Construction Management

Recitation-3

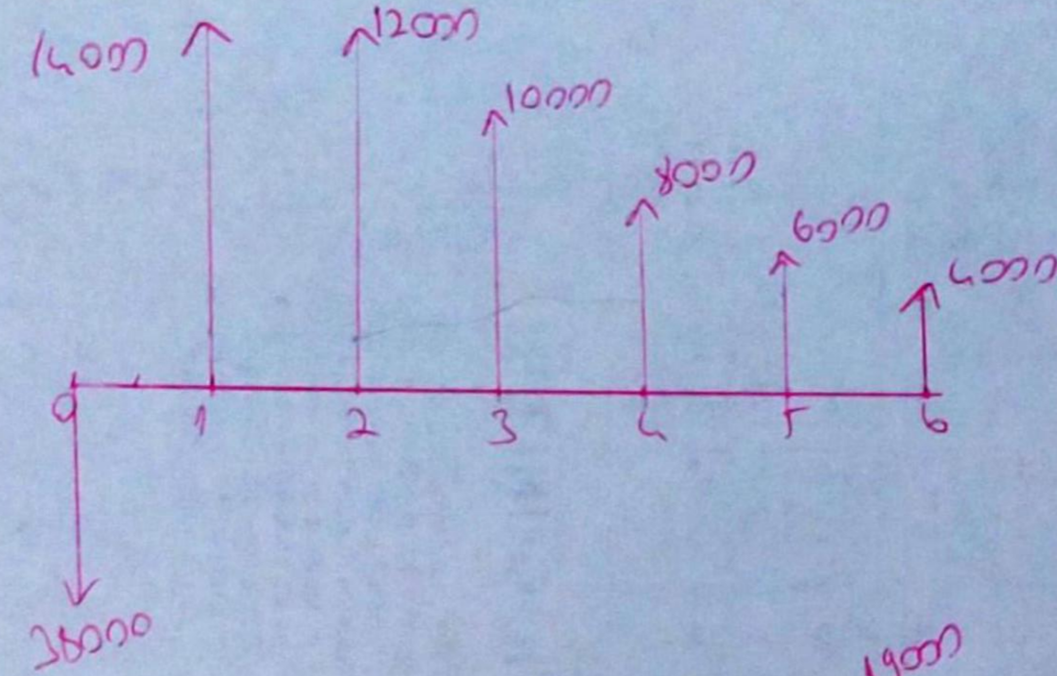
- Payback period
- Net Present value
- Breakeven point
- Benefit/Cost analysis

Problem-1

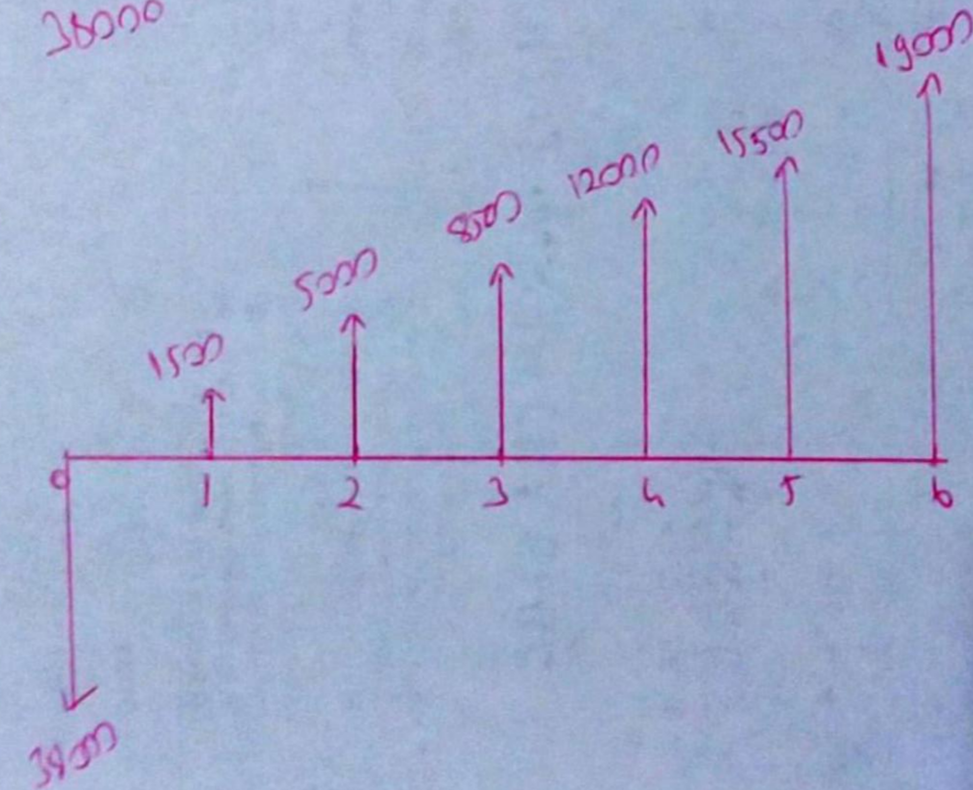
- A company wants to acquire new equipment for its new production plant. After determining the incomes and outcomes of the equipments, the procurement team is going to chose the best one among two alternatives. If MARR is 10%, please determine which the best alternative is.

	Machine X	Machine Y
Initial Cost	38000 $	38000$
Net Income at first year (After subtracting all expenses)	14000$	1500$
Income at upcoming years	Decreases by 2000$ each year	Increases by 3500$ each year
Service Life	6	6

	0	1	2	3	4	5	6
	-38000	+14000	12000	10000	8000	6000	4000
Present	-38000	14000(P/F,10%,1) =12727,27	12000(P/F,10%, 2)=9917,36	10000(P/F,10 %,3)=7513,15	8000(P/F,10% ,4)=5464,11	6000(P/F,10% ,5)	4000(P/F,10% ,6)
Net	-38000	=- 38000+12727,27	=- 25373+9917,36	=- 15355,37+75 13,15	-2378,11	1347,42	


14000
12000
10000
8000
6000
4000
0
1
2
3
4
5
6
38000

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


1500
5000
8500
12000
15500
19000
0
1
2
3
4
5
6
38000

Machine X

Years	0	1	2	3	4	5	6
Cash Flow	38000	14000	12000	10000	8000	6000	4000
Present Value	-38000	12727,27	9917,36	7513,15	5464,11	3725,53	2257,89
Net Present Value	-38000	-25373,73	-15355,37	-7842,22	-2378,11	+1347,42	+3605,31

1347

5

6

Machine Y

2378

Years	0	1	2	3	4	5	6
Cash Flow	38000	1500	5000	8500	12000	15500	19000
Present Value	-38000	1363,64	4132,23	6386,18	8196,16	9624,28	10725
Net Present Value	-38000	-36636,36	-32504,13	-26117,95	-17921,79	-8297,51	2427,49

Problem-2

a) If monthly interest rate is 2%, what is the effective interest rate semi-annually?
b) If the quarterly interest rate is 5%, what is the effective interest rate semiannually?
c) If the quarterly interest rate is 5% , what is the effective interest rate annually ?

Solution

a) $i = (1+0.02)^6 - 1 =$ **12.62 %**

b) $i = (1+0.05)^2 - 1 =$ **10.25 %**

c) $i = (1+0.05)^4 - 1 =$ **21.55 %**

$i_e = (1 + i)^m - 1$

Problem-3

What is the monthly effective interest rate so that a deposit can be tripled within 5 years?

Solution

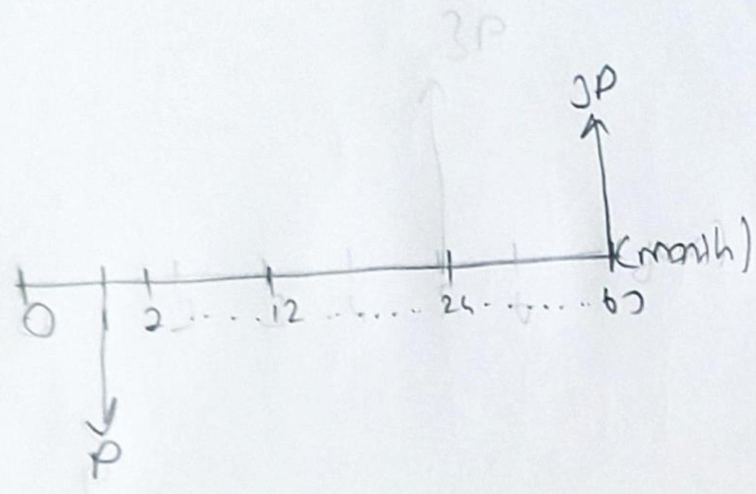
$3P = P(1 + i)^{60}$

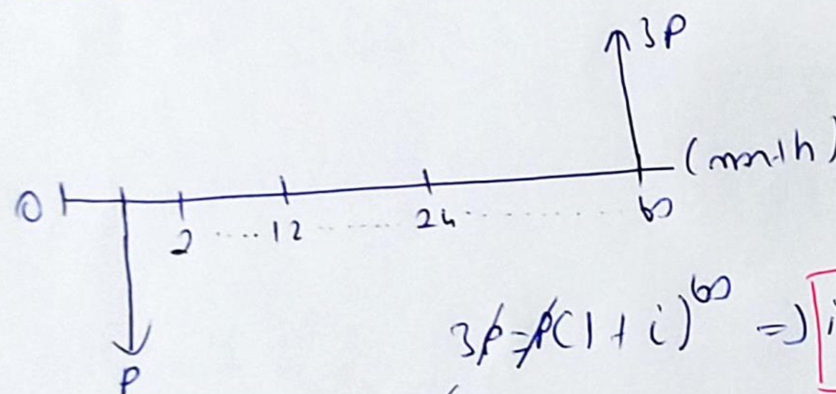
$3 = (1 + i)^{60}$

$i = 1.85\%$ aylık

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

Problem - 3





$3\cancel{P} = \cancel{P}(1+i)^{60} \Rightarrow \boxed{i = 1{,}85\%}$

$\Rightarrow \sqrt[60]{3} = 1+i \Rightarrow$

Problem-4 How much money should be paid every year to ensure that, at the end of two years, the annual deposit is equal to 600 TL paid every six months. Interest rate is 24%, compounding quarterly.

Solution

$$i_{3aylık} = \frac{24}{4} = 6\% \qquad i_{yıllık} = \left(1 + \frac{0.24}{4}\right)^4 - 1 = 26.25\%$$

$$i_{6aylık} = \left(1 + \frac{0.24}{4}\right)^2 - 1 = 12.36\%$$

$$600 \times (F/A, 12.36\%, 4) = X (F/A, 26.25\%, 2)$$

$$600 \times 4.806 = 2.2625 X$$

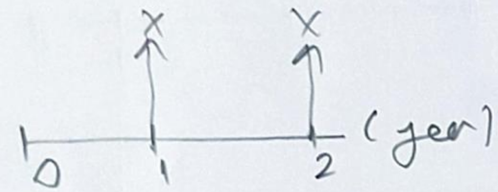
$$\mathbf{X = 1274.15\ \$}$$

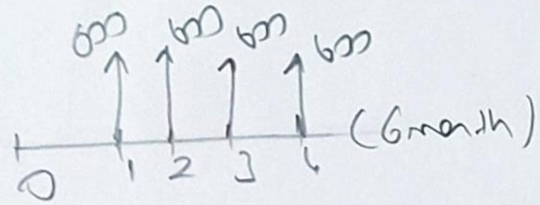
Problem-4

$i_{eff,quarter} = \frac{24}{4} = 6\%$

$i_{eff,annual} = (1+6/100)^4 - 1 = \boxed{0,2624}$

$i_{eff,6month} = (1+6/100)^2 - 1 = \boxed{0,1236}$



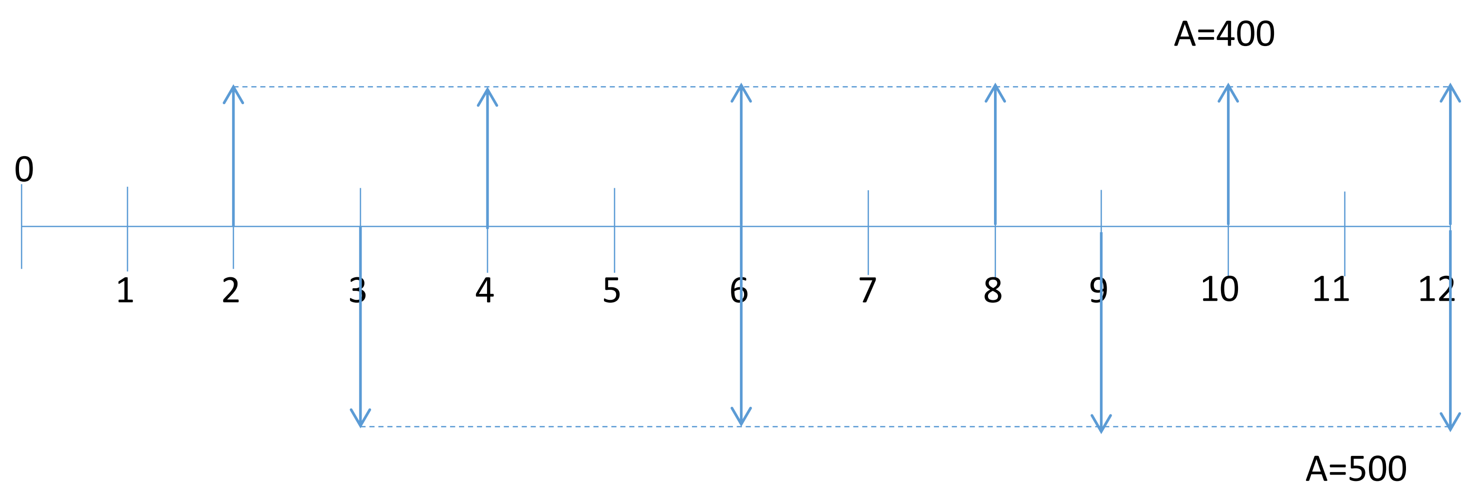


$$X \frac{(1+0,2624)^2}{0,2624(1+0,2624)^2} = 600 \frac{(1+0,1236)^4 - 1}{0,1236(1+0,1236)^4}$$

$$1,419X = 3,014 \times 600$$

$$\boxed{X = 1274,41\ \$}$$

PROBLEM-5



If present value of the given cash flow is zero, what is the value of monthly interest ratio?

P1=400(P/A, i 2 years, 6)=P2
P2=500(P/A,i 3 years,4)=P1

İ 2 years=(1+i year)^2-1

İ 3 years=(1+i year)^3-1

Problem-5

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

$$400 \frac{(1+i_{eff,2y})^6 - 1}{i_{eff,2y}(1+i_{eff,2y})^6} = 500 \frac{(1+i_{eff,3y})^4 - 1}{i_{eff,3y}(1+i_{eff,3y})^4}$$

$$i_{eff,2y} = (1+i_{eff,y})^2 - 1$$

$$i_{eff,3y} = (1+i_{eff,y})^3 - 1$$

insert in to eqs

PROBLEM-6

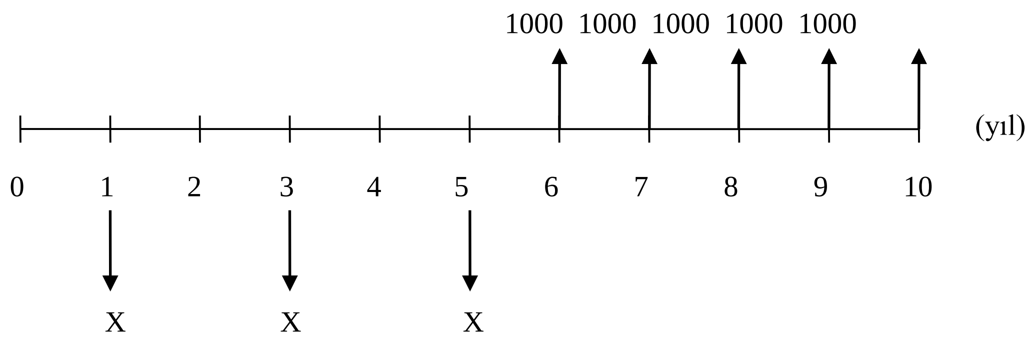
$$400 * \frac{\left(1 + i_{2ay}\right)^6 - 1}{i_{2ay} * \left(1 + i_{2ay}\right)^6} = 500 * \frac{\left(1 + i_{3ay}\right)^4 - 1}{i_{3ay} * \left(1 + i_{3ay}\right)^4}$$

$$i_{2ay} = \left(1 + i_{ay}\right)^2 - 1$$

$$i_{3ay} = \left(1 + i_{ay}\right)^3 - 1$$

PROBLEM-7

The interest rate is nominal rate of 24%, compounding quarterly. Accordingly, what should be the X value in order for the cash flow diagram below to be zero?
(Use the Equal Serial Payments method, including X payments)



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

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

$$i_{3ay}=0{,}24/4=0{,}06$$

$$i_{2yıl}=(1+0{,}06)^8-1 = 0{,}5939$$

$$i_{yıl}= (1+0{,}06)^4 - 1=0{,}2625$$

$$X.(F/A,i_{2yıl}, 3) = 1000*(P/A,i_{yıl}, 5)$$

$$X. \left[\frac{(1+0.5939)^3-1)}{0.5939}\right]= 1000\left[\frac{(1+0.2625)^5-1}{0.2625*(1+0.2625)^5}\right]$$

$$X= 510.610$$

PROBLEM-8

A construction company conducts feasibility study between two options.

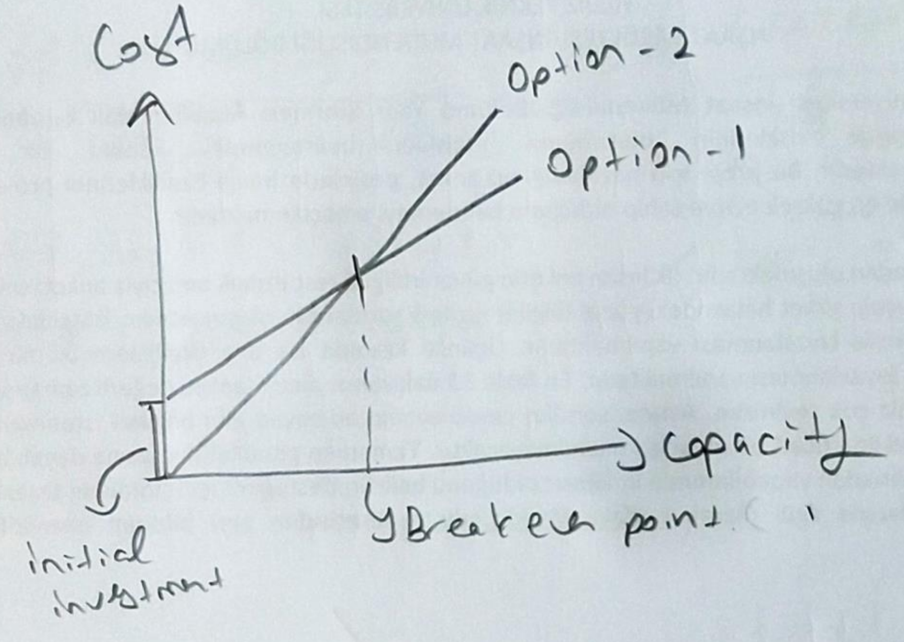
In the first option, the company can buy an excavation machine. This machine has an economic life of 8 years. The initial cost of this machine is 1.000.000 TL and the annual maintenance cost is 150.000 TL. In addition, for this machine, an operator must be employed for 3,000 TL per month and a helper for 100 TL per day. It is known that the salvage value of the machine is 250.000 TL.

Alternatively, the machine can be rented for 2,000 TL per day. This rental is included in the cost of personnel and all other costs.

Use the Break-even method to determine which option should be selected when the MARR value is 8%.

A=-1000.000(A/P,8%,8)-150.000+250.000(A/F,8%,8)-3000(F/A, 8%, 12)-100Tl/day*Xday/year

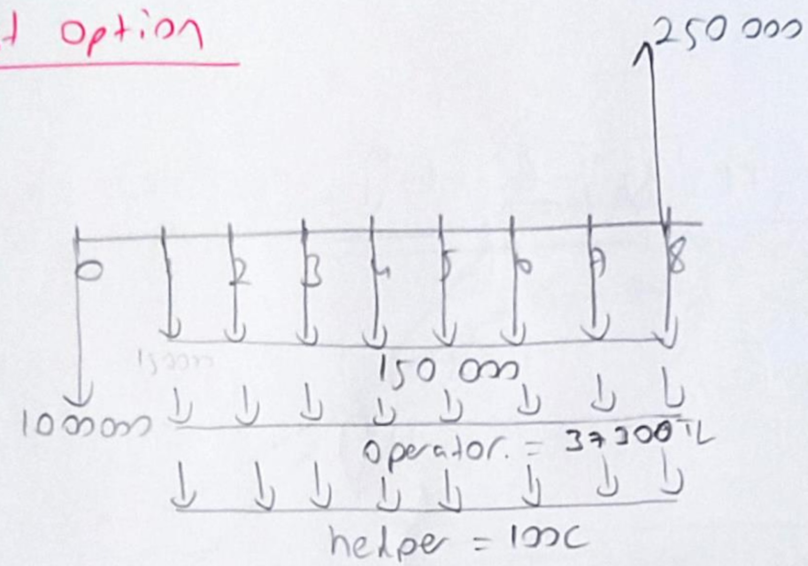
A2=-2000Tl/day*Xday/year



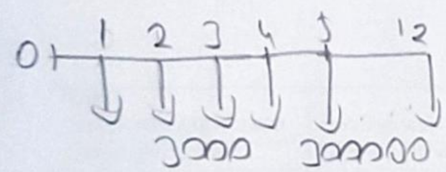
Cost
Option - 2
Option - 1
capacity
Breakeven point
initial investment

• Problem-8

First option



Operator



$$P = 3000 \frac{(1+0,00643)^{12}-1}{0,00643}$$

$$= \boxed{37300,82 \text{ TL}}$$

$$i_{eff,y} = (1+8/100)^{1/12} - 1 = 0,00643$$

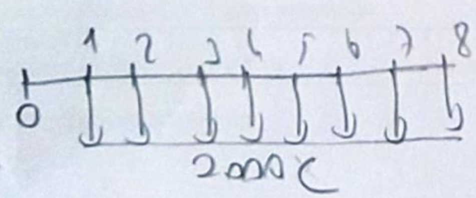
$$A = P\frac{i(1+i)^n}{(1+i)^n-1}$$

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

Annual expense

$$-150000 - 37300,82 - 100C - \underbrace{1000000\frac{0,08(1+0,08)^8}{(1+0,08)^8-1}}_{173927,30} + \underbrace{250000\frac{0,08}{(1+0,08)^8-1}}_{23503,69}$$

Second option



$$= -2000C$$

Find value of C

$C = 177,749$ TL

PROBLEM-8

$0,08=(1+i_{aylık})^{12} - 1 \quad >>> \quad i_{aylık}=0,00643$

- $A_{investment} = 1.000.000*[(0,08*(1+0,08)^8)/((1+0,08)^8-1)]=173.927,3071$
- $A_{annual\ operator} = 3000*[((1+0,00643)^{12}-1)/0,00643]=37.300,82651$
- $A_{maintenance} = 150.000$
- $A_{annual\ salvage} = 250.000*[0,08/((1+0,08)^8-1)]=23.503,69015$
- $A_{helper} = 100\ x$
- $A_{(second\ option)\ =}\ 2000\ x$

(-173.927,3071)-(37.300,82651)-(150.000)+(23.503,69015)-100x=-2000x

(-337.724,4435) = -1900 x

X=177,749

- If machine to be operated more than 178 days in a year, first machine should be selected.

Problem-9

A municipality plans to construct new Metrobus Line for its new residential area. Benefit and cost analysis of system is given as follow;

- Initial investment of the Metrobus system is 15.000.000 TL.
- In addition, Annual maintenance costs are 250.000 TL. Operating and energy costs are expected to be 500.000 TL/year and these expenses are expected to rise by 50.000 once a three year.
- Municipality expects that revenue of the system will be 1.000.000 TL and it is expected that this revenue is going to increase 200.000 once in two years.
- Users of this system also are going to save 3.000.000 TL in a year.
- Unfortunately, Costs of environmental effects of this systems are estimated as 1.000.000 in a year.
- Economic life of the system is 30 years.

As a decision maker of this municipality, by using benefits and costs analysis, please decide whether invest in this system or not. MARR should be taken as 10%.

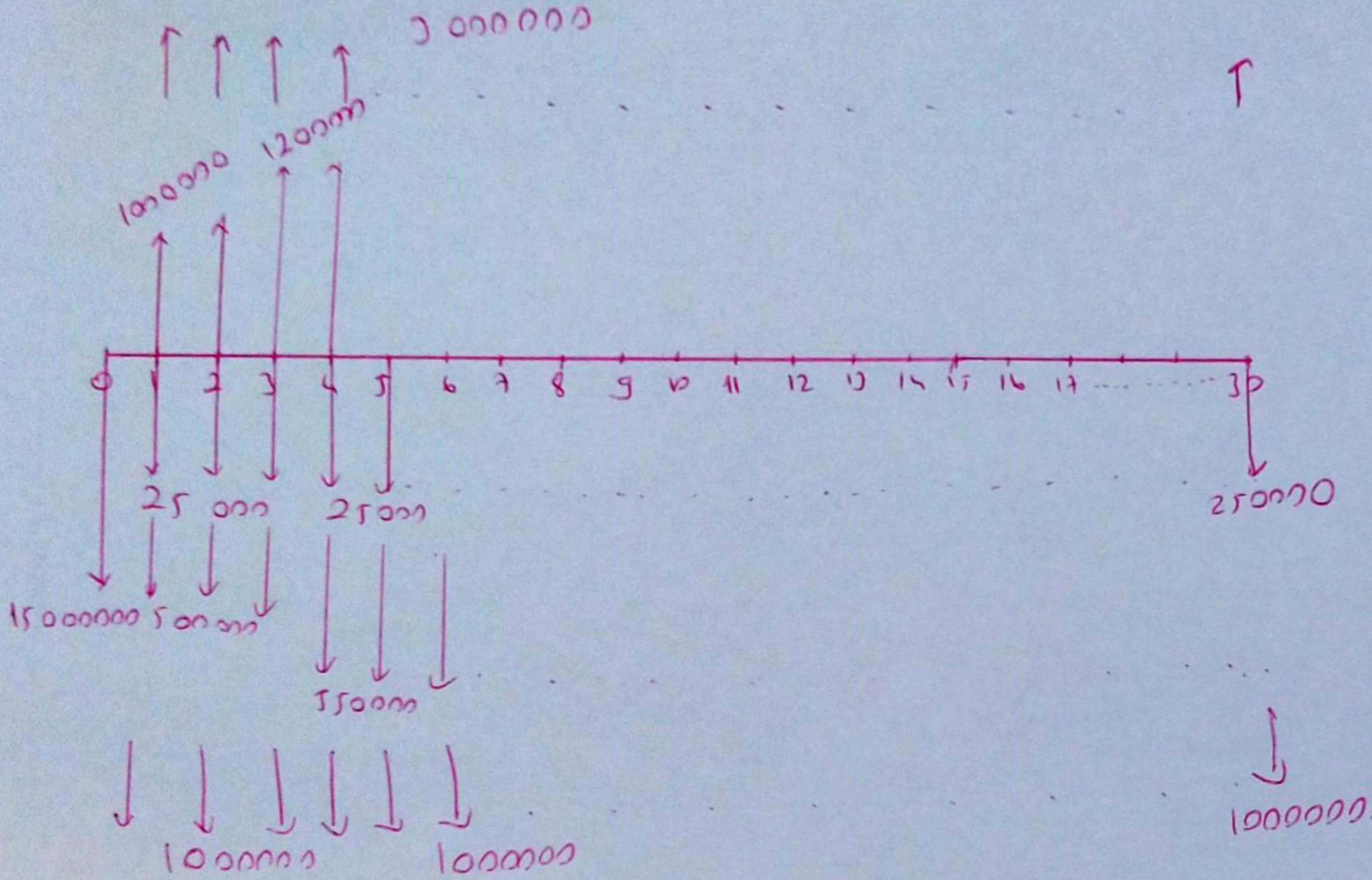
Problem-9

- **Costs?**

– Initial investment
– Maintenance
– Energy
– Direct Revenue obtained from the system

- **Benefits?**

– Benefits of users from the system
– Environmental Effects


3 000000
1000000
1200000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 ... 30
25 000
25000
250000
15000000
500000
550000
1000000
1000000
1000000.

Net Present value of costs

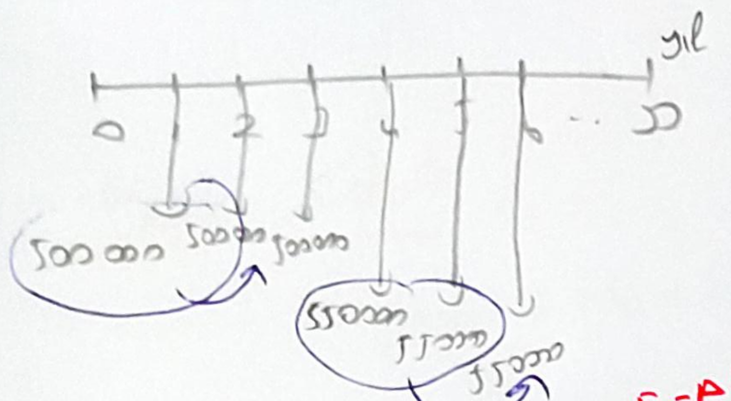
Maintenance

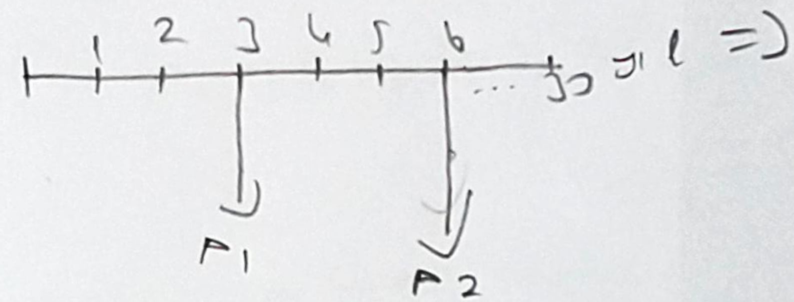
$$250000 \times \frac{(1,1)^{20}-1}{0,1(1,1)^{20}} = 2356728,616 \text{ TL} \qquad = P = A\frac{(1+i)^n-1}{i(1+i)^n}$$

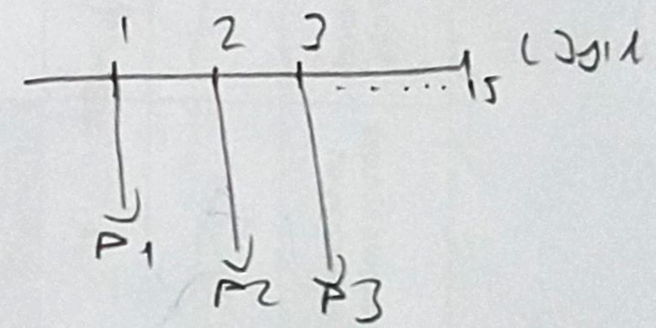
$$i_{2year} = (1,1)^2 - 1 = 0,21$$

$$i_{3year} = (1,1)^3 - 1 = 0,331$$

Energy







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

$$P_1 = 500000\,\frac{(1,1)^3-1}{0,1} = 1655000$$

$$P_2 = 550000\,\frac{(1,1)^3-1}{0,1} = 1820500$$

$$G = 165500$$

$$P = P_1 + G\left[\frac{1}{i} - \frac{n}{(1+i)^n-1}\right]$$

$$P = 1655000 + 165500 \times \left[\frac{1}{0,331} - \frac{10}{(1,331)^{10}-1}\right] = 2054388,661$$

$$P = 2054388,661\,\frac{(1,331)^{10}-1}{0,331(1,331)^{10}} = 5850919,772 \text{ TL}$$

Total Revenue

$$P_1 = 1000000 \times \frac{(1,1)^2 - 1}{0,1} = 210000$$

$$P_2 = 1200000 \times \frac{(1,1)^2 - 1}{0,1} = 252000$$

$$G = 42000$$

$$A = 210000 + 42000 \times \left[\frac{1}{0,21} - \frac{15}{(1,21)^{15} - 1}\right]$$

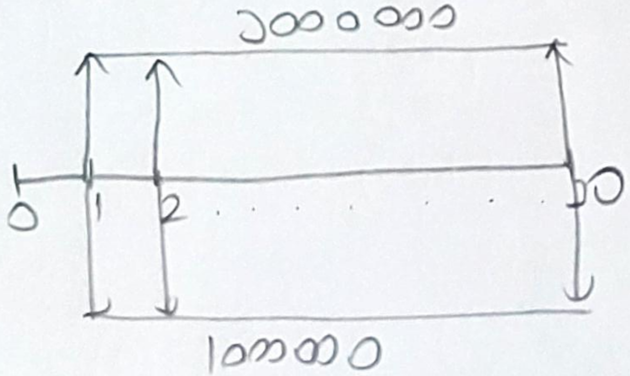
$$= 3717007,36$$

$$P = 3717007,36 \left(\frac{(1,21)^{15} - 1}{0,21\,(1,21)^{15}}\right) = 16685671,646$$

Net Cost

+ initial investment + Maintenance + Energy − Total revenue = + 6517897

Net Benefit



$$2000000 \times \frac{(1,1)^{30} - 1}{0,1\,(1,1)^{30}} = 18854000$$

$$\frac{\text{Fayda}}{\text{Maliyet}} = 2,8931$$

Problem-9

Costs=

$$-15.000.000 - 250.000 * 9{,}427 - 500.000 * \left[\frac{(1+0{,}1)^3 - 1}{0{,}1 * (1+0{,}1)^3}\right] - 550.000 * 2{,}487 * \frac{1}{(1+0{,}1)^3} - \cdots - 950.000 * 2{,}487 * \frac{1}{(1+0{,}1)^{27}} + 1.000.000 * \left[\frac{(1+0{,}1)^2 - 1}{0{,}1 * (1+0{,}1)^2}\right] + 1.200.000 * 1{,}736 * \frac{1}{(1+0{,}1)^2} + \cdots + 3.800.000 * 1{,}736 * \frac{1}{(1+0{,}1)^{28}} = -6.517.897$$

Problem-9

Benefits=

$$3.000.000 * \left[\frac{(1+0,1)^{30}-1}{0,1*(1+0,1)^{30}}\right] - 1.000.000$$
$$* \left[\frac{(1+0,1)^{30}-1}{0,1*(1+0,1)^{30}}\right] = 18.854.000$$

Problem-9

Benefits/ Costs=

Benefits/ Costs $=18.854.000/6.517.897$

$=2,89265 > 1$

Is the system feasible ?

PROBLEM-10

a) Draw the network.

b) Find critical paths

c) Calculate normal duration and cost

d) Please perform necessary crashing to complete project in 15 months and calculate the cost of crashing at every step.

Relationships between the activities
Activity D can start after activity A, B, C are completed.
In order to start activity E, activity B and C have to be completed.
Activity F can start after activity C is completed.
Activity G can start after activity D is completed.
Activity H is related to completion of activity D and E.

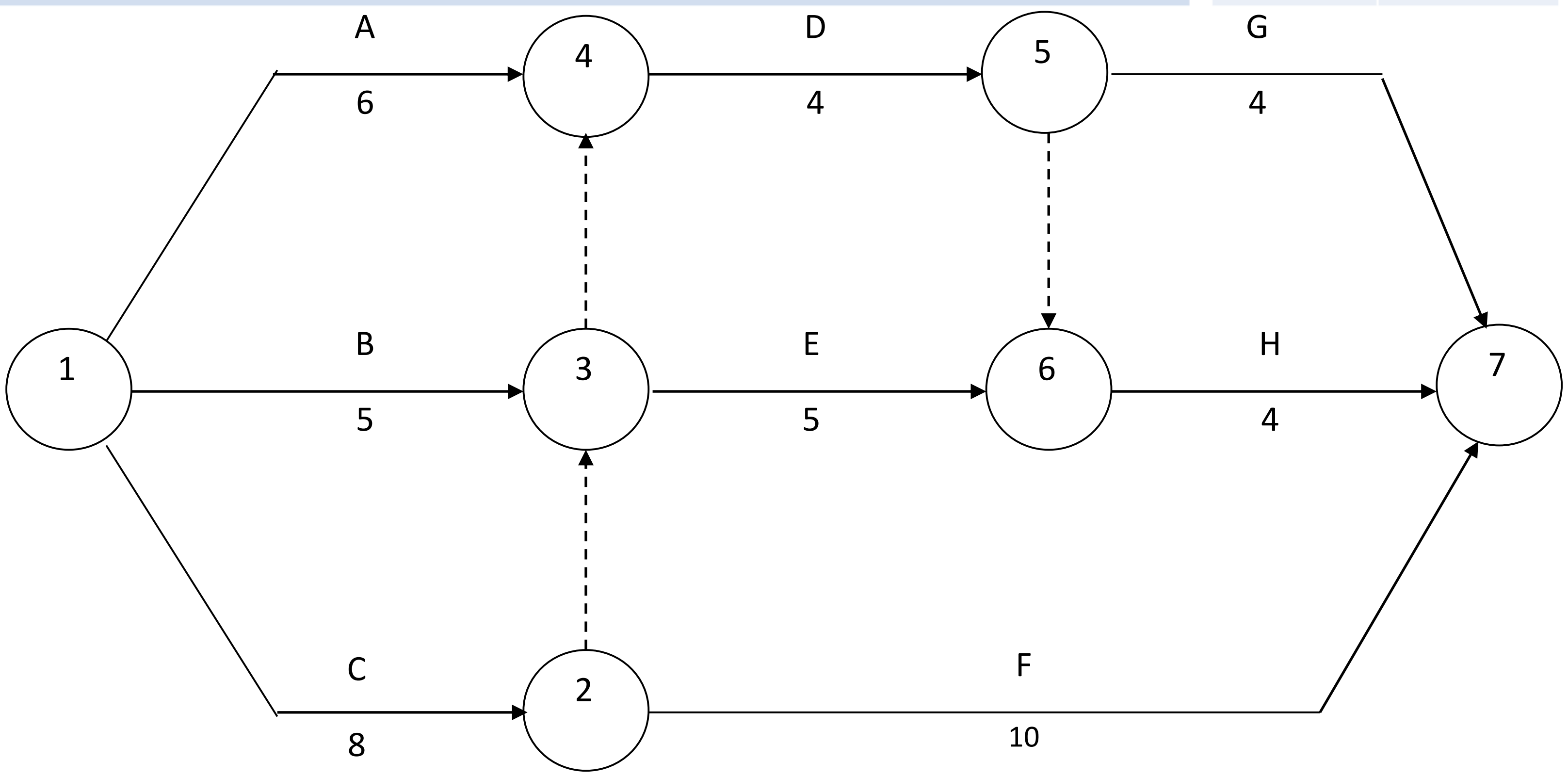
Act.	Dr. (Month)
A	6
B	5
C	8
D	4
E	5
F	10
G	4
H	4

PROBLEM-10

a)- Draw the network

Relationships between the activities
Activity can start after activity A, B, C are completed.
In order to start activity E, activity B and C have to be completed.
Activity F can start after activity C is completed.
Activity G can start after activity D is completed.
Activity H is related to completion of activity D and E.

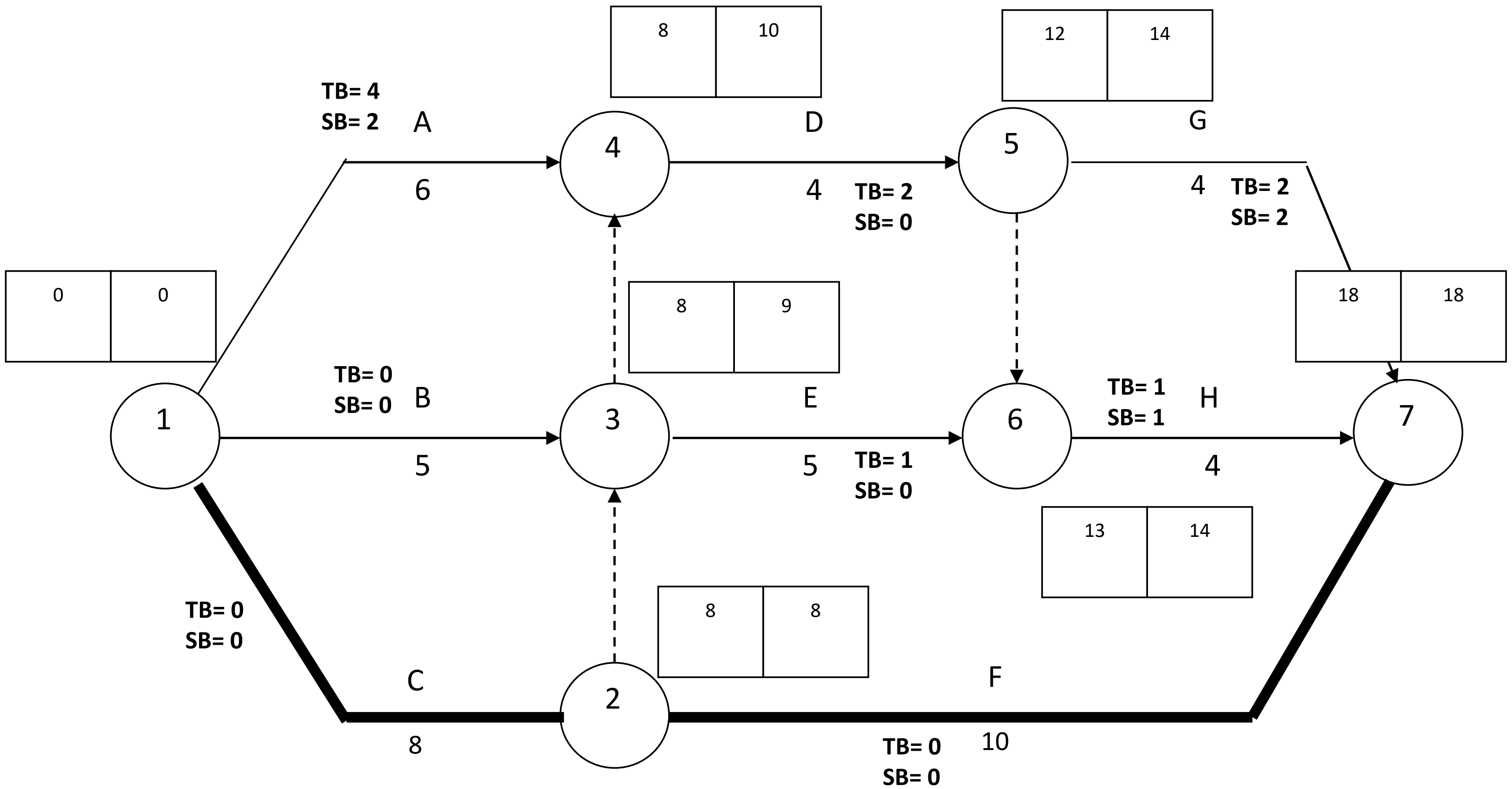
Act.	Dr. (Month)
A	6
B	5
C	8
D	4
E	5
F	10
G	4
H	4



PROBLEM-10

b) Find critical path

Act.	Dr. (Month)
A	6
B	5
C	8
D	4
E	5
F	10
G	4
H	4



Critical Path: 1-2, 2-7 or C-F

Normal Duration: 18 month

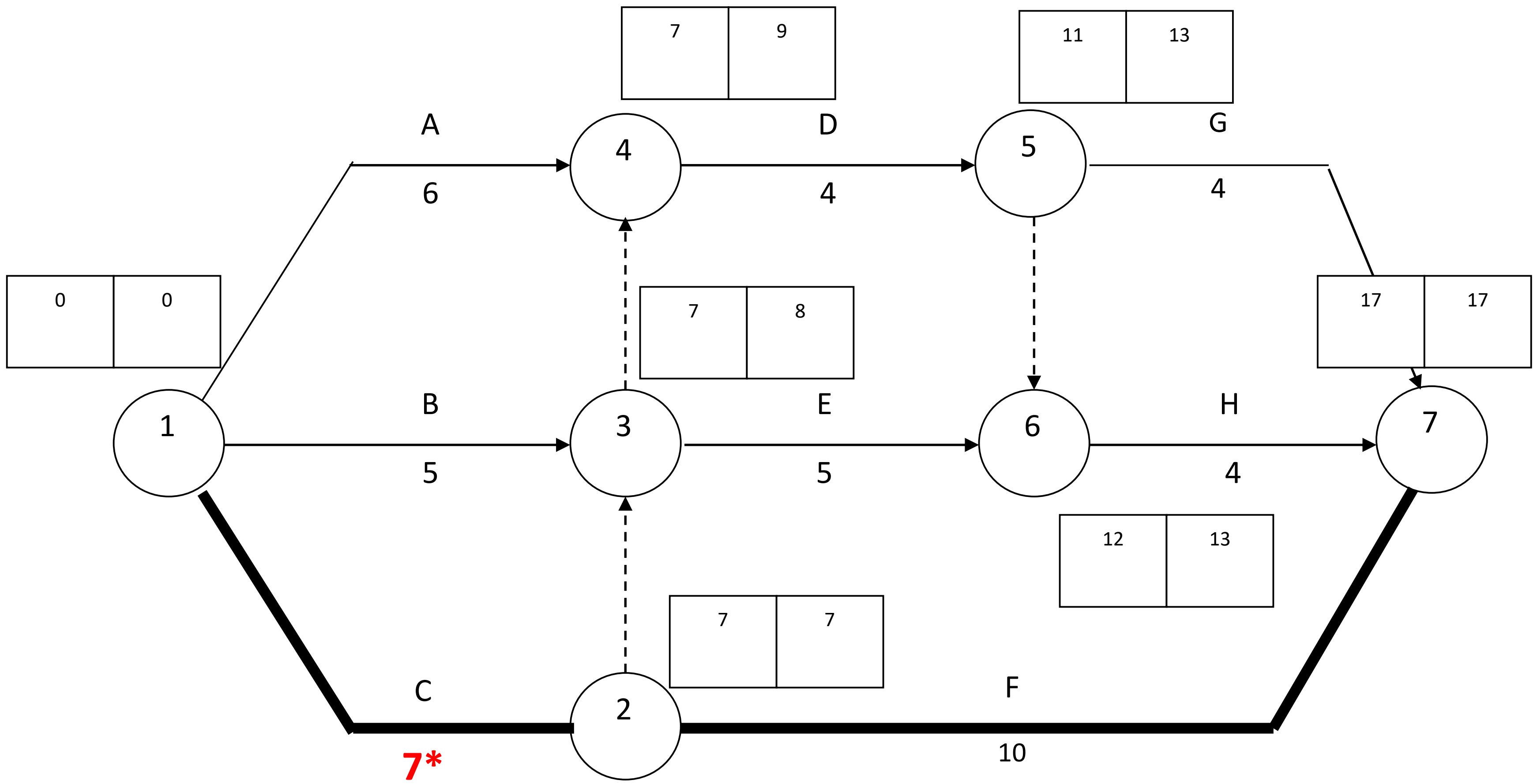
PROBLEM-10

c) Calculate normal cost

Akt.	ND (Month)	CD(Month)	NC (TL)	First CC (TL)	Second CC (TL)	Third CC (TL)	Fourth CC (TL)
A	6	5	200	225	-	-	-
B	5	3	400	440	480	-	-
C	8	4	900	920	965	1010	1060
D	4	1	600	610	640	685	-
E	5	3	400	415	440	-	-
F	10	6	700	730	745	775	835
G	4	2	500	520	550	-	-
H	4	2	100	120	150	-	-

Normal Duration: 18 ay
Normal Cost: 3800 TL

First Crashing: ACT. 1 – 2 (C) / 8 month ⟶ 7 month / Const = 20 TL



First Crashing

C- 1 Day, $T_1 = 17$

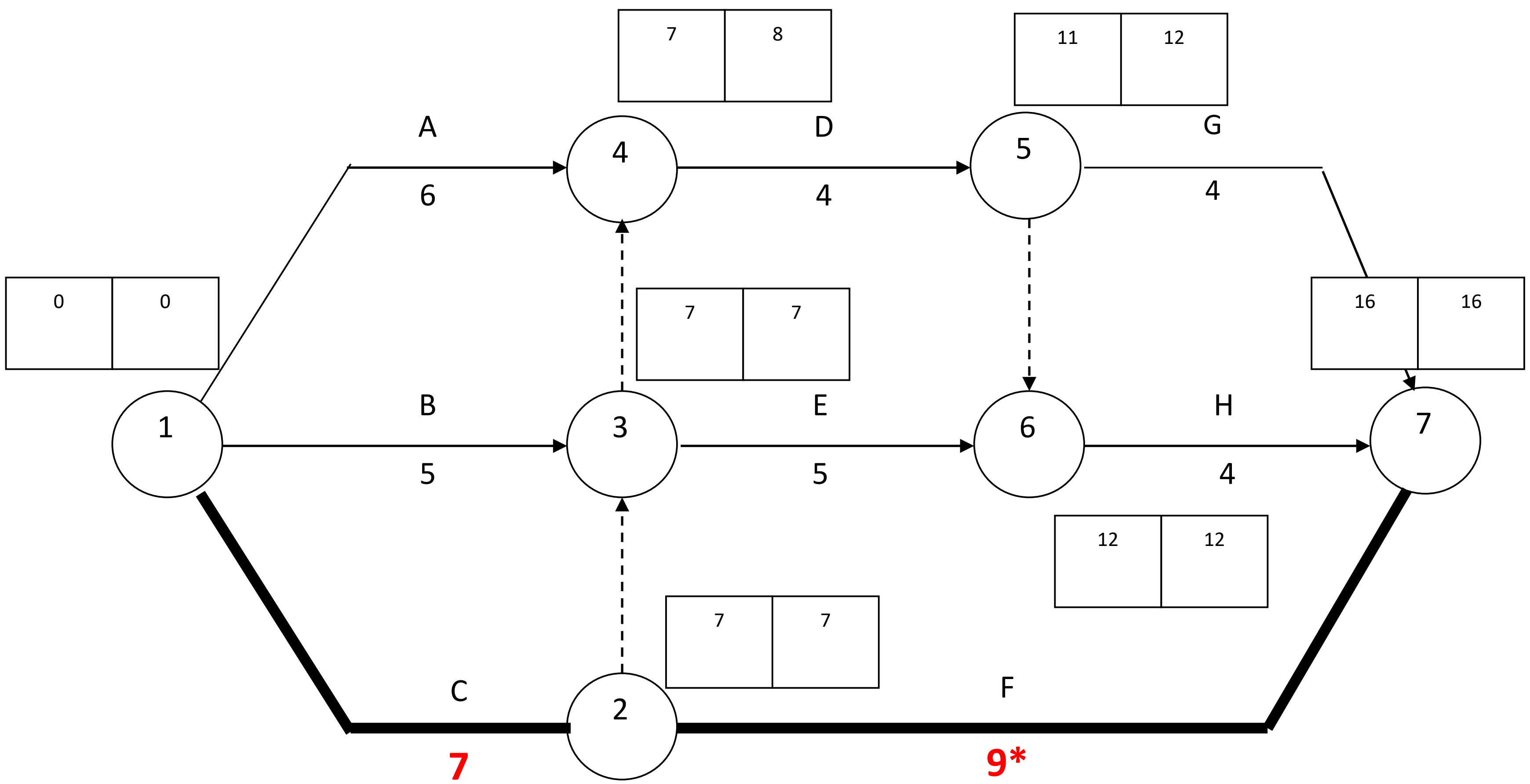
$C_1 = 3800 + 20 = 3820$ TL

920-900= 20 TL

CP : $C^{20} - F^{30}$

Akt.	ND (Month)	CD(Month)	NC (TL)	First CC (TL)	Second CC (TL)	Third CC (TL)	Fourth CC (TL)
A	6	5	200	225	-	-	-
B	5	3	400	440	480	-	-
C	8	4	900	920	965	1010	1060
D	4	1	600	610	640	685	-
E	5	3	400	415	440	-	-
F	10	6	700	730	745	775	835
G	4	2	500	520	550	-	-
H	4	2	100	120	150	-	-

Second Crashing: Act. 2 – 7 (F) / 10 month ⟶ 9 month / Cost = 20 TL



Second Crashing

F - 1 GÜN, $T_2 = 16$

$C_2 = 3820 + \mathbf{30} = 3850$ TL

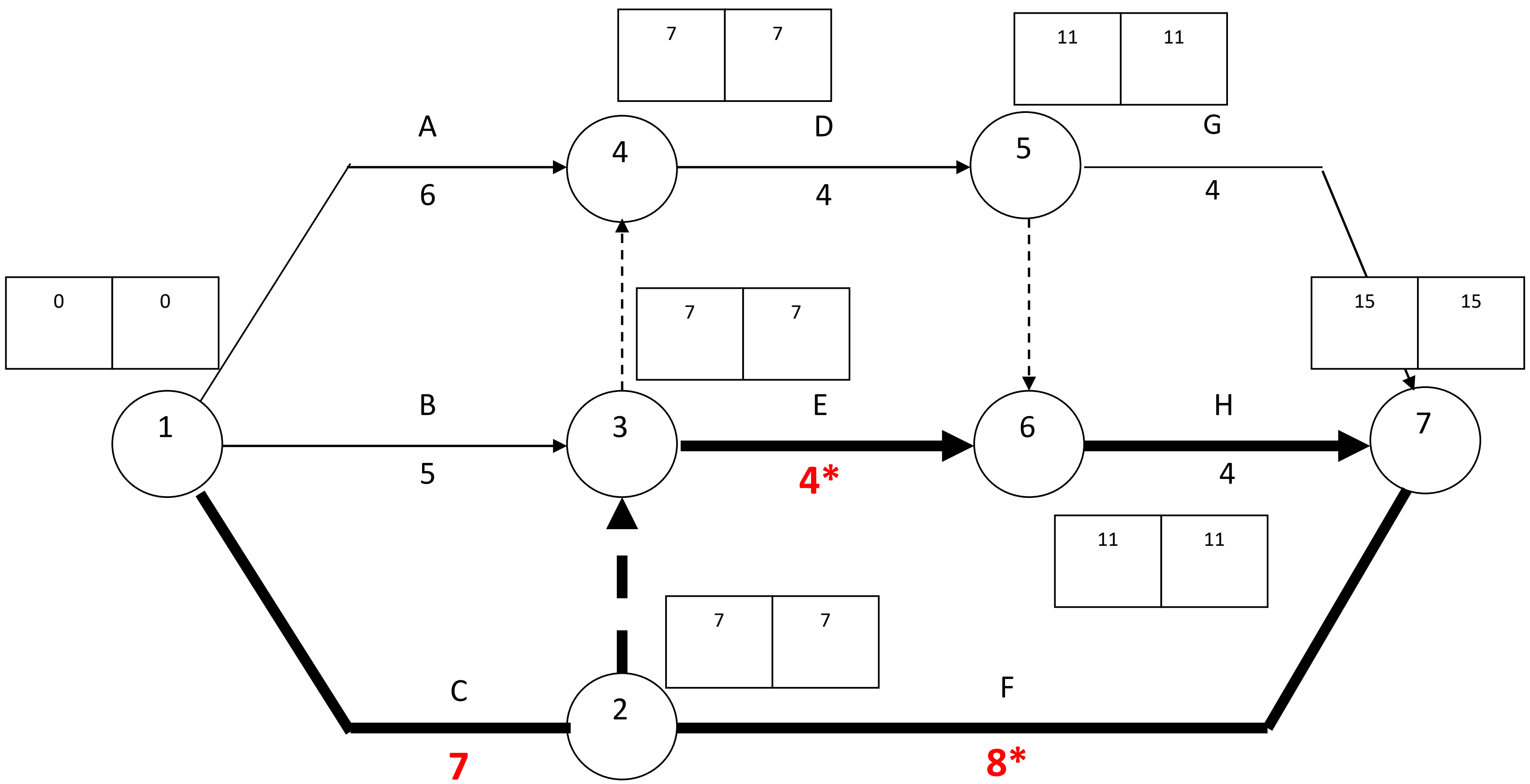
730-700= 30 TL

CP : $C^{45} - F^{30}$

Akt.	ND (Month)	CD(Month)	NC (TL)	First CC (TL)	Second CC (TL)	Third CC (TL)	Fourth CC (TL)
A	6	5	200	225	-	-	-
B	5	3	400	440	480	-	-
C	8	4	900	920	965	1010	1060
D	4	1	600	610	640	685	-
E	5	3	400	415	440	-	-
F	10	6	700	730	745	775	835
G	4	2	500	520	550	-	-
H	4	2	100	120	150	-	-

Third Crashing: Act. 2 – 7 (F) / 9 month → 8 month/ cost = 25 TL

Act 3 – 6 (E) / 5 month → 4 month/ cost = 15 TL



Third Crashing

E&F 1 DAY, $T_3 = 15$

$C_3 = 3840$ **+ 15 + 15** $= 3880$

745-730= 15 TL

415-400= 15 TL

CP : $C^{45} – F^{15}$

$C^{45} – E^{15} - H^{20}$

Akt.	ND (Month)	CD(Month)	NC (TL)	First CC (TL)	Second CC (TL)	Third CC (TL)	Fourth CC (TL)
A	6	5	200	225	-	-	-
B	5	3	400	440	480	-	-
C	8	4	900	920	965	1010	1060
D	4	1	600	610	640	685	-
E	5	3	400	415	440	-	-
F	10	6	700	730	745	775	835
G	4	2	500	520	550	-	-
H	4	2	100	120	150	-	-

Assessments related to cost

- **Crashing Costs**

1. Cost of first crashing**: 920 – 900 =20 TL**
2. Cost of second crashing: **730 – 700 =30 TL**
3. Cost of third crashing: **(745 – 730) + (415 – 400)= 30 TL**

Total crashing cost: **80 TL**

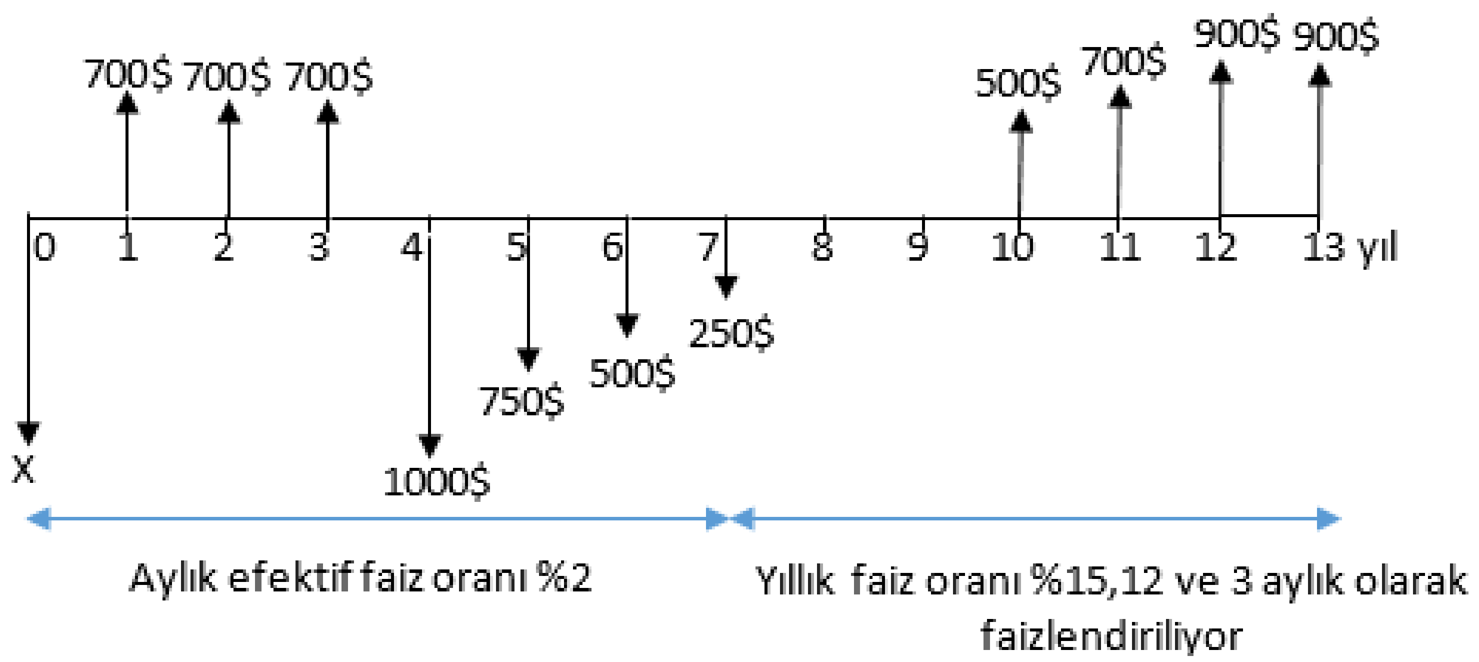
Total Cost of the Project

1. Total cost of the project after first crashing: 3800 +20= 3820 TL

2. Total cost of the project after second crashing : 3800 + 20 + 30 = 3850 TL

3. Total cost of the project after third crashing : 3800 + 20 + 30 + 15 + 15= 3880 TL

PROBLEM-11



$X = 700 * (P/A, 0{,}2682{,}3) - (1000 - 250(A/G, 0.02682{,}4))$ * (P/A,0.2682,4) * (P/F,0.2682,3)+(500+200*(A/G,0.16,3)) * (P/A,0.16,3) * (P/F,0.16,2) * (P/F,0.2682,7)+900 * (P/F,0.16,6) * (P/F,0.2682,7) = 832,243