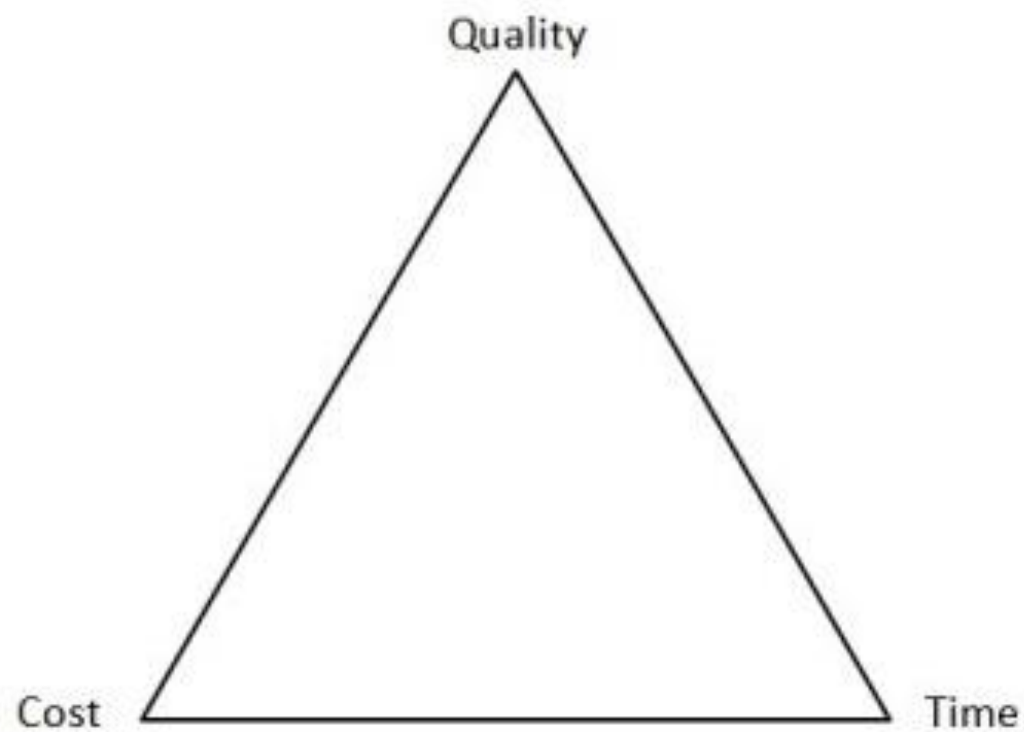
Construction Management

Recitation-2

Project Management Triangle

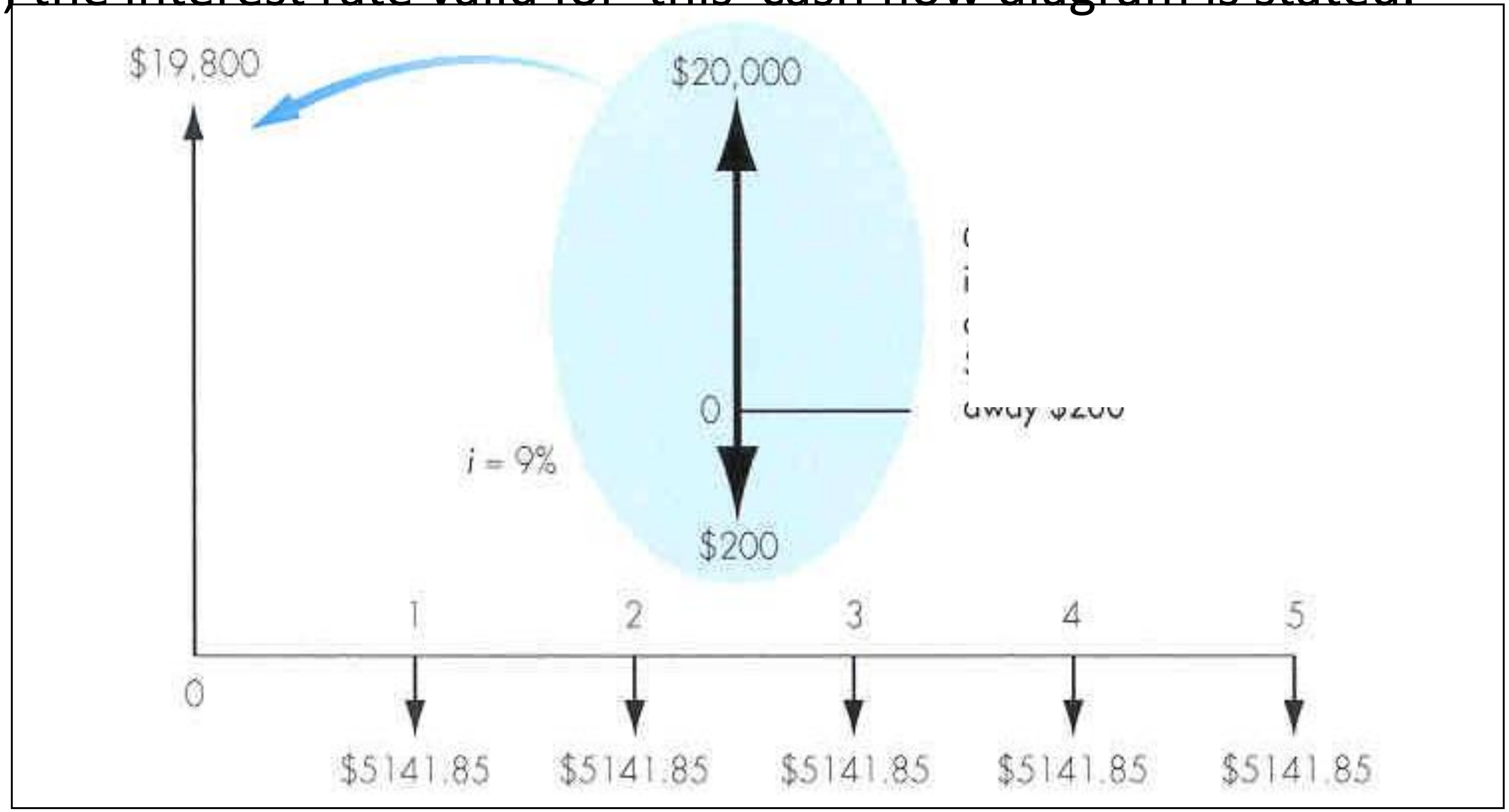


Cash Flow Diagrams

- The estimated inflows (revenues) and outflows (costs) of money are called cash flows.
- The cash flow is fundamental to every economy study.
- Without cash flow estimates over a stated time period, no engineering economy study can be conducted.
- They can be considered as free body diagrams.
- Every person or company has cash receipts- revenue and income (inflows); and cash disbursements- expenses, and costs (outflows).

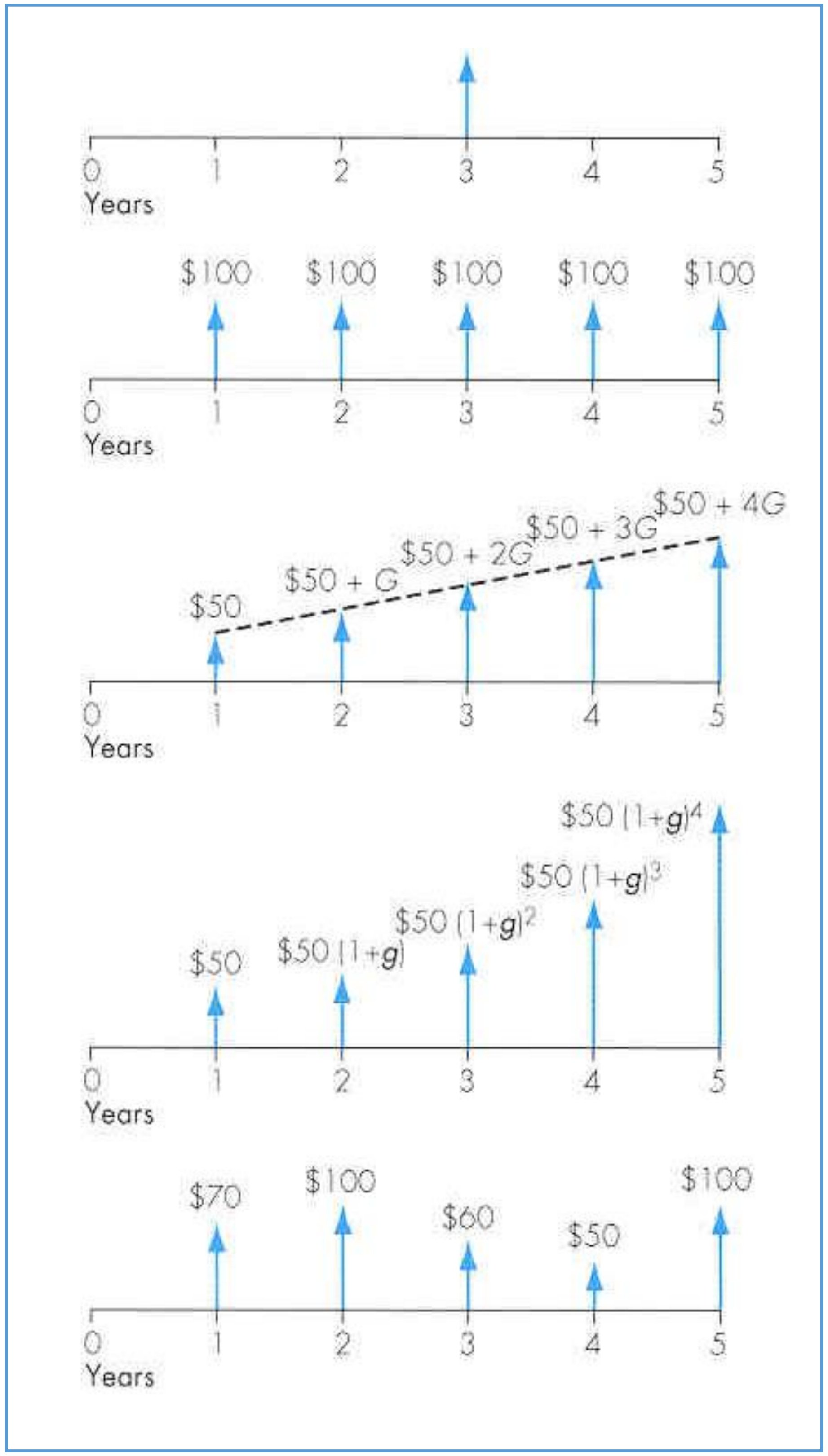
Cash Flow Diagram

An example of cash flow diagram is shown. The inflows and outflows of the company are illustrated as arrows. The direction of the arrows indicate the direction of the money. The time period is shown on the horizontal line. Finally, the interest rate valid for this cash flow diagram is stated.



Types of Cash Flows

- Single payment
- Uniform payment series
- Linear gradient series
- Geometrical gradient series
- Irregular payment series



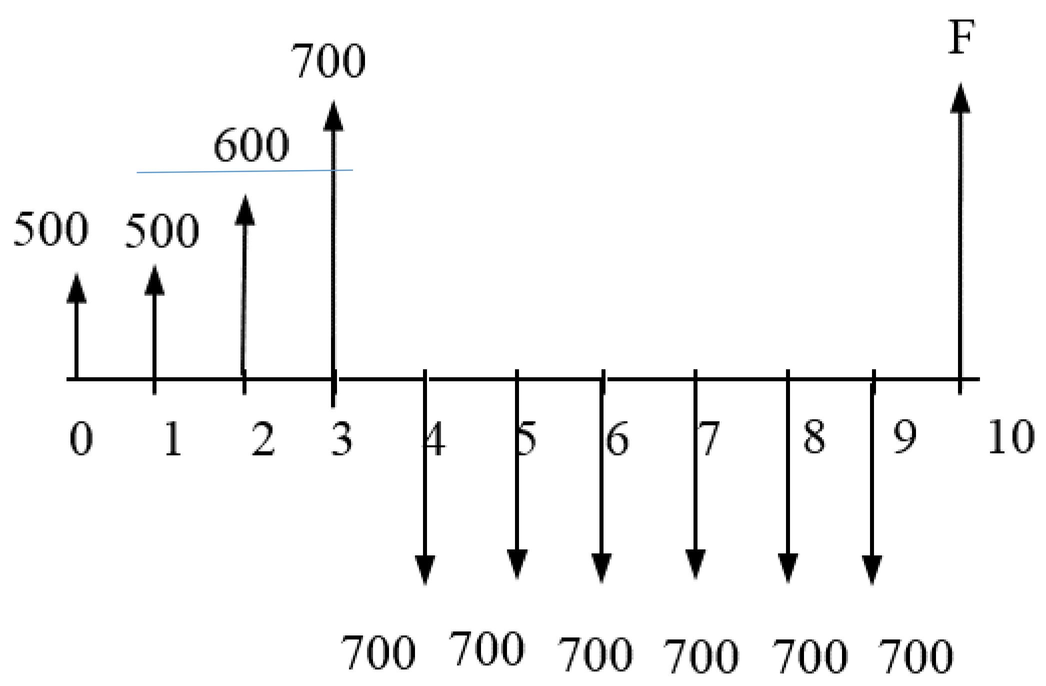
Problem Solving Strategy

1. Draw the cash flow
2. Group the payments in composite cash flow based on their similarity
3. Find payments’ present or future values by using the formulas taught during the class
4. Find Pnet or Fnet

Composite Cash Flows

Example 1:

Calculate the value of this cash flow at the end of 10th year. Annual interest rate is 10%.

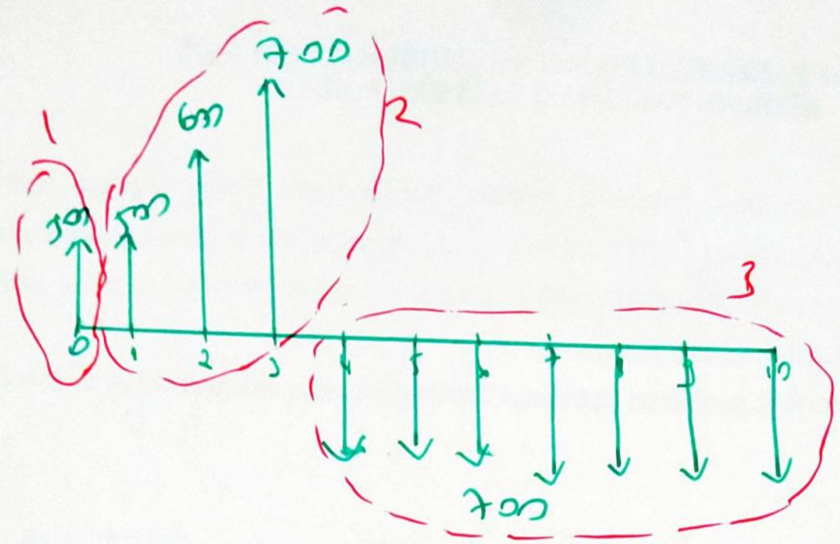


F=500(F/P,10%,10)+(500+100(A/G,10%,3))(F/A,10%,3)(F/P,10%,7)-700(F/A,10%,6)(F/P,10%,1)

Single-Payment Compound-Amount Factor	Single-Payment Present Worth Factor	Uniform Series Compound Amount	Sinking Fund Factor
$F = P(1+i)^n = P(F/P,i,n)$	$P = F\left[\frac{1}{(1+i)^n}\right] = F(P/F,i,n)$	$F = A\left[\frac{(1+i)^n - 1}{i}\right] = A(F/A,i,n)$	$A = F\left[\frac{i}{(1+i)^n - 1}\right] = F(A/F,i,n)$
Capital Recovery Factor	**Uniform-Series Present Worth Factor**	**Uniform Gradient Series Factor**	**Uniform Gradient Series Factor**
$A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$ $A = P(A/P,i,n)$	$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$ $P = A(P/A,i,n)$	$A = A_1 + G\left[\frac{1}{i} - \frac{n}{(1+i)^n - 1}\right]$ $A = A_1 + G(A/G,i,n)$	$A = A_1 - G\left[\frac{1}{i} - \frac{n}{(1+i)^n - 1}\right]$ $A = A_1 - G(A/G,i,n)$
Uniform Gradient Series for Feature Factor		$r = (1+\frac{j}{CK})^C - 1$	$r = (1+\frac{j}{m})^m - 1$
$F = Gx\frac{1}{i}\left[\frac{(1+i)^n - 1}{i} - n\right] = G(F/G,i,n)$			

F=500(F/P,10%,10)+(500+100(A/G,10%, 3))x(F/A,10%,3)x(F/P,10%,7)-700(F/A,10%,6)(F/P,10%, 1)

- 500(1+0,1)^10+(500+100(1/0,1-3/((1+0,1)^3-1))*(((1+0,1)^3-1)/0,1)*(1+0,1)^7-700*((1+0,1)^6-1)/0,1)*(1+0,1)^1



$F_1 = \underset{p}{500} \times (1+i)^n = 500 \times (1,1)^{10} = 1296,87$ TL

$F_2 =$

$$A_2 = A_1 + G\left[\frac{1}{i} - \frac{n}{(1+i)^n - 1}\right]$$

$$= 500 + 100\left[\frac{1}{0.1} - \frac{3}{(1,1)^3 - 1}\right] = 500 + 100 \times (0,9366)$$

$$= 593,66 \text{ TL}$$

$$F_2 = 593,66 \times \frac{(1,1)^3 - 1}{0,1} \times (1,1)^7 = 3829,81$$

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

F_3

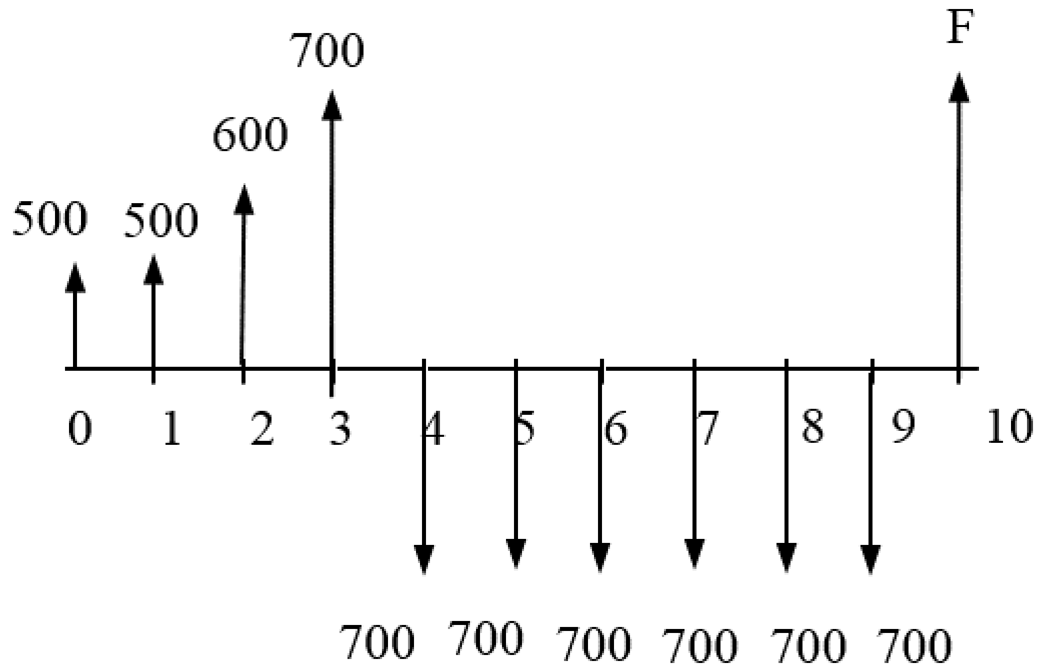
$$700 \times \frac{(1,1)^6 - 1}{0,1} = 700 \times 7,716 = 5401,2$$

$$5401,2 \times (1,1)^1 = 5941,32$$

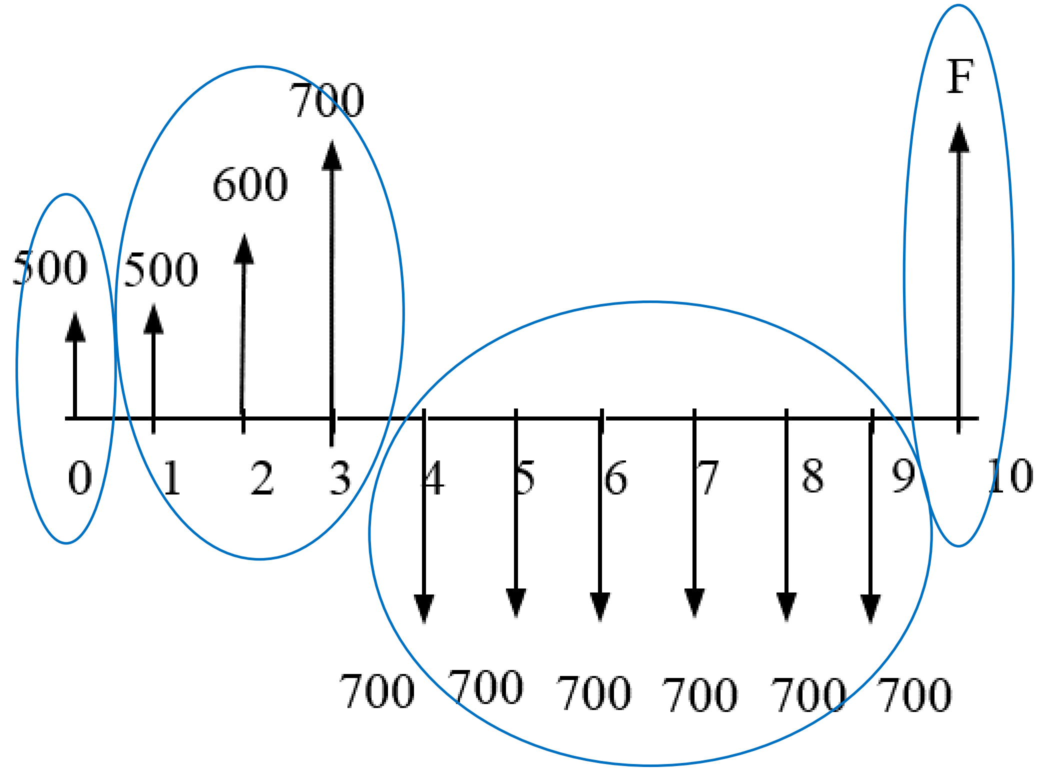
$$F_{net} = 1296,87 + 3829,81 - 5941,32 = -815,33$$

Example 1:

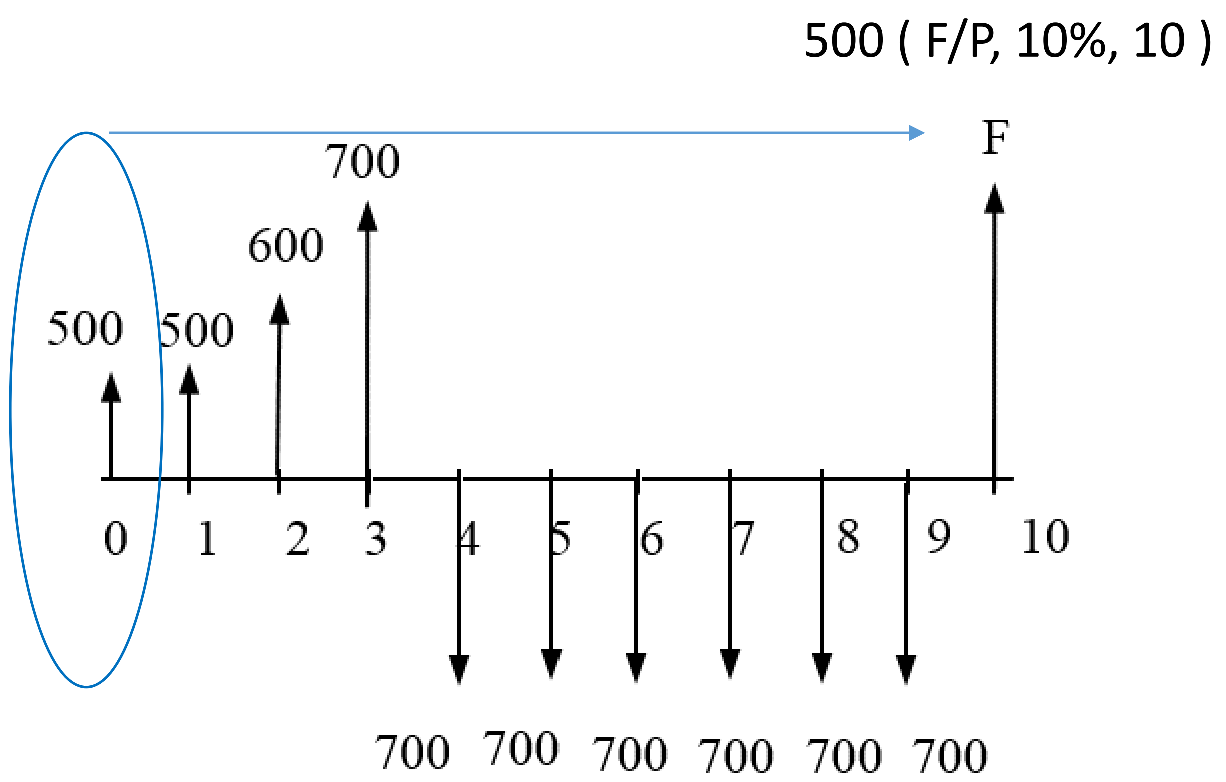
Calculate the value of this cash flow at the end of 10th year. Annual interest rate is 10%.

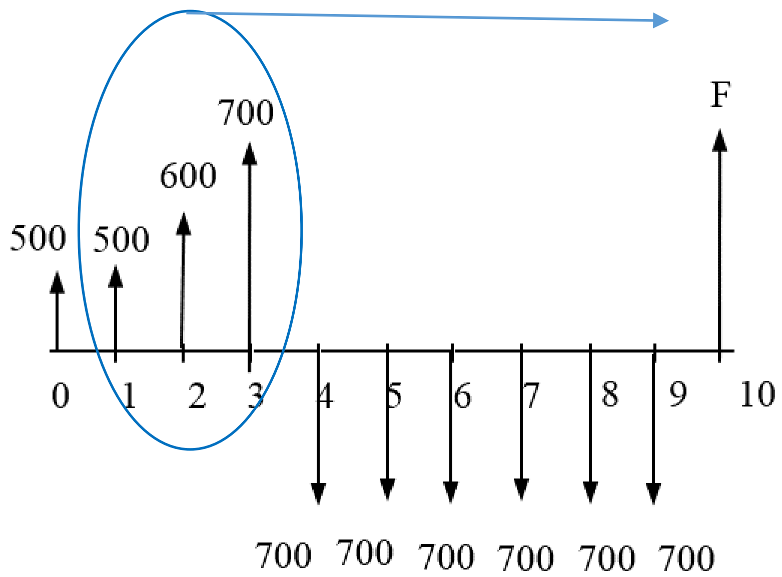


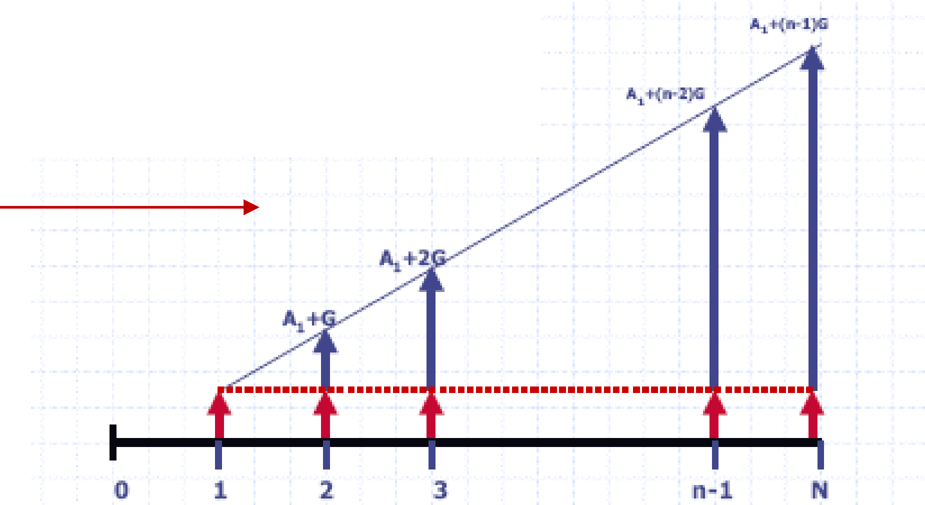
Solution



Solution

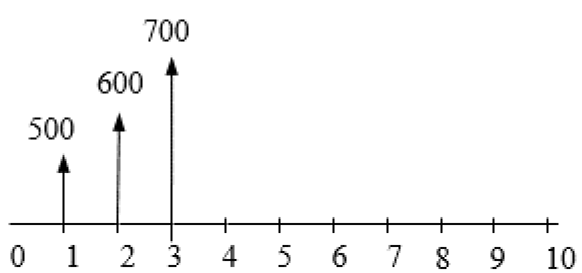

500 (F/P, 10%, 10)
F
700
600
500
500
0
1
2
3
4
5
6
7
8
9
10
700
700
700
700
700
700



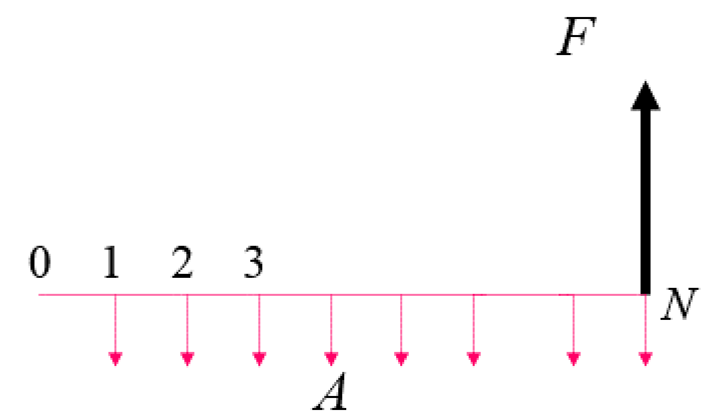


$$A = A_1 + G(A/G, i\%, N)$$

1) Calculation of A value for the arithmetic gradient series.

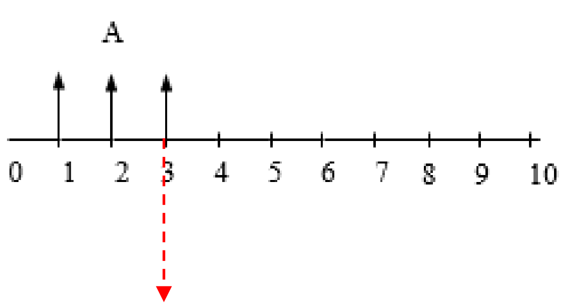


A= 500 + 100 (A/G, 10%, 3)



2) Formula for calculation of F value when A, i and N are given.

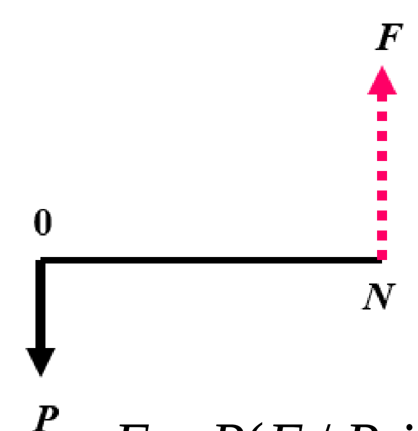
$$F = A(F/A, i\%, N)$$



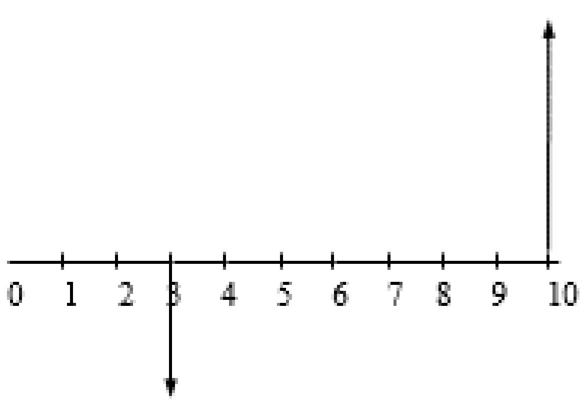
F3 = A (F/A, 10%, 3)

= [500 + 100 (A/G, 10%, 3)] (F/A, 10%, 3)

3) Calculation of F value for the single payment

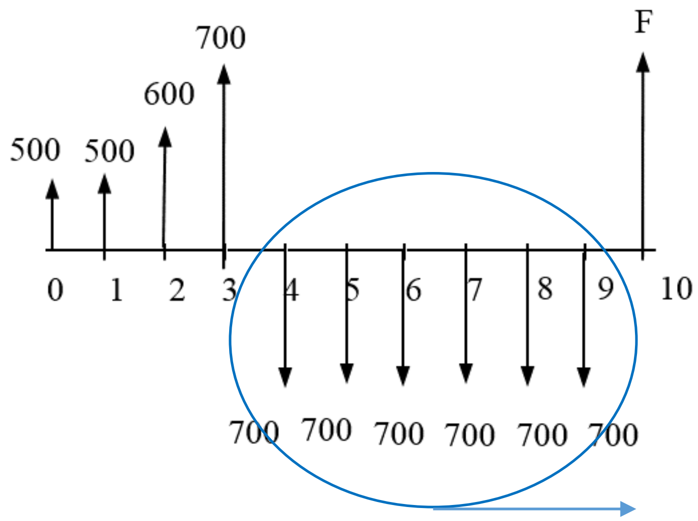


$$F = P(F / P, i, N)$$

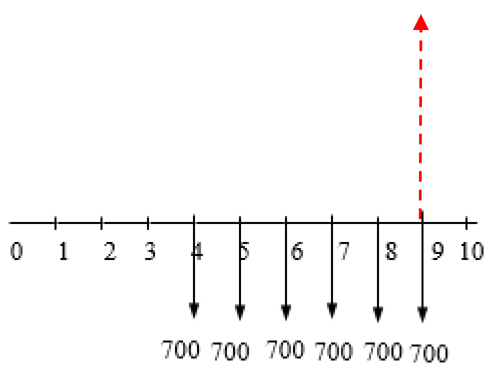


F10 = F3 (F/P, 10%, 7) *F10 is the future value for F3*

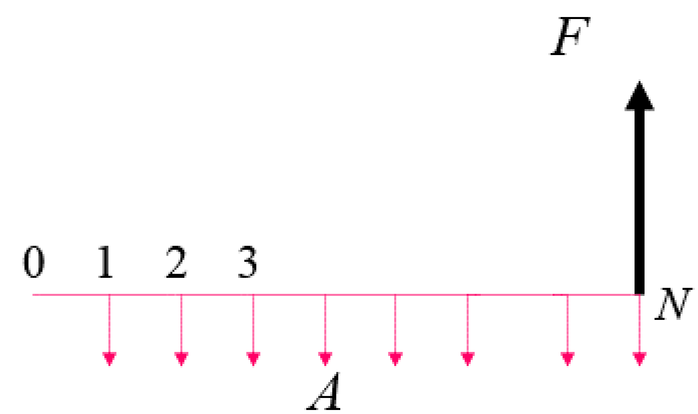
F10 = **[**500 + 100 (A/G, 10%, 3)**]** (F/A, 10%, 3) (F/P, 10%, 7)



2) Formula for calculation of F value when A, i and N are given.

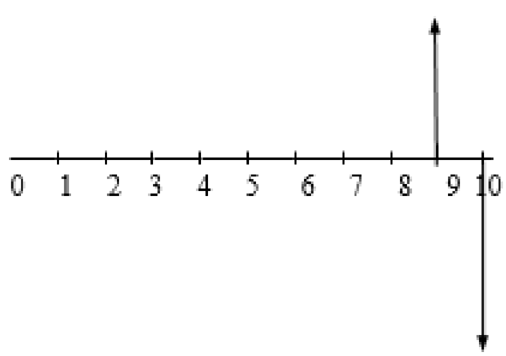


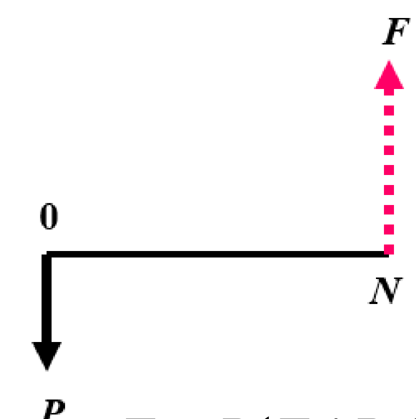
F9= 700 (F/A, 10%, 6)



$$F = A(F/A, i\%, N)$$

2) Calculation of F value for the single payment

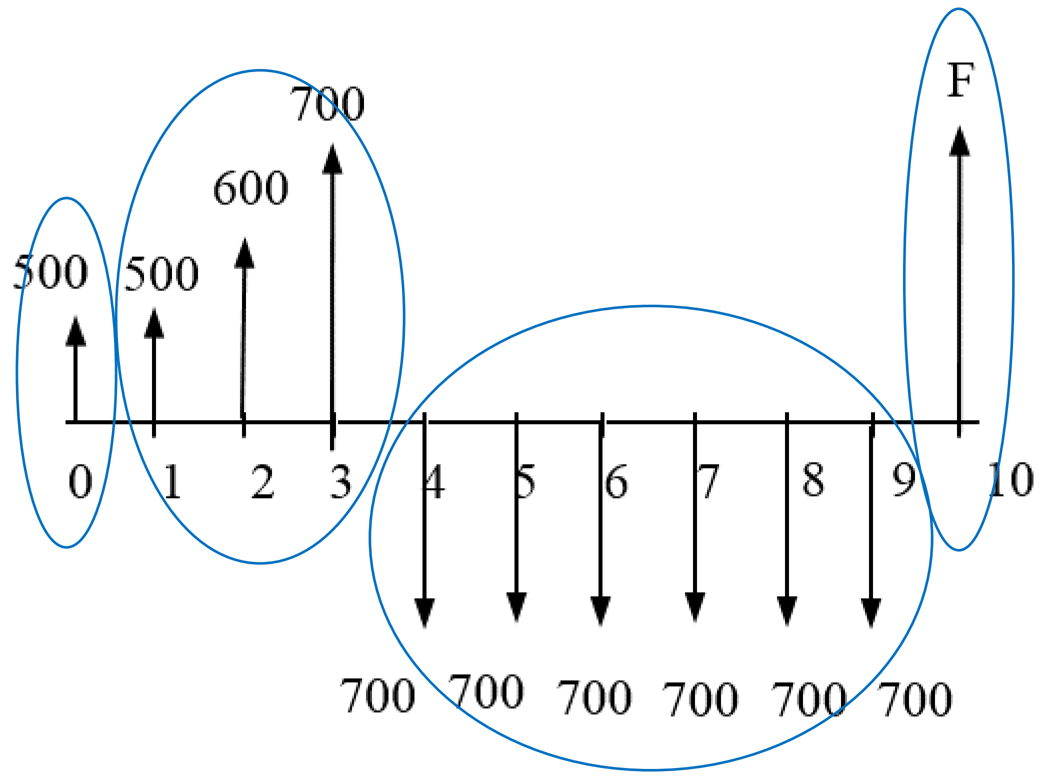




$$F = P(F / P, i, N)$$

F10= F9 (F/P, 10%, 1) *F10 is the future value of F9.*

= (F/A, 10%, 6) (F/P, 10%, 1)



F + 500 (F/P, 10%, 10) + [500 + 100 (A/G, 10%, 3)**]** (F/A, 10%, 3) (F/P, 10%, 7) - 700 (F/A, 10%, 6) (F/P, 10%, 1) = 0

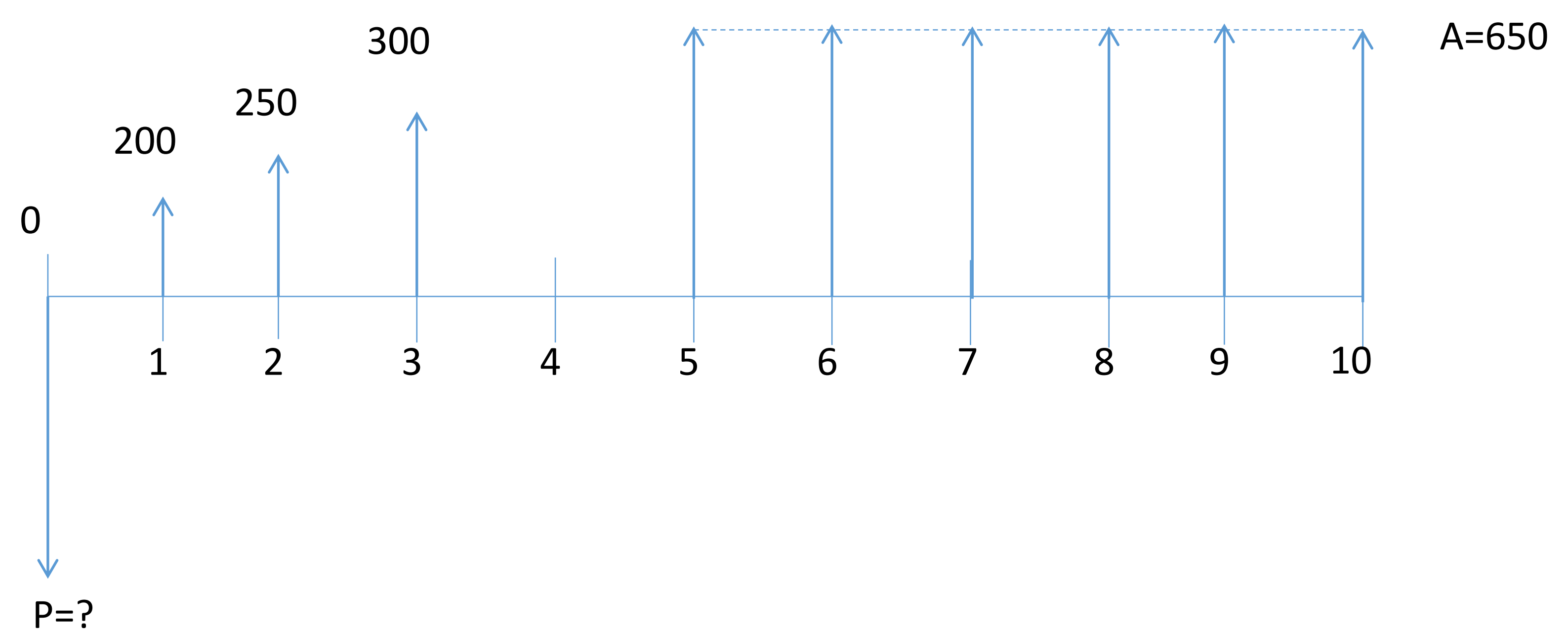
F + 500 x 2,594 + (500 + 100 x 0,9366) x (3,310) x (1,949) - 700 x 7,716 x 1,1 = 0

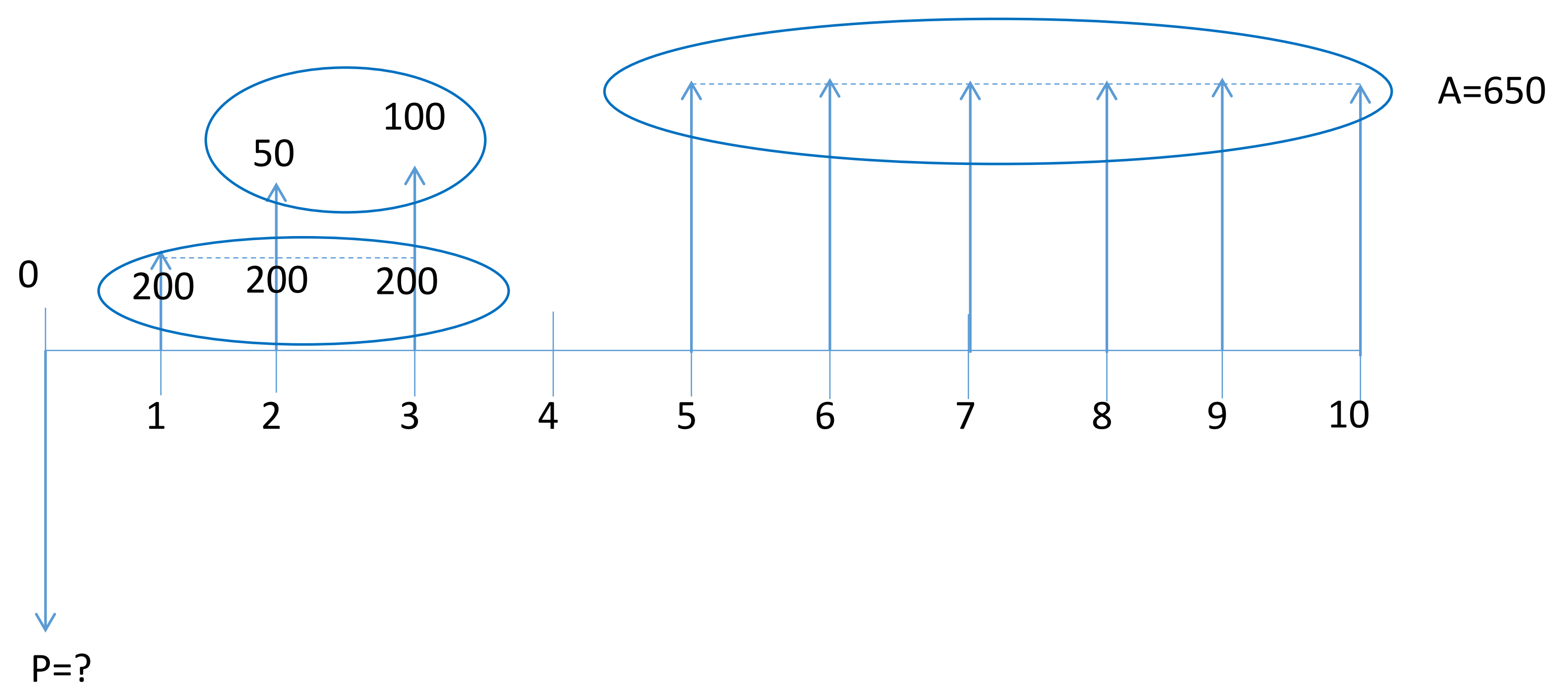
F + 1.297 + 3.829,81 - 5.941,32 = 0

F = 814,51 $

Example 2:

Calculate the net present value of cash flow given below. Annual interest rate is 10%.



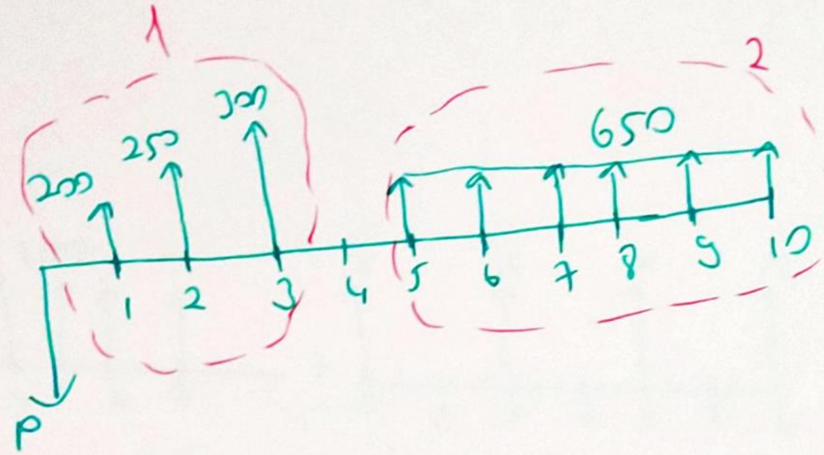


P=(200+50(A/G,10%,3))*(P/A,10%,3)+650(P/A,10%,6)*(P/F,10%,4)

Single-Payment Compound-Amount Factor	Single-Payment Present Worth Factor	Uniform Series Compound Amount	Sinking Fund Factor
$F = P(1+i)^n = P(F/P,i,n)$	$P = F\left[\frac{1}{(1+i)^n}\right] = F(P/F,i,n)$	$F = A\left[\frac{(1+i)^n - 1}{i}\right] = A(F/A,i,n)$	$A = F\left[\frac{i}{(1+i)^n - 1}\right] = F(A/F,i,n)$
Capital Recovery Factor	**Uniform-Series Present Worth Factor**	**Uniform Gradient Series Factor**	**Uniform Gradient Series Factor**
$A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$ $A = P(A/P,i,n)$	$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$ $P = A(P/A,i,n)$	$A = A_1 + G\left[\frac{1}{i} - \frac{n}{(1+i)^n - 1}\right]$ $A = A_1 + G(A/G,i,n)$	$A = A_1 - G\left[\frac{1}{i} - \frac{n}{(1+i)^n - 1}\right]$ $A = A_1 - G(A/G,i,n)$
Uniform Gradient Series for Feature Factor		$r = (1+\frac{j}{CK})^C - 1$	$r = (1+\frac{j}{m})^m - 1$
$F = Gx\frac{1}{i}\left[\frac{(1+i)^n - 1}{i} - n\right] = G(F/G,i,n)$			

P=(200+50(A/G,10%,3))*(P/A,10%,3)+650(P/A,10%,6)(P/F,10%,4)

- (200+50(1*0,1-3/((1+0,1)^3-1))))*(((1+0,1)^3-1)/(0,1(1+0,1)^3))+650(((1+0,1)^6-1)/(0,1(1+0,1)^6))*1/(1+0,1)^4



$\underline{P_1}$

$$P_2 = P_1 + G\left[\frac{1}{i} - \frac{n}{(1+i)^n}\right]$$

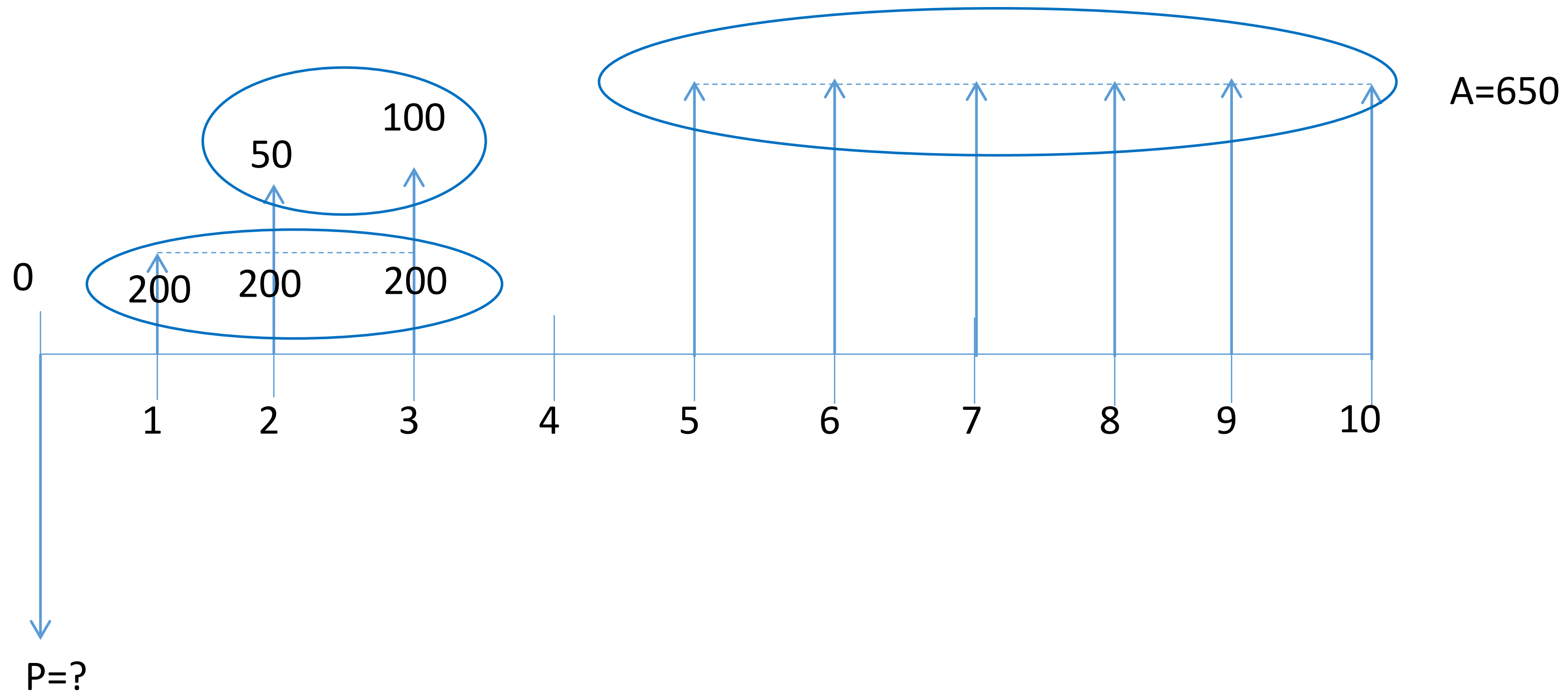
$$200 + 50\left[\frac{1}{0{,}1} - \frac{3}{(1{,}1)^3 - 1}\right] = 246{,}82 \text{ TL}$$

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

$$246{,}82\ \frac{(1{,}1)^3 - 1}{0{,}1(1{,}1)^3} = 613{,}80 \text{ TL}$$

$\underline{P_2}$

$$650 \times \frac{(1{,}1)^6 - 1}{0{,}1\,(1{,}1)^6} \times (1{,}1)^{-4} = 1933{,}54$$



First Solution

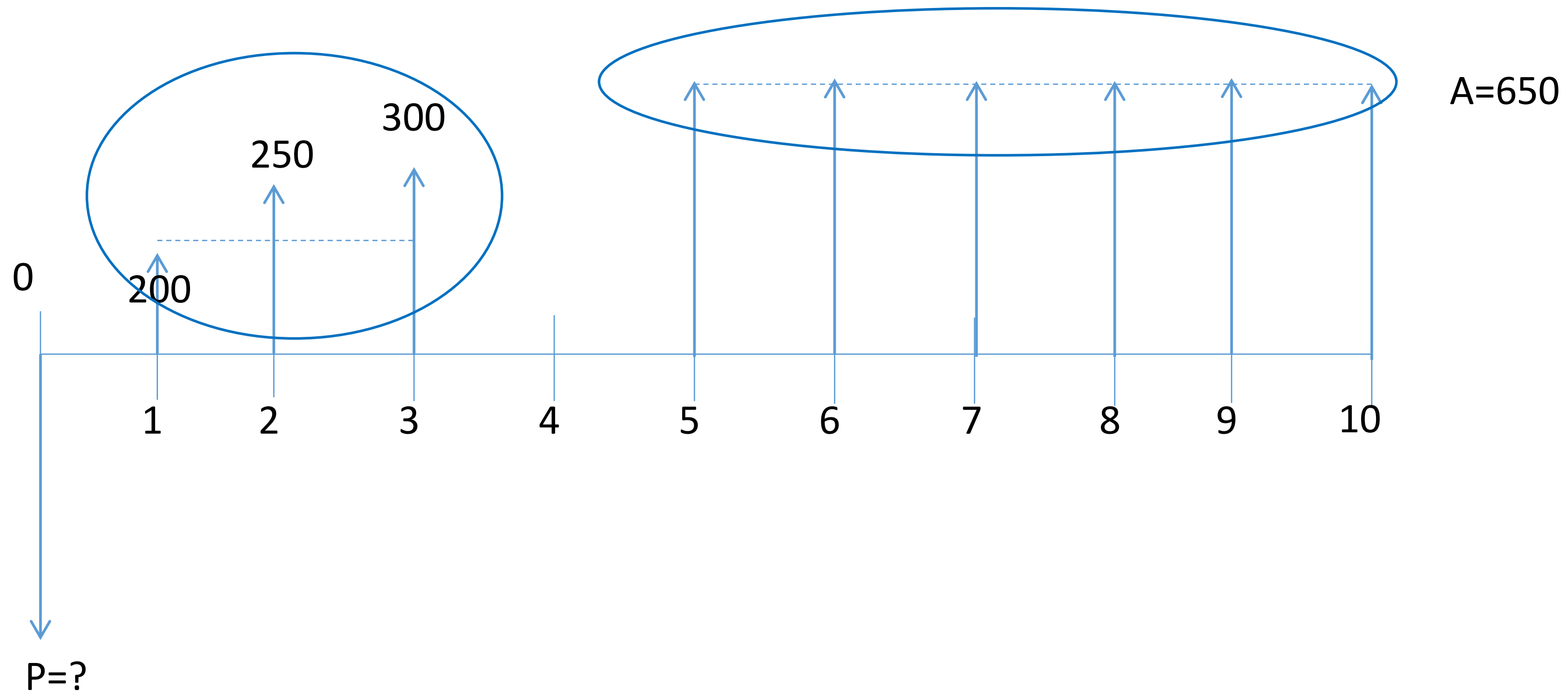
P= A1(P/A, %10, 3)+ G(P/G, %10, 3)+ A2(P/A,%10,6)*(P/F, %10, 4)

= 200*(2.4869) + 50*(2.3291) + 650*(4.3553)*(0.6830)

= 497.38 + 116.455+ 1933.54 >>>> P=2547

$$P = 200 * \left[\frac{(1+0{,}1)^3 - 1}{0{,}1 * (1+0{,}1)^3}\right] + \frac{50}{0{,}1 * (1+0{,}1)^3} * \left[\frac{(1+0{,}1)^3 - 1}{0{,}1} - 3\right] + 650 * \left[\frac{(1+0{,}1)^6 - 1}{0{,}1 * (1+0{,}1)^6}\right] * \frac{1}{(1+0{,}1)^4}$$

P=2547



Second Solution

$$P = [A1 + G*(A/G, \%10,3)]*(P/A, \%10, 3) + A2(P/A,\%10,6)*(P/F, \%10, 4)$$

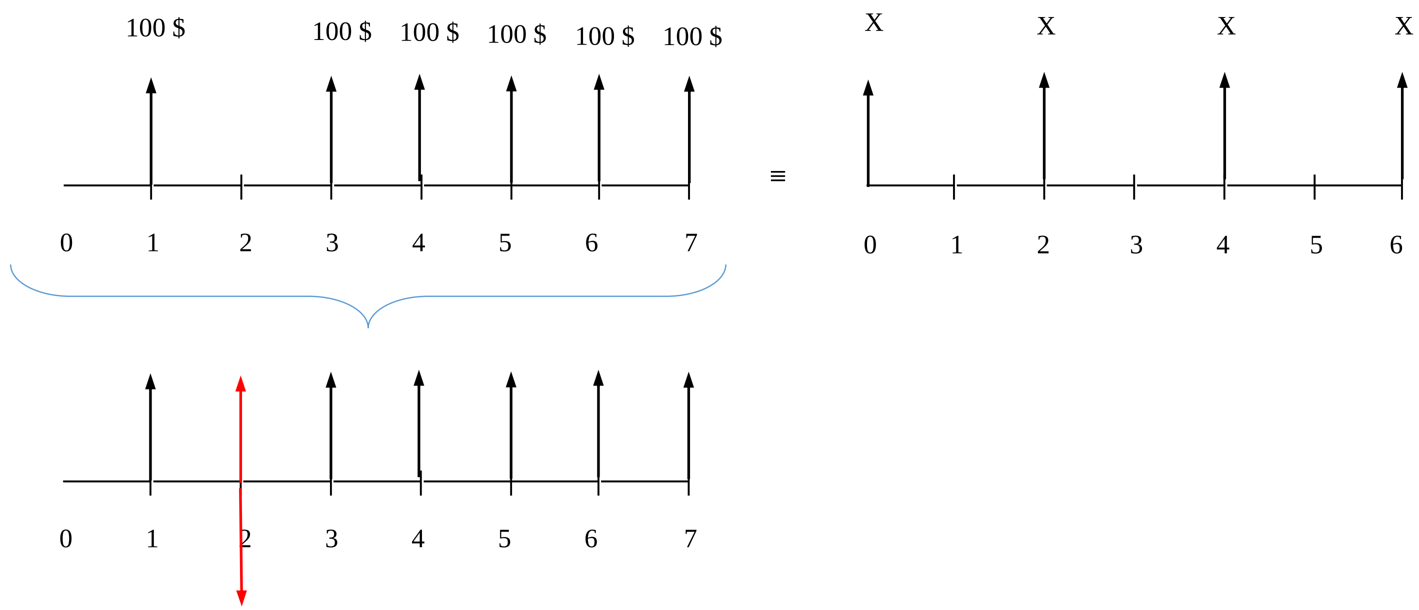
$$P = [200+50(0.9366)]*\ 2.4869 + 650*(4.3553)*(0.6830)$$

$$= (246.83*2.4869) + 1933.54 = 613.84+1933.54$$

$$P=2547$$

Example 3:

The two cash flow given below are equal to each other for an interest rate of 10%. . Please calculate the X value.



Solution

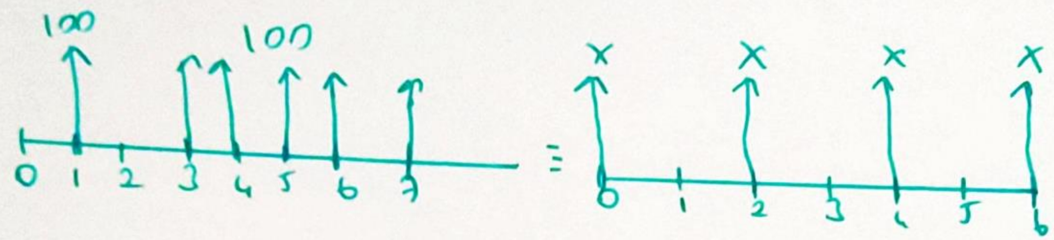
$$P = 100\ \underbrace{(\ P/A,\ 10\%,\ 7\ )}_{\textit{(4,8684)}} - 100\ \underbrace{(\ P/F,\ 10\%,\ 2\ )}_{\textit{(0,8265) read from interest table}} = (100 \times 4{,}8684) - (100 \times 0{,}826) = 404{,}19\ \$$$

404,19 = X + X (P/F, 10%, 2) + X (P/F, 10%, 4) + X (P/F, 10%, 6)

404,19 = 3,074X

X = 131,49 $ 100(P/A,10%,7)-100(P/F,10%,2)=X+X(P/F,10%,2)+X(P/F,10%,4)+X(P/F,10%,6)

EX



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

$$P_1 = 100 \times (1,1)^{-1} = 90,9092$$

$$P_2 = 100\,\frac{(1,1)^5 - 1}{0,1 \times (1,1)^5} \times (1,1)^{-2} = 313,28$$

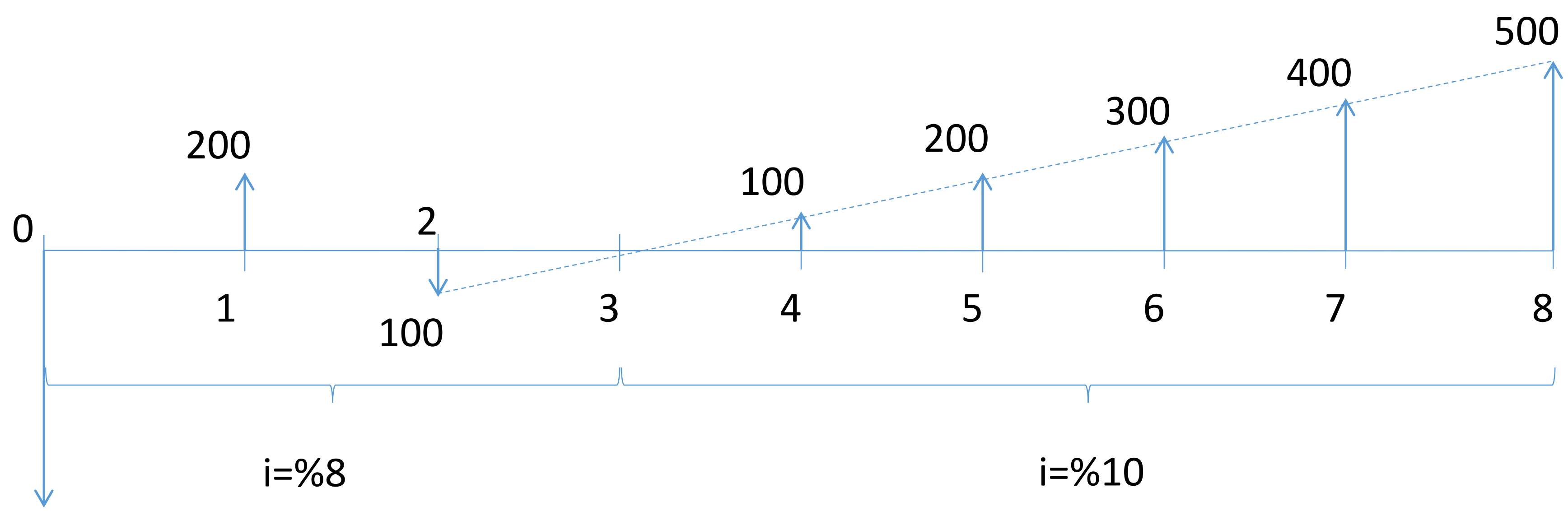
404,18

$$x + x(1,1)^{-2} + x(1,1)^{-4} + x(1,1)^{-6} = 3,074\,x$$

$$\boxed{X = 131,49\ \$}$$

Solution 4:

Please calculate the net present value of cash flow given below.



P=200(P/F, 8%,1)-100(P/F,8%,2)+(100+100(A/G,10%, 5)(P/A,10%,5)(P/F, 8%,3)

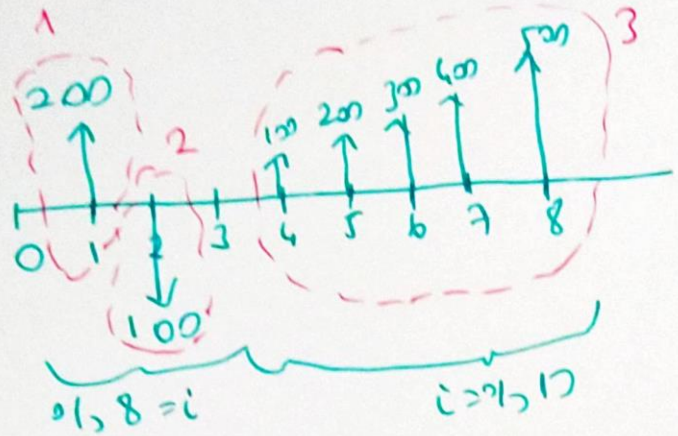
Solution

$$P= F_1(P/F, \%8, 1)- F_2(P/F, \%8, 2)+(A_1+G(A/G, \%10, 5)*(P/A, \%10, 5)*(P/F, \%8, 3)$$

$$P = \frac{200}{(1+0{,}08)} - \frac{100}{(1+0{,}08)^2} + \left[100 + 100 * \left[\frac{1}{0{,}1} - \frac{5}{(1+0{,}1)^5 - 1}\right]\right] * \left[\frac{(1+0{,}1)^5 - 1}{0{,}1 * (1+0{,}1)^5}\right] * \frac{1}{(1+0{,}08)^3}$$

P=945,306

Ex/



$$P_1 = 200 \times (1,08)^{-1}$$
$$= 185,185$$

$$P_2 = -100 \times (1,08)^{-2} = -85,73$$

$\underline{P_3}$

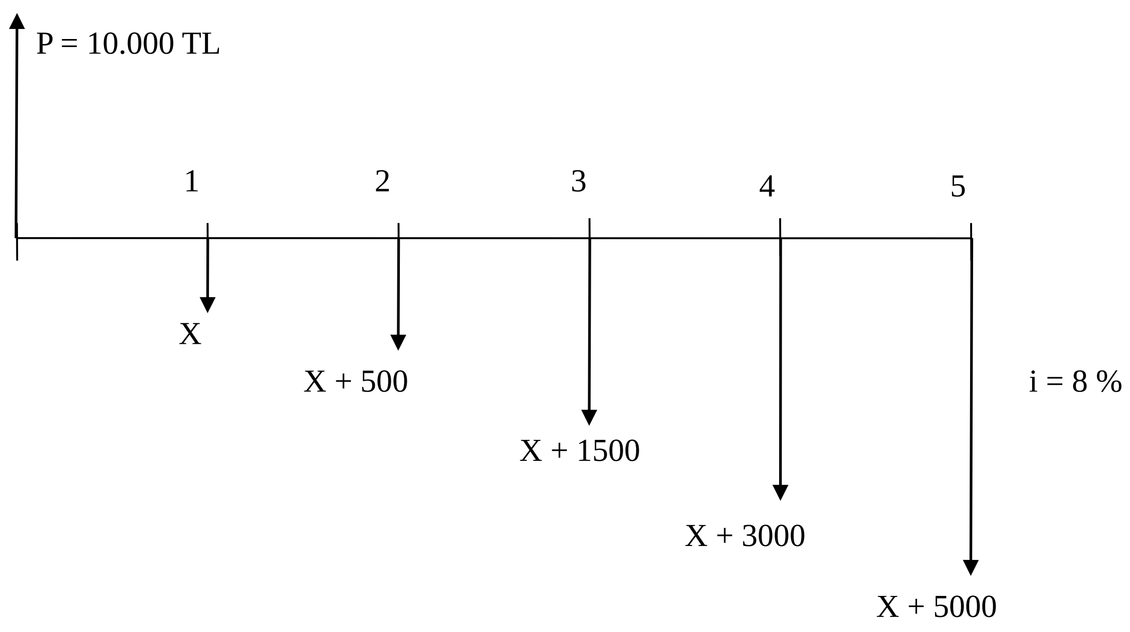
$$P_3 = 100 + 100\left[\frac{1}{0.1} - \frac{5}{(1,1)^5 - 1}\right] = 281,01$$

$$281,01 \times \frac{(1,1)^5 - 1}{0,1\ (1,1)^5} \times (1,08)^3 = 845,62$$

$$P_{net} = 185,185 + 845,62 - 85,73 = \boxed{945,083 \text{ TL}}$$

Problem-3: With an interest rate of 8% per annum, 10000 liras was withdrawn from the bank. In the first year, a certain amount was paid, in the following years respectively 500 TL, 1500 TL, 3000 TL and 5000 TL were added to the amount paid in the first year. Find the amount of the first payment accordingly?

Solution



1- First Solution

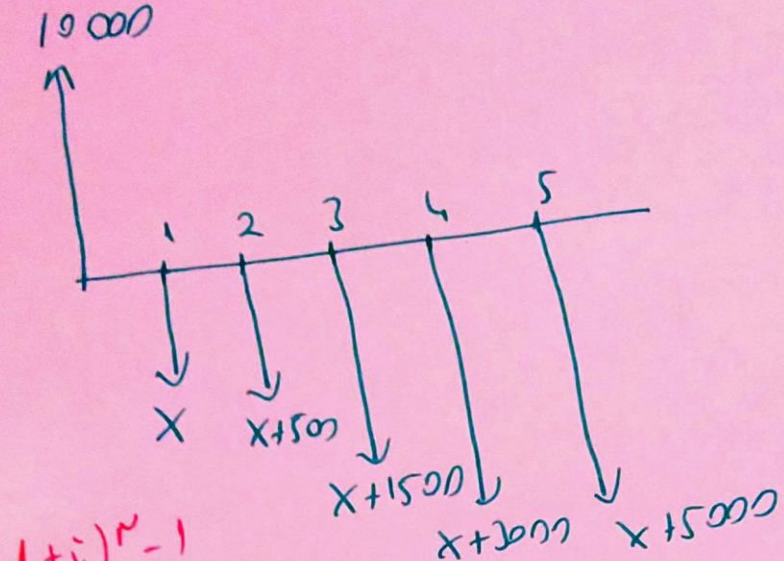
10.000(A/P, 8%, 5) = X + [500(P/F, 8%, 2) (A/P, 8%, 5)] + [1.500(P/F, 8%, 3) (A/P, 8%, 5)] + [3.000(P/F, 8%, 4) (A/P, 8%, 5)] + 5000(A/F, 8%, 5)

10.000 x 0,25046 = X + (500 x 0,8573 x 0,25046) + (1.500 x 0,7938 x 0,25046) + (3.000 x 0,7350 x 0,25046) + 5.000 x 0,17046

2.504,60 = X + 107,36 + 298,22 + 552,26 + 852,30

X = 2.504,60 - 1.810,14
= 694,46 TL

Ex/



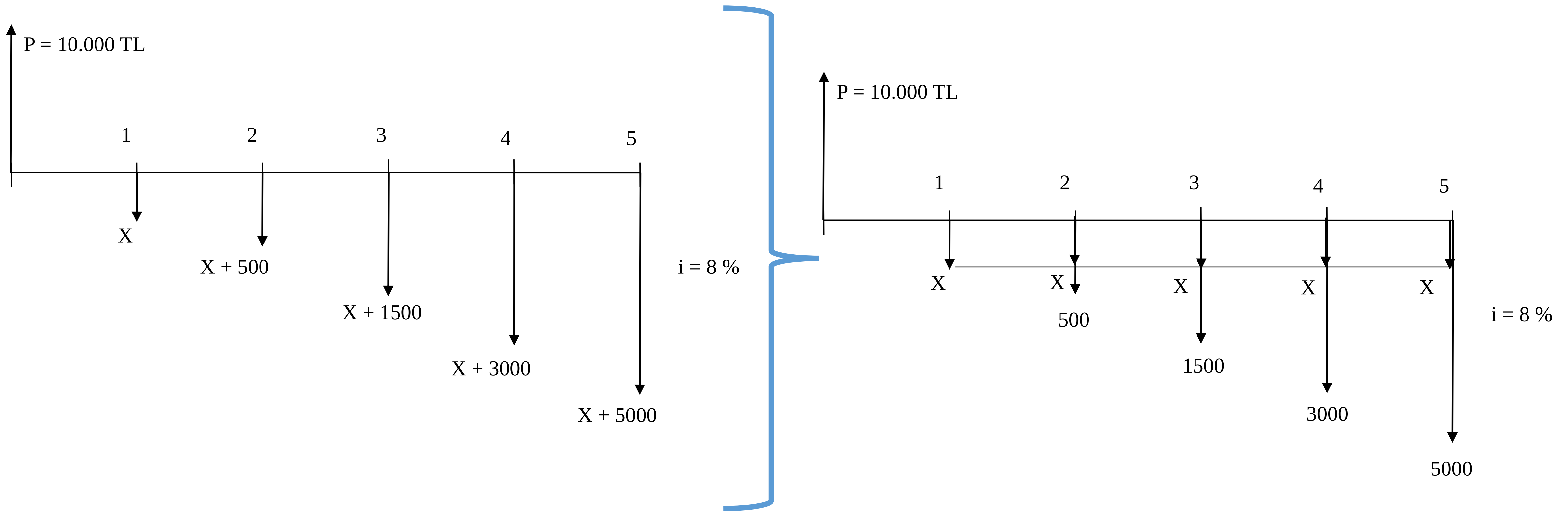
$$P = A\frac{(1+i)^n - 1}{i(1+i)^n}$$

$$10000 = X\frac{(1{,}08)^5 - 1}{0{,}08(1{,}08)^5} + 500(1{,}08)^{-2} + 1500(1{,}08)^{-3} + 3000(1{,}08)^{-4} + 5000(1{,}08)^{-5}$$

$$X = 694{,}46 \text{ TL}$$

Problem-3: With an interest rate of 8% per annum, 10000 liras was withdrawn from the bank. In the first year, a certain amount was paid, in the following years respectively 500 TL, 1500 TL, 3000 TL and 5000 TL were added to the amount paid in the first year. Find the amount of the first payment accordingly?

Solution



Second Solution

$10.000 - [500 *(P/F, 8\%, 2) + 1500* (P/F, 8\%, 3) + 3000* (P/F, 8\%, 4) + 5000 *(P/F, 8\%, 5) - X *(P/A, 8\%, 5)] = 0$

$10.000 - [\underbrace{(500* 0.8573)} + \underbrace{(1500*0.7938)} + \underbrace{(3000*0.7350)} + \underbrace{(5000* 0.6806)} – (3.9927 X)] = 0$

$10.000 - 428.65 + 1190.7 + 2205 + 3403 - 3.9927 X = 0$

$3.9927 X = 2772,65$

$\mathbf{X} = 694,46$ TL

8TL/1hour*3*1hour/6tons*xton/year

Example 6:

A construction company compares two alternatives. The first alternative is an automatic feeding machine, the other is a manual feeding machine.

- The initial cost of the first alternative, which is thought to have a 10-year economic life, is 23000 TL and the estimated salvage value is 4000 TL. Operation cost is 12 TL per hour. The expected production amount per hour is 8 tons. Annual maintenance and operation costs are considered to be 3500 TL.
- The second machine, which is considered as an alternative, has an initial cost of 8000 TL and no salvage value. Its economic life is estimated to be 5 years. In order to make this machine 6 tons per hour, three workers must be employed for 8 TL per hour. Annual maintenance and operation costs are estimated to be 1500 TL.

Since the whole project is estimated to yield 10%, how many tons of production should be produced per year so that an automatic machine can be selected?

X represents the annual production

- ❑ Annual variable cost for alternative 1= \$12/hour* 1hour/8ton* x ton/year

  $D_1 = 1.5x$

  $ENH_1 = -23{,}000(A/P,10\%,10) + 4000(A/F, 10\%,10) - 3500 - 1.5x$

  $ENH_1 = -6992-1.5x$

- ❑ Annual variable cost for alternative 2= \$8/hour*3*1hour/6ton* x ton/year

  $D_2 = 4x$

  $ENH_2 = -8000(A/P,10\%,5) - 1500 - 4x$

  $ENH_2 = -3610-4x$

- ❑ $ENH_1 = ENH_2$

$-6992-1.5x = -3610-4x$

x= 1353 ton/yıl

If annual production exceed the 1353 tons, automatic feeding machine should be acquired.

Operation planning example

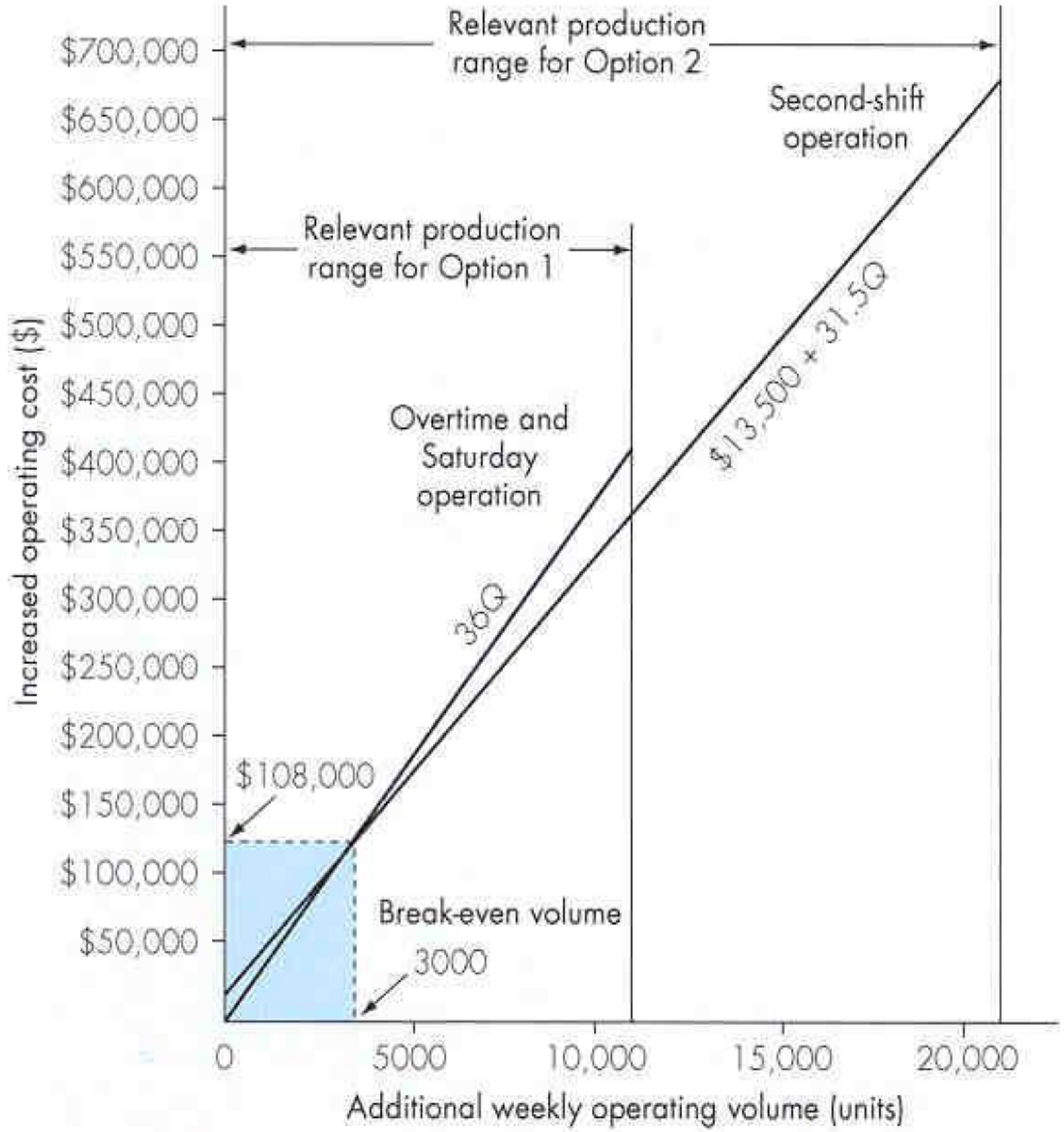
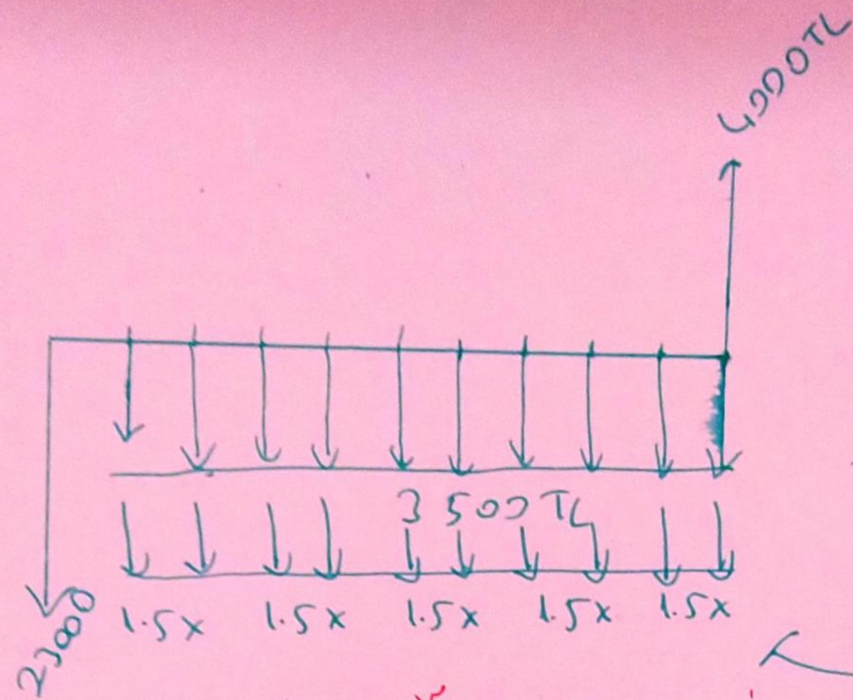


Figure 3.6 Cost-volume relationships of operating overtime and a Saturday operation versus second-shift operation beyond 24,000 units (Example 3.4)

Ex

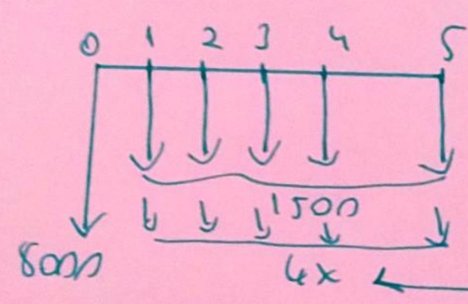


Let annual production = X

$\frac{x}{8}$ hour

$\frac{x}{8} \cdot 12 = 1.5x$ TL

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



$\frac{x}{6}$ hour

$\frac{x}{6} \times 24$ TL $= 4x$TL

$$-23000 \times \frac{0,1(1,1)^{10}}{(1,1)^{10}-1} + 4000 \frac{0,1}{1,1^{10}-1} - 3500 - 1.5x$$

$-6992,0 - 1.5x \Rightarrow$ cost line equation

$$-8000 \times \frac{0,1(1,1)^5}{(1,1)^5-1} - 1500 - 4x = -3610 - 4x$$

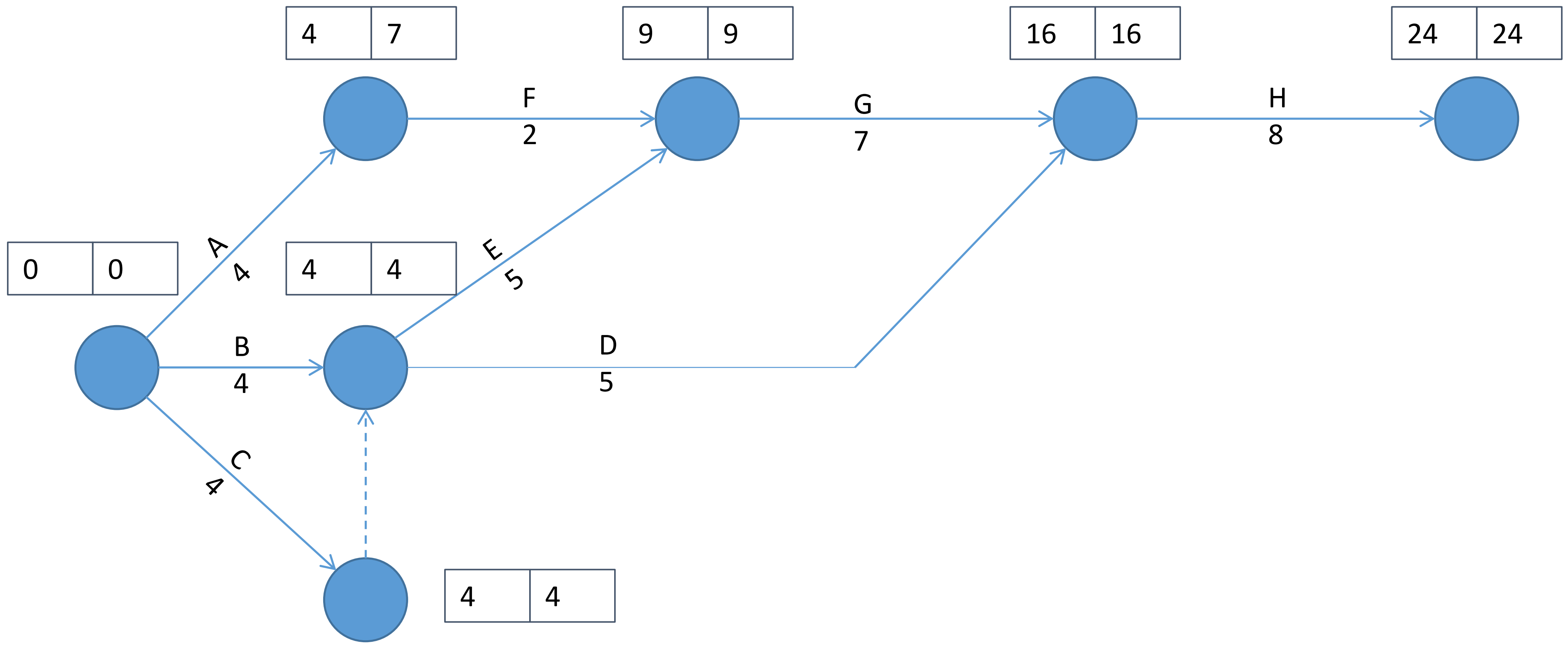
$-6992,0 - 1.5x = -3610 - 4x$ $\quad$ $x = 1353$ ton/year

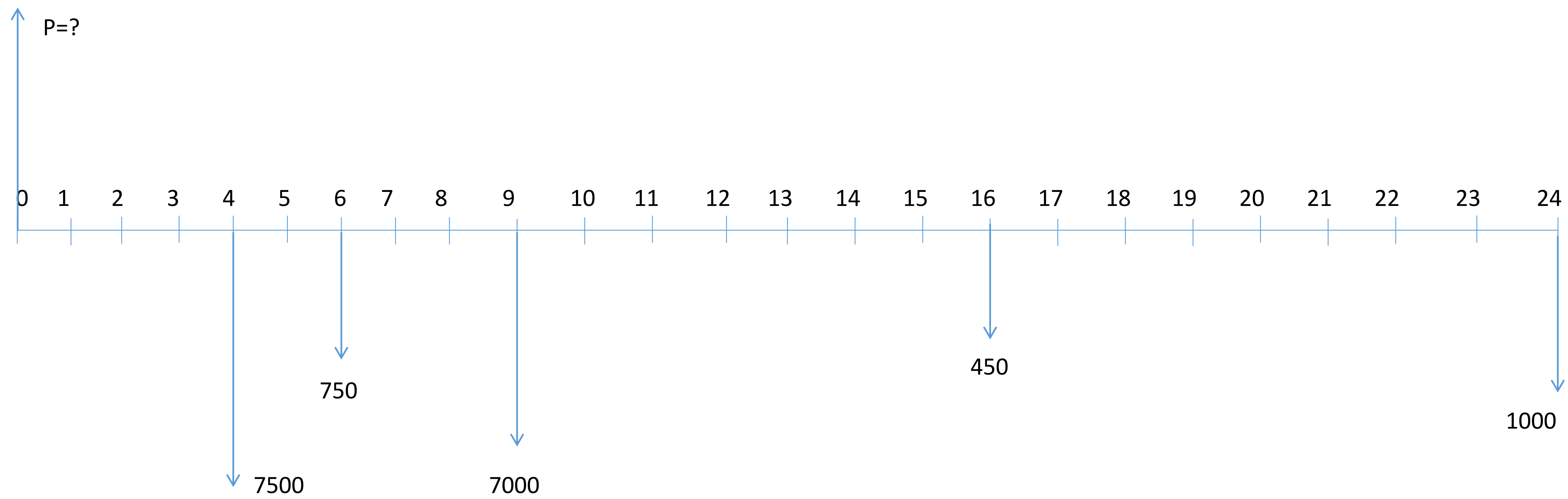
Solution 7:

Activity	Predecessor	Normal Duration	Activity Cost
A, B, C	-	4	2500
D, E	C, B	5	3500
F	A	2	750
G	F, E	7	450
H	D, G	8	1000

It is assumed that each activity will be completed without any delay and Cost of each activity will be paid right after its completion.
A client thinks to deposit all money required to complete this project into a bank with an interest rate of 2%, in order pay less amount of money. How much money this client should deposit to be able to cover all the expenses of the project.

Solution





$$P = \frac{7500}{(1+0{,}02)^4} + \frac{750}{(1+0{,}02)^6} + \frac{7000}{(1+0{,}02)^9} + \frac{450}{(1+0{,}02)^{16}} + \frac{1000}{(1+0{,}02)^{24}}$$

$$= 14401{,}63$$