Engineering Economic and Analysis:

* Invest → Bank → profit
↓
value of mony → (company / Project) → profit

* money (if invested) → generate mony

* present value intrest → New value
  - present value of mony
  - life time (# of years)
  - future value of mony
  - Intrest

* The yearly intrest rate = $\boxed{\dfrac{F-P}{n}}$
* Future value:
  $F = (1+ni)P$

* types of intrest:
  1- simple: $F = P(1+ni)$
  2- compound intrest: $F = P(1+i)^n$ ⇐ standard
  3- interest is changing w/ time: $F = P \prod_{i=1}^{n} (1+i)$ مضروب

example:
How much you need to invest in saving account based on 6% interest rate to have $5000 in 5 years??
sol:
$F = 5000\$$
$F = P(1+i)^n = P(1+0.06)^5 \Rightarrow P = 3736$.

Based for compound intrest:

- yearly
- monthly
- daily
- contineous

$$r = \frac{i_n}{m}$$ ← number of periods ⇒ example: i per year, needed per month ⇒ $r = \frac{i}{12}$

Effective intrest rate:

$$\boxed{i_{eff} = \left(1+\frac{i_n}{m}\right)^n - 1}, \quad \boxed{F = \left(1+\frac{i_n}{m}\right)^m}$$

example :-

what is the effective annual intrest for anominal rate of 8% per annum when compounded monthly?

sol:

$i_n = 8\%$, $m = 12$

$$i_{eff} = \left(1+\frac{8\%}{12}\right) - 1 = 8.3\%$$

for agiven $p = 1000$

$$F = p(1+i_{eff})$$
$$= 1000\left(1+\frac{0.08}{12}\right)^{12} = 1083$$

conteneous compound intrest:-

$$\boxed{i_{eff} = e^{i_n} - 1}$$

Example:

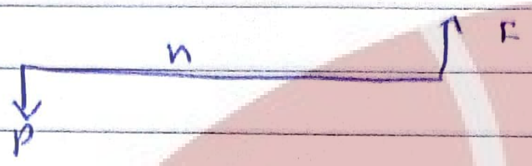
How much you would have to invest at 6% for 6 years to obtain \$1791 , Assume Basic intrest.

sol:

$$p = F\left(\frac{1}{(1+i)^n}\right) = 1791\left(\frac{1}{1+0.06}\right)^6 = 12.63$$

No.

Chash flow diagram :-



x-axis → time

y-axis → cash flow

upword → earnd mony

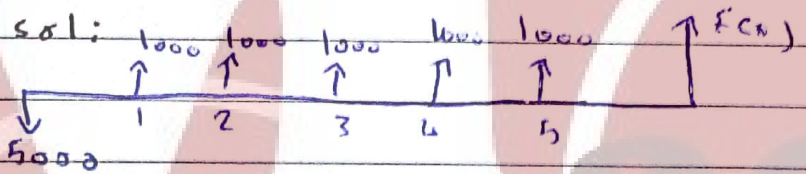
down word → Loss mony

Example :-

you invest today with draw \$1000 at the end of each year , how much you have at the end of 6 years ?

$i = 6\%$.

sol:



$P_1 = \frac{F_1}{(1+0.06)^1} = \frac{1000}{1+0.06} = 943.4$

$P_2 = \frac{F_2}{(1+0.06)^2} = \frac{1000}{(1+0.06)^2} = 890$

$P_3 = 839.6$

$P_4 = 792.1$

$P_5 = 747.3$

$P_x = \frac{x}{(1+0.06)^6} \Rightarrow 5000 = 943.4 + 890 + 839.6 + 792.1 + 747.3 + \frac{x}{(1+0.06)^6}$

$x = 1117.2$ \$ →

No.

Another sol: bring all mony till the end

$F_p = 5000(1+0.06)^6 = 7092.6$

$F_1 = 1000(1+0.06)^5 = 1338.2$

$F_2 = 1000(1+0.06)^4 = 1265.5$

$F_3 = 1000(1+0.06)^3 = 1191$

$F_4 = 1123.6$

$F_5 = 1060$

$F_p = \sum_{i=1}^{5} F_i = X = 1117.2$

A uniform series of cash flow transaction :-

$F_n = A[(1+i)^1 + (1+i)^2 + \cdots]$

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

$F_n = P(1+i)^n$

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

$$A = \frac{Fi}{(1+i)^n - 1}$$

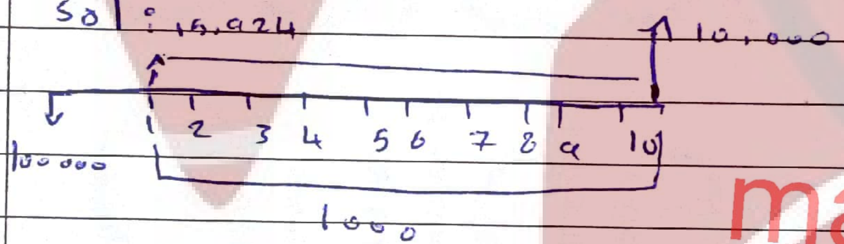
$$A = \frac{P(1+i)^n * i}{(1+i)^n - 1}$$

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

example :-

a piece of equipment costs \$ 100,000 . if a U of engineer is borrowed this amount from a bank with 9% interest and should these amount be paid within 10 years ~~a aprat~~ with a fixed payment yearly. The equipment needs \$ 1000/year for operation and yield a profit of \$ 15,924 yearly, she was expecting to sell this equip. ~~at~~ at the end with \$10000 . Do you think this engineer learn something from economy ??

sol :



$A = 15,924 - 1000 = 14,924$

$P = 100\,000$

$F = 10\,000$

$$A = \frac{P(1+i)^n * i}{(1+i)^n - 1} = \frac{100\,000\,(1+0.09)^{10} * 0.09}{(1+0.09)^{10} - 1}$$

$\boxed{= 15,582}$

$$A = \frac{Fi}{(1+i)^n - 1} = \frac{10\,000\,(0.09)}{(1+0.09)^{10} - 1} = \boxed{658.2}$$

$\sum A_i = 14,924 + 658.2 - 15,582 = \boxed{\$0.2}$

save based on $i = 0.08$

$\sum A_i = 14,924 + 690.3 - 14\,902 = \boxed{\$712}$

No.

Plant :-

7-11-2017

Depreciation :-

1- straight line:-, $d_k^{sL} = \dfrac{FCI - SV}{n}$

2- Declining balance method:- → $V_{\text{at present}} = V_{\text{origenal}} (1-f)^{a}$ → no. of years.

at year 2 → a = 2
at year 5 → a = 5

$$f = 1 - \left(\frac{S}{V}\right)^{1/n}$$

present

Example:-

origenal price of equipment \$22,000, used for 10 years, soll for \$2000. what is the price of this equipment after 5 years?

sol:

- straight Line $\quad d = \dfrac{FCI - SV}{n} = \dfrac{22{,}000 - 2000}{10} = 2000$

$$V_5 = FCI - ad = 22000 - 5 \times 2000 = 12000$$

- Declining balance :

$$f = 1 - (S/V)^{1/n} = 1 - \left(\frac{2000}{22000}\right)^{1/10} = 0.2131$$

$$V_5 = V(1-f)^5 = 22000(1 - 0.2131)^5 = \$6650$$

3- Sum of year Digits method:-

total no of years → the year I want

$$d_k^{syn} = \frac{[n+1-k](FCI - S)}{n/2\,(n+1)}$$

why syn: $\quad n/2(n+1)$

year 1 : 1 $\quad$ 1

year 2 : 2 $\quad$ 3

year 3 : 3 $\quad$ 6

year 4

No.

4- Double declining balance method :-

$$d_k^{DDB} = \frac{2}{n}\left[FCI - \sum_{i=0}^{k-1} d_i\right]$$

example:-

FCI = 150 000 000

S = 10 000 000

n = 7 years

depreciation comparsion ??

year	d_k^{SL}	d_k^{SYD}	d_k^{DDB}	$BV = FCI - \sum d_i$ $= FCI - \sum d_i$ $\times 10^{-6}$
0	-	—	—	150
1	$\frac{150-10}{7} = 20$	$\frac{(7+1-1)(150-10)}{28} = 35$	$\frac{2}{7}(150-0) = 42.9$	150 - 42.9 = 107.1
2	20	= 30	2/7 (150-42.9) = 30.6	107.1 - 30.6 = 76.5
3	20	= 25	2/7 (76.5) = 21.9	76.5 - 21.9 = 54.6
4	20	= 20	15.6	39
5	20	= 15	11.1	27.9
6	20	= 10	8	19.9
7	20	= 5	9.9 FCI - $\sum d_i$ - S	10
	140	140	140	10

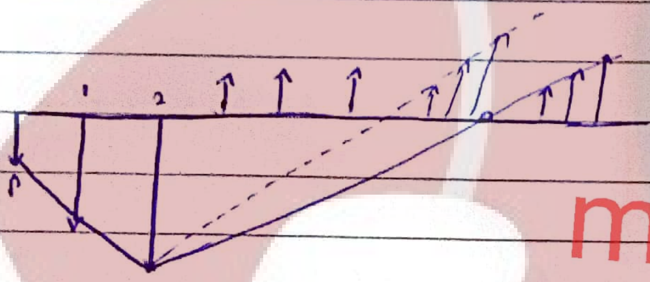
No.

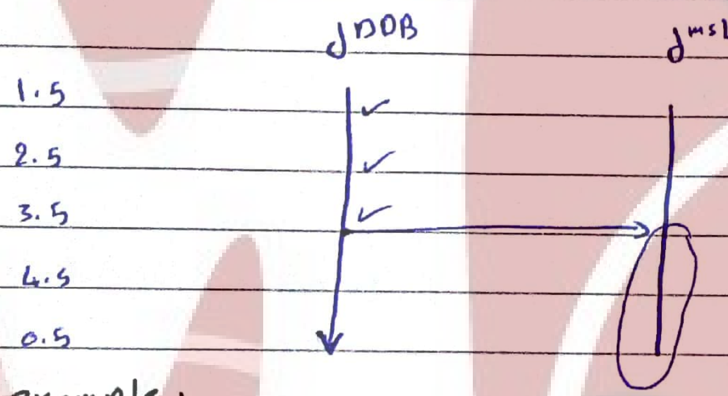
14-11-2017

Current dipreciation method:-

Modified accelerated cost recovery system [MACRS]

=> starting with DDB ending with msL. => work for 5years.





as $d\uparrow \Rightarrow tax\downarrow$

example :-

consider an equipment that has a FCI = 100000$

calculat the modefide accelerated cost recovery dep. system.

$$d_k^{DDB} = 2/5\left[FCI - \sum_{i=0}^{k-1} d_i\right] \quad , \quad d_k^{sL} = \frac{FCI - \sum d_{k-1}}{(m-k)}$$

ضربت بـ ½ لأن

ال relation علي معوض (1) مرة

year	d_k^{DDB}	d_k^{sL}
1/2	$= 2/5[100k - 0] \times 1/2 = 20k$	—
1.5	$= 2/5[100 - 20] = 32$	$= (100 - 20)/4.5 = 7.78$
2.5	$= 2/5[100 - 52] = 19.2$	$= (100 - 52)/3.5 = 13.71$
3.5	$= 2/5[100 - 71.2] = \boxed{11.52}$	$= (100 - 71.2)/2.5 = \boxed{11.52}$ تساوت القيم
4.5	$= 2/5[100 - 82.7] = 6.91$	$= (100 - 82.7)/1.5 = 11.52$ ← منذ ذلك فأنتقل عليها
0.5	....	= dep for last 0.5 year

$$= 0.5\left(\frac{100 - 82.7}{1.5}\right) = 5.76$$

Depreciation

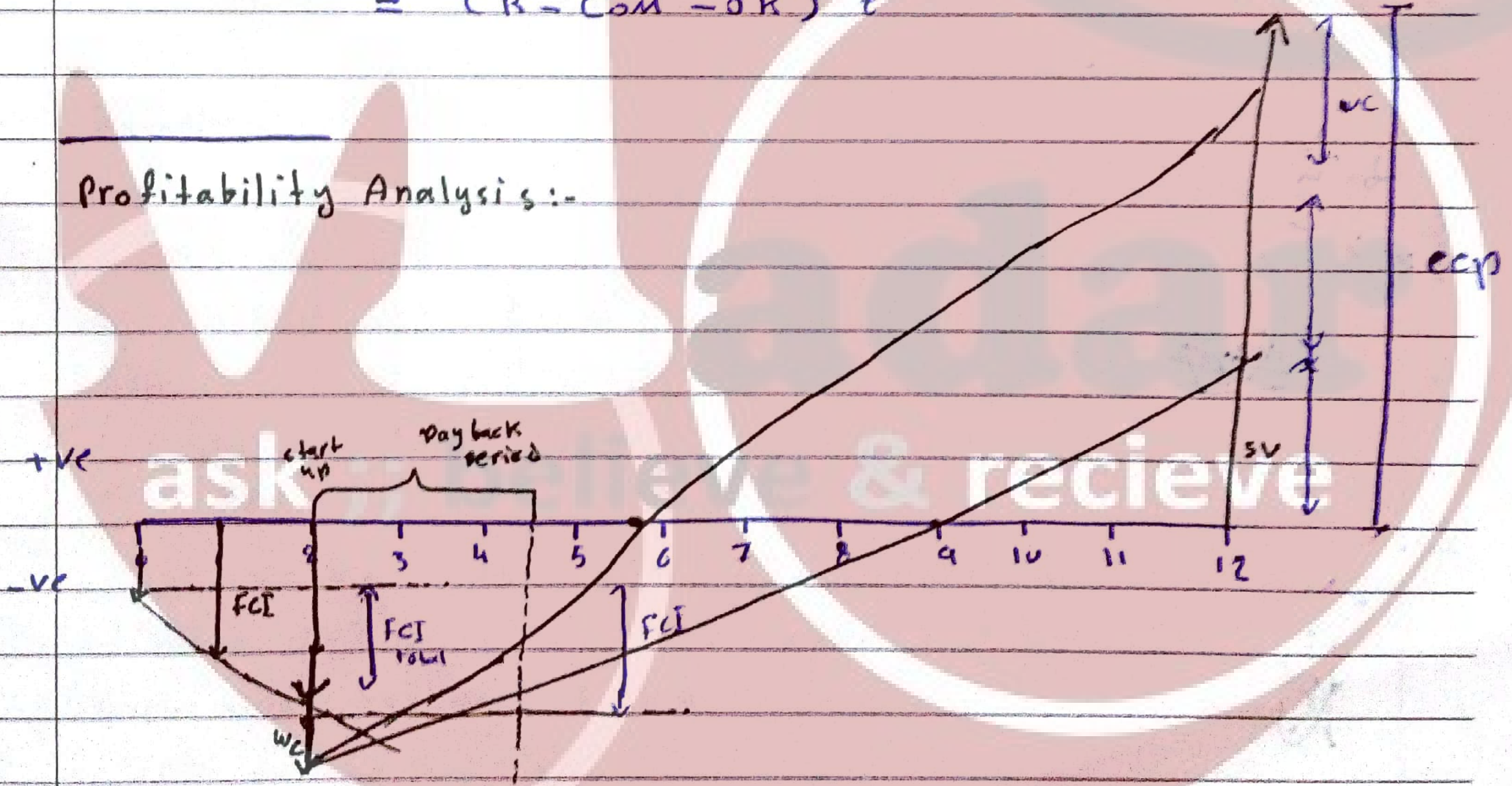
year	dk
0.5	20
1.5	32
2.5	19.5
3.5	11.52
4.5	11.52
0.5	5.76

Taxation, cashflow, profit:-

income tax = (Revenue − expenses). tax rate

= $(R - C_{OM} - d_k)\ t$

Profitability Analysis:-



* Criteria : $\boxed{1}$ time ⟶ Payback period

$\boxed{2}$ net positive value $\boxed{3}$ rate of return

No.

1- time criteria:-

pay back period: time from start up, to recover the FCI

2- cash criteria:-

cummulative cash position (CCP)

cummulative cash Recovery (CCR), $\frac{\Sigma \text{ of all positive values}}{\Sigma \text{ of all negative cash}}$

$$CCR = 1 + \frac{CCP}{\text{land} + WC + FCI}$$

3- Intrest Rate criteria:-

Rate of return on investment (RoRoI)

$$RoRoI = \frac{\text{Avg annual net profit}}{FCI} \Rightarrow \frac{\text{slope}}{FCI}$$

$\frac{1}{n}$ n servace life [10 years] from start up

Example:-

A new chemical plant is going to be built with the required capital investment:

1)- cost of land = \$10 M

2)- FCI = \$150 M

FCI_1 = \$90 M

FCI_2 = \$60 M

* plant starts up after 2 years from installation.

WC = 20% of FCI = 0.2 * 150 = \$30 M

yearly sales revenue = \$75 M

COM = \$30 M

Taxation = 45 %

salvage value = \$10 M

Depreciation based on 5 years MACRs

project life = 10 years.

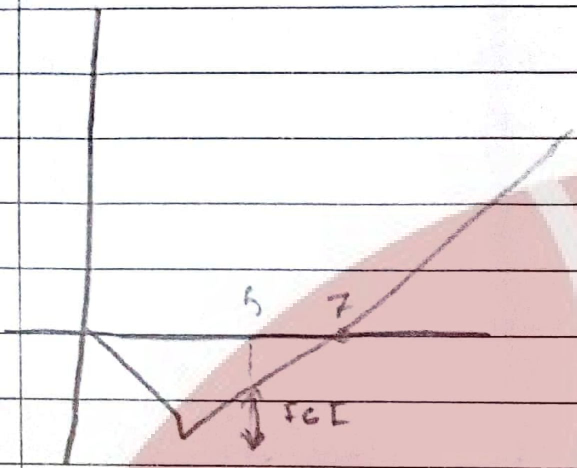
* calculate, PBP, RoR, Net positive cash flow.

No.

End of year	investment	dk	FcI - Σdi	R	COM	net profit
0	-10	—	0	—	—	—
1	-90	—	90	—	—	—
2	-30-60	—	150	—	—	—
3		30	120	75	30	38.25
4		48	72	75	30	46.35
5		28.8	43.2	75	30	37.71
6		17.28	25.92	75	30	32.53
7		17.28	8.64	75	30	32.53
8		8.64	0	75	30	28.64
9				75	30	24.74
10				75	30	
11				75	30	
12				75	30	24.75

Cash flow	net cash flow
-10	-10
-90	-100
-90	-190
38.25	-151.75
46.35	-105.4
	-67.69
	-35.16
	-2.64
	+26
	+50.75
	+75.50
	+100.25
	+170.3

No.



$\tan\theta = \frac{7-5}{67-69} = \frac{X}{67.69-40}$

$x = 0.818$

$PBP = 0.188 + 3$

$= 3.1818$ years

$CCP = 170.5$

$CCR = 1 + \frac{CCP}{L + W_c + FCI} = 1 + \frac{170.5}{10+30+150} = 1.897$

$RoRoI = \frac{\text{avarage profit}}{FCI}$

net profit $= (R - COM - d)(1 - \tan x)$

time

0

1

2   8.25

3   -1.65

4   8.91

5   15.25

6

15.25

20

24.75

30.25

avarge net Profit $= 17.05$

No.

* Discounted profitubility criteria.

[DPBP] – Discounted payback period = time to Recover FCI

[DCCP] – cash critiria = Discounted cummulative cash position

= Net present value = cummulative cash at the end of project

$$\text{present value ratio} = \frac{\text{Net +ve values}}{\text{Net -ve values}}$$

* كل ما قل الـ tax زاد الـ DR of return *

madar_team

Example :- Repeat the same example for non discounted C.F but For discounted , rate = 10% ?

year	non Discounted C.F	Discounted	cummulative
0	–10	– –10	–10.
1	–90	– $\frac{-90}{(1+0.1)^1} = 81.82$	–91.82
2	–60–30	– $\frac{-90}{(1+0.1)^2} = 74.37$	–166.2
3	38.25	– 28.74	–137.46
4	46.38	– 31.41	–105.8
5	37.71	– 23.4	–82.39
6	32.52	– 18.59	–64.03
7	32.52	–16.64	–47.34
8	28.64	–13.36	–33.98
9	24.75	–10.5	–23.48
10	24.75	–9.54	–13.94
11	24.75	–8.67	–5.26
12	70.25	–22.38	+17.12

→

No.

DPBP = 5.9 year

NPV = 17.12

$$PVR = \frac{28.74 + 31.66 + \dots + 22.38}{10 + 81.82 + 74.38} = 1.1$$

(٧)	(٤)
i	NPV
0 %	170.5
10 %	17.12
12 %	0.72
13 %	−6.32

By Interpolation.
NPV @ $i = 12.1$ %

⇐ Q ١ كل ما زادت الـ discounted rate of return من صالحي أو لأ؟ ولماذا؟

ـ لو تغير سعر الفلوس مع الزمن رح أخذ أربح
كل ما زادت i↑ أنا ربحان
من صالحي

No.

Comparing several Large projects:-

as ↑ DCROR ⟶ better choice for investment

DCROR is calculated at NPV = 0

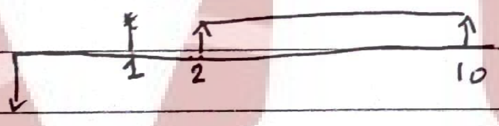
example:-

Invest using three different project

	initial invest.	after tax cash flow	
		$n=1$	$n=2 \rightarrow 10$
Project A :	\$ 60 M	\$ 10 M	\$ 12 M
project B :	\$ 120 M	22	22
project C :	\$ 100 M	12	20

The min acceptable RoR = 10%

soln:-



A- $0 = -60\,(\frac{F}{P}, i, 10) + 10\,(F/P, i, 10) + 12\,(F/A, i, 9) \Rightarrow i = 0.1435$

B- $0 = -120\,(F/P, i, 10) + 22\,(F/P, i, 10) + 22\,(F/A, i, 9) \Rightarrow i = 0.1287$

C- $i = 0.1334$

max i = 14.35% ⇒ so this is the best choice (A) ✓

Evaluation of equipment alternatives:-

used for equip. w/ same life time.

1) pump, CS
2) pump, SS

example:-

if we need to cool down a product using either Air cooler or exchanger based on water. if the following information are provided for each equip. what is your recommendation, based on life time of 12 years, i = 8%.

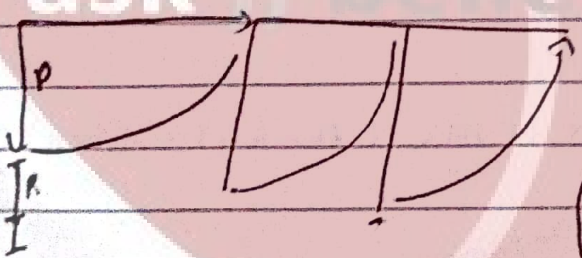
	Initial invest	yearly op. cost.
Air cooler	\$ 23,000	\$ 1200
exchanger	\$ 12,000	\$ 3,300

$$NPV = \text{initial invest.} + \text{op. cost} \left(\frac{P}{A}, i, n\right)$$

NPV = \$32,040 ⟹ air cooler ✓ ⟹ this is the best.

NPV = \$36,870 ⟹ exchanger

Equipments with Different life time



$$\boxed{R(1+i)^n - R = P}$$

$$\text{capitalized cost} = P + R = P + \frac{P}{(i+1)^n - 1}$$

$$\boxed{P = R(1+i)^n + P}$$

No.

equiv. capital cost :-

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

example:-

pump	capital cost	op. cost	life time
C S	8000	1800	4
S S	16,000	1600	7

Assume $i = 8\%$

sol :-

capitalized cost (CS) $= \dfrac{(8000)(1.08)^4 + (1800)\dfrac{(1.08)^4 - 1}{0.08}}{(1.08)^4 - 1} = 52,700$

capitalized cost (SS) $= \dfrac{16000(1.08)^4 + (1600)\dfrac{(1.08)^4 - 1}{0.08}}{(1.08)^7 - 1} = 58,400$

most feasible is carbon steel,

capetalized cost = 52,700

No.

Equivalent Annual operating cost (EAoC) :-

$\boxed{\text{project 1}}$

↓

$\boxed{\text{project 2}}$

↓

EAOC = (capital investment) (A/p, i, n) + yoc

example:-

	capital cost	op. cost	n
CS (pump)	8000	1800	4
SS (pump)	16000	1600	7

, $i = 8\%$

$$EAoc\ (cs) = 8000\left[\frac{0.08\,(1.08)^4}{1.08^4 - 1}\right] + 1800 = 4220$$ ✓

$$EAoc\ (ss) = 16000\left[\frac{0.08\,(1.08)^7}{1.08^7 - 1}\right] + 1600 = 4670$$

⇓

$\boxed{\text{is not accurate if we have diff. life times.}}$

Common denominater method :-

This method solve (EAoC) by multiplying the life time of each eq. with the other.

Total year = nm = 4 x 7 = 28 year

$NPrV_{cs} = 8000 + 1800\ (P/A, 0.08, 28) + 8000\ (P/F, 0.08, 4)$
$+ 8000\ (P/F, 0.08, 8) + \ldots$

$NPrV_{ss} = 16000 + 1600\ (P/A, 0.08, 7) + 16000\ (P/F, 0.08, 7) +$
$16000\ (P/F, 0.08, 14) + \ldots$

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incremental Analysis for Retrofiting :-

1) Rate of return of incremental investment (RoRII)
(should be max)

$$RoRII = \frac{\text{investment yearly saving}}{\text{incremental invest.}}$$

2) incremental Payback period (should be min)

$$IPBP = \frac{\text{incremental invest.}}{\text{invest. yearly saving}} = \frac{1}{RoRII}$$

example:
you have apipeline need to be insulolated to save energy according to the following ~~___~~: options:-

option	project cost	saving	RoRII	IPBP
1	∅	∅	—	—
2	3000	1400	$\frac{1400}{3000} = 0.47$	2.1
3	5000	1900	0.38	2.6
4	6000	2000	0.33	3
5	9700	2400	0.25	4

choose option (2)
change from (2) → (3)
incremental invest = 5000 − 3000 = 2000
incremental saving = 1900 − 1400 = 500

$$RoRII = \frac{500}{2000} = 0.4 \checkmark$$

No.

Chang from (3) ⟶ (4)

Incr. invest = 6000 − 5000 = 1000

" saving = 2000 − 1900 = 100

$RoRII = \frac{100}{1000} = 0.1$ X

Chang from (4) ⟶ (5)

$II = 9700 - 6000 = 3700$

$IS = 2400 - 2000 = 400$

$RoRII = \frac{400}{3700} = 0.108$ X

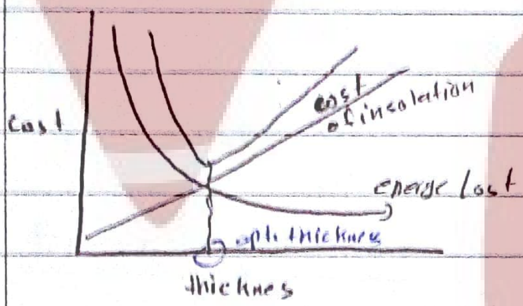
if the acceptable RoRII = 15 % ⇒ then (3)→(4) and (4)→(5) is rejected.

Optimization Design and Design strategy :-

Factors need to be optimized :-

1- cost per unit production
2- profit
3- Amount of final product / unit time
4- conversion , yield , etc.

(1) optimization per one unit (variable) :



the thickness of insulation

$$\text{capital cost (insulation)} = a + bx = f(x)$$

$$\text{cost / energy loose} = c + \frac{d}{x}$$

$$\text{Total cost} = a + bx + c + \frac{d}{x}$$

$$\frac{\partial C_T}{\partial x} = 0 = b - \frac{d}{x^2}$$

$$x = \left(\frac{d}{b}\right)^{\frac{1}{2}}$$

example:-

option	CC cost of insulation	CH cost related to heet lost
0	0	8000
1	2326	1000
2	4653	4500
3	6980	5666
4	9306	6250

$$CC = 2326.7\,x$$

$$C_H = 8000 - \frac{7000}{x}$$

$$C_T = C_c + C_H = 2326.7\,x + 8000 - \frac{7000}{x}$$

$$\frac{\partial C_T}{\partial x} = 2326.7 + \frac{7000}{x^2} = 0$$

$$x^2 =$$

No.

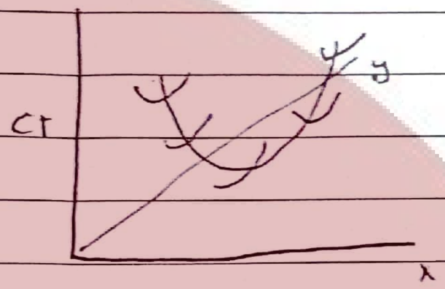
(2) two variables :-

$$C_c = f(x) = a + bx + cx^2$$

$$C_y = f(y) = \frac{d}{y^2} + fy$$

$$C_T = C_c + C_y$$

$$= a + bx + cx^2 + \frac{d}{y^2} + fy$$



$$\frac{\partial C_T}{\partial x} = 0 = b + 2cx \rightarrow x$$

$$\frac{\partial C_T}{\partial y} = \frac{-d}{y^2} + f = 0 \rightarrow y$$

Break even point :-