 = 0$$

$$\Rightarrow i = IRR(A3 - A1) = 12.54\%$$

(A3) ✓

(A3 & A4)

A4 - A3

$$-250 + 60 \left[\frac{(1+i)^5 - 1}{i} \right] + 50 = 0$$

$$\Rightarrow i = IRR(A4 - A3) = 10.95\%$$

(A3) ✓

~~A5 - A1~~

A3 & A5

~~-200 +~~

A3 good

→ converting different life to same life.

Comparing Alternatives having Different useful lives.
Select the best project. MARR = 10%.

Project	A	B	
Initial cost	100	150	
Net Annual income	30	40	
Useful life, Year	4	6	← Different
Salvage value	20	25	

⇒ Different life? ⇒ Convert to same life (study period)

Options ③

① Repeatability Assumption

Find LCM of each alternatives

(eg: LCM(4, 6) = 12)

So, study period = 12 yrs or its multiple.

And, for A ⇒ $\frac{12}{4} \Rightarrow$ Repeat cash flow for three times.

For B ⇒ $\frac{12}{6} \Rightarrow$ Repeat cashflow for two times.

Then, find PW or FW or AW.

Thus,

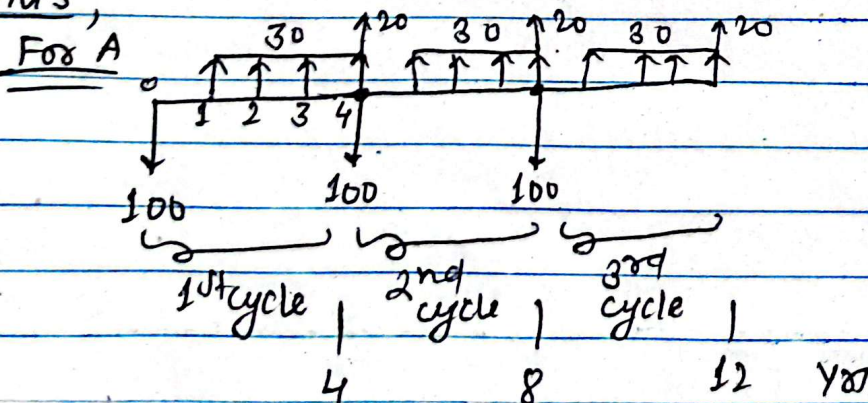
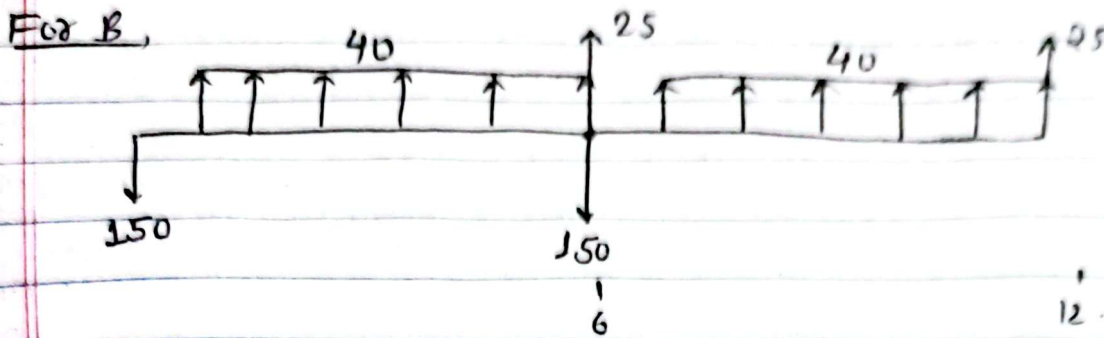


Fig: Cash flow diagram for study period.



Thus,

$$\begin{aligned}
 PW(A) &= (-100 - \frac{100}{1.1^4} - \frac{100}{1.1^8}) + 30 \left[\frac{1.1^{12} - 1}{0.1 \times 1.1^{12}} \right] \\
 &\quad + \frac{20}{1.1^4} + \frac{20}{1.1^8} + \frac{20}{1.1^{12}} = 0 \\
 &= 18.822
 \end{aligned}$$

$$\begin{aligned}
 PW(B) &= -150 \left(1 + \frac{1}{1.1^6} \right) + 40 \left[\frac{1.1^{12} - 1}{0.1 \times 1.1^{12}} \right] + 25 \left[\frac{1}{1.1^6} + \frac{1}{1.1^{12}} \right] \\
 &= 59.95.
 \end{aligned}$$

$$PW(A) < PW(B) \Rightarrow \text{select } \underline{\underline{B}}$$

Similarly,

$$\begin{aligned}
 FW(A) &= -100 (1.1^{12} + 1.1^8 + 1.1^4) + 30 \left[\frac{1.1^{12} - 1}{0.1} \right] \\
 &\quad + 20 (1.1^8 + 1.1^4 + 1) = 0 \\
 &= 59.071
 \end{aligned}$$

$$\begin{aligned}
 FW(B) &= -150 (1.1^{12} + 1.1^6) + 40 \left[\frac{1.1^{12} - 1}{0.1} \right] + 25 [1.1^6 + 1.1] \\
 &= 188.15
 \end{aligned}$$

$$FW(B) > FW(A) \Rightarrow \text{select } \underline{\underline{B}}$$

(PW)
for AW

$$\begin{aligned}
 AW(A) &= \left[-100 - \frac{100}{1.14} + \frac{-100}{1.18} \right] \left[\frac{0.1 \times 1.1^{12}}{1.1^{12} - 1} \right] \\
 &\quad + 30 + \left[\frac{20}{1.14} + \frac{20}{1.18} + \frac{20}{1.1^{12}} \right] \left[\frac{0.1 \times 1.1^{12}}{1.1^{12} - 1} \right] \\
 &= 2.762
 \end{aligned}$$

$$\begin{aligned}
 AW(B) &= \left(-150 - \frac{150}{1.16} \right) \left[\frac{0.1 \times 1.1^{12}}{1.1^{12} - 1} \right] + 40 + \left[\frac{25}{1.16} + \frac{25}{1.1^{12}} \right] \left[\frac{0.1 \times 1.1^{12}}{1.1^{12} - 1} \right] \\
 &= 8.80
 \end{aligned}$$

select 'B'

(OR)
 original cash flow for time

$$\begin{aligned}
 AW(A) &= -100 \left[\frac{0.1 \times 1.1^4}{1.1^4 - 1} \right] + 30 + 20 \left[\frac{0.1}{1.1^4 - 1} \right] = 2.76 \\
 AW(B) &= -150 \left[\frac{0.1 \times 1.1^6}{1.1^6 - 1} \right] + 40 + 25 \left[\frac{0.1}{1.1^6 - 1} \right] = 8.79
 \end{aligned}$$

Select the best project Assume Repeatability.

	A	B	C
Initial cost	100	150	250
Annual cost	30	20	10
Useful life, yr	3	5	7
Salvage value	20	30	50

$$AW(A) = -100 \left[\frac{0.1 \times 1.13}{1.13 - 1} \right] - 30 + 20 \left[\frac{0.1}{1.13 - 1} \right]$$

$$= -64.169$$

$$AW(B) = -150 \left[\frac{0.1 \times 1.15}{1.15 - 1} \right] - 20 + 30 \left[\frac{0.1}{1.15 - 1} \right]$$

$$= -71.253 - 54.65 \leftarrow \underline{\text{Min}^m}$$

$$AW(C) = -250 \left[\frac{0.1 \times 1.12}{1.12 - 1} \right] - 10 + 50 \left[\frac{0.1}{1.12 - 1} \right]$$

$$= -56.08$$

Thus, B is best project.

	A	B	C
Initial Investment	300,000	400,000	500,000
Annual Income	100,000	125,000	150,000
Annual cost	5000	10,000	15,000
Useful life	4	6	8
Salvage value	50,000	75,000	100,000

MARR = 12% [Use FW formulation.] & repeatability

$$AW(A) = 6691.39$$

$$AW(B) = 3870.49$$

$$AW(C) = 4123.81$$

$$FW(A) = 790622.80$$

$$FW(B) = 457318.679$$

$$FW(C) = 4858954.813$$

OK'

$$FW(A) = -300000 (1.12^{24} + 1.12^{20} + 1.12^{16} + 1.12^{12} + 1.12^8 + 1.12^4) + 780$$

$$+ (100000 - 5000) \left[\frac{1.12^{24} - 1}{0.12} \right]$$

$$+ 50000 (1.12^{20} + 1.12^{16} + 1.12^{12} + 1.12^8 + 1.12^4 + 1.12)$$

$$= 790622.80$$

$$FW(B) = -400000 (1.12^6 + 1.12^{12} + 1.12^{18} + 1.12^{24})$$

$$+ (125000 - 100000) \left[\frac{1.12^{24} - 1}{0.12} \right]$$

$$+ 75000 (1.12^{24} + 1.12^{18} + 1.12^{12} + 1.12^6)$$

$$= 457397.679$$

$$PW(C) = 4858984.875 \cdot 5019099.946$$

$$= -500000 (1.12^4 + 1.12^{16} + 1.12^8) +$$

$$(180000 - 15000) \times \frac{1.12^{24} - 1}{0.12}$$

$$+ 100000 (1.12^{16} + 1.12^8 + 1.12)$$

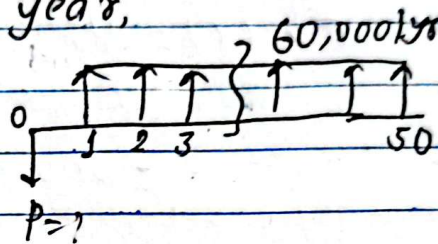
Capitalized Worth (CW) Method:

→ Selection of a project if study period is Infinite.
(We require the project for indefinite period)
 $[N \rightarrow \infty]$

We know,

$$P = A \left[\frac{(1+i)^N - 1}{i(1+i)^N} \right]$$

Q. How much Rs. should you deposit now to draw Rs. 60,000/year for 50 years.
 $i = 10\%$ per year,



$$P = 60,000 \left[\frac{1.1^{50} - 1}{0.1 \times 1.1^{50}} \right]$$

$$= 5,94,888.87.$$

Q. How much Rs. should you deposit now to draw Rs. 60,000 per year for indefinite period ($N \rightarrow \infty$)

$$\Rightarrow P = A \left[\frac{(1+i)^N - 1}{i(1+i)^N} \right] = A \left[\frac{1}{i} - \frac{1}{i(1+i)^N} \right]$$

$$N \rightarrow \infty$$

$$P = A \left[\frac{1}{i} - \frac{1}{\infty} \right] = \frac{A}{i}$$

→ Thus,

$$P = \frac{60000}{0.1} = 600000.$$

अक्षय कोष
(क्षय नहुने कोष)
<Endowment Fund>

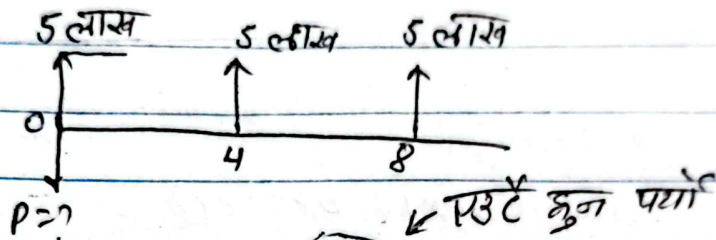
↓
Initial principle नक्षदने कोष

If हमें 8 वर्षों में 5 लाख का भुगतान करना है $\Rightarrow$ अनुमानित $\Rightarrow$

(i) आज 5 lakh + 5 लाख in every

(ii) आज NO + 5 in every 4 yrs.

(i) आज वहाँ 5 लाख रकमों दिए

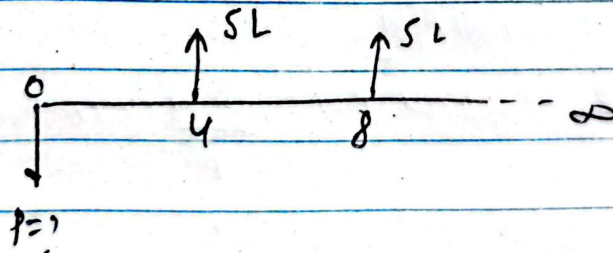


$$P = \frac{A}{i} = \frac{5 \text{ lakh in } 4 \text{ yrs}}{8\% \text{ per yr}} + 5L$$

$$i_{4 \text{ yrs}} = (1 + yr)^4 - 1 = (1.08)^4 - 1 = 0.3605$$

$$P = \frac{A}{i} = \frac{500,000}{0.3605} + 5L = 13,88,969 + 5L = \underline{\underline{15,188,962}}$$

(ii) आज NO + 5 in every 4 yrs.



$$P = \frac{A}{i} = \frac{500000}{0.3605} = \underline{\underline{1386962.55}}$$

#	A	B
	Unlined canal	Lined canal
Initial Investment	10,00,000	22,00,000
Annual cost	100,000	60,000
Useful life	10 yrs	20 yrs
Salvage value	400,000	800,000

MARR = 10%

Which one is better?

Study period = ? कति सालनु पर्ला?

→ Canal को चरन परा

$$P = \frac{A}{i} \rightarrow (N \rightarrow \infty)$$

$$PW \rightarrow (N \rightarrow \infty)$$

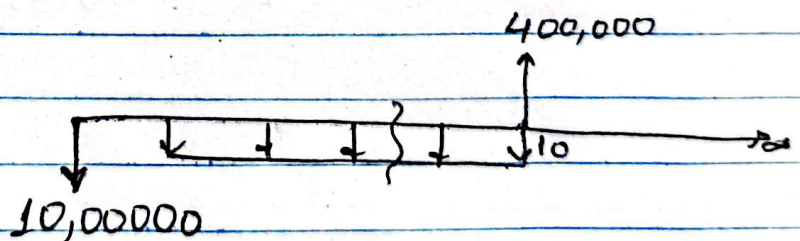
$$PW = \frac{AW}{i}$$

Step 1 → Find AW

Step 2 → Find $PW = \frac{AW}{i} (N \rightarrow \infty)$

PW if $N \rightarrow \infty$ is CW

CW = Capitalized worth



Unlined

$$AW = -10,00,000 \left[\frac{0.1 \times 1.1^{10}}{1.1^{10} - 1} \right] - 20,00,000 + 4,00,000 \left[\frac{0.1}{1.1^{10} - 1} \right]$$

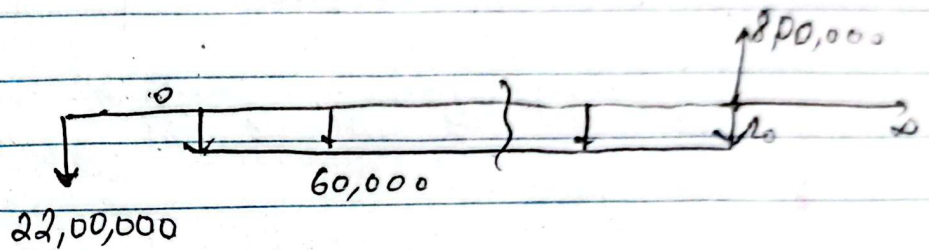
$$= -33,76,47.24$$

$$CW = \frac{AW}{i} = \frac{-337647.24}{0.1} = -33,76,474.40$$

$\Rightarrow$ If CW is -ve it is called 'CC' = capitalized cost

$$CC(A) = 33,76,474.40$$

(B)



$$AW = -2200000 \left[\frac{0.1 \times 1.1^{20}}{1.1^{20} - 1} \right] - 60,000 + 800000 \left[\frac{0.1}{1.1^{20} - 1} \right]$$

$$= -304443.47$$

$$CC = \frac{AW}{i} = 30,44,434.70$$

$$CC_B (\text{lined canal}) < CC_A (\text{unlined})$$

Select lined canal.

Select the best project / Machine

	Option 1 Machine 1	Option 2 Machine 2
Initial cost	100,000	150,000
Annual income	30,000	40,000
Useful life yrs	4	6
Salvage value	20,000	25,000

We need the machine for

- Study period }
 (i) 3 yrs
 (ii) 4 yrs
 (iii) 6 yrs
 (iv) 10 yrs.
 [MARR = 10%]

→ Solution

(i) Study period = 3 years

∝ Machine 1 & Machine 2 at CR = ?

$$CR = I \left[\frac{i(1+i)^N}{(1+i)^N - 1} \right] - S_v \left[\frac{i}{(1+i)^N - 1} \right]$$

$$CR(1) = 100000 \left[\frac{0.1 \times 1.1^4}{1.1^4 - 1} \right] - 20000 \left[\frac{0.1}{1.1^4 - 1} \right]$$

$$= 27237.66$$

$$CR(2) = 150000 \left[\frac{0.1 \times 1.1^6}{1.1^6 - 1} \right] - 25000 \left[\frac{0.1}{1.1^6 - 1} \right]$$

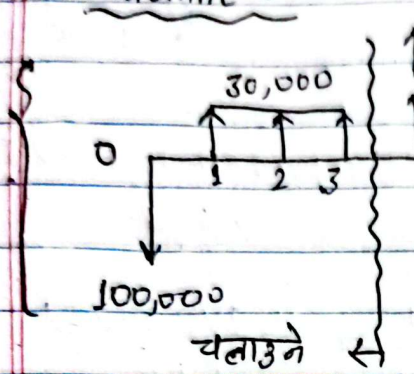
$$= 31200.92$$

[CR = Rental cost]

Now, (Analysis)

Machine J

Option I

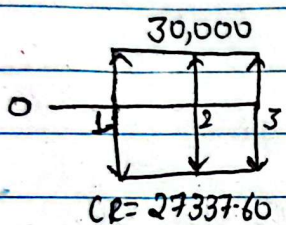


$SV = 20,000$
 $CR = \text{आवाम दिने} = 27237.66$

$$PW = -100,000 + 30,000 \left[\frac{1.1^3 - 1}{0.1 \times 1.1^3} \right] + \frac{20,000 + 27237.66}{1.1^4}$$

$$PW = +6869.68$$

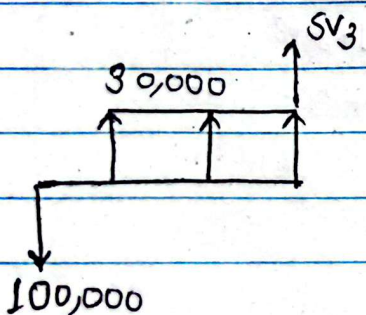
Option II



$$PW = (30,000 - 27337.66) \left[\frac{1.1^3 - 1}{0.1 \times 1.1^3} \right]$$

$$PW = +6869.68$$

Option III



$SV_3 > 20,000$ -
 (४ वर्ष भन्दा अगाडि लेने salvage value will be more)

$$PW = -100,000 + 30,000 \left[\frac{1.1^3 - 1}{0.1 \times 1.1^3} \right] + \frac{SV_3}{1.1^3}$$

But, $PW = 6869.68$

Thus,
 $[SV_3 = 42943.54]$

'OP'

$$\left\{ \begin{aligned} SV_3 &= \frac{20,000 + 27237.60}{1.1^3} \\ \{ SV_3 &= 42943.544 \} \end{aligned} \right. \left\{ \begin{aligned} &\text{Option (D) is the} \\ &\text{best value as it} \\ &\text{is the best} \\ &\text{value} \end{aligned} \right.$$

← { Inputed Market value }

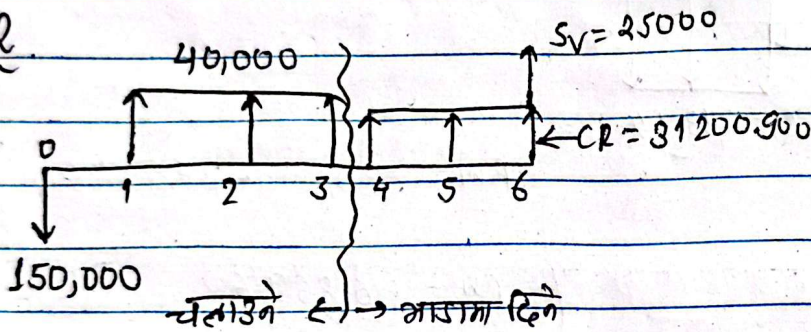
Thus,

$$PW = -100000 + 30000 \left[\frac{1.1^3 - 1}{0.1 \times 1.1^3} \right] + \frac{42943.544}{1.1^3}$$

$$= 6869.68$$

Option (D) etc. is the best way to do this way

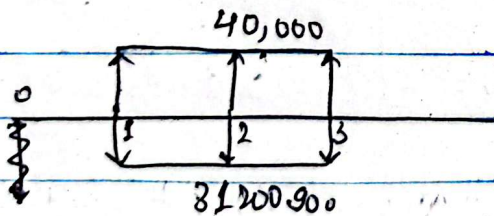
Machine 2



$$PW = -150000 + 40000 \left[\frac{1.1^3 - 1}{0.1 \times 1.1^3} \right] + \left[31200.90 \left[\frac{1.1^3 - 1}{0.1 \times 1.1^6} \right] \right]$$

$$+ \frac{25000}{1.1^6}$$

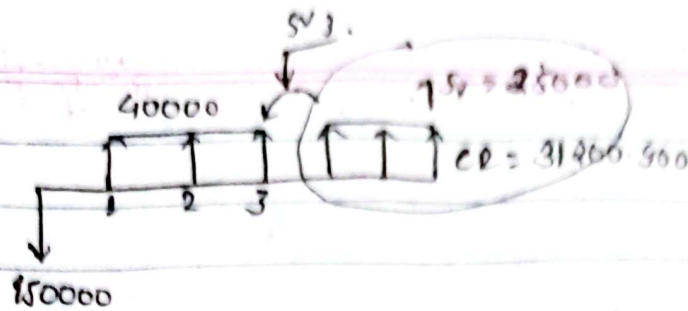
$$= 21882.06$$



$$PW = (40000 - 31200.90) \left(\frac{1.1^3 - 1}{0.1 \times 1.1^3} \right)$$

$$= 21882.06$$

III



$$SV_3 = IMV_3 = 31200.9 \left[\frac{1.1^3 - 1}{0.1 \times 1.1^3} \right] + \frac{25000}{1.1^3}$$

$$= 96374.89$$

$$PW = -150000 + 40000 \left[\frac{1.1^3 - 1}{0.1 \times 1.1^3} \right] + \frac{IMV_3}{1.1^3}$$

$$= 21882.06$$

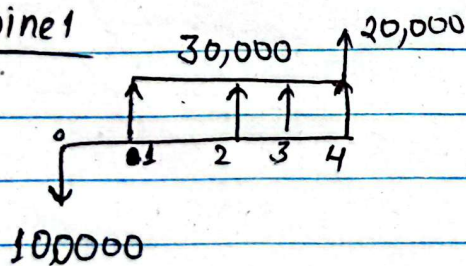
Since,

$$PW(2) > PW(1)$$

[Select (2)].

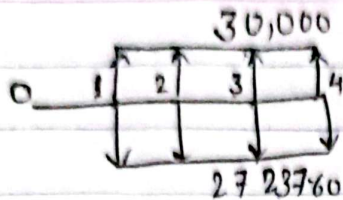
II Study Period = 4 yrs

Machine 1



$$PW = -100000 + 30000 \left[\frac{1.1^4 - 1}{0.1 \times 1.1^4} \right] + \frac{20000}{1.1^4}$$

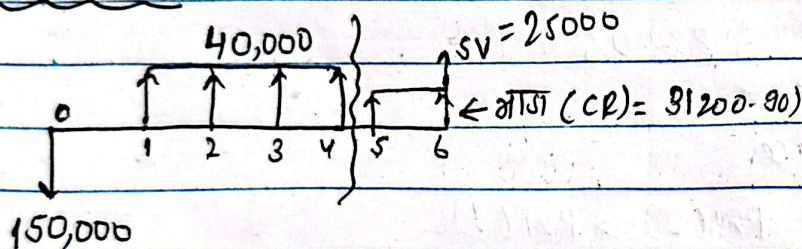
$$= 8756.23$$



$$PW = (30000 - 27237.60) \left[\frac{1.1^4 - 1}{0.1 \times 1.1^4} \right]$$

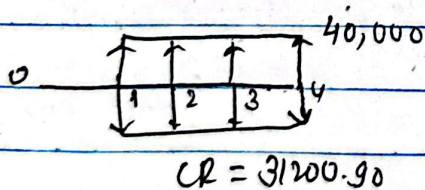
$$= 8756.23$$

Machine 2



$$PW = -150000 + 40000 \left[\frac{1.1^4 - 1}{0.1 \times 1.1^4} \right] + 31200.90 \left[\frac{1.1^2 - 1}{0.1 \times 1.1^6} \right] + \frac{25000}{1.16}$$

$$= 27891.96$$



$$PW = (40000 - 31200.90) \left[\frac{1.1^4 - 1}{0.1 \times 1.1^4} \right]$$

$$= 27891.96$$

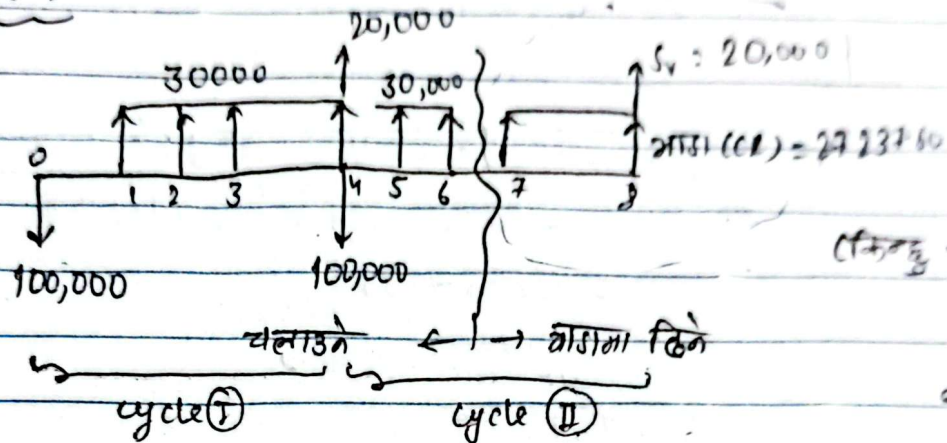
$$PW(2) > PW(1)$$

Select 2 →

- (iii) Study period = 6 years
i.e. we require machine for 6 years.

Machine 1

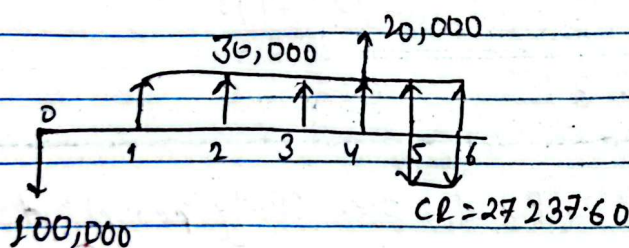
Opt I



$$PW = -100000 + 30000 \left[\frac{1.1^6 - 1}{0.1 \times 1.1^6} \right] + \frac{(100000 + 20000)}{1.1^4} + 27237.60 \left[\frac{1.1^6 - 1}{0.1 \times 1.1^6} \right] + \frac{20000}{1.1^8}$$

$$= 12030.97$$

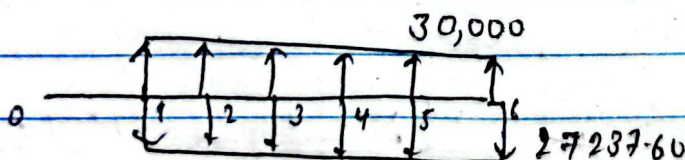
Opt II



$$PW = -100000 + 30000 \left[\frac{1.1^6 - 1}{0.1 \times 1.1^6} \right] + \frac{20000}{1.1^4} - 27237.60 \left[\frac{1.1^2 - 1}{0.1 \times 1.1^6} \right]$$

$$= 12030.97$$

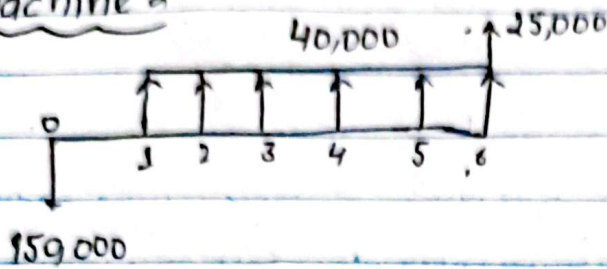
Opt III



$$PW = 12030.97$$

Machine 2

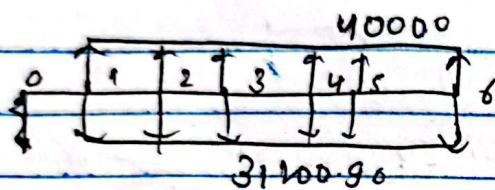
(i)



$$PW = -150000 + 40000 \left[\frac{1.1^6 - 1}{0.1 \times 1.1^6} \right] + \frac{25000}{1.1^6}$$

$$= 38322.37$$

(ii)



$$PW = (40000 - 31200.90) \left[\frac{1.1^6 - 1}{0.1 \times 1.1^6} \right]$$

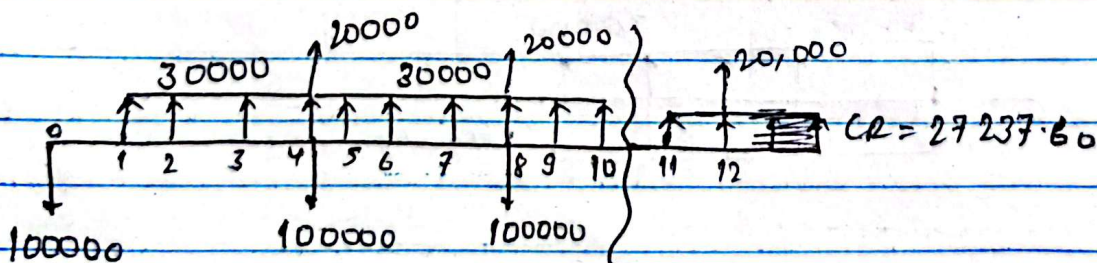
$$= 38322.37$$

Still $PW(2) > PW(1)$ i.e. study period doesn't matter

(iv)

Study period = 10 years

Machine 1

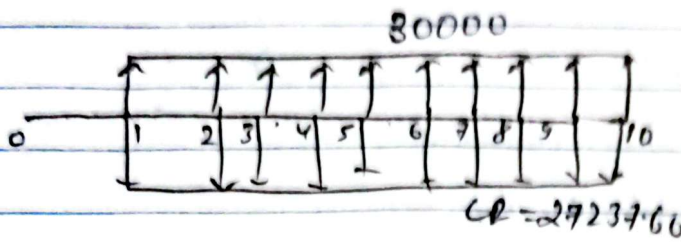


$$PW = -100000 + 30000 \left[\frac{1.1^{10} - 1}{0.1 \times 1.1^{10}} \right] - 80000 \left[\frac{1}{1.1^4} + \frac{1}{1.1^8} \right]$$

$$+ 27237.60 \left[\frac{1.1^2 - 1}{0.1 \times 1.1^{12}} \right] + \frac{20000}{1.1^{12}}$$

$$= 16973.75$$

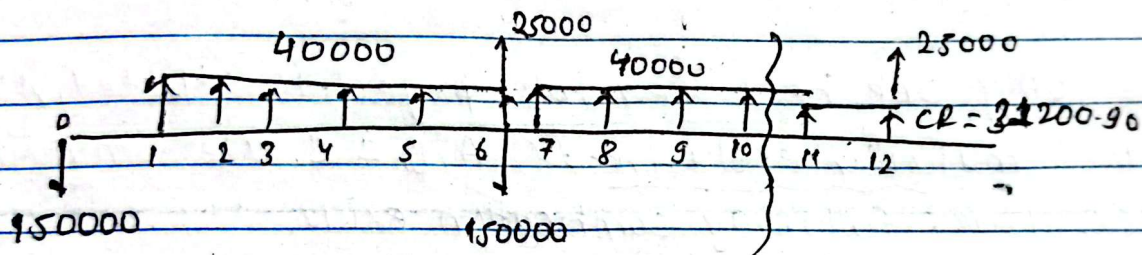
DP 1.



$$PW = (30000 - 27237.66) \left[\frac{1.1^{10} - 1}{0.1 \times 1.1^{10}} \right]$$

$$= 16923.75$$

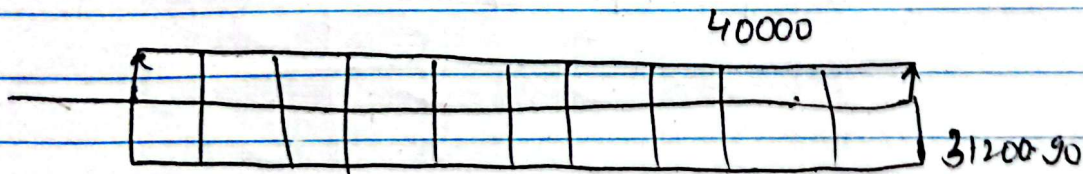
Machine 2



$$PW = -150000 + 40000 \left[\frac{1.1^{10} - 1}{0.1 \times 1.1^{10}} \right] + \frac{(-150000 + 25000)}{1.1^6} + 31200.90 \left[\frac{1.1^2 - 1}{0.1 \times 1.1^2} \right]$$

$$+ \frac{25000}{1.1^{12}}$$

$$= 54066.66$$



$$PW = (40000 - 31200.90) \left[\frac{1.1^{10} - 1}{0.1 \times 1.1^{10}} \right] = 54066.66$$

u If useful life is different (study period)

- ① Repeatability (LCM)
- ② Capitalized worth ($N \rightarrow \infty$)
- ③ Co-terminated any

$\Rightarrow$ AW is common Method
(to select the Best)

check.

* Mutually Exclusive, Independent & contingent (dependent) project.

* If only one best feasible project is selected, Alternatives are mutually exclusive. If A, B, & C are mutually exclusive, following combination exists.

Combination	A	B	C	select
1	✓	x	x	A
2	x	✓	x	B
3	x	x	✓	C
4	x	x	x	None

- Independent: If all the feasible projects can be selected, those are independent. If A, B and C are independent, following combination exists

Combination	1	2	3	4	5	6	7	8
A	✓	x	x	✓	✓	x	✓	x
B	x	✓	x	✓	x	✓	✓	x
C	x	x	✓	x	✓	✓	✓	x
Select	A	B	C	A+B	A+C	B+C	All	None

- If selection of a project depends on the selection of any other in the group the later one is contingent e.g.

દાર વગર છે is dependent on જગમા કિન્ને
Printer કિન્ને is dependent on Computer કિન્ને

→ If A is દાર વગર છે

C is જગમા કિન્ને

B is independent → Bire કિન્ને

Following combination exists

Combination	A	B	C	Select
1	✓	x	x	A(?)
2	x	✓	x	B
3	x	x	✓	C
4	✓	✓	x	A+B(?)
5	✓	x	✓	A+C
6	x	✓	✓	B+C
7	✓	✓	✓	All
8	x	x	x	None

x (દાર વગર છે જગમા કિન્ને)

(Invalid)

Combination
 Single
 Double
 All
 None

Q If A is contingent on B
 C & D are mutually exclusive
 Select Best combination

Project	A	B	C	D
Initial cost	50	80	100	200
Annual Income	20	25	30	40
Life	3	4	5	6
S_v	10	20	25	30

(Life फरक है
 so AW)

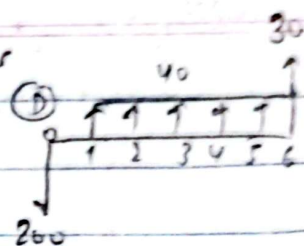
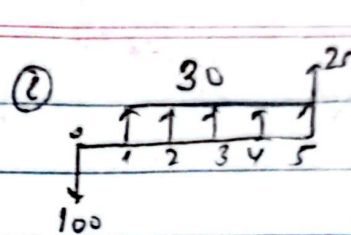
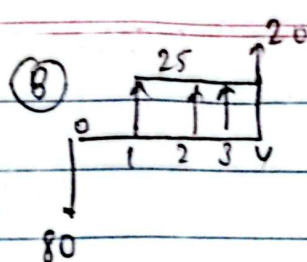
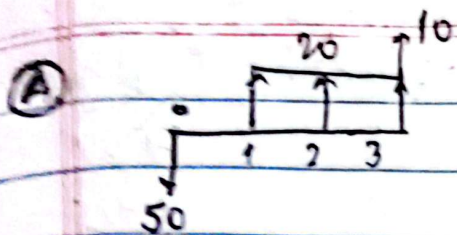
MARR = 10%

Investment is limited to Rs 3000

→ C & D → Mutually Exclusive → Either C or D / (C+D) x

A is contingent of B → A+B ✓
 B ✓ } A only No

Combination	A	B	C	D	Select
(I)	x	✓	x	x	B
	x	x	✓	x	C
	x	x	x	✓	D
(II)	✓	✓	x	x	A+B
	x	✓	✓	x	B+C
	x	✓	x	✓	B+D
(III)	✓	✓	✓	x	A+B+C
	✓	✓	x	✓	A+B+D
(IV)	x	x	x	x	None



$$AW(A) = -50 \left[\frac{0.1 \times 1.1^3}{1.1^3 - 1} \right] + 20 + 10 \left[\frac{0.1}{1.1^3 - 1} \right]$$

$$= 2.915$$

$$AW(B) = -80 \left[\frac{0.1 \times 1.1^4}{1.1^4 - 1} \right] + 25 + 20 \left[\frac{0.1}{1.1^4 - 1} \right]$$

$$= 4.071$$

$$AW(C) = -100 \left[\frac{0.1 \times 1.1^5}{1.1^5 - 1} \right] + 30 + 25 \left[\frac{0.1}{1.1^5 - 1} \right]$$

$$= 7.715$$

$$AW(D) = -200 \left[\frac{0.1 \times 1.1^6}{1.1^6 - 1} \right] + 40 + 30 \left[\frac{0.1}{1.1^6 - 1} \right]$$

$$= -2.033$$

Combination	A	B	C	D	Select	AW
					B	4.07
					C	7.715
					D	-2.03
					A+B	6.99
					B+C	1.178
					B+D	2.04
					A+B+C	14.7 $\rightarrow$ Max ^d
					A+B+D	4.955
SURENDRA SHARMA					None	0

A+B+C investment = 230 < 300 (OK)

A+B+D = 350 > 300 (Can't select even though it had max^d)

Select	AW
B	4.07
C	7.715
D	-2.03
A+B	6.99
B+C	1.178
B+D	2.04
A+B+C	14.7 $\rightarrow$ Max ^m .
A+B+D	4.955
None	0

O.K.)
 $\rightarrow$ Can't select
 even though it had
 max^m)

Initial Investment

80
 100
 200
 130
 180
 280
 230
~~380~~

Chapter-5

Replacement Analysis

⇒ Old/Existing Machine → Defender

⇒ Replace by

new machine - challenger

• Why to replace?

- to increase efficiency
- as O&M cost increases
- Machine becomes outdated

Existing Machine has market value of Rs. 5000. Its O&M cost is Rs. 4000/year & Salvage value after year 5 = 2000/-

New machine costs Rs. 12000

Its O&M cost = 2500/year

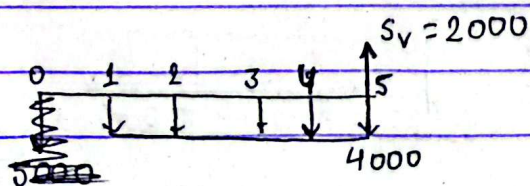
Salvage value in 5 years = 5500/-

Is it worthwhile to replace now?

① Draw cashflow diagram for both options & Decide
MARR = 10%

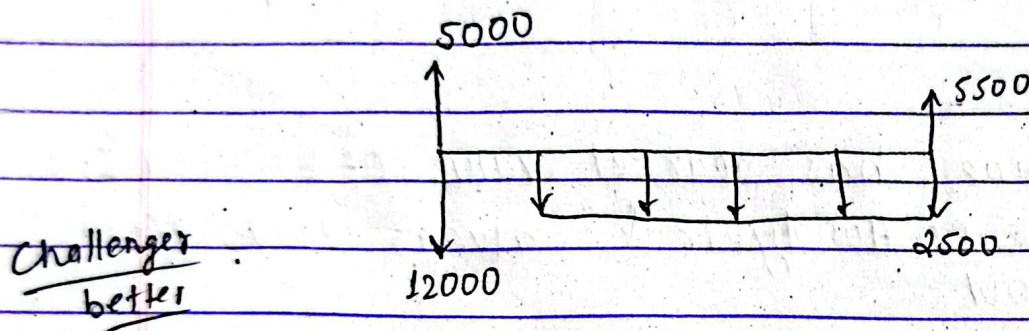
→ Solⁿ:-

Defender



$$\begin{aligned}
 PW &= -8000 - 4000 \times \frac{1.15 - 1}{0.1 \times 1.15} + \frac{2000}{1.15} \\
 (D) \\
 &= -1397.30
 \end{aligned}$$

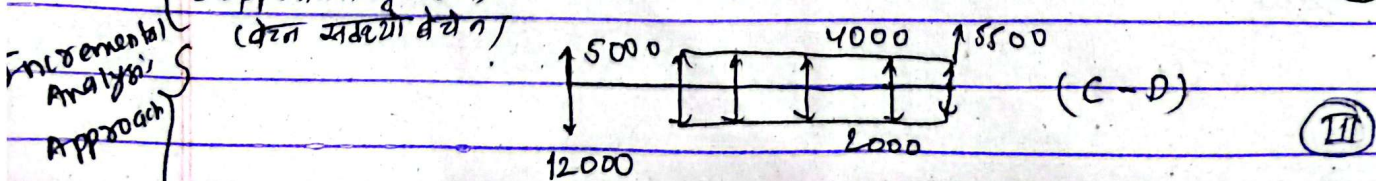
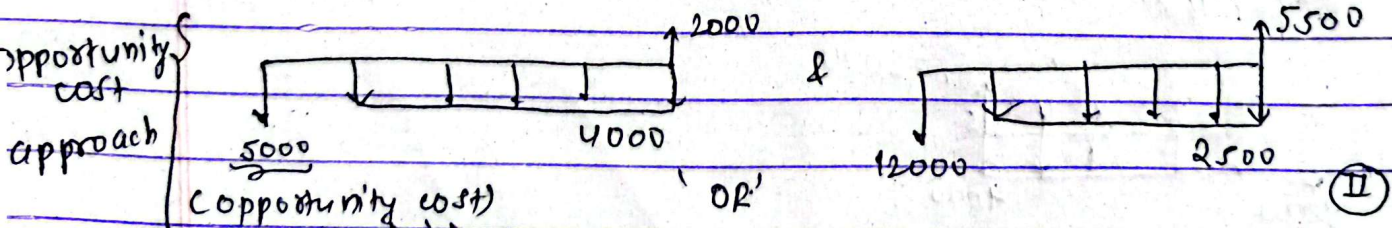
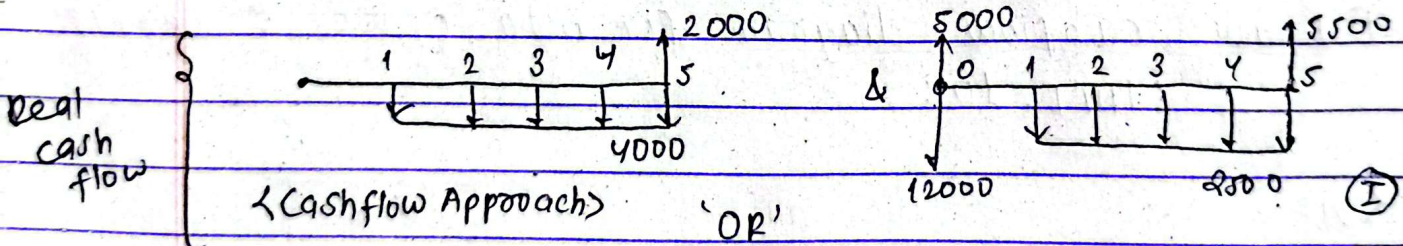
Challenger CFD



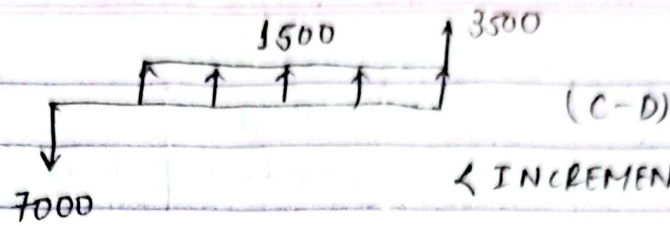
$$\begin{aligned}
 PW &= -7000 - 2500 \times \frac{1.15 - 1}{0.1 \times 1.15} + \frac{5500}{1.15} \\
 (C) \\
 &= -1306.30
 \end{aligned}$$

Defended (Old-Existing)

New



III



← INCREMENTAL ANALYSIS

I Defender

$$PW_{(D)} = -5000 - 4000 \times \left[\frac{1.15^5 - 1}{0.1 \times 1.15} \right] + \frac{2000}{1.15}$$

$$= -18921.30$$

Challenger

$$PW_{(C)} = -12000 - 2500 \times \left[\frac{1.15^5 - 1}{0.1 \times 1.15} \right] + \frac{5500}{1.15}$$

$$= -18061.90$$

II

$$PW_{(C-D)} = -7000 + 1500 \times \left[\frac{1.15^5 - 1}{0.1 \times 1.15} \right] + \frac{3500}{1.15}$$

$$= 859.404$$

PW (C-D) is +ve → select C.

(Challenger better)

[Extra investment of Rs. 7000 is justified]

Thus, it is worth to replace the old machine with new one.

Economic Service Life (ESL)

NO Interest



Year	Cost	Total cost	Average Annual cost
0	100	100	$100/0 = ?$
1	10	110	$110/1 = 110$
2	15	125	$125/2 = 62.5$
3	25	150	$150/3 = 50$
4	35	185	$185/4 = 46.25$
5	50	235	$235/5 = 47$
6	60	295	$295/6 = 49.1$
7	70	365	$365/7 = 52$

For MARR=10% (i=10%)

(AW)

①

$$= -\left(100 + \frac{10}{1.1}\right) \left(\frac{0.1 \times 1.1^1}{1.1^1 - 1}\right) = -120$$

PW → Annuity

②

$$= -\left(100 + \frac{10}{1.1} + \frac{15}{1.1^2}\right) \left(\frac{0.1 \times 1.1^2}{1.1^2 - 1}\right) = -70$$

③

$$= -\left(100 + \frac{10}{1.1} + \frac{15}{1.1^2} + \frac{25}{1.1^3}\right) \left(\frac{0.1 \times 1.1^3}{1.1^3 - 1}\right) = -56.40$$

④

$$= -\left(100 + \frac{10}{1.1} + \frac{15}{1.1^2} + \frac{25}{1.1^3} + \frac{35}{1.1^4}\right) \left(\frac{0.1 \times 1.1^4}{1.1^4 - 1}\right) = -51.8$$

⑤

$$= -\left(100 + \frac{10}{1.1} + \frac{15}{1.1^2} + \frac{25}{1.1^3} + \frac{35}{1.1^4} + \frac{50}{1.1^5}\right) \left(\frac{0.1 \times 1.1^5}{1.1^5 - 1}\right) = -51.5$$

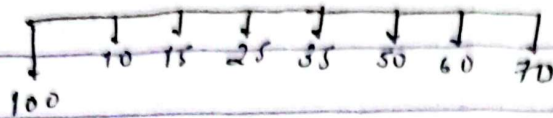
⑥

$$= -\left(100 + \frac{10}{1.1} + \frac{15}{1.1^2} + \frac{25}{1.1^3} + \frac{35}{1.1^4} + \frac{50}{1.1^5} + \frac{60}{1.1^6}\right) \left(\frac{0.1 \times 1.1^6}{1.1^6 - 1}\right) = -52$$

AEC $\rightarrow$ Annual Equivalent cost in minimum when $N = 5$ year

So, Economic service life $ESL = 5$ year

$AEC \sim EVAC + \text{Equivalent Uniform Annual cost} = AEC$



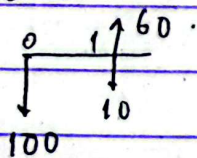
$$= -\left(100 + \frac{10}{1.1} + \frac{15}{1.1^2} + \frac{25}{1.1^3} + \frac{35}{1.1^4} + \frac{50}{1.1^5} + \frac{60}{1.1^6} + \frac{70}{1.1^7}\right) \left(\frac{0.1 \times 1.1^7}{1.1^7 - 1}\right)$$

$$= -54.43$$

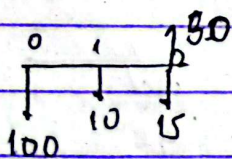
Year	cost	Total cost	S_v
0	100	100	-
1	10	110	60
2	15	125	50
3	25	150	40
4	35	185	30
5	50	235	20
6	60	295	10
7	70	365	5

Find EVAC/AEC & ESL.

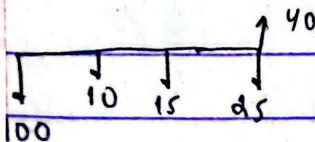
Solⁿ:-



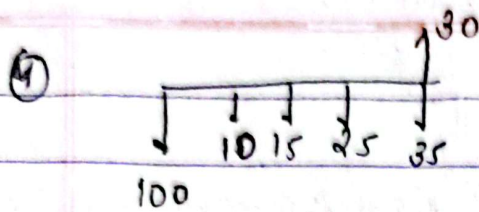
$$AW = -\left(100 + \frac{10}{1.1} + \frac{60}{1.1^1}\right) \left(\frac{0.1 \times 1.1^1}{1.1^1 - 1}\right) = -60$$



$$AW = \left(-100 - \frac{10}{1.1} - \frac{15}{1.1^2} + \frac{30}{1.1^2}\right) \left(\frac{0.1 \times 1.1^2}{1.1^2 - 1}\right) = -46.19$$

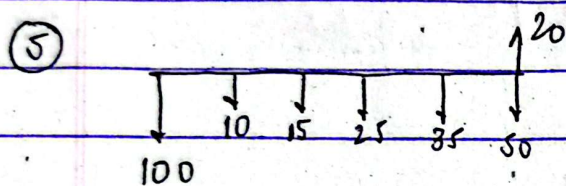


$$AW = \left(-100 - \frac{10}{1.1} - \frac{15}{1.1^2} - \frac{25}{1.1^3} + \frac{40}{1.1^3}\right) \left(\frac{0.1 \times 1.1^3}{1.1^3 - 1}\right) = -32$$



$$AW = \left(-100 - \frac{10}{1.1^1} - \frac{15}{1.1^2} - \frac{25}{1.1^3} - \frac{35}{1.1^4} \right) \left(\frac{0.1 \times 1.1^4}{1.1^4 - 1} \right)$$

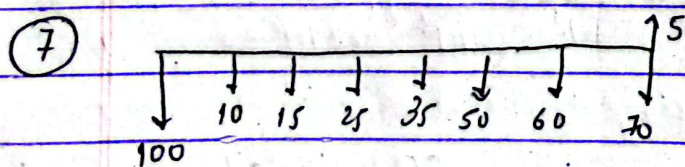
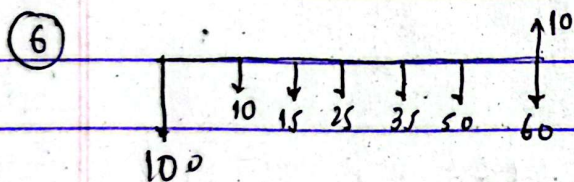
$$= -45.328$$



$$AW = \left(-100 - \frac{10}{1.1^1} - \frac{15}{1.1^2} - \frac{25}{1.1^3} - \frac{35}{1.1^4} - \frac{50}{1.1^5} \right) \left(\frac{0.1 \times 1.1^5}{1.1^5 - 1} \right)$$

$$+ \frac{20}{1.1^5}$$

$$= -48.223$$



Economic Service life (ESL)

From the following details, Calculate AEC (Annual Equivalent cost) or EUAC (Equivalent Uniform Annual Cost).

$$AEC = EUAC$$

- A machine costs Rs. 15000 now. Its life is 6 years. OIM cost in year 1 is Rs. 2000 and it increases by 20% each years. Its salvage value (S_v) = 12000 in year 1 and decrease by Rs. 2000/year.

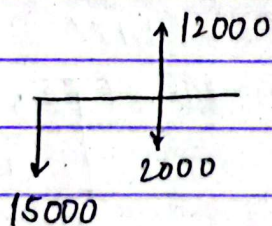
$$MARR(i) = 15\%$$

→ Solution:-

Year	0	1	2	3	4	5	6
Cost	15000	2000	2400	2880	3456	4147.2	4976.64
S_v	x	12000	10000	8000	6000	4000	2000

Calculate AEC/EUAC

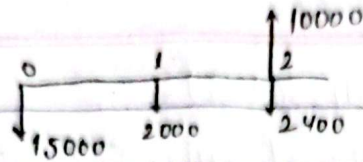
Years



$$A_j = \left[15000 - \frac{(12000 - 2000)}{1.15} \right] * \left[\frac{0.15 \times 1.15^6}{1.15 - 1} \right]$$

$$= 6424.78 \quad 7250$$

Year 2



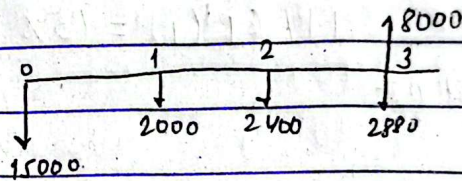
$$A_2 = \left[15000 + \frac{2000}{1.15} + \frac{10000 - 2400}{1.15^2} \right] \left[\frac{0.15 \times 1.15^2}{1.15^2 - 1} \right]$$

$$= 6761.63$$

Year 3

$$A_3 = \left[15000 + \frac{2000}{1.15} + \frac{2400}{1.15^2} + \frac{8000 - 2880}{1.15^3} \right] \left[\frac{0.15 \times 1.15^3}{1.15^3 - 1} \right]$$

$$= 6651.73$$



Year 4

$$A_4 = \left[15000 + \frac{2000}{1.15} + \frac{2400}{1.15^2} + \frac{2880}{1.15^3} + \frac{6000 - 3456}{1.15^4} \right] \left[\frac{0.15 \times 1.15^4}{1.15^4 - 1} \right]$$

$$= 6652.58$$

Year 5

$$A_5 = \left[15000 + \frac{2000}{1.15} + \frac{2400}{1.15^2} + \frac{2880}{1.15^3} + \frac{3456}{1.15^4} + \frac{4000 - 4147.2}{1.15^5} \right] \left[\frac{0.15 \times 1.15^5}{1.15^5 - 1} \right]$$

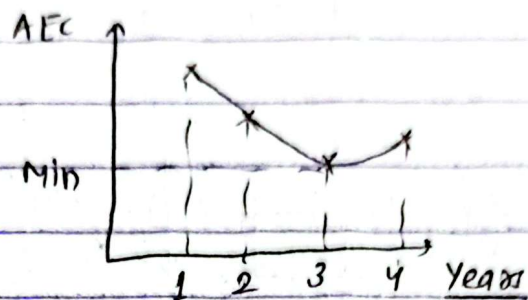
$$= 6711.11$$

Year 6

$$A_6 = \left[15000 + \frac{2000}{1.15} + \frac{2400}{1.15^2} + \frac{2880}{1.15^3} + \frac{3456}{1.15^4} + \frac{4147.2}{1.15^5} + \frac{2000 - 4971}{1.15^6} \right] \left[\frac{0.15 \times 1.15^6}{1.15^6 - 1} \right]$$

$$= 6809.99$$

* Find ESL मात्र लगेगे लगे A_5 र A_6 निकल करती है
(calculate only if you have enough time)



But, if asked find AEC calculate A_5 & A_6 as well.

(Q)	Alternative	1	2	3	4	5	6
	Defender (AEC)	54	52	55	62		
	Challenger (AEC)	70	62	57	54	56	60

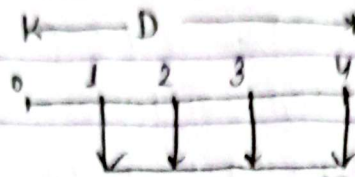
Formulate Best replacement strategy if $MARR = 10\%$ & we require the machine for 4 years.

Replacement strategies

- (a) D-4, C-0 (पुराना मशीन 4 वर्ष खर्चा चलाउने नयाँ नकिजे)
- (b) D-3, C-1
- (c) D-2, C-2
- (d) D-1, C-3
- (e) D-0, C-4

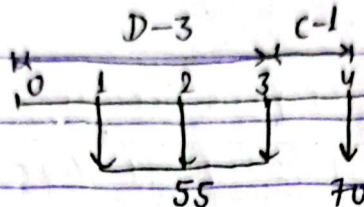
CFD

(a)



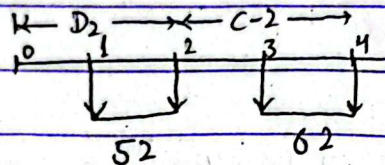
62 (value cost Alternative 4 in D)

(b)

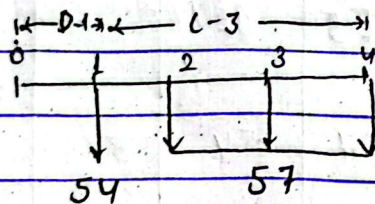


(Cost to
using
defender 3
year)

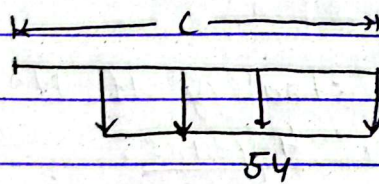
(c)



(d)



(e)



Taking
to
future

For (a)
$$FW = \frac{62}{0.1} \left[\frac{1.1^4 - 1}{0.1} \right] = 287.742$$

(All in
future
or
present)

For (b)
$$FW = 55 \left[\frac{1.1^3 - 1}{0.1} \right] \times 1.1 + 70 = 252.05 \quad 270.255$$

For (c)
$$FW = 52 \left[\frac{1.1^2 - 1}{0.1} \right] \times 1.1^2 + 62 \left[\frac{1.1^2 - 1}{0.1} \right] = 243.6 \quad 267.41 \quad 262.33$$

For (d)
$$FW = 54 \times 1.1^3 + 57 \left[\frac{1.1^3 - 1}{0.1} \right] = 260.54$$

$$\text{Find } FW = 54 \left[\frac{1.1^4 - 1}{0.1} \right] = 250.61 \rightarrow \min$$

Best option is Replace the old machine now.

* Similarly, find best replacement strategy if machine is required for

- (a) 6 years
- (b) 8 years
- (c) ∞ years.

x (You cannot repeat old machine i.e. Defender again)

(a) 6 years

(a) D-4, C-2

(b) D-3, C-3

(c) D-2, C-4

(d) D-1, C-5

(e) ~~D-0, C-6~~

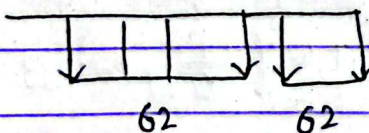
(f) D-1, C-4, C-1

(g) D-0, C-6, (or min for 4)

(h) D-0, C-4, C-2

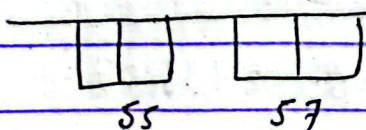
(i) D-0, C-5, C-1

(a)



$$FW = 62 \left[\frac{1.1^6 - 1}{0.1} \right] = 478.37$$

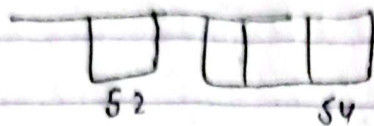
(b)



$$FW = 55 \left[\frac{1.1^3 - 1}{0.1} \right] \times 1.1^3 + 57 \left[\frac{1.1^3 - 1}{0.1} \right]$$

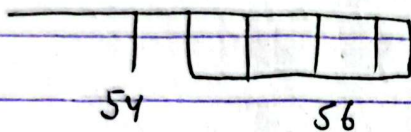
$$= 370.72 \quad 430.98$$

①



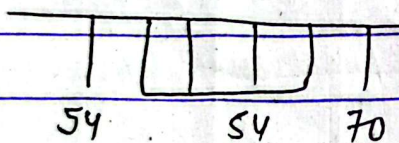
$$FW = 52 \left[\frac{1.1^2 - 1}{0.1} \right] \times 1.1 + 54 \left[\frac{1.1^4 - 1}{0.1} \right] = 410.43$$

②



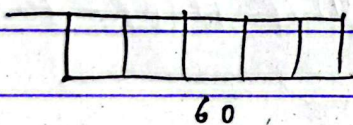
$$54 \times 1.15 + 56 \left[\frac{1.15 - 1}{0.1} \right] = 428.85$$

③



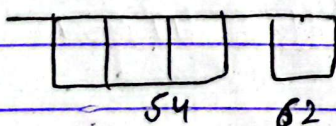
$$54 \times 1.15 + 54 \left[\frac{1.1^4 - 1}{0.1} \right] \times 1.1 + 70 = 432.64$$

④



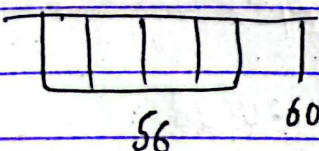
$$60 \times \left[\frac{1.1^6 - 1}{0.1} \right] = 462.94$$

⑤



$$54 \left[\frac{1.1^4 - 1}{0.1} \right] \times 1.1 + 62 \left[\frac{1.1^2 - 1}{0.1} \right] = 433.44$$

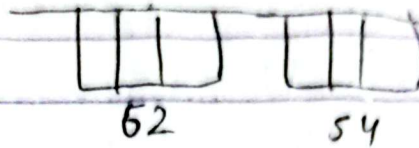
⑥



$$56 \left[\frac{1.15 - 1}{0.1} \right] \times 1.1 + 60 = 436.07$$

⑥ 8 years

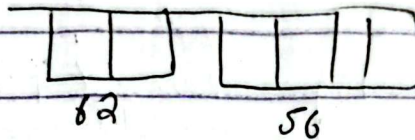
(i) D-4, C-4



PW =

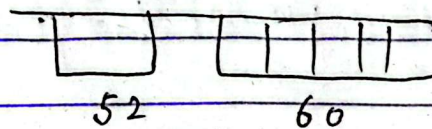
$$62 \times \left[\frac{1.1^4 - 1}{0.1} \right] \times \frac{1}{1.1^4} + 54 \times \left[\frac{1.1^4 - 1}{0.1} \right] \times \frac{1}{1.1^4} = 313.44$$

(ii) D-3, C-5



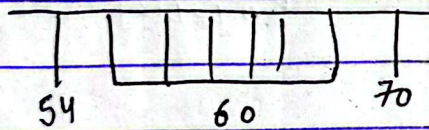
PW = ~~309.47~~ 313.68

(iii) D-2, C-6



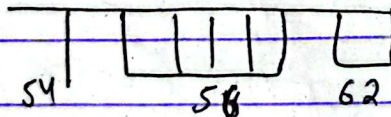
PW = 306.21

(iv) D-1, C-6, C-1



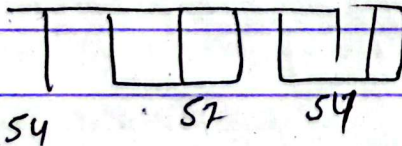
PW = 319.31

(v) D-1, C-5, C-2



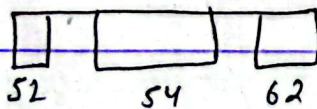
PW = 302.81

(vi) D-1, C-3, C-4



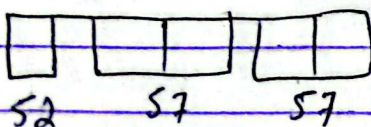
PW = 294.87

(vii) D-2, C-4, C-2



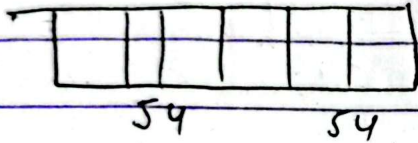
PW = ~~291.77~~ 292.45

(viii) D-2, C-3, C-3



PW = 295.41

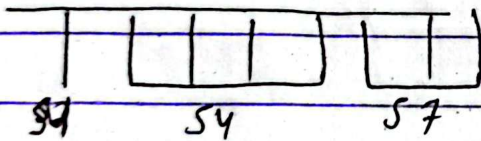
(ix) D-0, C-4, C-4



$$PW = 54 \left[\frac{1.1^8 - 1}{0.1 \times 1.1^8} \right]$$

$$PW = 288.086 \text{ (min)}$$

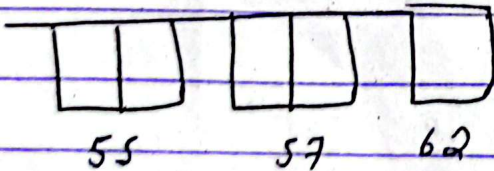
(x) D-1, C-4, C-3



$$PW = \frac{54}{1.1} + 54 \left[\frac{1.1^4 - 1}{0.1 \times 1.1^5} \right] + \frac{57}{1.1^5} \left[\frac{1.1^3 - 1}{0.1 \times 1.1^8} \right]$$

$$PW = 291.72$$

(xi) D-3, C-3, C-2



$$PW = 55 \times \left[\frac{1.1^3 - 1}{0.1 \times 1.1^3} \right] + 57 \left[\frac{1.1^2 - 1}{0.1 \times 1.1^6} \right] + 62 \left[\frac{1.1^2 - 1}{0.1 \times 1.1^8} \right]$$

$$PW = 304.015$$

$$\frac{1.1^2-1}{1.1+1}$$

$$\frac{1^2-1}{1+1} + \frac{5.7}{1.1+1} \left[\frac{1.1^3-1}{0.1 \times 1.1} \right]$$

$$7 \left[\frac{1.1^3-1}{0.1 \times 1.1} \right] + 62 \left[\frac{1.1^2-1}{0.1 \times 1.1} \right]$$

(c)

$P_{10} =$

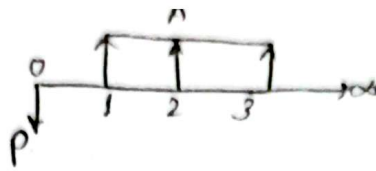
(1) D-1, C-

0 —
↙

(say

(ii) D-2,

(u)



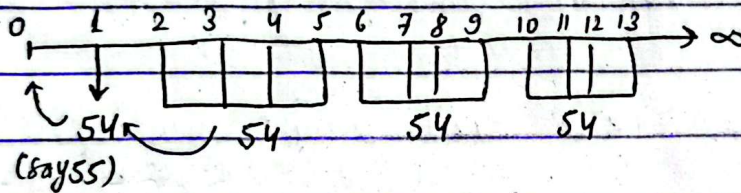
$$\left\{ \begin{array}{l} A(1 \rightarrow \infty) \\ P(0) \end{array} \right\} 1 - 1.1 \cdot 2.91$$

$$\left[P = \frac{A}{i} \right] \text{ (A) } \rightarrow 1.1 \cdot 2.91 \text{ after}$$

(c) ∞ years.

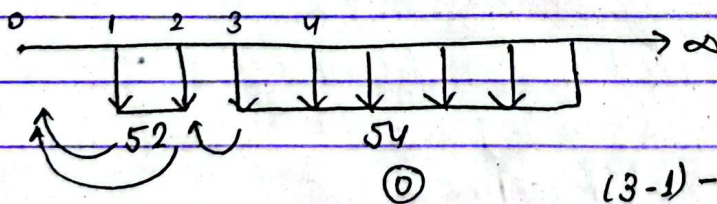
$$PW = 52 \times \left[\frac{1.1^3 - 1}{0.1 \times 1.1^3} \right] \times 54 \left[\frac{1.1^4 - 1}{0.1} \right]$$

$$\times 1.1^{12+1} \times 1.1^4$$

(i) D-1, C-4, C-4, C-4, $\rightarrow \infty$ 

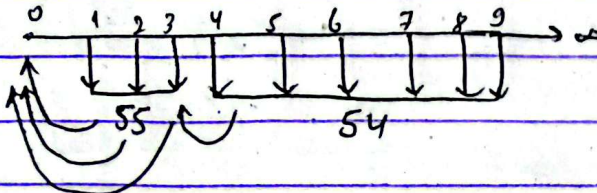
$$PW(CW) = \frac{55}{1.1} + \left\{ \left(\frac{54}{0.1} \right) / 1.1 \right\} = 540.91$$

(1-1) (1) - (1)

(ii) D-2, C-4, C-4, C-4, $\dots \rightarrow \infty$ 

$$PW(CW) = \left(\frac{52}{1.1} + \frac{52}{1.1^2} \right) + \left(\frac{54}{0.1} \right) \times \frac{1}{1.1^2} = 536.53$$

(min^m)
w (best)

(iii) D-3, C-4, C-4, C-4, $\dots \rightarrow \infty$ 

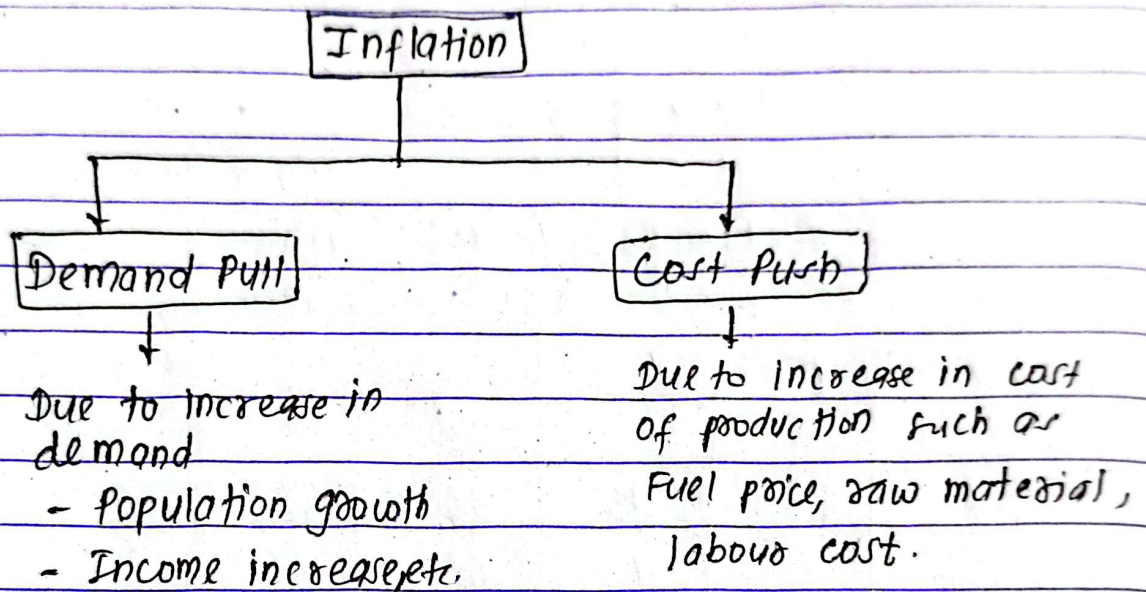
$$PW(CW) = \frac{55}{1.1} \left[\frac{1.1^3 - 1}{0.1 \times 1.1^3} \right] + \left(\frac{54}{0.1} \right) \times \frac{1}{1.1^3}$$

$$= 542.486$$

Inflation (मुद्रा स्थिति)

→ Increase in price of goods & services
'OR'

→ Decrease in purchasing power of currency is known as Inflation



⇒ Nepal Rastra Bank (NRB) ले देशभर बाटै → Price collect गर्ने Inflation कति भयो भनेर publish गर्दछ।

— Consumer Price Index

# 2042-	Now 2081
महि तेल : 6.75/L	170
कुन ÷ 3000/लेन	160000

Avg Inflation = ?

[f = Inflation]

$$F = P(1+f)^N$$

(2081) ↑ ↑ - 39 years
(2042)

2078-79 $\rightarrow$ 8% $\rightarrow f_1$

2079-80 $\rightarrow$ 7.5% $\rightarrow f_2$

80-81 $\rightarrow$ 6% $\rightarrow f_3$

Average inflation $f = ?$

$$P = 100$$

$$P_1 = 100 \times 1.08 =$$

$$P_2 = P_1 \times 1.075 =$$

$$P_3 = P_2 \times 1.06 =$$

$$\left. \begin{array}{l} \text{Avg.} \\ \text{inflation} \end{array} \right\} \left. \begin{array}{l} P_3 = P(1+f)^3 \\ \Rightarrow f = \quad \% \end{array} \right\}$$

(9) Deposit = 1000 Rs

In 5 yrs 2000 Rs. जमा अथवा

(i) i = Bank Interest $\Rightarrow$

(ii) $f = 10\%$ (दरम दर)

(c) $i' = \text{net interest}$ $\Rightarrow$
(Inflation adjusted interest rate)

$$(i) \quad F = P(1+i)^N$$

$$2000 = 1000(1+i)^5$$

$$\Rightarrow [i = 14.87\%]$$

$$[\text{Approx.} = 14.87 - 10 = \underline{4.87\%}] \leftarrow (\text{Not actual})$$

$$(ii) P_5 = 1000(1+f)^5 = 1000(1.1)^5 = 1610.51$$

(iii) Adjusted Interest Rate:

$$1610.51(1+i')^5 = 2000$$

$$[i' = 4.427\%] \leftarrow \text{Actual.}$$

3 relations:-

$$\left\{ \begin{array}{l} P(1+i)^5 = \cancel{2000} 2000 = F \\ P(1+f)^5 = 1610.51 \\ 1610.51(1+i')^5 = 2000 \end{array} \right\}$$

Find relation of i, i', f without N&P.

$$\star \left\{ (1+i) = (1+i')(1+f) \right\}$$

$$\rightarrow \left[i' = \frac{(1+i)}{(1+f)} - 1 \right]$$

$$\rightarrow \left[f = \frac{(1+i)}{(1+i')} - 1 \right]$$

$$\rightarrow [i = i' + f + i'f]$$

Q. $i = 10\%$, $f = 6\%$, $i' = ?$

$$i' = \frac{1+0.1}{1+0.06} - 1 = 3.77\%$$

Q. $i = 10\%$, $i' = 2\%$, $f = ?$

$$f = \frac{1+0.1}{1+0.02} - 1 = 7.84\%$$

Q. $i' = 3\%$, $f = 7\%$, $i = ?$

$$i = 0.03 + 0.07 + 0.03 \times 0.07 = 10.21\%$$

(Q)	Year	Real Cashflow Actual
	0	-60
	1	+20
	2	+25
	3	+30

IRR (i) = ... %

For i , $Fw = 0$

$$\Rightarrow -60(1+i)^3 + 20(1+i)^2 + 25(1+i) + 30 = 0$$

$$\Rightarrow [i = 11.218\%]$$

If inflation = 8%
 $i' = ?$

$$[i' = \frac{1+i}{1+f} - 1 = \frac{1.11218}{1.08} - 1 = 2.98\%]$$

(constant \$
cashflow)

Date _____
Page _____

(Q)	Year	Real Actual cashflow (\$)	Inflation adjusted cashflow
	0	-60	-60
	1	20	$\frac{20}{1.08} = 18.51$
	2	25	$\frac{25}{1.08^2} = 21.43$
	3	30	$\frac{30}{1.08^3} = 23.81$

IRR?

$$-60(1+i)^3 + 18.51(1+i)^2 + 21.43(1+i) + 23.81 = 0$$

$$\Rightarrow \underline{\underline{[i = 2.98\%]}}$$

[same as i']

Thus,

{	Actual \$ cashflow $\rightarrow i$	}	#
	constant \$ cashflow $\rightarrow i'$		

(9)	Years	Constant \$ Cashflow
	0	-100
	1	+55
	2	+55

$$f = 8\%$$

$$MARR = 13\% (1)$$

Feasible or unfeasible.

$$(M.I) \rightarrow -100(1+i')^2 + 55(1+i') + 55 = 0$$

$$\Rightarrow i' = 6.596\%$$

Thus

$$i = i' + f + i'f = 0.06596 + 0.08 + 0.06596 \times 0.08$$

$$[i = IRR = 15.12\%]$$

$IRR > MARR$ feasible

(MII) By real \$ cashflow

Year	constant \$ CF	Real \$ cashflow
0		-100
1		$55 \times 1.08 = 59.4$
2		$55 \times 1.08^2 = 64.152$

$i = IRR$

$$-100(1+i)^2 + 59.4(1+i) + 64.152 = 0$$

$$\Rightarrow [i = IRR = 15.12\%]$$

$IRR > MARR \Rightarrow$ feasible.

3-7 → 4

Date _____
Page _____

(9)

Loan = 100,000/-

EMI = 5000 for 24 month

$f = 10\%$

Inflation free yearly

Interest rate = ?%

SURENDRA SHARMA

- * Future is uncertain
- * We estimate cost (Expenditure), Income, Life, Interest rate, etc. based on certain assumption.
- * But things do not go like that or results vary from our estimate

⇒ Various factors affect this

- | | |
|-----------------------|---|
| - Political situation | - Corruption |
| - Strike | - Inbalance Demand-supply |
| - Climatic condition | - Commission to intermediate parties |
| - Natural Calamities | - Under bid of project |
| - Import tax | - International Sanctions. |
| - Pandemic | - Lack of International Funding |
| - Favourism | - Local disputes |
| | - Fluctuation in foreign currency exchange rate |
- यदि हमीने सोचेको भन्दा फरक situation भयो भने

- Initial Investment छठी/कम भयो
- आम्दानी छठी/कम भयो
- Life छठी/कम भयो
- i फरक भयो (MARR)
- Life फरक भयो, S_v फरक भयो भने

ने

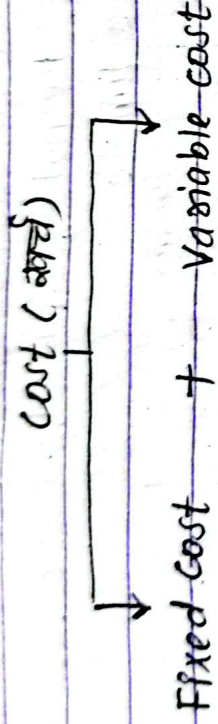
PW	} के हुन्छ ?	} Feasible/Unfeasible के हुन्छ ?
IRR		
PBP		
BCR		

अनेर Analysis गरियो

ने → Risk Analysis गरियो!

* Methods of Risk Analysis

1. Breakdown Analysis



- Those cost which remain constant over certain period & independent with the production are Fixed cost.
- Opposite are variable cost. Vary directly with output.

GIS (AEC) Training for civil III / GH students.

Cost Estimate, Cost Teacher

$$7 \times 2 = 14 \text{ hr} \times 1500 \text{ Rs/hr} = 21000/- \text{ (fixed cost)}$$

Training:

Tea/Biscuit

$$(30 \text{ Rs/student/day}) \times \underset{\substack{\uparrow \\ \text{Student} \\ \text{Numbers}}}{x} \times 7 = 210 \times x \text{ (Variable cost)}$$

Thus,

Total cost = Fixed cost + Variable cost

$$= FC + C_v \times x$$

$$= FC + 210 \times x$$

∴ C_v = Variable cost per unit

Fee (Total),

$$= \text{Fee/Student} \times x$$

$$= 100 \times x$$

At Breakeven

↑ NO profit & NO loss is Business

Total Fee = Total cost

$$f \times x = FC + C_v \times x$$

$$\left\{ x = \left(\frac{FC}{f - C_v} \right) \right\}$$

Say, $f = 100$ & $C_v = 210$

$$FC = 21000$$

So,

$$x = \frac{21000}{100 - 210} = 72.4 \text{ NOS.}$$

↑ Breakeven value

(कमि जमा student एरका मर
cost उठएगा)

Again,

Say, $f = 1000$

$$x = \frac{21000}{1000 - 210} = 26.6 \text{ NOS.}$$

Cement Factory

Fixed cost (FC) = 15 lakh/month

$C_v = 380 \text{ Rs/bag}$

$S_p = 510 \text{ Rs/bag}$

(a) સમિનામા કિંમતિ Bag cement ઉત્પાદન ગરે Break even કુનદે?

(b) સમિનામા 25 લાકવ મુનાફા કમાડન કિંમતિ Bag cement લેચનુ પદે?

(c) Market Competing લે ગર્લ cement price 10% લે ઘટુથો મથો. મને, Breakdown કો ભાગી કિંમતિ Bag ઉત્પાદન/લેચનુ પર્ભો?

(d) ઉત્પાદન cost 25% લટુથો ન S_p 15% લે ઘટુથો મને $\text{Rs. } 10,00,000$ /મહિના મુનાફા કમાડન કિંમતિ Bag લેચનુ પર્ભો?

→ 20/21.

(d) For Break even,

$$FC + C_v \times x = S_p \times x$$

$$\text{or, } x = \frac{FC}{S_p - C_v}$$

$$= \frac{15,00,000}{510 - 380}$$

$$= 11538.46$$

$$\approx 11539 \text{ Bags}$$

$$\approx 11539 \text{ Bags}$$

(b) $[\text{Profit} = \text{Sale} - \text{total cost}]$

$$2500000 + FC + C_v \times x = S_p \times x + 2500000$$

$$\Rightarrow x = \frac{2500000 - FC}{S_p - C_v}$$

$$= \frac{1500000 + 2500000}{510 - 380}$$

$$= 30769.23$$

$$\approx 30770 \text{ bags}$$

(c) $S_p = 510 \times 0.9 = 459 \text{ Rs/bag}$

$$FC + C_v \times x = S_p \times x$$

$$\Rightarrow x = \frac{1500000}{510 - 380} = \frac{18987.34 \approx 18988 \text{ bags}}{8287.29 \approx 8288 \text{ bags}}$$

(d) $C_v = 1.25 \times 380 = 475 \text{ Rs/bag}$

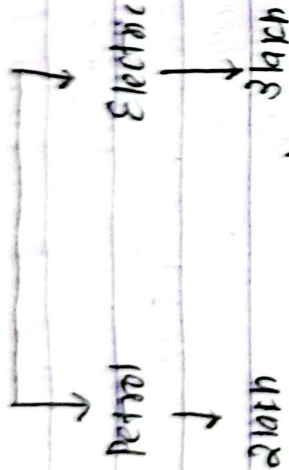
$$S_p = 510 \times 0.85 = 433.5 \text{ Rs/bag}$$

$$FC + 10,00,000 + C_v \times x = S_p \times x$$

$$x = \frac{1500000 + 1000000}{433.5 - 475}$$

$$= -60240.96$$

Bike



$$(111780(16800) = 35 \text{ km}) \quad (1 \text{ km} = 100 \text{ m})$$

$$\text{i.e. } 15.4 \cdot 8 / 11780$$

$$\text{Life} = 5 \text{ years} \quad \text{Life} = 5 \text{ yr.}$$

• सहीनामा कति km मा Breakeven हुन्छ ?

होत्र गुडाउडा - Electric सक्ती

कुम गुडाउडा - Petrol सक्ती

(For Breakeven,

$$2,00,000 + 4.5 \times x = 3,00,000 + x$$

$$\Rightarrow x = 28571.43 \quad 26315.79$$

$$\approx 28572 \approx 26316 \text{ km.}$$

$$\frac{2,00,000}{60} + 4.8 \times x = \frac{3,00,000}{60} + 1 \times x$$

$$\Rightarrow [x = 438.6 \text{ km}]$$

$$A = \text{Petrol Monthly cost} = \frac{21000}{60} + \frac{168 \times \text{km}}{35} \text{ / month.}$$

$$5 \times 12$$

$$B = \text{Electric Monthly cost} = \frac{31900}{60} + \frac{168 \times \text{km}}{35} \text{ / month}$$

$$\text{For } A=B \Rightarrow \text{km/month} = 438 \text{ km/month} \\ = 14.6 \text{ km/day}$$

* Same qn

Say $i = 10\%$ / year

$$i_{\text{month}} = (1 + i_{\text{yr}})^{1/12} - 1$$

$$= 7.97 \times 10^{-3}$$

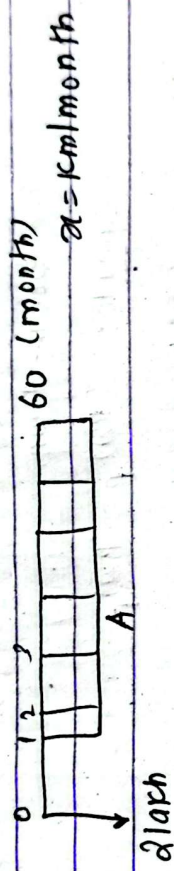
$$= 0.797\%$$

Now,

For Break even:-

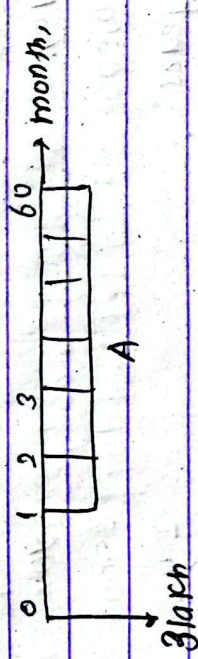
$$\text{Annual cost (A)} = ₹ 2,00,000$$

Petrol



$$A = \frac{(1.68)}{(35)} \times a = 4.8a$$

Electric



$$A = 1 \times a$$

$i = 10\%$ per year

$$i_{\text{mo}} = (1 + i_{\text{yr}})^{1/12} - 1 = 0.797\%$$

For Break even, {equate PW, FW or Annuity $\Rightarrow$ life span}
 {If life diff. equate in annuity}

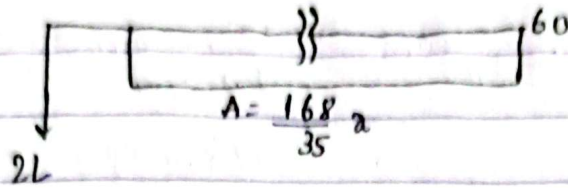
$$FWP = FWE$$

$$\text{or, } 2,00,000 + 4.8a \left[\frac{1 - 0.00797^{60}}{0.00797} \right] = 3,00,000 \times 1.00797^{60}$$

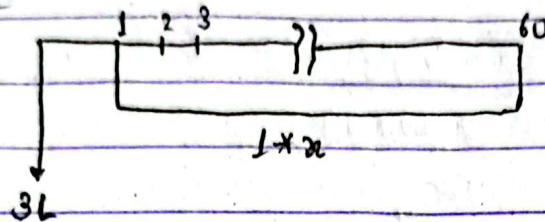
$$+ 1.00797^{60} + a \left[\frac{1.00797^{60} - 1}{0.00797} \right]$$

$$\Rightarrow [a = 553.5 \text{ km}]$$

Petrol



Electric



For break-down,

equation: $(PW)_p = (PW)_e$

#

Khasa Motor

SARVO Motor

Capacity	5hp	5hp
Efficiency	75%	90%
Cost	10,000	25,000
Life	3 years	2 years
O&M/yr.	5000	2000
Tax & Insurance (1 years)	5% of initial cost	
Salvage value	4000	6000

* How many hours/year the pump has to be operated for breakeven?

If electricity cost = 10 Rs/unit

* Select the pump if we operate the pump 6hrs/day
MARR = 10%

1hp = 746 watt = 0.746 kW

→ Soln

$$\text{Cost of electricity} = \frac{(5 \text{ hp} \times 0.746) \text{ kW} \times \alpha}{\eta}$$

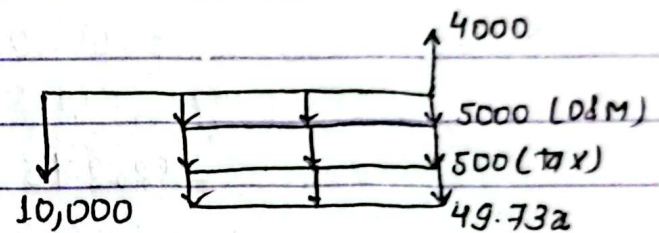
where,

α = no. of hours of operation (per day or per year)

Here, life is different. So, AW is calculated i.e.

Make $AW_{\text{khasa}} = AW_{\text{Salvo}}$. Find x .

Khasa:-



variable cost = Electricity cost

$$= \frac{5 \times 0.746 \alpha \times 10}{\eta}$$

$$= \left(\frac{5 \times 0.746 \alpha \times 10}{0.75} \right) \text{ per year}$$

$$= 49.73 \alpha \text{ per year}$$

$$AW_{\text{khasa}} = \frac{-10000 \times 1.1^3 \times 0.1}{1.1^3 - 1} - 5000 - 500 - 49.73 \alpha + \frac{4000 \times 0.1}{1.1^3 - 1}$$

$$= -8312.69 - 49.73 \alpha$$

SARVO

$$\text{var. cost} = \frac{5 \times 0.746x}{0.9} \times 10 = 41.44x$$

$$\text{Tax \& Insurance} = 5\% \text{ of } 25000 = 1250$$

So,

$$\begin{aligned} \text{AW}_{\text{SARVO}} &= - \frac{25000 \times 1.15 \times 0.1}{1.15 - 1} - 2000 - 1250 - 41.44x \\ &\quad + \frac{6000 \times 0.1}{1.15 - 1} \\ &= -8862.15 - 41.44x \end{aligned}$$

For break even,

$$\text{AW}_{\text{SARVO}} = \text{AW}_{\text{Khafra}}$$

$$\text{Or, } -8312.69 - 49.73x = -8862.15 - 41.44x$$

$$x = 66.28 \text{ hrs/yr}$$

$$[x = 0.181 \text{ hr/day}]$$

Break even मंदा गति use जर्ने परे low yearly cost भएको use जर्ने

So, use SARVO motor.

$$\left. \begin{aligned} \text{AW}_K &= -11608.79 \\ \text{AW}_S &= -11608.79 \end{aligned} \right\} \text{For Breakeven.}$$

* Sensitivity Analysis

Perform sensitivity Analysis of following project over a range of $\pm 30\%$ (with increment of 10%) in

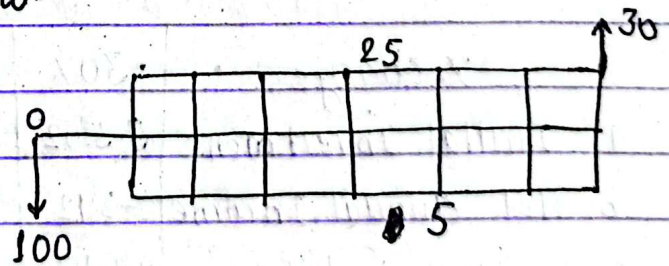
- i. Initial Investment
- ii. Net Annual Income
- iii. Useful life
- iv. MARR
- v. Salvage value

Using AW formulation (or PW, IRR, BCR)

Initial Investment I	100
Annual Income	25
Annual cost (O & M)	5
Useful life	8 years
Salvage value	30
MARR	10%

→ Solⁿ:-

Question is AW formulation is asked so, first of all find AW of given cashflow.



$$\begin{aligned}
 AW &= -100 \times \frac{0.1 \times 1.1^8}{1.1^8 - 1} + (25 - 5) + 30 \times \frac{0.1}{1.1^8 - 1} \\
 &= 3.88 > 0 \text{ - so, is feasible.}
 \end{aligned}$$

4. Initial investment = 100

+30% to -30% change जबसे हो

i.e. 140 to 60

30% 20% 10% 0%

130 120 110 100

-30% -20% -10% 0%

70 80 90 100

Change in I	I	AW
30%	130	-1.744
20%	120	0.130
10%	110	2.004
0%	100	3.88
-30%	70	9.502
-20%	80	7.02
-10%	90	5.75

% change	-30%	-20%	-10%	0%	10%	20%	30%
a. Initial Investment	9.502	7.02	5.75	3.88	2.004	0.103	-1.744
b. Net Annual Income	-2.12	-0.12	1.88	3.88	5.88	7.88	9.88
c. Useful Life	0.075	1.67	2.90	3.88	4.67	5.32	5.87
d. Salvage Value	3.09	3.35	3.62	3.88	4.14	4.40	4.60
e. MARR	6.18	5.42	4.65	3.88	3.10	2.31	1.51

यो Table मा भन्ने $\rightarrow AW$ (PW भन्दा भए PW)

b. Net Annual Income = $25 - 5 = 20$

[Find AW, changing net annual income, other constant]

% change	-30	-20	-10	0	10	20	30
NAI	14	16	18	20	22	24	26
AW	-2.12	-0.12	1.88	3.88	5.88	7.88	9.88

c. Change in Useful Life

	-30%	-20%	-10%	0	10%	20%	30%
N	5.6	6.4	7.2	8	8.8	9.6	10.4
AW	0.075	1.67	2.90	3.88	4.67	5.32	5.87

(d) Salvage Value

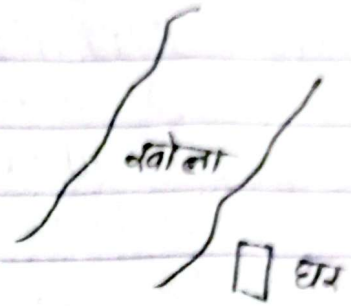
	-30%	-20%	-10%	0	10%	20%	30%
S_v	21	24	27	30	33	36	39
AW	3.09	3.35	3.62	3.88	4.14	4.40	4.60

(e) MARR

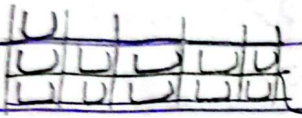
	-30%	-20%	-10%	0	10%	20%	30%
i	7	8	9	10	11	12	13
AW	6.18	5.42	4.65	3.88	3.10	2.31	1.51

* Decision Tree Analysis

वर्षासमय बाढ़ीबाढ़ घर जोगाउन के गर्ने ?



• Gabion work $\rightarrow$ 3 lakhs (estimated cost)

•  $\rightarrow$ 50,000

बॉक्स गाउंर

Cement + बोराम sand हालेर बाउने

• पूजा गर्ने : Rs. 2500

Engineering Analysis

Hydrological record Analysis

10 years $\rightarrow$ Flood data पाइयो

2 years $\rightarrow$ High flood $P(HF) = 0.2$

5 years $\rightarrow$ Medium Flood $P(MF) = 0.5$

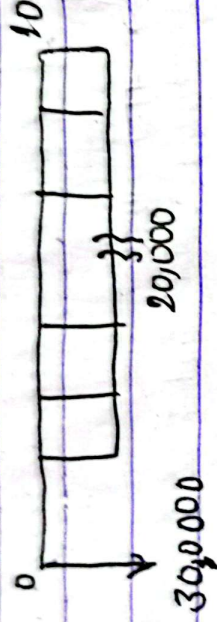
3 years $\rightarrow$ Low Flood $P(LF) = 0.3$

	P	Damage Gabion	Bamboo + sand bag	पूजा
High flood	0.2	100,000	500,000	1,000,000
Med. Flood	0.5	No. = 0	50,000	200,000
Low Flood	0.3	No = 0	No.	10,000
Life	10 yrs	10 yrs	5 yrs	

Expected damage each year $\rightarrow$

a. Expected damage each year:

$$G_{\text{bion}} = \left(\frac{0.2 \times 100000 + 0.5 \times 0 \times 0.3 \times 0}{1} \right) = 20000$$



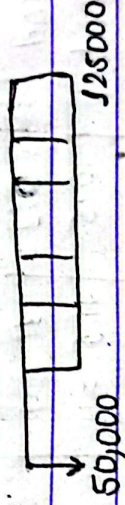
$$AW = -300000 \times \frac{1.1^{10} \times 0.1}{1.1^{10} - 1} - 20000$$

$$= -68823.62$$

b. Expected damage in bamboo + sand bag

$$= \frac{0.2 \times 500000 + 0.5 \times 50000 + 0.3 \times 0}{1}$$

$$= 125000$$



$$AW = -50000 \times \frac{1.15^{10} \times 0.1}{1.15^{10} - 1} - 125000$$

$$= -138189.87$$

(c) Expected damage (year in pqa)

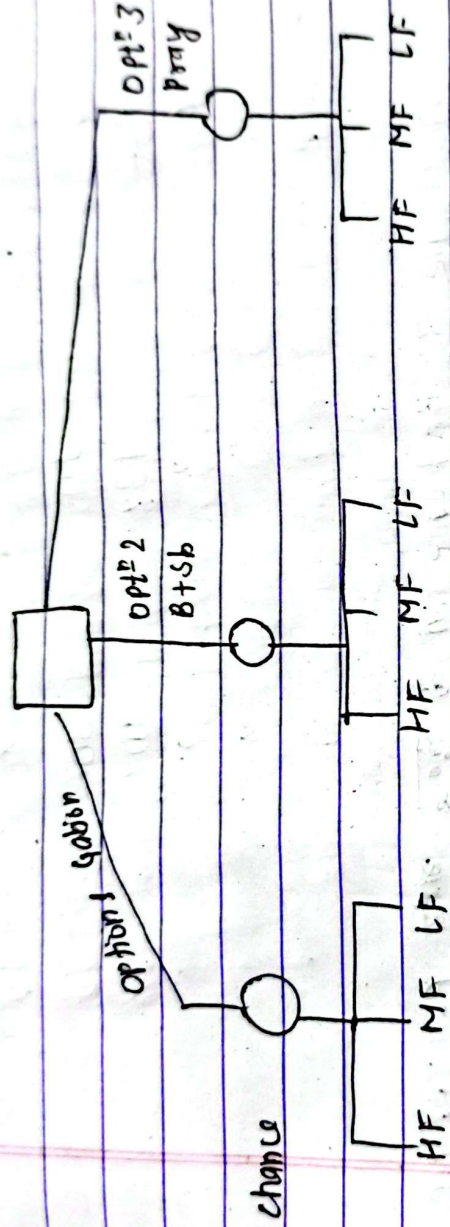
$$= 1000000 \times 0.2 + 0.5 \times 200000 + 0.3 \times 10000$$

$$= 303000$$

$$AW = 2500 + 303000 = 305500$$

$AW(gablon) < AW(bambou + sand bag) < AW(Juti)$

Decision node



Scenario Analysis

	worst (pessimistic)	Most likely	Best (optimistic)
Initial cost	150	100	80
Annual Income	20	25	30
Life	5	8	10
S_v	10	30	50
MARR	13%	10%	8%
PW	?	?	?
IRR	?	?	?
BCR	?	?	?

Worst case & Best case में कूट एवं अंतर PW IRR BCR
Analyse करें is scenario analysis

Depreciation & Taxes:

Decrease or loss in value of an asset is known as depreciation.

Method of depreciation calculation:-

(i) Straight Line Method

(ii) Sum of Year Digit Method

(iii) Declining Balance Method $\rightarrow$ S_v not given

(iv) Declining Balance Method $\rightarrow$ S_v given

(v) Matheson's Formula

(vi) Switch over to straight line

(vii) Double Declining Balance

(viii) MACRS

(ix) Sinking Fund Method

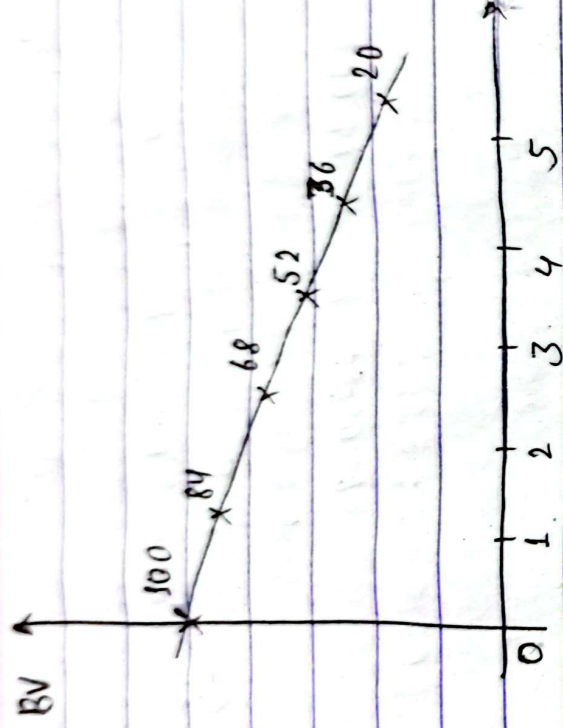
(i) Straight Line Method $\rightarrow$ constant amount depreciation

$$\text{Depreciation Amt.} = d = \frac{I - S_v}{N}$$

If $I = 100$, $S_v = 20$ & $N = 5$ years

$$d = \frac{100 - 20}{5} = 16 \text{ [Each year]}$$

Year	depreciation	Book value
0	X	$100 = I$
1	16	$100 - 16 = 84$
2	16	$84 - 16 = 68$
3	16	$68 - 16 = 52 \Rightarrow$
4	16	$52 - 16 = 36$
5	16	$36 - 16 = 20 \Rightarrow S_v$



④ Sum of year Digit Method (SOYD)

$$I = 100, N = 5, S_V = 20$$

$$SOYD = 1 + 2 + 3 + 4 + 5(N) = 15 \quad (\text{sum upto } N)$$

$$(or) = \frac{N(N+1)}{2} = \frac{5 \times 6}{2} = 15$$

$$d_1 = \frac{N}{SOYD} (I - S_V) = \frac{5}{15} \times 80 = 26.66$$

precipitation
Ampl

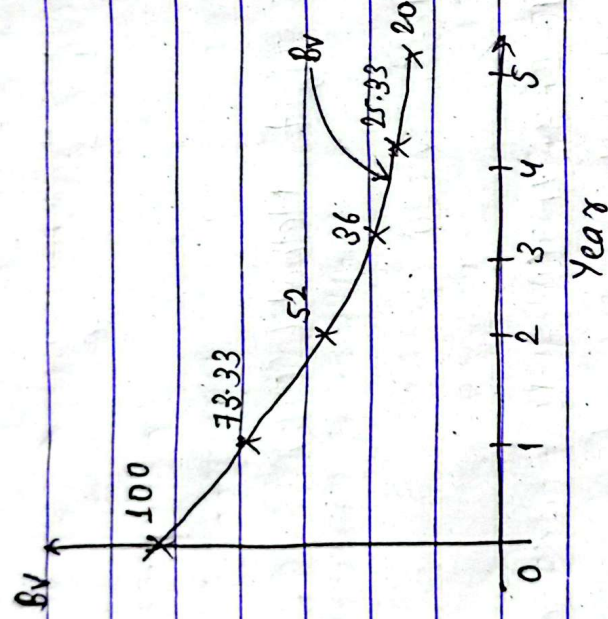
$$d_2 = \frac{N-1}{SOYD} (I - S_V) = \frac{4}{15} \times 80 = 21.33$$

$$d_3 = \frac{N-2}{SOYD} (I - S_V) = \frac{3}{15} \times 80 = 16$$

$$d_4 = \frac{N-3}{SOYD} (I - S_V) = \frac{2}{15} \times 80 = 10.67$$

$$d_5 = \frac{N-4}{SOYD} (I - S_V) = \frac{1}{15} \times 80 = 5.33$$

Year	Depreciation	BV
0	x	100
1	26.67	$100 - 26.67 = 73.33$
2	21.33	$73.33 - 21.33 = 52 \Rightarrow$
3	16	$52 - 16 = 36$
4	10.67	$36 - 10.67 = 25.33$
5	5.33	$25.33 - 5.33 = 20$



For SOYD method

$$\begin{aligned}
 \text{(Q)} \quad \text{Depreciation in } n^{\text{th}} \text{ year} \quad & \left\{ \begin{aligned} d_n &= \frac{N - \frac{N-1}{2}}{\text{SOYD}} (I - S_v) \\ \text{(a)} \quad \frac{I - S_v}{N} \\ \text{(b)} \quad I - \frac{n}{N} (I - S_v) \\ \text{(c)} \quad I - \left(\frac{n-1}{N} \right) (I + S_v) \end{aligned} \right. \\
 & \left\{ \begin{aligned} d_n &= \left[\frac{N - (n-1)}{\text{SOYD}} \right] (I - S_v) \\ \text{r.e.} \\ d_n &= \frac{N - n + 1}{\text{SOYD}} (I - S_v) \end{aligned} \right.
 \end{aligned}$$

(Q) None.

Depreciation amt. decreases
with time

iii) Declining Balance (DB) method.

(Govt. Ind.)

• Constant Percentage depreciation:

(i) $I = 100$, $N = 5$, S_v not given

$$\text{Rate of depreciation} = \frac{1}{N} = \frac{1}{5} = 0.2 = 20\%$$

Calculation:-

Year	depreciation	Book value	
0	x	100	I
1	$0.2 \times 100 = 20$	$100 - 20 = 80$	$I(1-x)^1$
2	$0.2 \times 80 = 16$	$80 - 16 = 64$	$I(1-x)^2$
3	$0.2 \times 64 = 12.8$	$64 - 12.8 = 51.2$	$I(1-x)^3$
4	$0.2 \times 51.2 = 10.24$	$51.2 - 10.24 = 40.96$	$I(1-x)^4$
5	$0.2 \times 40.96 = 8.192$	$40.96 - 8.192 = 32.768$	$I(1-x)^5$

In General,

$$S_v = I(1-x)^N$$

धर जगा मूलांकन

जोरणी → Sudin धर + जगा

(valuation)

जगा → 2.5 अगा

Rate

Market

Govt

60lakh/अगा, 40lakh/अगा

$$= 2.5 [0.7 \times 60 + 0.3 \times 40]$$

(0.7 to 3 weightage)

$$= 1.35 \text{ Cr}$$

Land $\rightarrow$ non-depreciable.

$\text{ETD} \rightarrow 800 \text{ sqft}$

$\times 9 \text{ (new)}$

8000 sqft.

Say. 3500 Rs/sqft.

$$3200 \times 3500 = 1.12 \text{ cr. (New ETD)}$$

$n = 20 \text{ years (ETD ETD)}$

$$\text{Present, } B_v = I(1-\delta)^n = 1.12 [1 - 0.01933]^{20} = 0.856 \text{ cr.}$$

$$[\text{Total valuation} = 1.35 \text{ cr} + 0.856 \text{ cr} = 2.2063 \text{ cr}] \quad (\text{present valuation}).$$

Why? Depreciation?

(I) Wear & Tear

(II) Loss in efficiency

(III) Obsolescence (Out-date)

Declining Balance Method if S_v is given

$$\textcircled{Q} \quad T = 100, \quad N = 5 \text{ years,} \quad S_v = 20$$

$\delta = ?$

$$B_v = I(1-\delta)^n$$

$$[S_v = I(1-\delta)^N]$$

Find δ from this,

$$(1-\delta)^N = \frac{S_v}{I} \quad \delta_0, \quad \left[\delta = 1 - \left(\frac{S_v}{I} \right)^{\frac{1}{N}} \right] \quad \downarrow$$

Matheson's Formula

IV Double declining Balance Method if

Q Sv is not given

(double depreciation)

7/21/2021

$$I = 100, N = 5$$

$$d = \frac{2}{N}$$

$$d = \frac{2}{5} = 0.4 = 40\%$$

Year	Depreciation (0.4)	BV
0	X	100
1	$0.4 \times 100 = 40$	$100 - 40 = 60$
2	$0.4 \times 60 = 24$	$60 - 24 = 36$
3	$0.4 \times 36 = 14.4$	$36 - 14.4 = 21.6$
4	$0.4 \times 21.6 = 8.64$	$21.6 - 8.64 = 12.96$
5	$0.4 \times 12.96 = 5.184$	$12.96 - 5.184 = 7.776$

* Double Declining Balance (DDB) with switch over to straight line.

Q $I = 100, N = 5, Sv = 0$ $\left[d = \frac{2}{5} = 0.4 \right]$

Year	SLD	DDB	Actual dep ⁿ	BV
0	X	X	X	100
1	$10\% = 20$	$0.4 \times 100 = 40$	40	60
2	$60\% = 15$	$0.4 \times 60 = 24$	24	$60 - 24 = 36$
3	$36\% = 12$	$0.4 \times 36 = 14.4$	14.4	$36 - 14.4 = 21.6$
4	$\frac{21.6}{2} = 10.8$	$0.4 \times 21.6 = 8.64$	10.8	$21.6 - 10.8 = 10.8$
5	$\frac{10.8}{1} = 10.8$	$0.4 \times 10.8 = 4.32$	10.8	$10.8 - 10.8 = 0$

⑧ $I=100, N=5, \text{ DDB with } 50 \text{ to } 5\% \quad S_v=10$
 $\left[d = \frac{2}{5} = 0.4 \right]$

Year	SLD	DDB	Actual dep ⁿ	BV
0	x	x	x	100
1	$\left(\frac{100-10}{5} \right) = 18$	$0.4 \times 100 = 40$	40	60
2	$\left(\frac{60-10}{4} \right) = 12.5$	$0.4 \times 60 = 24$	24	36
3	$\left(\frac{36-10}{3} \right) = 8.67$	$0.4 \times 36 = 14.4$	14.4	21.6
4	$\left(\frac{21.6-10}{2} \right) = 5.8$	$0.4 \times 21.6 = 8.64$	8.64	12.96
5	$\left(\frac{12.96-10}{1} \right) = 2.96$	$0.4 \times 12.96 = 5.184$	<u>2.96</u>	<u>10</u>

↑
 10 to 21.6
 21.6

(10 to 21.6)

⑨ $I=100, N=5, \text{ DDB with } 50 \text{ to } 5\% \Rightarrow S_v=20$

$[d = 0.4]$

for last depⁿ

Year	SLD	DDB	Actual dep ⁿ	BV
0	x	x	x	100
1	$\left(\frac{100-20}{5} \right) = 16$	$0.4 \times 100 = 40$	40	60
2	$\left(\frac{60-20}{4} \right) = 10$	$0.4 \times 60 = 24$	24	36
3	$\left(\frac{36-20}{3} \right) = 5.33$	$0.4 \times 36 = 14.4$	14.4	21.6
4	$\left(\frac{21.6-20}{2} \right) = 0.8$	$0.4 \times 21.6 = 8.64$	8.64 $\Rightarrow 1.6$	<u>20</u>
5			0	20

↑
 20 ~ Already S_v
 20
 can't be less than S_v

Method of Depreciation (contd...)

→ MACRS-Method

Modified Accelerated Cost Recovery System

(Donald Trump को तब तक मिला कि फॉर मीथोड) (US Government)

Nepal → DB Method

→ In MACRS →

+ Double Declining Balance with Switch over to straight line

+ $S_v = 0$

* Year $N = 3, 5, 7, \text{etc.}$ - Give But

→ Year 1, मा 50% मात्र Depreciate गर्ने जाती $N+1^{\text{th}}$ year मा 50% Depreciation आउने

→ $J = 100$ $N = 5$ year $[S_v = 0]$

Calculate Depreciation Amount and corresponding Book value

Year	SL Dep ⁿ	DDB Dep ⁿ	Actual Dep ⁿ	Book Value
0	x	x	x	100
1	$(\frac{100}{5}) \times \frac{1}{2} = 10$	$\frac{0.4 \times 100}{2} = 20$	20	$100 - 20 = 80$
2	$(80/4.5) = 17.78$	$0.4 \times 80 = 32$	32	$80 - 32 = 48$
3	$(48/3.5) = 13.71$	$0.4 \times 48 = 19.2$	19.2	$48 - 19.2 = 28.8$
4	$(28.8/2.5) = 11.52$	$0.4 \times 28.8 = 11.52$	11.52	$28.8 - 11.52 = 17.28$
5	$(17.28/1.5) = 11.52$		11.52	$17.28 - 11.52 = 5.76$
6	$(5.76/0.5) = 11.52$		5.76	0

↓
0

(1/2 year)

input

Depreciation $\rightarrow$ Amount

(Tax Free $\text{\pounds}500$)

* 10 lakh $\rightarrow$ 20% of 10 lakh = 2 lakh Tax

But,

amt $\rightarrow$ 1 yr dep't amt = 4 lakh Dep't

So, taxable ~~in~~ = 6 lakh (10 - 4)

Inc. Tax = 20% of 6 = 120000/-

Depreciation amt. in tax $\text{\pounds}500$ so company keeps depreciated amt. in tax calculation.

g) J = 100 N = 7 yrs $S_v = 0$

Calculate Depreciation Amt. and corresponding Book

value. $\left\{ \text{Rate of depreciation} = \frac{2}{7} = 0.2857 \right\}$

Year	SL Dep't	DDB Dep't	Actual Dep't	Book Value
0	X	X	X	100
1	$\left(\frac{100}{7} \right) \times \frac{1}{2} = 7.14$	$0.286 \times \frac{100}{2} = 14.35$	14.35	$100 - 14.35 = 85.65$
2	$\left(\frac{85.65}{6.5} \right) = 13.18$	$0.286 \times 85.65 = 24.5$	24.5	$85.65 - 24.5 = 61.15$
3	$\left(\frac{61.15}{5.5} \right) = 11.12$	$0.286 \times 61.15 = 17.49$	17.49	$61.15 - 17.49 = 43.66$
4	$\left(\frac{43.66}{4.5} \right) = 9.70$	$0.286 \times 43.66 = 12.49$	12.49	$43.66 - 12.49 = 31.17$
5 $\Rightarrow$	$\left(\frac{31.17}{3.5} \right) = 8.91$	$0.286 \times 31.17 = 8.91$	8.91	$31.17 - 8.91 = 22.26$
6			8.91	$22.26 - 8.91 = 13.35$
7			8.91	$13.35 - 8.91 = 4.44$
8	$\frac{8.91}{2} = 4.44$		4.44	$4.44 - 4.44 = 0$

(only $\frac{1}{2}$ year)

* Sinking Fund Method of Depreciation

(Q) $I = 100$, $N = 5$ yrs, $S_v = 20$ [$i = 10\%$]

⇒ Only method in which i (interest)

⇒ Time value of money is considered

⇒ Depreciation

$$d_1 = (I - S_v) \left[\frac{i}{(1+i)^N - 1} \right] = 80 \times \left[\frac{0.1}{(1+0.1)^5 - 1} \right] = 13.1$$

↑
(Sinking Fund Factor)

$$d_2 = d_1 \times (1+i) = 13.1 \times 1.1 = 14.4$$

$$d_3 = d_2 \times (1+i) = 14.4 \times 1.1 = 15.86$$

$$d_4 = d_3 \times (1+i) = 15.86 \times 1.1 = 17.44$$

$$d_5 = d_4 \times (1+i) = 17.44 \times 1.1 = 19.18$$

(d_N)

$$\left\{ \begin{array}{l} d_1 + d_2 + d_3 + d_4 + d_5 = 13.1 + 14.4 + 15.86 + 17.44 + 19.18 \\ \parallel \\ (I - S_v) \approx 80 \end{array} \right\}$$

Year	depreciation	Book value
0	x	100
1	13.1	86.9
2	14.4	72.5
3	15.86	56.64
4	17.44	39.18
5	19.18	(20)

Depreciation amount

* Increase with time

* i is considered

In This method

only

Sinking fund Method

* A machine was bought 3 years ago at Rs. 15000/-
Calculate Book value now using

- (a) SL method
(b) SOYD method } $S_v = 2000$
(c) DB with SO
(d) MACRS

If $N = 5$ year property.

Year	SL Dep ⁿ $\times$	SOYD Dep ⁿ $\times$	DB Dep ⁿ $\times$	Actual BV
0				15000 15000
1	$\left(\frac{15000-2000}{5}\right) = 2600$	$\frac{5}{15} \times (15000-2000) = 4333.33$	$0.2 \times 13000 = 2600$	
2	$\left(\frac{12400-2000}{4}\right) = 2600$	$\frac{4}{15} \times (10800-2000) = 3733.33$	$0.2 \times (12400-2000) = 2080$	
3	$\left(\frac{9800-2000}{3}\right) = 2600$	$\frac{3}{15} \times (8355.56-2000) = 2637.11$	$0.2 \times (10320-2000) = 1664$	

	BV (SL)	BV (SOYD)	BV (DB)
1	12400	10666.67	12400
2	9800	8355.56	10320
3	7200	7084.45	8656

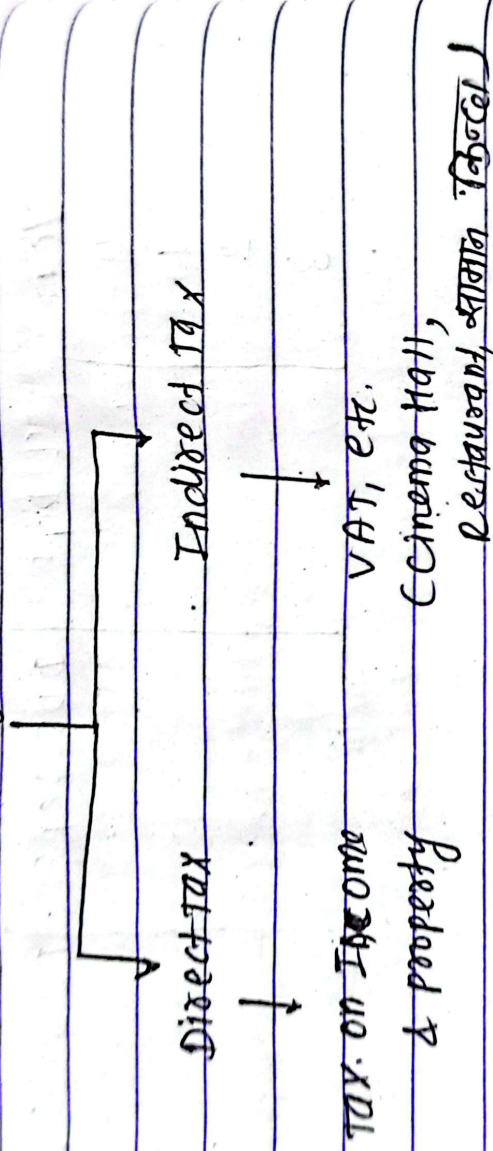
MACRS

$$\text{dep rate} = 2 \times \frac{1}{N} = 2 \times \frac{1}{5} = 0.4$$

Year	SL Dep ^r	DDB Dep ^r	Actual Dep ^r	BV
0				
1				
2				
3				

Taxation:

Compulsory Payment to Government



→ Capital Gain Tax

{ उज्जा/घर विक्रे वरदा } हुने profit मा लिनुने

Share किने वरदा

* Numerical *

Year	0	1	2	3	4	5
cashflow	-100	20	22	24	26	28+20 S _V

Depreciation

$$I = 100 \quad S_V = 20$$

$$d = \left(\frac{I - S_V}{N} \right) \text{ (SL method)}$$

$$= \left(\frac{100 - 20}{5} \right) = 16 \text{ /yr.}$$

⇒

Year	0	1	2	3	4	5
(a) Cashflow	-100	20	22	24	26	28+20
(b) dep ^r	x	16	16	16	16	16
(c) Taxable income	x	4	6	8	10	12+20 = 32
(a-b)						
(d) Tax @ 20% (take 20% if not given)	x	0.8	1.2	1.6	2	6.4
(e) After Tax						
a)-(d) Cashflow	-100	19.2	20.8	22.4	24	41.6

(Q) Find NPV of After tax cash flow

'OR' IRR of after tax cashflow

4	5
26	$28 + 20$
	SV

4	5	
26	$28 + 20$	← Before tax cash flow
16	16	Exam
10	$12 + 20$ $- 32$	All other Method
		(SOYD/DB etc.)
2	6.4	
24	41.6	

$\begin{array}{|l} -20 \\ +5 \\ +10 \\ +15 \end{array}$

For IRR

IRR (cell)

← Excel

$\Rightarrow$ NPV (cell, i)

NPV (i, cell)

IRR (A1:A4)
 $= 19.43$
 NPV (D-1, A1:A4)
 Page 3 of 8

For IRR

$$Fw = 0$$

$$-100(1+i)^5 + 19 \cdot 2(1+i)^4 + 20 \cdot 8(1+i)^3 + 22 \cdot 4(1+i)^2 + 24(1+i) + 41 \cdot 6 = 0$$

$$\Rightarrow i = 0.077$$

$$NPV = -5.73$$