

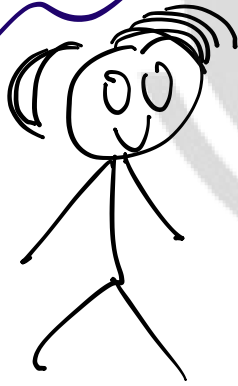
# Mathematics of finance

By Anurag Chauhan

# finance: Art & science of management of money

# Interest: cost of using others' money

waapas de to Dege na?



Mr. X  
(Rich)  
↓  
Lender



Mr. Y  
(Poor)  
↓

Borrower

mujhe udhaare de do



wants  
Return

wants  
Reward

wants  
compensation  
for maintaining  
same purchasing  
power

↓  
wants  
at least  
same  
profit

Because of all these  
↓  
"Interest is charged"

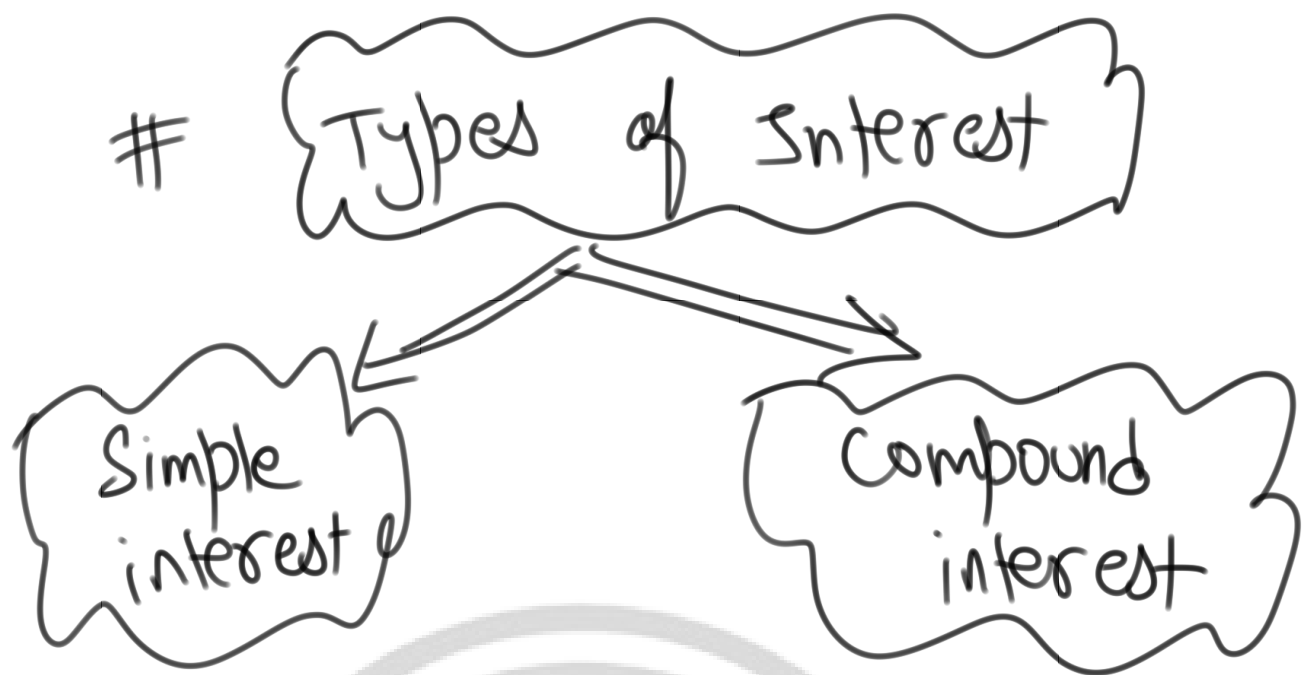
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# Some important terms

→ Principal = Borrowed money  
(Invested money)

→ Amount or (Accumulated Amount)  
= Principle + Interest

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# Simple Interest

No interest on interest

eg Mr. X Borrowed ₹10,000  
@ 10% S.I. for 3 years.

|                                     |   |          |
|-------------------------------------|---|----------|
| Principle                           | = | 10,000   |
| + Interest for 1 <sup>st</sup> year |   | + (1000) |
| <hr/>                               |   | 11000    |
| Amount after 1 <sup>st</sup> year   |   |          |
| + Interest for 2 <sup>nd</sup> year |   | + (1000) |

Amount after II<sup>nd</sup> year 12000  
+ Interest for III<sup>rd</sup> year + (1000)

Amount after II<sup>nd</sup> year 13000

Answer Chapter Six

Principle = ₹10,000

Interest for 3 year = 3000

Amount after 3 year = 13000

#  $S.I = P \cdot r \cdot t$

P = Principle

r = Rate of interest  
in decimals

t = Time

Now Amount =  $P + I$   
 $= P + P r t$



$$\# \text{ Amount} = P[1 + rt]$$

In Simple interest  
for Double amount

$$r = \frac{1}{t} \quad \& \quad t = \frac{1}{r}$$

for Triple amount

$$r = \frac{2}{t} \quad \& \quad t = \frac{2}{r}$$

In Simple interest  
when two time & two amounts  
are given

$t_1$

$t_2$

$A_1$

$A_2$

Then 
$$r = \frac{A_2 - A_1}{A_1 t_2 - A_2 t_1}$$

In simple interest  
when two rates & two  
amounts are given

$\%1$

$A_1$

$\%2$

$A_2$

Then 
$$j = \frac{A_2 - A_1}{A_1 \%2 - A_2 \%1}$$

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# # Compound Interest

Interest on Interest  
is also calculated

Mr. X Borrowed £ 200,000  
@ 20% for 3 years

Principle = £ 200,000

|                                |          |
|--------------------------------|----------|
| Int for 1 <sup>st</sup> year = | + 40,000 |
|--------------------------------|----------|

|                                   |          |
|-----------------------------------|----------|
| Amount after 1 <sup>st</sup> year | 2,40,000 |
|-----------------------------------|----------|

|                                 |          |
|---------------------------------|----------|
| Int. for 2 <sup>nd</sup> year = | + 48,000 |
|---------------------------------|----------|

|                      |          |
|----------------------|----------|
| Amount after 2 years | 2,88,000 |
|----------------------|----------|

|                               |          |
|-------------------------------|----------|
| Int. for 3 <sup>rd</sup> year | + 57,600 |
|-------------------------------|----------|

|                      |          |
|----------------------|----------|
| Amount after 3 years | 3,45,600 |
|----------------------|----------|

$$\left[ \begin{array}{l} \text{Principle} = 200,000 \end{array} \right.$$

$$\left[ \begin{array}{l} \text{Amount} = 3,45,600 \end{array} \right.$$

$$\left[ \begin{array}{l} \text{Interest} = A - P \\ \quad \quad \quad = 1,45,600 \end{array} \right.$$

In compound interest

$$\text{Amount} = P \left[ 1 + \frac{r}{m} \right]^{t \times m}$$

$m = \text{No. of conversion period in a year}$

for Annually  $\Rightarrow m = 1$

for Semiannually  $\Rightarrow m = 2$

for Quarterly  $\Rightarrow m = 4$

for monthly  $\Rightarrow m = 12$

for Daily  $\Rightarrow m = 365$

अगर Direct C.I. find  
करना हो तो

$$\begin{aligned} \text{C.I.} &= A - P \\ &= P \left[ 1 + \frac{r}{m} \right]^{t \times m} - P \end{aligned}$$

$$\text{C.I.} = P \left\{ \left( 1 + \frac{r}{m} \right)^{t \times m} - 1 \right\}$$

#

$$\text{C.I.} = P \left\{ \left( 1 + \frac{r}{m} \right)^{t \times m} - 1 \right\}$$



# # Calculator Tricks

#1> Square of Any Number

$$\boxed{x^2}$$

→ Press  $\boxed{\times}$  एक बार

→ Press  $\boxed{=}$  एक बार

#2> Cube of Any Number

$$\boxed{x^3}$$

→ Press  $\boxed{\times}$  एक बार

→ Press  $\boxed{=}$  दो बार

#3> For  $(x)^n = ?$

→ Press  $\boxed{\times}$  one time

→ Press  $\boxed{=}$   $(n-1)$  times

Examples  $(2)^{10}$

→  $\boxed{\times}$  one time

→  $\boxed{=}$  9 times

#4] Reciprocal of Any Number

$(\frac{1}{n})$

→  $\boxed{\div}$  one time

→  $\boxed{=}$  one time

e.g.  $\frac{1}{2} = 0.5$

→ 2 on the screen

→ press  $\boxed{\div}$

→ press  $\boxed{=}$

#5]  $(x)^{1/n} = ?$

→ Press  $\boxed{\sqrt{\phantom{x}}}$  12 times

→ Subtract 1  $\boxed{\text{Press } [-]}$

→ Divide by n

→ Add 1  $\boxed{\text{Press } [+]}$

→ Press  $\boxed{[X]}$  then  $\boxed{[=]}$  → 12 times

eg  $(8)^{1/3} \Rightarrow 8$  on the screen

→ Press  $\sqrt{\phantom{x}}$  12 times

→ -1

→  $\div 3$

→ +1

→  $\begin{matrix} \lambda = \\ x = \end{matrix}$

x =  
x =  
x =  
.  
.  
x =  
12 times

g for (2) 4.5  
→ 2 on the screen  
→ Press  $\sqrt{\phantom{x}}$   $\sqrt{\phantom{x}}$   $\sqrt{\phantom{x}}$   $\sqrt{\phantom{x}}$  ... 12 times  
→ -1  
→ multiply by 4.5  
→ +1  
→ x =  
x =  
x =  
x =  
.  
.  
12 times

$$\#6] \log_{10}(x) = ?$$

[  $\rightarrow 5$  19 times  
 $\rightarrow -1$   
 $\rightarrow$  multiply by 227695

$\Downarrow$

Remember Property of log

$\Downarrow$

$$\log(x)^n = n \log x$$

eg  $\log(1.5)^{10} = 10 \log(1.5)$

# 7] Antilog (x) = ?

$$\left[ \begin{array}{l} \rightarrow \div 227695 \\ \rightarrow +1 \\ \rightarrow \boxed{x=} \text{ 19 times} \end{array} \right.$$

eg

$$P = 100$$

$$A = 200$$

$$r = 10\% \text{ Annually}$$

find time

Sol:

$$A = P \left[ 1 + \frac{r}{m} \right]^{t \times m}$$

$$200 = 100 \left[ 1 + \frac{0.10}{1} \right]^{t \times 1}$$

$$2 = (1.10)^t$$

Here power is variable  
so we have to use log



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Put log Both side

$$\log 2 = \log (1.10)^t$$

$$\log 2 = t \log (1.10)$$



$$t = \frac{\log 2}{\log (1.10)}$$

} now  
use  
log Trick

$$t = \frac{0.3010}{0.0414}$$

$$t = 7.27 \text{ years}$$

Q

$$P = 100$$

$$A = 300$$

$$t = 8 \text{ years}$$

find compound rate of interest.

Sol:

$$A = P \left[ 1 + \frac{r}{m} \right]^{n \times m}$$

$$300 = 100 \left[ 1 + r \right]^8$$

$$(3)^1 = \underbrace{(1+r)^8}$$

Here base is variable, so transfer power 8 to left side

$$(3)^{1/8} = 1 + r$$

$$(3)^{1/8} - 1 = r$$

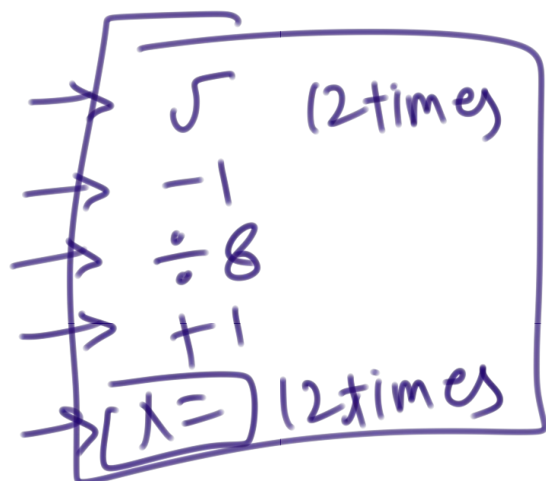
$$r = \underbrace{(3)^{1/8} - 1}$$

calculator trick

$$r = 1.1472 - 1$$

$$r = 0.1472$$

$$\text{or } 14.72\%$$



# Depreciation



Decrease in value of Asset



$C = \text{Cost}$

$d = \text{Rate of Depreciation}$

$t = \text{Time period for which asset is used}$

(Scrap value)

$S.v. = \text{value of Asset after 't' years}$

$$S.v. = C [1 - d]^t$$

#

Nominal Rate



Any Rate which is compounded

→ monthly

→ quarterly

→ Semiannually

→ Daily

(Isme interest kam dikhta  
But interest Jaada milta hai)

#

Effective Rate



Any Annual compounding Rate



(Isme interest jitna dikhta hai,  
utna hi milta hai)

# Nominal Rate can be converted to Effective Rate

$$r_e = \left[ 1 + \frac{r}{m} \right]^m - 1$$

Example

8% Semi annually is nominal Rate

It can be converted in Annually

$$\begin{aligned} r_e &= \left[ 1 + \frac{r}{m} \right]^m - 1 \\ &= \left[ 1 + \frac{0.08}{2} \right]^2 - 1 \\ &= (1.04)^2 - 1 \\ &= 1.0816 - 1 \\ &= 0.0816 \end{aligned}$$

$\propto$   
8.16%

Effective Rate

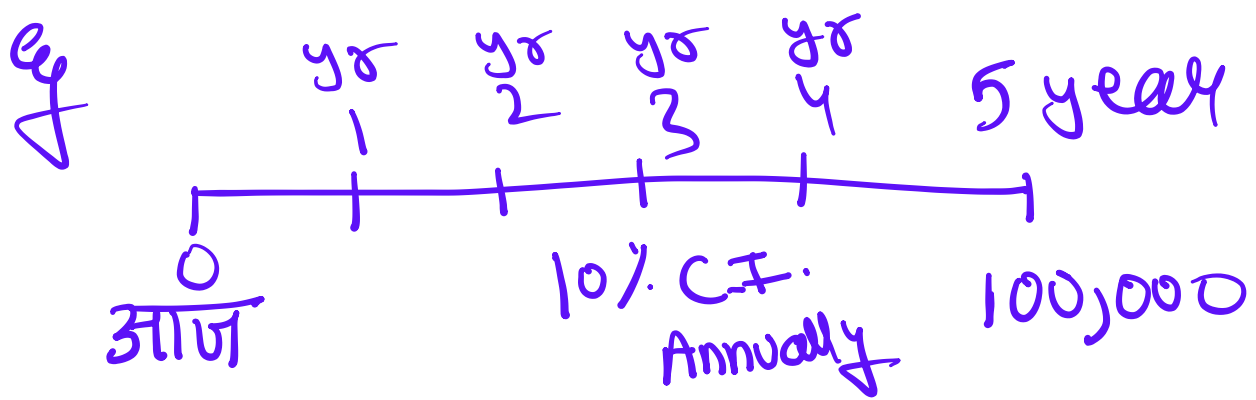
8% SemiAnnually  $\Rightarrow$  8.16% Annually

Both are same

#

Present value of an Amount which is to be Received in future

$$\text{Present value} = \frac{\text{Future value}}{\left[1 + \frac{r}{m}\right]^t \times m}$$



5 years ke baad ₹ 100,000  
 milenge, lekin wo Paise aaj  
 Aaj milenge to ₹ 100,000  
 nahi milega, thoda kam milega

$$P.V. = \frac{100,000}{[1 + \frac{0.10}{1}]^5}$$

$$= \frac{100,000}{1.61051}$$

$$P.V. = 62,092$$

आज Rs इतना  
 ही मिलेगा

# # Annuity

- Sequence of payments  
(or Receipts)
- Same payment  
(5000, 5000, 5000, 5000)
- Same time interval  
b/w two payments  
(3m, 3m, 3m, 3m, ...)

- g → LIC premium
- House Loan EMI



# Two Type of Annuities

Regular Annuity  
(Ordinary)

↓  
when regular payment  
are made at  
the end of period  
↓

g House loan EMI  
(Har machine ke  
end mein paise  
Bank se katenge)

Immediate  
(Annuity Due)

↓  
when regular  
payments are  
made in beginning  
of each period  
↓

g LIC Premium  
har year ki  
starting mein  
Bank se katenga

# # Regular Annuity

⇒ Future value : when benefit  
of many periodic  
investments is received in future

$$F.V_0 = R \left\{ \frac{(1+i)^n - 1}{i} \right\}$$

$R$  = Regular periodic payment

$$i = \frac{\delta}{m}$$

$$n = t \times m \quad (\text{Total payments})$$

Q You start investing £5000 every year in a recurring deposit which gives 10% C.I. How much will you receive after 15 years?

Sol: Here you are investing 5000 every year (Assuming in the end)

↓  
Benefit will be received after 15 years in future

$$\text{Future value} = 5000 \left[ \frac{(1+0.10)^{15} - 1}{0.10} \right]$$

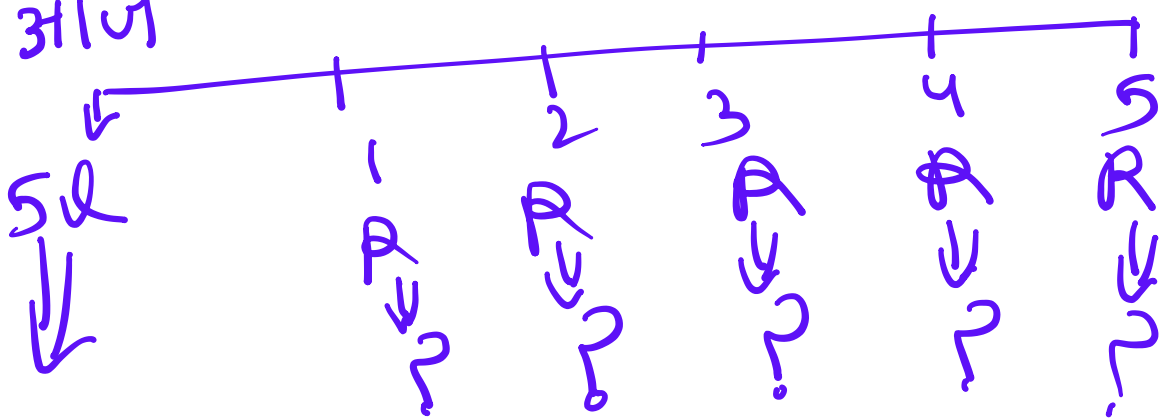
$$= \text{£}158,862$$

⇒ Present value : when some monetary benefit is received today then it repaid in installments.

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

Q. Mr. X took a loan of Rs 500,000 which is to be repaid in 5 yearly installments. Its rate of interest is 6% compounded Annually. Find the value of each installment.

Soln: अनुमान



आज Benefit

के मा

↓  
P.V.

$$500000 = R \left\{ \frac{1 - (1 + 0.06)^{-5}}{0.06} \right\}$$

$$500000 = R (4.2123)$$

$$R = \frac{500000}{4.2123}$$

$$R = ₹ 1,18,700$$

Calculator

$$(x)^{-n} \Rightarrow \text{press } \left[ \frac{x}{y} \right]$$

press  $\left[ = \right]$  'n' times

$$g \quad (1.06)^{-5} = 0.7472$$

press  $\left[ \div \right]$

press  $\left[ = \right]$  5 times

## # Immediate Annuity

$$F.V. = R \left[ \frac{(1+i)^n - 1}{i} \right] (1+i)$$

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

## # Perpetuity



Infinite Period  
Annuity

Ordinary  
Perpetuity

$$P.V. = \frac{R}{i}$$

Immediate  
Perpetuity

$$P.V. = \frac{R}{i} (1+i)$$

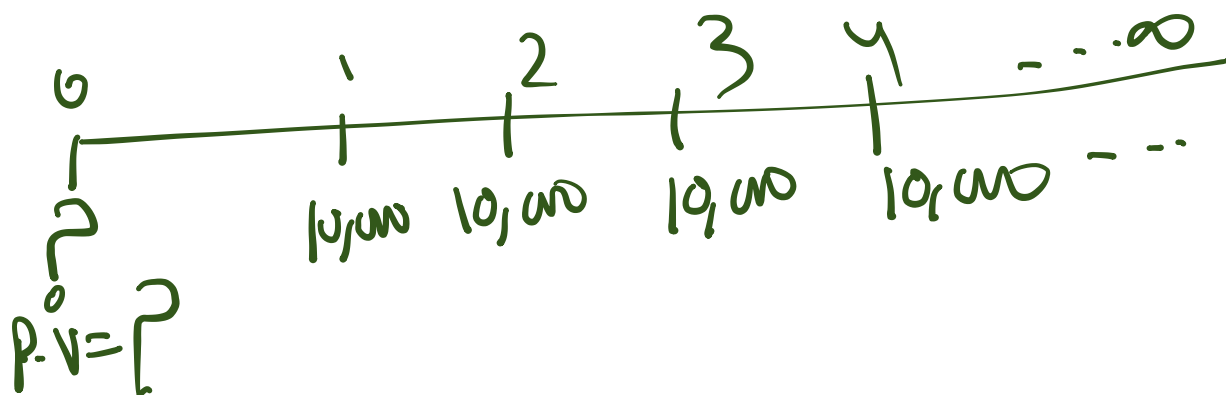
or

$$\frac{R}{i} + R$$

Q

How much you should invest now to receive £10,000 at the end of every year for indefinite period if rate of discount is 8% C.F. Annually?

Sol:



$$P.V. = \frac{R}{i} = \frac{10,000}{0.08} = 1,25,000$$

Q How much you should invest now to receive ₹ 10,000 in the beginning of every year starting from today for indefinite period if rate of discount is 8% C.F. Ann

Sol:

$$\begin{aligned} P.V. &= \frac{R}{i} (1+i) \\ &= \frac{10,000}{0.08} (1+0.08) \\ &= 1,35,000 \end{aligned}$$



# # Growing Perpetuity

When regular payment is received with growth for infinite period



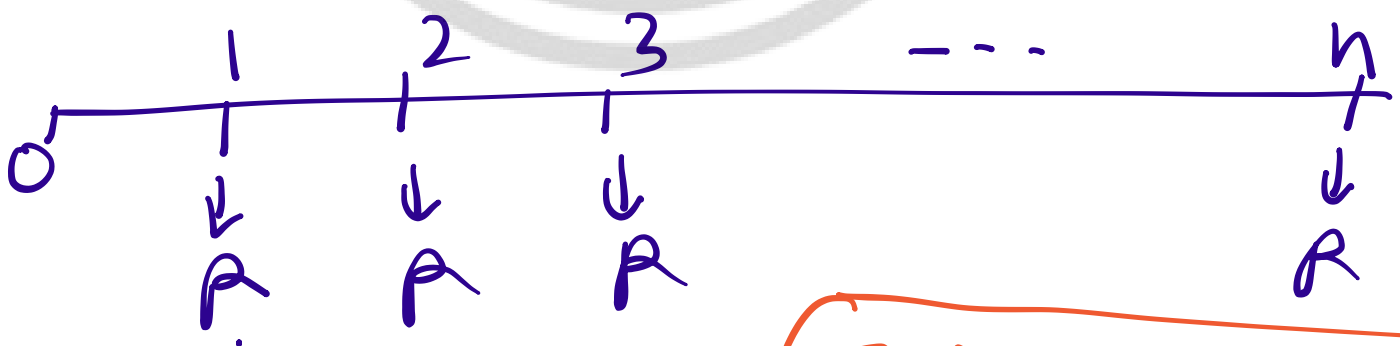
$$P.V. = \frac{R}{i - g}$$

$$P.V. = \frac{A(1+i)}{i - g}$$

# # Sinking Fund

Saving money out of Profits  
so that you can purchase an  
Asset in future or you can  
payoff a liability in future

↓  
Saved amount is invested in which  
interest is earned

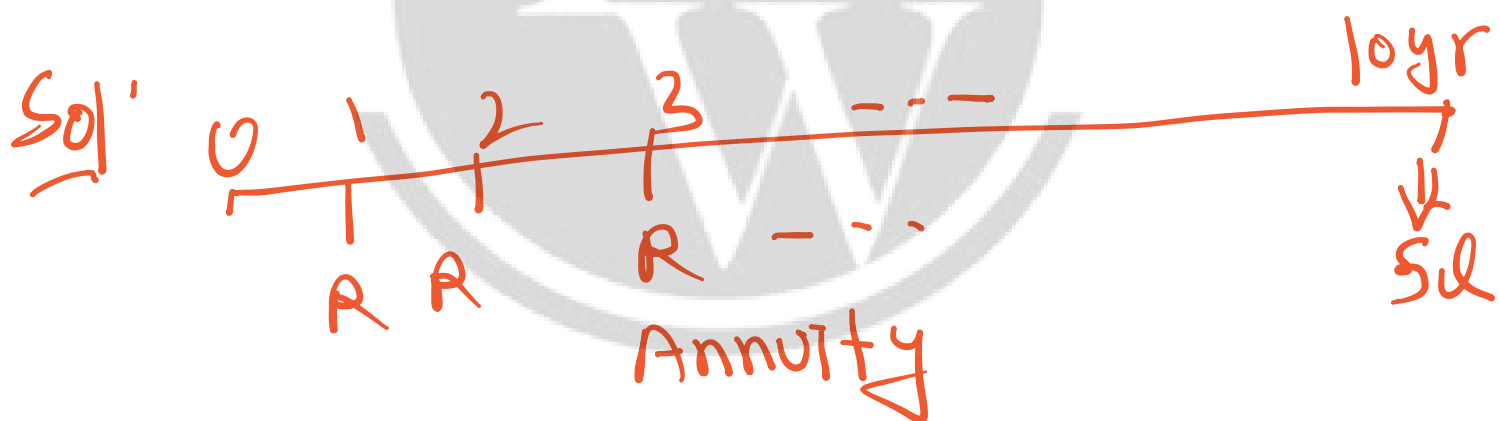


$R = \text{Saving}$

F.V. of Regular  
Annuity will be used

In this case benefit is received  
in future

Q Suppose you have to payoff a liability after 10 years for that you require ₹ 500000 after 10 years. How much you should invest in a sinking fund which gives 12% p.a. compounded annually so that you can fulfill your future needs?



$$F.V. = R \left[ \frac{(1+i)^n - 1}{i} \right]$$

$$500000 = R \left[ \frac{(1.12)^{10} - 1}{0.12} \right]$$

$$500000 = R (17.54)$$

$$R = 28506$$

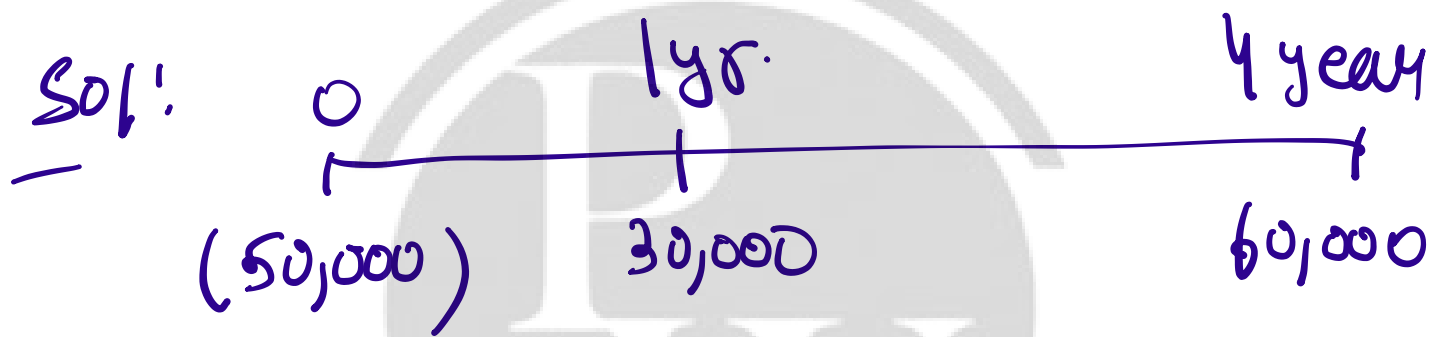
# # Net Present value

used for taking  
investment decisions

$$NPV = \text{Present value of all cash inflow} - \text{Present value of all cash outflow}$$

- if  $NPV \geq 0$  Accept Proposal
- if  $NPV < 0$  Reject Proposal

Q In a project ₹ 50,000 spent today.  
It generated ₹ 30,000 after one year  
& 60,000 after 4 years.  
Find NPV of Project if  
discount Rate is 10% Annually.



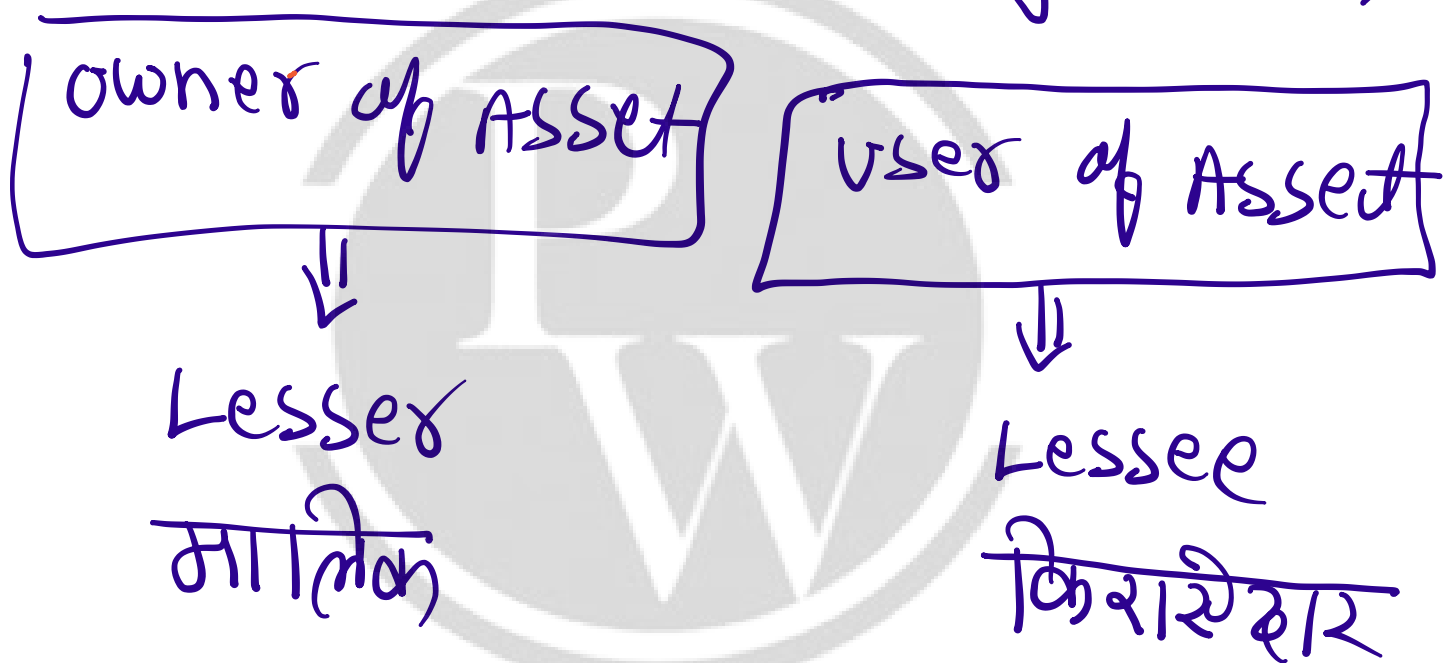
$$NPV = \frac{30000}{(1.10)^1} + \frac{60,000}{(1.10)^4} - 50,000$$

$$= 27272.72 + 49586.77 - 50,000$$

$$= 26859.49$$

# # Leasing

Taking Asset on Rent  
(For Long period)



In this type of question  
Purchase value of Asset  
will be given.

But Problem is we don't

know how much should be  
the Annual Rent?



use P.V. of Regular Annuity  
to find Reasonable Rent



$$\text{Cost of Asset} = \text{Rent} \left\{ \frac{1 - (1+i)^{-n}}{i} \right\}$$

Q. Mr. X can purchase a  
machine for £ 50,000 Today or  
he can take the machine on lease  
for 7 years in £ 9000 Annual  
Rent. which option is better?

Purchasing or Leasing of money is worth 10% Annually.

Sol: In this question find reasonable rent & then compare it with actual Rent (i.e. 9000)

$$50,000 = \text{Rent} \left[ \frac{1 - (1+i)^{-n}}{i} \right]$$

$$50,000 = R \left[ \frac{1 - (1.10)^{-7}}{0.10} \right]$$

$$50,000 = R (4.8684)$$

$$R = 10,270$$

Reasonable Rent is £10,270  
But he is getting the machine on lease in much more cheaper price (i.e. 9000)



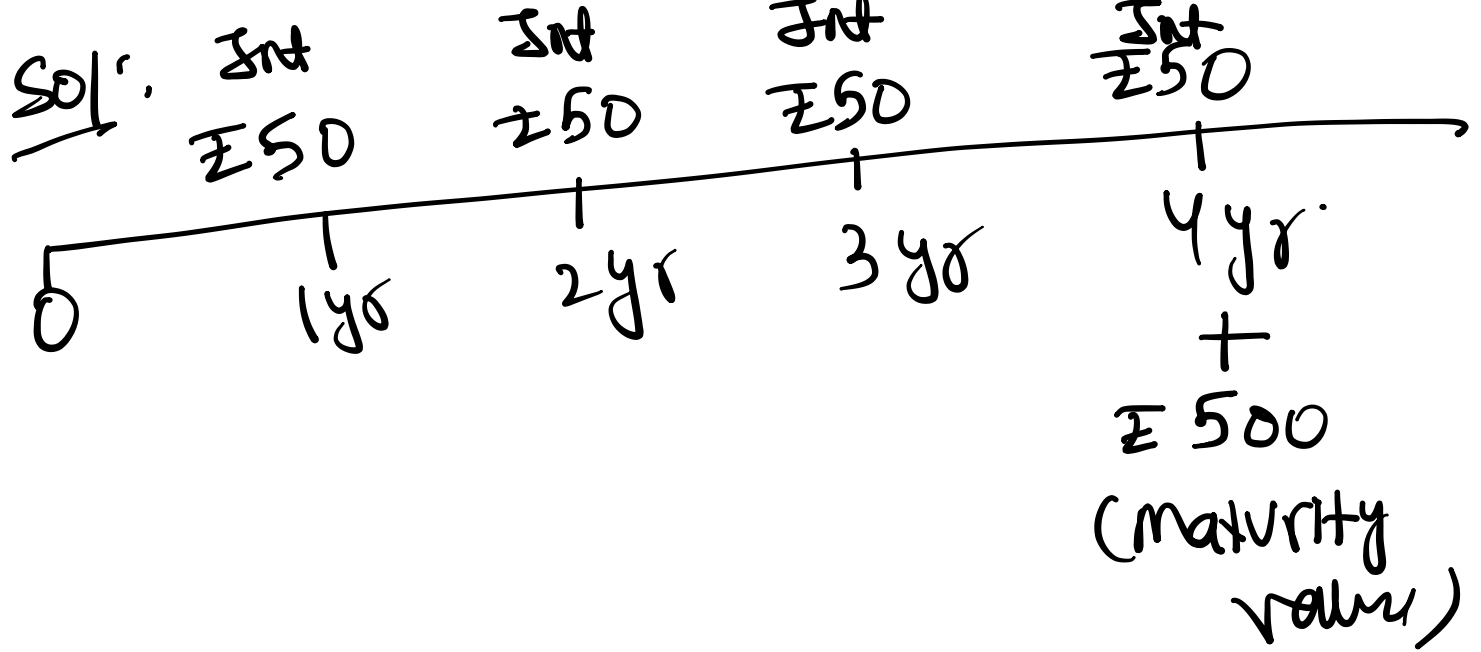
So He should go for leasing

## # Valuation of Bond

↓

Price at which Bond should be Purchased = Present value of All future interest + Present value of Bond's maturity value

Q Bond of ₹ 500 at which interest rate is 10% & maturity period is 4 years. At what price it should be purchased if investor wants 15% return.



Price of Bond

$$= \frac{50}{(1.15)^1} + \frac{50}{(1.15)^2} + \frac{50}{(1.15)^3} + \frac{50}{(1.15)^4} + \frac{500}{(1.15)^4}$$

$$= 43.47 + 37.80 + 32.87 + 28.58 + 285.87$$

$$= £428.59$$

# C. A. U. R.

Compound Annual Growth Rate

| Time    | 2010 | 2011 | 2012 | 2013 |
|---------|------|------|------|------|
| Revenue | 100  | 110  | 140  | 160  |

find CAUGR

Sol:

$$P = 100$$

$$A = 160$$

$$\text{Time} = 2013 - 2010 = 3 \text{ years}$$

$$A = P[1+r]^t$$

$$160 = 100 [1+r]^3$$

$$\frac{160}{100} = (1+r)^3$$

$$\left(\frac{160}{100}\right)^{1/3} = 1+r$$

$$r = \left(\frac{160}{100}\right)^{1/3} - 1$$

0.4

Use Direct formula

$$\begin{aligned} \text{CAGR} &= \left[ \frac{V(t_n)}{V(t_0)} \right]^{\frac{1}{t_n - t_0}} - 1 \\ &= \left( \frac{160}{100} \right)^{\frac{1}{2013 - 2010}} - 1 \end{aligned}$$

$$= \left( \frac{160}{100} \right)^{\frac{1}{3}} - 1$$

$$= 1.1696 - 1$$

$$= 0.1696$$

$$\text{or} \\ 16.96\%$$

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