PW of Cost = –34,000 - 5,000 (P/A, 8%, 20) + 3,400 (P/F, 8%, 20)

= –34,000 - 5,000 (9.8181) + 3,400 (0.2145)

= – Rs 82,361.20

Since, PW of cost of 24'' pipeline is lowest.

Therefore, Choose 24" pipeline **Ans.**

Example 4.15

An engineering analysis by net present worth (NPW) is to be made for the purchase of two devices A and B. If an 8% interest rate is used, recommend the device to be purchased.

Devices	*Device A*	*Device B*
Initial Cost	*60,000*	*70,000*
Annual Benefits	*10,000*	*10,000*
Salvage value	*25,000*	*18,000*
Useful Life (years)	*5*	*10*

Solution: Device A

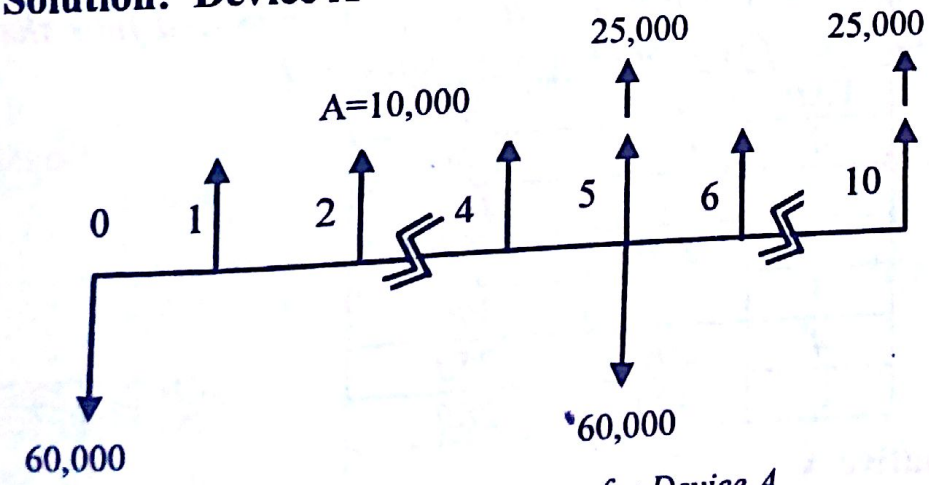

Fig 4.32: *Cash Flow Diagram for Device A.*

NPW_A = – 60,000-60,000 (P/F, 8%, 5) + 25,000 (P/F, 8%, 5) + 25,000 (P/F, 8%, 10) +10,000 (P/A, 8%, 10)

= – 60,000 – 60,000 (0.6806) + 25,000 (0.6906) + 25,000 (0.4632) +10,000 (6.7101) = - Rs 5,140

Device B

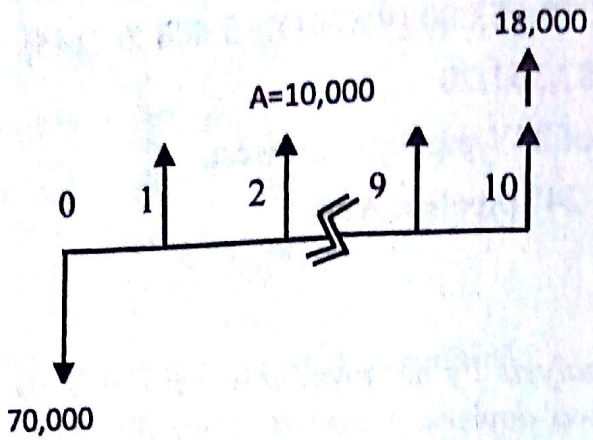

Fig 4.33: *Cash Flow Diagram for Device B.*

$NPW_B = -70,000 + 10,000\ (P/A, 8\%, 10) + 18,000\ (P/F, 8\%, 10)$
$= -70,000 + 10,000\ (6.7101) + 18,000\ (0.4632)$
$= Rs\ 5,438.6$

Since, $NPW_B > NPW_A$. Therefore, select device B **Ans.**

Example 4.16

Two alternatives with cost of Rs 1,000 and useful live of 5 years. Assu i = 7%. Calculate the PW or NPW over a five year span and junk equipment at the end of the five years (salvage value = 0).

Year	A	B
0	–1,000	–1,000
1	300	400
2	300	350
3	300	300
4	300	250
5	300	200

Solution: Alternative A

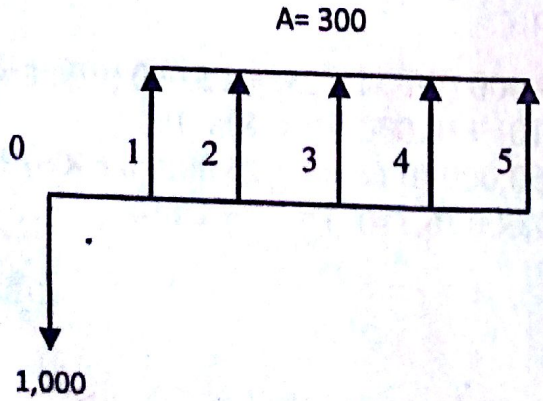

Fig. 4.34: *Cash Flow Diagram for Alternative A.*

Present worth of benefits (PWB_A) = 300 (P/A, 7%, 5)
= 300 (4.1002) = **Rs1,230.06**

Alternative B

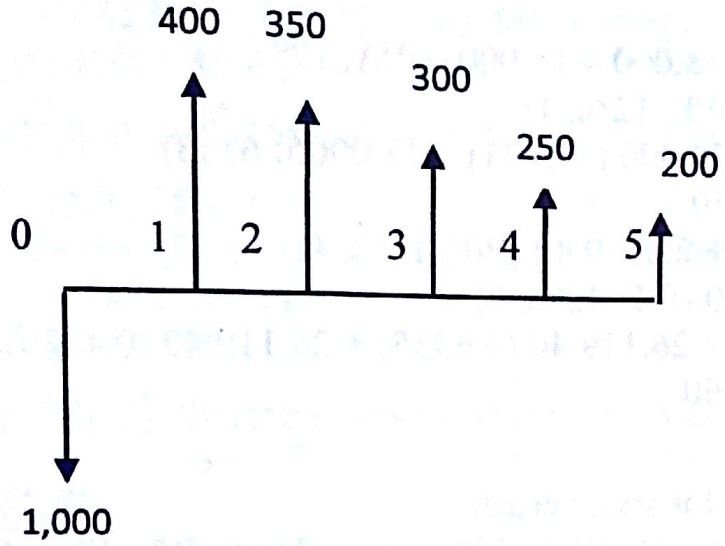

Fig. 4.35: *Cash Flow Diagram for Alternative A.*

Here we have a combination of a uniform series (A = 400) and a negative gradient (G = 50).

PW of Benefits (PWB_B) = 400 (P/A, 7%, 5) – 50 (P/G, 7%, 5)
= 400 (4.1002) – 50 (7.6467)
= **Rs 1257.75**

Result

PWB_A Alternative A = Rs 1,230.06
PWB_B Alternative B = Rs 1,257.75
Since, $PWB_B > PWB_A$. Therefore, B is preferred **Ans.**

Example 4.17

The following data are associated with three grape crushing machines under consideration by a Construction company.

	Smart Crush	*Super Crush*	*Savage Crush*
Initial Cost	*52,000*	*63,000*	*1,05,000*
O and M Cost/yr	*15,000*	*9,000*	*12,000*
Benefits/yr	*38,000*	*31,000*	*37,000*
Salvage Value	*13,000*	*19,000*	*22,000*
Useful Life (years)	*4*	*6*	*12*

If the company uses a MARR of 12%, which alternative, if any, should be chosen?

Solution:
A 12 year analysis period is necessary. (There are three cycles for smart crush)

Smart Crush

$NPW_4 = -52,000 + (38,000 - 15,000)\ (P/A, 12\%, 4)$
$+ 13,000\ (P/F, 12\%, 4)$
$= -52,000 + 23,000\ (3.0373) + 13,000(0.6355)$
$= Rs\ 26,119.40$

$NPW_{12} = 26,119.40 + 26,119.40\ (P/F, 12\%, 4)$
$+ 26,119.40\ (P/F, 12\%, 8)$
$= 26,119.40 + 26,119.40\ (0.6355) + 26,119.40\ (0.4039)$
$= Rs\ 53,267.90$

Super Crush

There are two cycles for super crush

$NPW_6 = -63,000 + 22,000\ (P/A, 12\%, 6) + 19,000\ (P/F, 12\%, 6)$
$= -63000 + 22,000\ (4.1114) + 19,000\ (0.5066)$
$= Rs\ 37,067.20$

$NPW_{12} = 37,067 + 37,067\ (P/F, 12\%, 6)$
$= 37,067.20 + 37,067.20\ (0.5066)$
$= Rs\ 55,845.44$

Savage Crush

$NPW_{12} = -1,05,000 + 25,000\ (P/A, 12\%, 12) + 22,000\ (P/F, 12\%, 12)$
$= -1,05,000 + 25,000\ (6.1944) + 22,000\ (0.2567) = Rs55,507.40$

Maximize NPW, choose Super Crush **Ans.**

Example 4.18

For the data concerning the two machines are presented below. If minimum attractive rate of return (MARR) is 15%, which machine should be chosen? Machine 1 or Machine 2.

Machines	*Machine M_1*	*Machine M_2*
Initial Cost	*45,000*	*24,000*
Annual Operating Costs	*31,000*	*35,000*
Overhaul in	*Year 2 and 4 − 6,000*	*in Year 5 −12,000*
Salvage value	*10,000*	*8,000*
Useful Life (years)	*8*	*6*

Solution:

$EUAC_1 = 45{,}000\ (A/P, 15\%, 8) + 31{,}000 + 6{,}000\ [(P/F, 15\%, 2) - (P/F, 15\%, 4)]\ (A/P, 15\%, 8) - 10{,}000(A/F, 15\%, 8)$

$= 45{,}000\ (0.2229) + 31{,}000 + 6{,}000\ [(0.7561) - (0.5781)]\ (0.2229) - 10{,}000(0.0729)$

$=$ Rs 42085.86

$EUAC_2 = 24{,}000\ (A/P, 15\%, 6) + 35{,}000 + 12{,}000[(P/F, 15\%, 5)\ (A/P, 15\%, 6)] - 8{,}000\ (A/F, 15\%, 6)$

$= 24{,}000\ (0.2642) + 35{,}000 + 12{,}000[(0.4972)\ (0.2642)] - 8{,}000\ (0.1142)$

$=$ Rs 42,003.50

Minimize $EUAC_2$, therefore choose Machine 2 **Ans.**

Example 4.19

Data for tractors A and B are listed below. With interest of 12%, which tractor would be selected based on equivalent uniform annual cost (EUAC)?

Tractors	A	B
Initial Cost	30,000	36,000
Maintenance Cost/yr	1,500	2,000
Salvage value	5,000	8,000
Useful Life (years)	6	6

Solution:

We Know,

$EUAC = P\ (A/P, i\ \%, n) - S\ (A/F, i\ \%, n) +$ Other Costs

For Tractor A

$EUAC_A = 30{,}000\ (A/P, 12\%, 6) - 5{,}000\ (A/F, 12\%, 6) + 1{,}500$

$= 30{,}000\ (0.2432) - 5{,}000\ (0.1232) + 1{,}500 =$ Rs 8,180

For Tractor B

$EUAC_B = 36{,}000(A/P, 12\%, 6) - 8{,}000\ (A/F, 12\%, 6) + 2{,}000$

$= 36{,}000(0.2432) - 8{,}000\ (0.1232) + 2{,}000 =$ Rs 9,769.60

Since, criteria are to minimize EUAC select tractor A **Ans.**

Example 4.20

ABC a local concrete finishing company is considering investing in newer, more productive curb forming equipment. Data concerning the three best alternatives are presented below.

	A	B	C
Initial Cost	50,000	22,000	15,000
Annual Income	5,093	2,077	1,643
Salvage Value	0	0	0
Computed IRR	8%	7%	9%

Each alternative has a twenty year useful life with no salvage value. If the MARR for ABC is7%, which alternative should be chosen?

Solution:

Incremental analysis is required for IRR.

NPW = 0 at IRR

	A	B	C	A - B	A - C
Initial Cost	50,000	22,000	15,000	28,000	35,000
Annual Income	5,093	2,077	1,643	3,016	3,450

IRR_{A-B}

$-28,000+ 3,016 (P/A, i\%, 20) = 0$

$(P/A, i\%, 20) = 9.2838$

@8% P/A = 9.8181

@9% P/A = 9.1285

By interpolating i = 8.77% > MARR Choose A

IRR_{A-C}

$-35,000 + 3,450 (P/A, i\%, 20) = 0$

$(P/A, i\%, 20) = 10.144$

@7% P/A = 10.5940

@8% P/A = 9.8181

By interpolating i = 7.58%

Since, IRR_{A-C} > MARR. Therefore, choose alternative A **Ans.**

Example 4.21

A telecommunication company must rebuild a cell tower recently destroyed by the earthquake. If made of normal steel, the tower will cost Rs30, 000 to construct and should last 15 years. Maintenance will cost Rs 1,000 per year. If corrosion resistant steel is used, the tower will cost Rs 36,000 to build and the annual maintenance cost will be reduced to Rs 250 per year. Determine the IRR of building the corrosion resistant tower. If it requires a return of 9% on its capital projects, which tower should they build?

Solution: We have given,

	Normal Steel	Corrosion Resistant Steel
Initial Cost	30,000	36,000
Maintenance/yr	1,000	250
Useful Life Years	15	15

$NPW_{NS} = -30,000 - 1,000(P/A, i\%, 15)$
$NPW_{CRS} = -36,000 - 250(P/A, i\%, 15)$

$NPW_{CRS - NS}$
Or, $-36,000 - 250\ (P/A, i\%, 15) - \{30,000 - 1,000\ (P/A, i\%, 15)\} = 0$
Or, $-\ 6,000 + 750\ (P/A, i\%, 15) = 0$
Or, $(P/A, i\%, 15) = 8.000$
@9% P/A = 8.0607
@10% P/A = 7.6061

By interpolating i = 9.13%

Since, i = 9.13% > 9%. Therefore, build the tower using corrosion resistant steel **Ans.**

Example 4.22

Make a present worth comparison of the different-life machines for which costs are shown below, if i = 15%. Which machine would you select?

Machines	*Machine A*	*Machine B*
First Cost (P)	*11,000*	*18,000*
O and M Costs (E)	*3,500*	*3,100*
Salvage Value (SV)	*1,000*	*2,000*
Service life years (n)	*6*	*9*

Solution:
The cash flow for one cycle of an alternative must be duplicated for the least common multiple of years, so that service life is compared over the total life for each alternative. Since the machines have different lives, they must be compared over the least common multiple of years, 18 years.

For Machine A

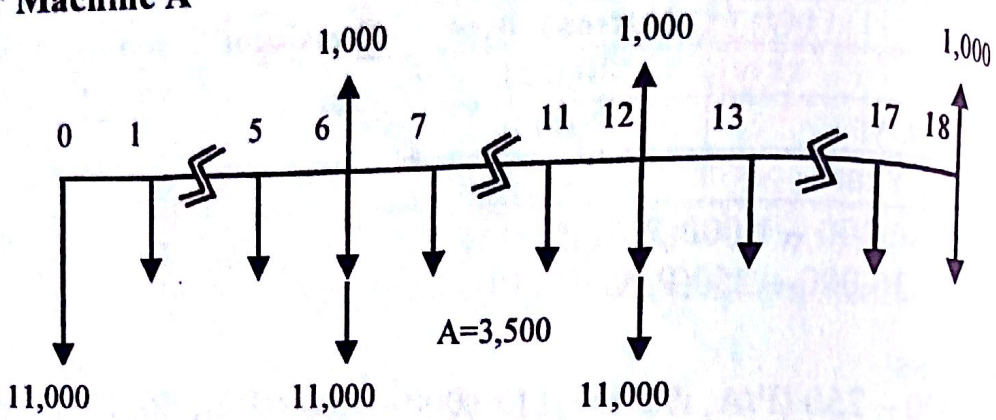

Fig. 4.36: *Cash Flow Diagram for Machine A.*

$PW_A = -11,000 - 11,000\ (P/F, 15\%, 6) - 11,000\ (P/F, 15\%, 12) - 3,5$
$(P/A, 15\%, 18) + 1,000(P/F, 15\%, 6) + 1,000\ (P/F, 15\%, 1$
$+1,000\ (P/F, 15\%, 18)$
$= -11,000 - 11,000\ (0.4323) - 11,000\ (0.1869) - 3,500\ (6.128$
$+1,000(0.4323) + 1,000\ (0.1869) + 1,000\ (0.0808)$
$= -$ Rs 38,559.20

For Machine B

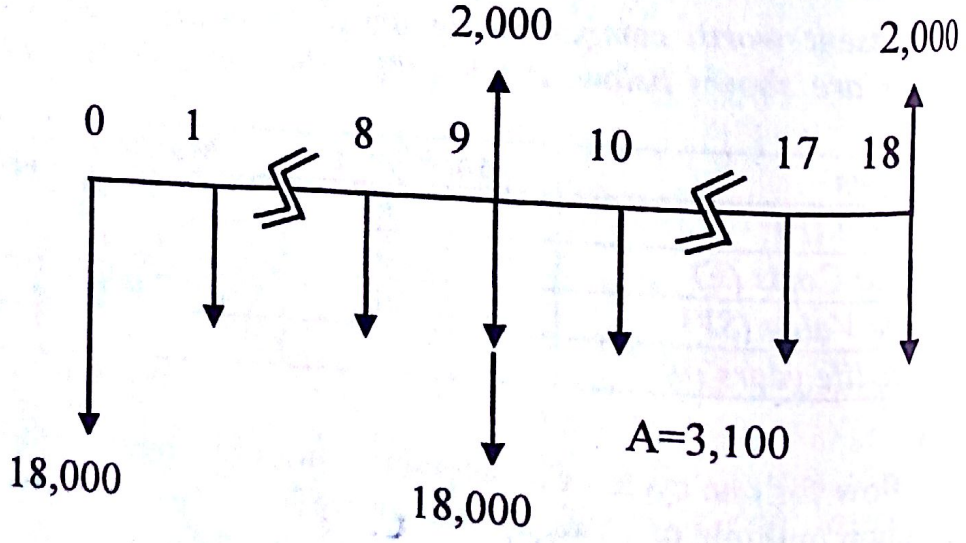

Fig. 4.37: *Cash Flow Diagram for Machine B.*

$PW_B = -18,000 - 18,000\ (P/F, 15\%, 9) - 3,100\ (P/A, 15\%, 18)$
$+2,000\ (P/F, 15\%, 9) + 2,000\ (P/F, 15\%, 18)$
$= -18,000 - 18,000\ (0.2843) - 3,100\ (6.1280) + 2,000\ (0.2843)$
$+ 2,000\ (0.0808) = -$ Rs 41,384

Since, both the machines have negative values $PW_A < PW_B$ i.e. machine A has less negative values. Therefore, select machine A **Ans.**

Example 4.23

Calculate the capitalized cost of a project that has an initial cost of Rs150,000 and an additional investment cost of Rs50,000 after 10 years. The annual operating cost will be Rs 5,000 for the first 4 years and Rs 8,000 thereafter. In addition, there is expected to be a recurring major rework cost of Rs 15,000 every 13 years. Assume that i = 15% per year.

Solution:

Step 1:

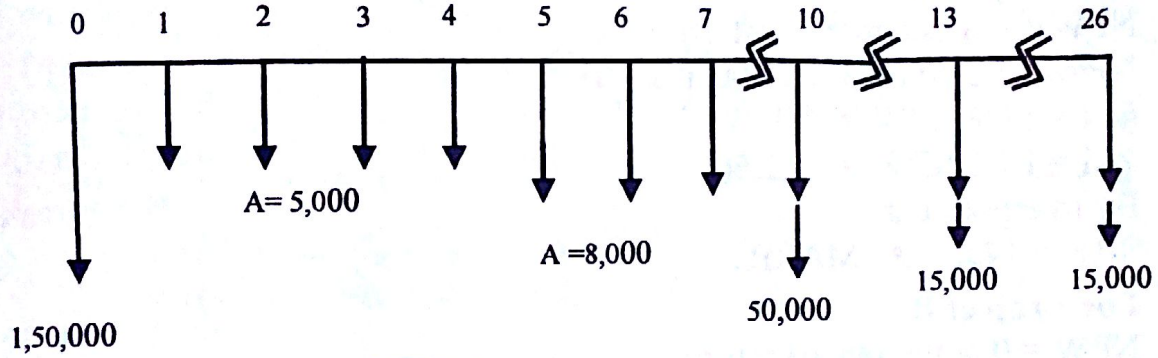

Fig.4.38: *Cash Flow Diagram.*

Step 2:

Calculate Present Worth of all Non-recurring Costs

Initial cost Rs1,50,000, additional investment cost of Rs 50,000 after 10 years, and '+ 3,000' adjustment for the first four years to make annul cost A=Rs 8000.

$CC_1 = -1,50,000 - 50,000(P/F, 15\%, 10) + 3,000(P/A, 15\%, 4)$

$= -1,50,000 - 50,000(0.2472) + 3,000\ (2.8550) = -$ Rs1,53,795

Step 3:

Calculate Annual Costs of all Recurring Costs

Major rework cost of Rs15,000 every 13 years

$A = -15,000\ (A/F, 15\%, 13) - 8,000$

$= -15,000(0.02911) - 8,000 = -$ Rs 8,436.65

Step 4: Obtain CC Value of Recurring Costs

$$CC_2 = -\frac{8436.65}{0.15} = -\text{Rs}56,\ 244.33$$

Step 5: Total Capitalized Cost

$CC_T = CC_1 + CC_2$

$= -$ Rs 2,10,039.33

Therefore, capitalized cost of project = – Rs 2,10,039.33 **Ans.**

Example 4.24

Choose the best project among these alternatives using IRR if MARR= 12% and study period 10 years. TU-2071

Projects	*A*	*B*	*D*	*E*
First Cost Rs	*2,000*	*1,500*	*4,000*	*3,000*
Annual Revenue Rs	*390*	*276*	*925*	*500*

Solution:

For Project A

NPW = 0 at the rate of return

NPW = −2,000 + 390 (P/A, i%, 10)

@ i = 12% NPW = 203.57

@ i = 15% NPW = – 42.66

By interpolating

IRR = 14.48% > MARR

For Project B

NPW = 0 at the rate of return

NPW = −1,500 +276 (P/A, i%, 10)

@ i = 10% NPW = 195.9

@ i = 12% NPW = 59.46

By interpolating

IRR = 12.87% > MARR

For Project D

NPW = 0 at the rate of return

NPW = − 4,000 + 925 (P/A, i%, 10)

@ i = 15% NPW = 642.39

@ i = 20% NPW = –121.93

By interpolating

IRR = 19.83% > MARR

For Project E

NPW = 0 at the rate of return

NPW = −3,000 + 500 (P/A, i%, 10)

@ i =10% NPW = 72.3

@ i =12% NPW = –171.9

By interpolating

IRR = 10.59% < MARR rejected.

Projects	A	D	D-A
Initial Costs Rs	2,000	4,000	-2,000
Annual Revenue Rs	500	925	535

Taking alternative A as base alternative having lowest investment.

For Project D-A

NPW = 0 at the rate of return

NPW = −2,000 + 535 (P/A, i%, 10)

@ i = 20% NPW = 242.98

@ i = 25% NPW = – 89.78

By interpolating

IRR = 23.65% > MARR

Therefore, D is the best alternative than A.

Again, comparing D and B, choosing B as base alternative having lowest investment.

Projects	B	D	D-B
Initial cost (Rs)	1,500	4,000	2,500
Annual revenue (Rs.)	276	925	649

For D – B

NPW = 0 at the rate of return

NPW = – 2,500 + 649(P/A, i%, 10)

$$\text{or, } 0 = -2{,}500 + 649 \times \frac{(1+i)^{10}-1}{(1+i)^{10} \times i}$$

Solving, i = 22.57% > MARR

Hence, D is the best alternative among all.

Example 4.25

A company is looking at expanding its business by purchasing a small new store that will operate for 10 years before being sold and replaced with a newer larger store. Three sites have been recommended to the owner each with different costs and expected revenues based on its location. The company operates with a MARR of 15% before taxes. Rate the alternatives based on

a. PW comparison and

b. IRR comparison.

	Site 1	Site 2	Site 3
Land Purchase Price	1,00,000	1,50,000	1,60,000
Renovations	40,000	40,000	60,000
Resale	1,25,000	1,55,000	1,75,000
Expected Revenue	1,25,000	1,95,000	3,00,000
Annual Power Costs	35,000	55,000	75,000
O and M Costs/yr	66,000	1,09,000	1,84,000

Solution:

At first, determine total initial cost, net revenues and rank the sites in order of first cost.

	Site 1	Site 2	Site 3
Initial Cost	1,40,000	1,90,000	2,20,000
Resale	1,25,000	1,55,000	1,75,000
Net Revenue/yr	24,000	31,000	41,000

Present Worth Comparison of Infinite Analysis Periods

a. Present Worth Comparison

Where i =15%

Site 1

$PW_1 = -1,40,000 + 1,25,000 (P/F, 15\%, 10) + 24,000 (P/A, 15\%, 10)$
$= -1,40,000 + 1,25,000 (0.2472) + 24,000 (5.0188)$
$=$ Rs 11,351.20

Site 2

$PW_2 = -1,90,000 + 1,55,000 (P/F, 15\%, 10) + 31,000 (P/A, 15\%, 10)$
$= -1,90,000 + 1,55,000 (0.2472) + 31,000 (5.0188)$
$=$ Rs 3,898.80

Site 3:

$PW_3 = -2,20,000 + 1,75,000 (P/F, 15\%, 10) + 41,000 (P/A, 15\%, 10)$
$= -2,20,000 + 1,75,000 (0.2472) + 41,000 (5.0188)$
$=$ Rs 29,030.80

Here, $PW3 > PW_1 > PW_2$. Therefore, select Site 3 then Site 1 and then Site 2 **Ans.**

b. IRR Comparison

Site 1

$-1,40,000 + 1,25,000 (P/F, i\%, 10) + 24,000 (P/A, i\%, 10) = 0$
@i = 15%= PW= $-1,40,000 + 1,25,000 (0.2472) + 24,000 (5.0188)$
$= 11351.2$
@i = 20% = PW = $-1,40,000 + 1,25,000 (0.1615) + 24,000 (4.1925)$
$= -19192.5$
By interpolating $IRR_1 = 16.85\% >$ MARR accepted.

Site 2

$-1,90,000 + 1,55,000 (P/F, i\%, 10) + 31,000 (P/A, i\%, 10) = 0$
@i = 15%= PW= $-1,90,000 + 1,55,000 (0.2472) + 31,000 (5.0188)$
$= 3898.8$
@i = 20%= PW= $-1,90,000 + 1,55,000 (0.1615) + 31,000 (4.1925)$
$= -35,000$
By interpolating IRR_2 15.5% > MARR accepted.

Site 3

PW = – 2,20,000 + 1,75,000 (P/F, 15, 10) + 41,000 (P/A, 15, 10)

@ i = 15% = PW = – 2,20,000 + 175,000 (0.2472) + 41,000 (5.0188)
= 29,030.8

@ i = 20% = PW = – 2,20,000 + 1,75,000 (0.1615) + 41,000 (4.1925)
= –19845

By interpolating IRR_3= 17.96% > MARR accepted.

Incremental Analysis

Select site 1 as the base alternative having lowest initial cost.

	Site 1	Site 2	Site 3	Site 2-1	Site 3-1
Initial Cost	1,40,000	1,90,000	2,20,000	50,000	80,000
Resale	1,25,000	1,55,000	1,75,000	30,000	50,000
Net Revenue/yr	24,000	31,000	41,000	7,000	17,000

Incremental site 2- site 1

– 50,000 + 30,000 (P/F, i%, 10) + 7,000 (P/A, i%, 10) = 0

@ i = 10% = PW= – 50,000 + 30,000 (0.3855) + 7,000 (6.1446)
= 4,577.20

@ i = 15% = PW= – 50,000 + 30,000 (0.2472) + 7,000 (5.0188)
= –7,452.40

By interpolating i = 11.90%

Since ΔIRR_{2-1} < MARR site 2 is rejected

Incremental site 3- site 1

– 80,000 + 50,000 (P/F, i%, 10) + 17,000 (P/A, i%, 10) = 0

@ i = 15%= PW= – 80,000 + 50,000 (0.2472) + 17,000 (5.0188)
= 17679.60

@ i = 20%= PW= – 80,000 + 50,000 (0.1615) + 17,000 (4.1925)
= – 652.50

By interpolating i = 19.82%

Since, ΔIRR_{3-1} > MARR

Therefore, select Site 3 then Site 1 and then Site 2 **Ans.**

Example 4.26

Select the best project using AW and ERR method. Useful life is 10 years and MARR 10%. Reform incremental analysis if necessary.

Projects	*A*	*B*
Initial Investment	*24,00,000*	*35,50,000*
Annual Revenue	*8,20,000*	*12,00,000*
Annual Expenses	*1,10,000*	*1,40,000*
Salvage Value	*2,50,000*	*3,50,000*

Solution:

a. Using AW Method

For Project A

$AW_A = -24,00,000\ (A/P, 10\%, 10) + 8,20,000 - 1,10,000 + 2,50,000\ (A/F, 10\%, 10)$

$= -24,00,000\ (0.1627) + 8,20,000 - 1,10,000 + 2,50,000\ (0.0627)$

$= 335195$

For Project B

$AW_B = -35,50,000\ (A/P, 10\%, 10) + 12,00,000 - 1,40,000 + 3,50,000\ (A/F, 10\%, 10)$

$= -35,50,000\ (0.1627) + 12,00,000 - 1,40,000 + 3,50,000\ (0.0627)$

$= 504360$

Since, $AW_B > AW_A$ Therefore select project B **Ans.**

b. Using ERR Method

For Project A

Step 1: Discounting all the cash outflows to the present

(Assume at $\epsilon = 10\%$)

$= 24,00,000 + 1,10,000\ (P/A, 10\%, 10)$

$= 24,00,000 + 1,10,000\ (6.1446)$

$= Rs\ 30,75,906$

Step 2: Compounding all the cash inflows to the future at $\epsilon = 10\%$

$= 8,20,000\ (F/A, 10\%, 10) + 2,25,000$

$= 8,20,000\ (15.9374) + 2,25,000$

$= Rs\ 1,32,93,668$

Step 3: Establishing equivalence between two equations

$30,75,906\ (F/P, i'\%, 10) = 1,32,93,668$

$(1 + i')^{10} = 4.32$

$i' = 15.75\% >$ MARR justified.

For Project B

Step 1: Discounting all the cash outflows to the present (Assume at $\epsilon = 10\%$)

$= 35,50,000 + 1,40,000\ (P/A, 10\%, 10)$

$= 35,50,000 + 1,40,000\ (6.1446)$

$= Rs\ 44,10,244$

Step 2: Compounding all the cash inflows to the future at $\epsilon = 10\%$

$= 12,00,000\ (F/A, 10\%, 10) + 3,50,000$

= 12,00,000 (15.9374) + 3,50,000
= Rs 1,94,74,880

Step 3: Establishing equivalence between two equations
44,10,244 (F/P, i' %, 10) = 1,94,74,880
$(1 + i')^{10} = 4.158$
i' = 16.1% > MARR justified.

For Incremental ERR (B-A)

Projects	A	B	B-A
Initial Investment	24,00,000	35,50,000	11,50,000
Annual Revenue	3,20,000	12,00,000	3,80,000
Annual Expenses	1,10,000	1,40,000	30,000
Salvage Value	2,25,000	3,50,000	1,25,000

Step 1: Discounting all the cash outflows to the present (Assume at ϵ = 10%)
= 11,50,000 + 30,000 (P/A, 10%, 10)
= 11,50,000 + 30,000 (6.1446)
= Rs 13,34,338

Step 2: Compounding all the cash inflows to the future at ϵ = 10%
= 3,80,000 (F/A, 10%, 10) + 1,25,000
= 3,80,000 (15.9374) + 1,25,000
= Rs 61,81,212

Step 3: Establishing equivalence between two equations
13,34,338 (F/P, i' %, 10) = 61,81,212
$(1 + i')^{10} = 4.634$
i' = 16.56% > MARR

The extra investment in the project B is justified. Therefore, select project B. **Ans.**

Example 4.27

The following information showing the cash flows for two alternatives. If the MARR is 15%, which one is preferred?

	Alternative 1	*Alternative 2*
Initial Cost	*8,000*	*13,000*
Annual Cost	*3,500*	*1,600*
Salvage Value	-	*2,000*
Useful Life	*10*	*5*

Solution:

As all cash flows are expenditures, we use the incremental rate of return. Also, as the useful lives are different, we use the common multiplier for both alternative, 10 years for comparison.

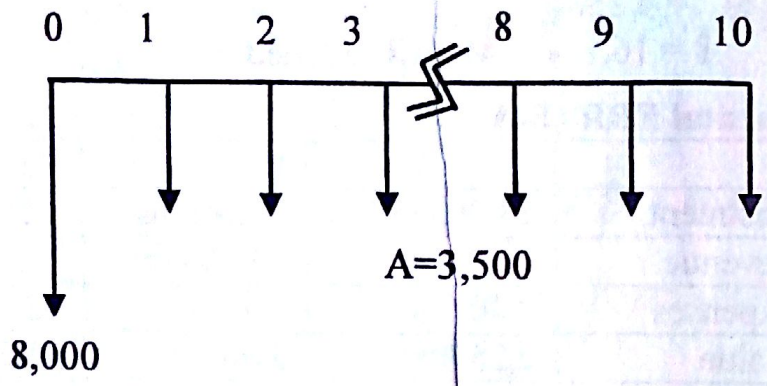

Fig.4.39: *Cash Flow Diagram for Alternative 1.*

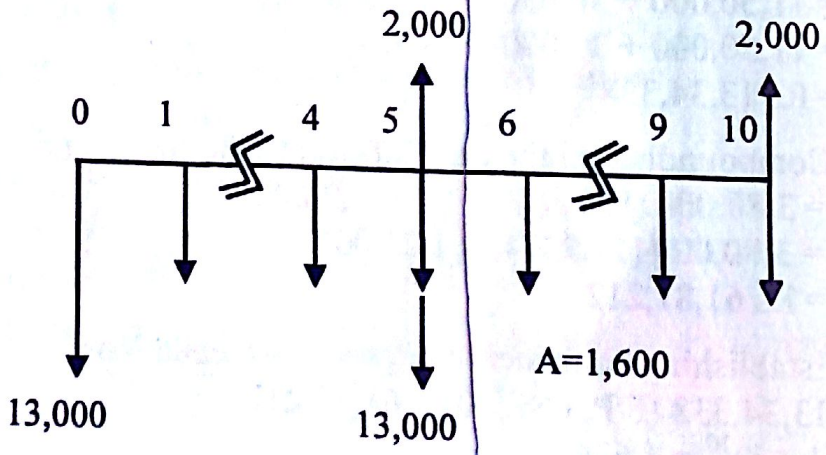

Fig.4.40: *Cash Flow Diagram for Alternative 2.*

Year	Alternative 1	Alternative 2	Alt. (2 – 1)
0	– 8,000	– 13,000	– 5,000
1-5	– 3,500	– 1,600	1,900
5	-	+ 2,000 –13,000= – 11,000	– 11,000
6-10	– 3,500	– 1,600	1,900
10	-	+2,000	2,000

$NPV_{2-1} = 0 = -5,000 + 1,900(P/A, i\%, 10) - 11,000\ (P/F, i\%, 5) + 2,000\ (P/F, i\%, 10)$

Solving by trial and error; then $IRR_{2-1} = 12.65\%$

Where $IRR_{2-1} < MARR$, then choose alternative 1 **Ans.**

Example 4.28

A company has decided to buy new equipment for a project with 4 year duration. There are two different equipment can be used for this project. The cash flows of those types are shown in the table below. What are the payback period for each equipment and which one should be selected? (Note that negative cash flow means expenditures).

Year	Cash Flow	
	Equipment A	Equipment B
0	– 35,000	– 35,000
1	20,000	10,000
2	15,000	10,000
3	10,000	15,000
4	10,000	20,000

Solution:

To find the payback period, find the time at which the cumulative cash flows equal zero.

Year	Cash Flow		Cumulative Cash Flow	
	Equipment A	Equipment B	Equipment A	Equipment B
0	– 35,000	– 35,000	– 35,000	– 35,000
1	20,000	10,000	– 15,000	– 25,000
2	15,000	10,000	0	– 15,000
3	10,000	15,000	10,000	0
4	10,000	20,000	20,000	20,000

As shown from the table above:

The payback period for equipment A (PBP_A) = **2** years

The payback period for equipment B (PBP_A) = **3** years

Since, $PBP_A < PBP_B$. Therefore, project A is selected **Ans.**

Example 4.29

Calculate the discounted payback period for the following two alternatives if the investment rate is 15%. Which one do you recommend?

Projects	Alternative 1	Alternative 2
Initial Costs	12,000	8,000
Annual Benefits/yr	3,000	1,500
Useful Life (Years)	7	15

Solution:

Let's assume that the payback period is n years. So, it is required to find n where the PW of cost equals the PW of benefits. Let's assume that the salvage value is constant and can be obtained at any time for the payback period.

$PW_{cost} = PW_{benefits}$ .....(1)

Alternative 1:

$PW_{cost} = 12{,}000$

$PW_{benefits} = 3{,}000(P/A, 15\%, n_1)$

Substituting these values in equation (1)

Then, $(P/A, 15\%, n_1) = 4$

From the interest table, n lie between year 6 and year 7.

By interpolation $n_1 = 6.6$ years

Alternative 2:

$PW_{cost} = 8{,}000$

$PW_{benefits} = 1{,}500(P/A, 15\%, n_2)$

Substituting these values in equation (1)

$8{,}000 = 1{,}500(P/A, 15\%, n_2)$

Then, $(P/A, 15, n_2) = 5.33$

From the interest table, n_2 lie between year 11 and year 12.

By interpolation $n_2 = 11.5$ years

Since, $n_1 < n_2$. Therefore, alternative 1 is selected **Ans.**

Example 4.30

The following are proposed projects their interrelationships are respective cash flows for the coming budgeting period. Some of the projects are mutually exclusive noted below and B_1 and B_2 are independent of C_1 and C_2. Similarly, C_1 and C_2 are mutually exclusive and contingent on the acceptance of B_2. Project D contingent on the acceptance of C_1. Using the PW and MARR=10%, determine what combination of projects is best if the capital to be invested is **(a)** *Limited to Rs 48,000 and* **(b)** *Unlimited*

Project	0	1	2	3	4
B_1	−50	20	20	20	20
B_2	−30	12	12	12	12
C_1	−14	4	4	4	4
C_2	−15	5	5	5	5
D	−10	6	6	6	6

Solution:

Mutually Exclusive Projects Combinations

Mutually Exclusive Combination	Projects					Explanation
	B_1	B_2	C_1	C_2	D	
1	0	0	0	0	0	Do nothing
2	1	0	0	0	0	Accept B_1
3	0	1	0	0	0	Accept B_2
4	0	1	1	0	0	Accept B_2 & C_1
5	0	1	0	1	0	Accept B_2 & C_2
6	0	1	1	0	1	Accept B_2, C_1 & D

Cash Flow and Present Worth for Combined Projects

Mutually Exclusive Combination	Cash Flow (000) Rs					PW(000) Rs= -I + A (P/A, 10%, 4)
	0	1	2	3	4	
1	0	0	0	0	0	
2	– 50	20	20	20	20	– 50 + 20 (3.1699) = 13.4
3	– 30	12	12	12	12	– 30 + 12 (3.1699) = 8.04
4	– 44	16	16	16	16	– 44 + 16 (3.1699) = 6.71
5	– 45	17	17	17	17	– 45 + 17 (3.1699) = 8.88
6	– 54	22	22	22	22	– 54 + 22 (3.1699) =15.73

a. If capital investment is to be limited to Rs 48,000 mutually exclusive combination 5 is the best combination, since combination 2 and 6 are not feasible due to limited investment.

b. If capital investment is unlimited mutually exclusive combination 6 is the best combination because is gives maximum PW.

Questions

1. Calculate PW of the following two projects by using repeatability assumptions when MARR is 12%.

	A	B
Initial Costs	4,00,000	6,00,000
Annual Revenue	30,000	35,000
Annual O and M	3,000	4,000
Useful Life (Years)	6	8
Salvage Value	4,000	7,000

2. From the following information select the best project. If MARR=10%.

	A	B
Initial Investment	3,50,000	50,000
Annual Revenue	1,6,450	25,000
Annual O and M	3,000	1,3,830
Useful Life (Years)	4	8
Salvage Value at the End of Useful Life	0	0

When service period required is:

a. 4 years by FW method.

b. 8 years by IRR method with PW formulation.

3. Which project is feasible? Use PW or FW using repeatability method.

	A	B
Initial Investment	3,50,000	4,50,000
Annual Revenue	1,50,000	1,75,000
Annual Costs	30,000	40,000
Salvage Value	50,000	75,000
Useful Life (Years)	4	5
MARR	15%	

4. The following data have been estimated for two feasible investments X and Y having different useful lives. If minimum attractive rate of return is 10% choose best one project using PW method. Use repeatability assumption.

	X	Y
Initial Investment	3,500	5,000
Annual Revenue	1,900	2,500
Annual Costs	645	1,383
Useful Life (Years)	4	6

5. The following data have been estimated for two feasible investments X and Y having different useful lives. If minimum attractive rate of return is 10% choose best one project using PW method. Use repeatability assumption.

	X	Y
Initial Investment	7,000	10,000
Annual Revenue	3,500	5,500
Annual Costs	1,500	2,500
Useful Life (Years)	5	6
Market Value at the end of Useful Life	0	0

6. Three mutually exclusive alternative public work projects are currently under consideration. Their respective cost and benefit are included in the table below. If life for each project is 5 years and nominal interest rate is 10% choose best alternative using B/C ratio.

	A	B	C
Capital Investment	8,500	10,000	12,000
Annual O & M Costs	750	725	700
Salvage Value	1,250	1,750	2,000
Annual Benefits	2,150	2,265	2,500

7. Following are two mutually exclusive alternatives.

	Machine X	Machine Y
Initial Costs	2,000	7,000
Uniform Annual benefits	950	1,200
Annual Costs	500	1,500
Useful Life (Years)	5	10

Using 10% interest rate, which machine should be bought? Use conventional and modified benefit cost ratio method.

8. The following data have been estimated for two feasible investments X and Y having different useful lives. If minimum attractive rate of return is 10% choose the best one project using PW method. Use repeatability assumptions.

Machines	X	Y
Investment	30,000	45,000
Net Annual Revenue	10,000	16,000
Salvage Value	5,000	7,000
Useful Life (Years)	3	5

9. Evaluate the following two feasible investments A and B having different useful lives, if MARR is 15% per year. Use PW method with repeatability assumptions.

	Investment A	Investment B
Investment	40,000	50,000
Net Annual Revenue	15,000	20,000
Salvage Value	5,000	6,000
Useful Life (Years)	3	5

10.

11. A mobile company is taking quotations for purchase, installation and operation of microwave towers for long period. If MARR is 15% determine the best alternative project using repeatability assumption and PW method.

	Project A	Project B
Equipment Cost	6,50,000	5,80,000
Installation	15,00,000	20,00,000
Annual Maintenance	1,00,000	1,25,000
Annual Extra Charge	0	50,000
Salvage Value	0	0
Useful Life (Years)	40	35

12. The following data have been estimated for two mutually exclusive feasible investments X and Y. If minimum attractive rate of return is 10%, choose best one project using IRR method.

	X	Y
Investment	35,000	50,000
Annual Cash Flow After Tax	5,000	8,000
Useful Life (Years)	8	8

13. Using PW method to choose the best one from the following projects. Take MARR= 12% and use repeatability assumption.

	X	Y
Investment	10,500	15,000
Annual Revenues	6,000	7,500
Annual Costs	2,000	3,000
Salvage Value	3,000	5,000
Useful Life (Years)	3	4

14. Three mutually exclusive alternative public works projects are currently under consideration. Their respective costs and benefits are included in the table below. Each of the projects has a useful life of 50 years and the nominal interest rate is 10% per year. Which, if any of these projects should be selected? Use B/C ratio with AW method.

	A	B	C
Capital Investment (Rs in millions)	850	1,000	1,200
Annual O & M Costs (Rs in millions)	75	72.5	70
Salvage Value (Rs in millions)	125	175	200
Annual Benefits (Rs in millions)	215	226.5	250

15.

16. The following are five proposed projects being considered by an engineer in an integrate system for a company.

The interrelationships among the projects and respective cash flows for the coming budgeting period are as shown.

Project A_1 and Project A_2: Mutually exclusive and independent on B set.

Projects B_1 and Project B_2: Mutually exclusive and contingent on the acceptance o A_2.

Project C: Contingent on the acceptance of B_1.

	A_1	A_2	B_1	B_2	C
Initial Investment	50,000	30,000	14,000	15,000	10,000
Annual Benefits	20,000	12,000	4,000	5,000	6,000

Assume MARR= 8% per year and all the equipments are having useful life of four years. Determine what combination of projects is best if the capital to be invested is

a. Unlimited

b. Limited to 48,000

17. Define mutually exclusive project, independent project and contingent project with proper combination.

18. State the procedure to calculate capitalized cost.

19. Explain the techniques for comparing mutually exclusive alternatives having unequal useful lives.

20. write short note

a. Repeatability assumption.

b. Co-terminated assumption.

c. Capitalized cost method for comparing alternatives.

d. Incremental analysis.