ENVIRONMENT ENGINEERING

Vol - 01

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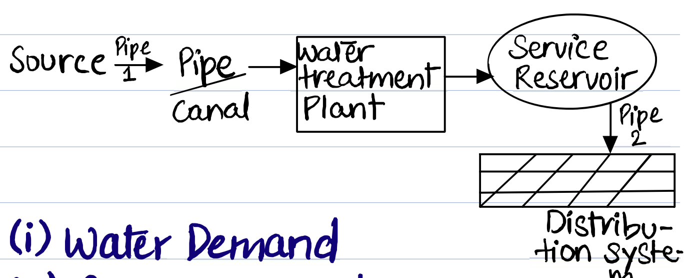
Ex-IES

WATER DEMAND

Raw Water : The water which is derived from natural resources

- river - Sedimentation.
- rain - aeration.
- good water - filtration



(i) Water Demand
(ii) Source of water
(iii) Quality of Water
(iv) Treatment of Water
(v) Pipes
(vi) Service reservoir
(vii) Distribution System

- **Water Demand / draft :**

(i) Annual draft (V)

(ii) Annual average daily draft $= \frac{V}{365}$

(iii) Annual average per capita daily draft

$$= \frac{V}{365 \cdot P}$$ P = Present Population

- **Total Demand**

(i) Domestic water demand
= 135 - 225 (200) (50-60)% flushing system

(ii) Industrial water demand
= 50 - 450

(iii) Institution water demand
= 20 - 50 l/c/d

(iv) Water for public use =
(5-6)% of total demand = (10-20) L/c/d

(v) Fire demand = 1 or emperical

IS code = $100\sqrt{P}$ ← (Kl)
thousand

- **Kuchling method**

$= Q = 3182\sqrt{P}$ l/min

P = population in thousand

- **Freeman method**

$= Q = 1136\left(\frac{P}{10}+10\right)$ l/min

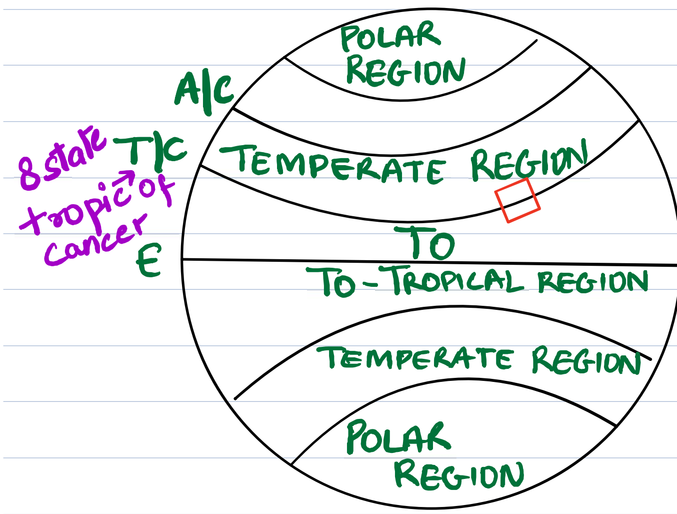
P = population in thousand

- **National Board of fire**

$= Q = 4637\sqrt{P}\,(1-0.01\sqrt{P})$ l/min

Buston $= Q = 5663\sqrt{P}$ l/min

(v) Climatic Condition (depends on location of community, latitude; higher latitude - less temperature, lower latitude - high temperature).



(vi) Cost of water

(vi) Losses and theft
= (10-15)% of total demand.

$\boxed{\text{Total demand} = 250\text{-}350\ (355)\ l/c/d}$

- **factors Influencing demand of water -**

(i) Size of the city.

(ii) Extent of industrialisation

(iii) Type of Sewage system (flush system)

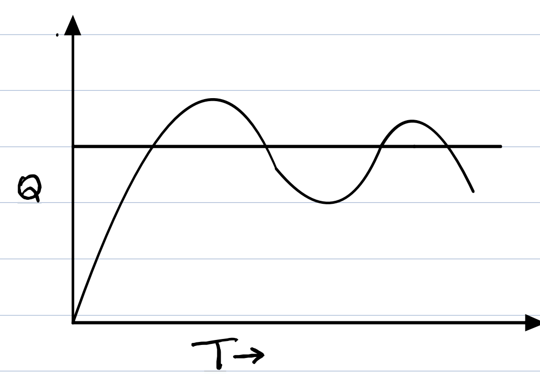
(iv) Standard of living/gantry.

(vii) Quality of water

(viii) Pressure in distribution System.

(ix) Type of distribution system
(Continuous and intermittent)

$$FI = \frac{Max.P}{Avg.P} = \frac{Avg.P}{Min.P}$$



Maximum daily demand

= 1.8 Annual average daily demand = $\frac{V}{365}$

$\frac{x+y}{365}$

Maximum hourly demand of maximum day = 1.5 Avg. hourly demand of maximum day

$= 1.5 \times \frac{\text{Maximum daily demand}}{24}$

$= \frac{1.5 \times 1.8 \text{ Annual average daily demand}}{24}$

Maximum hourly demand of maximum day

= 2.7 Annual average hourly demand

(Bigger the sample lesser the standard deviation).

Population	Peak factor
< 50,000	3
50,000 - 2,00,000	2.5
> 2,00,000	2

aug 2.7

We know that, raw water scheme designed for maximum hourly design.

(i) Q_{MH} - max^m hourly

(ii) $Q_{MH} + Q_{FD} \rightarrow$ Fire demand

(on including fire demand cost increased)

Good rich eq^n :-

percentage fluctuation,

$$p\% = \frac{\text{Max}^m \text{ demand}}{\text{Avg demand}}$$

$$= 180\, t^{-0.1}$$

(t = days)

t = time (days) ≥ 1 days and less than 1 year.

Time		Fluctuation
hourly	=	2.7 — peak factor
daily	=	1.8
weekly	=	1.48
Month	=	1.28
yearly	=	1

(iii) $Q_{MD} + Q_{FD}$ [coincident demand / draft]

* Design should be done.

$\left.\begin{matrix}\text{(i) } Q_{MH} \\ \text{(ii) } Q_{MD} + Q_{FD}\end{matrix}\right\}$ max^m

• Design life and design discharge :-

Component	Design life (yrs)	Design Discharge
Source	50	Q_{MD}
Pipe-I	30	Q_{MD}
Pump Canal	15	Q_{MD}
WTP	15	Q_{MD}
Service Reservoir	15	Volume
Pipe-II	30	Q_{MH}, $Q_{MD}+Q_{FD}$ } max
Distribution System	30	Q_{MH}, $Q_{MD}+Q_{FD}$ } max

Q $P = 2\times10^5$, AAPOD = 300 L/c/d

(i) find important type of demand.

(ii) design capacity of all components of RWS.

Q_{MD} – Maximum daily demand = 1.8 AADD $= 1.8 \times 300 = 2\times10^5 \times 10^{-6}$

= 108 MLD

Q_{MH} = Maxᵐ hourly demand $= 2.7\left(\frac{Q}{24}\right)$

$= 2.7 \times 300 \times 10^5 \times \frac{10^{-6}}{24}$

= 6.75 MLH

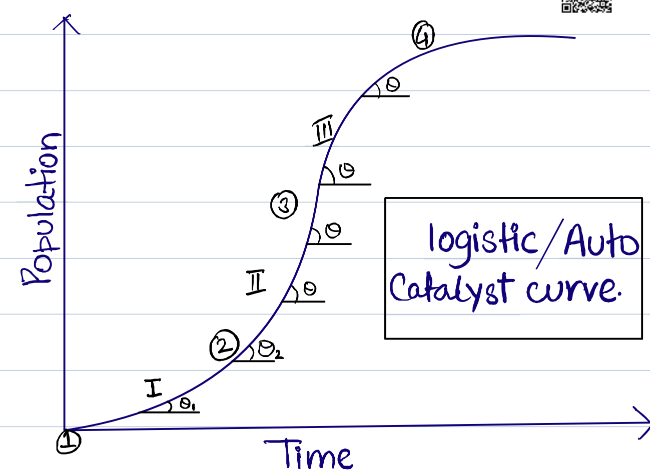
= 6.75 × 24 MLD = 162 MLD

or, $Q_{MH} = 1.5\, Q_{MD} = 1.5 \times 108 = 162$ MLD

Pipe-II and distribution system design for Q_{CD} = 189 MD

Soure, Pipe-I, Pump, WTP, Q_{MD} = 108 MLD

• Population forecasting



$y = f(x)$

$P = f(t)$

• Fire demand

As per NBFUH

$Q_{FD} = 4637\sqrt{P}\,(1 - 0.01\sqrt{P})$

$= 4637\sqrt{200}\,(1 - 0.01\sqrt{200})$

= 56303 l/min

$= 56303 \times 10^{-6} \times 60 \times 24$ MLD

= 81.07 MLD

• Coincident demand

$\left.\begin{array}{l} Q_{CD} = Q_{MD} + Q_{FD} \\ \quad = Q_{MH} \end{array}\right\} \text{Max}^m$

$\left.\begin{array}{l} Q_{MD} + Q_{FD} = 108 + 81 = 189 \text{ MLD} \\ Q_{MH} = 162 \text{ MLD} \end{array}\right\} \text{Max}^m$

(I) $\frac{dy}{dx} = \frac{dp}{dt}$ (↑) in a young city rate of growth of population increase $(\theta_2 > \theta_1)$

(II) In old city rate of development stabilises $\frac{dp}{dt} \simeq c$

$\theta_2 \sim \theta_1$

(III) Very old city – Population is increasing but its rate is decreasing.

$\theta_2 < \theta_1$

$\frac{dp}{dt}$ (↓) $\propto (P_s - P_t)$↓

Part-III

- Population of any community depends upon :-

(a) Growth rate } depend upon
(b) Death rate } city development

(c) Migration rate (+,-)

(d) Increase due to annexation - [forcefully taking land of other country] eg - China taking land of Hongkong.

• Do You know?

Pandemic - when it is in every place of world.

Epidemic - when it was only in wuhan (local area)

* Methods of Population forecasting :-

(i) Arithemetic Increase Method:

- In arithemetic Increase method we considered rate of growth of population is constant.

$$\boxed{dp/dt = \text{constant}}$$

- In this method, we consider the average increasing of population over the present population.

eg	1970	1980	1990	2000	2001
Pop^n	25	50	100	175	200

increase, $\bar{x}$ = 25, 50, 75, 25

2020	2023
= 200+43.75 = 243.75	243.75+43.75 = 287.5 ~ 288

average, $\bar{x} = \frac{25+50+75+25}{4}$ = 43.75 / decade.

$t = t_0$ $\quad P = P_0$

$t = t_1$ $\quad P_1 = P_0 + \bar{x}$

$t = t_2$ $\quad P_2 = P_1 + \bar{x} = P_0 + 2\bar{x}$

$t = t_n$ $\quad P_n = P_{n-1} + \bar{x} = P_0 + (n-1)\bar{x} + \bar{x}$

$= P_0 + n\bar{x}$

(ii) Geometric Increase Method/ Compounding/uniform increments

- In this method, percentage rate of growth is constant.

Year	1970	1980	1990	2000	2010	2020	2030
Pop^n	25	50	100	175	200	$=P_0(t+r)^1$ $=314.4$	$=200\times(1+0.572)^2$ $=494.23$ ~ 495

$$\frac{50-25}{25}\times 100 = 100\%$$

$$\frac{100-50}{50}\times 100 = 100\%$$

$$\frac{175-100}{100}\times 100 = 75\%$$

$$\frac{200-175}{175}\times 100 = 14.28\%$$

$$\boxed{r\% = \frac{dP}{dt}\times\frac{1}{P}\times 100 = \text{const.}}$$

Using Arithemetic mean method :

$$= \frac{100+100+75+14.28}{4}\ \%/\text{decade}$$

$$= 72.32\ \%/\text{decade}$$

— To calculate % rate growth (% r)

(i) Arithemetic mean method :

Used when 3 values given

$$\boxed{\%\, r = \frac{r_1+r_2+r_3\ldots\ldots+r_n}{n}}$$

(ii) Geometric mean method :-

Used when 3 values given

$$\boxed{\%\, r = \sqrt[n]{r_1\cdot r_2\cdot r_3\ldots\ldots r_n}}$$

$$\boxed{AM > GM}$$

(iii) $P_n = P_0(1+r)^n$:- when two value given

$$\boxed{r = \sqrt[n]{\frac{P_n}{P_0}} - 1}$$

By using geometry mean method

$$= \sqrt[4]{100\times 100\times 75\times 14.28}$$

$$= 57.2\ \%/\text{decade}.$$

$t = t_0 \qquad P = P_0$

$t = t_1 \qquad P_1 = P_0 + r.\, P_0.1 = P_0(1+r)$

$t = t_2 \qquad P_2 = P_1 + r.\, P_1.1 = P_1(1+r)$

$= P_0(1+r)(1+r) = P_0(1+r)^2$

....

$t = t_n = P_n \pm P_{n-1} + r.-P_{n-1}.1$

$= P_{n-1}(1+r)$

$= P_0(1+r)^{n-1}(1+r)$

$= P_0(1+r)^n$

$$\boxed{r\% = \frac{dP}{dt}\times\frac{1}{P}\times 100 = \text{Constant}}$$

Our code says, when you are using geometric increase method you should use geometric mean method.

(iii) Incremental Increase Method.

- In this method we don't assume rate of growth of population constant.

- In this method we consider an average of incremental over the increase in population.

$t = t_0 \qquad P = P_0$

$t = t_1 \qquad P_1 = P_0 + \bar{x} + \bar{y}.1 = P_0 + \bar{x} + \bar{y}$

$t = t_2 \qquad P_2 = P_1 + \bar{x} + 2.\bar{y}$

$= P_0 + \bar{x} + \bar{y} + \bar{x} + 2\bar{y}$

$= P_0 + 2\bar{x} + 3\bar{y}$

$t = t_3 \qquad P_3 = P_2 + \bar{x} + 3\bar{y} = P_0 + 2\bar{x} + 3\bar{y} + \bar{x} + 3\bar{y}$

$= P_0 + 3\bar{x} + 6\bar{y}$

$\vdots$

$t = t_n \qquad P_n = P_{n-1} + \bar{x} + n\bar{y}$

$= P_0 + n\bar{x} + \frac{n(n+1)}{2}\bar{y}$

	Population	City
Arithmetic	Lowest	very old
Geometric	Highest	Young city
Incremental	Intermediate	old city

Q.

Year	1970	1980	1990	2000	2030
Pop^n	20	24	27	30	?

x = 4 3 3

y = −1 0

Arithmetic method

$\bar{x} = \frac{4+3+3}{3} = 3.33$

$P_{2030} = 30 + 3 \times 3.33$

$= 40$

Q

year	1970	1980	1990	2000	2010	2020	2023
pop^n	30	50	100	130	165		

Increase (x) 20 50 30 35

y = 30 −20 5

$\bar{x} = \frac{20+50+30+35}{4} = 33.75/\text{decade}$

$\bar{y} = \frac{30+(-20)+5}{3} = 5/\text{decade}$

$P_{2020} = P_0 + n\bar{x} + \frac{n(n+1)}{2}\bar{y}$

$= 165 + 1 \times 33.75 + \frac{2}{2} \times 5$

$= 203.75$

$P_{2030} = P_0 + 2\bar{x} + \frac{n(n+1)}{2}\bar{y}$

$= 165 + 2 \times 33.75 + 2 \times \frac{3}{2} \times 5$

$= 247.5$

1. First Calculate % r

20 24 27 30

$\frac{4}{20} \times 100 \qquad \frac{3}{24} \qquad \frac{3}{27} = 1/9$

$= 20\% \qquad = 12.5\% \qquad = 11.11\%$

% r is decreasing with time so it is very old city, so use arithmetic increase method.

Q. Present population = 56,000, water demand = 84000 m^3/day

It is expected that after population after 20 years = 88000 we have to provide water supply scheme.

Water Treatment plant capacity = 12000 m^3/day.

No. of years plant will reach its design capacity. Assume geometric growth.

$$r\% = \sqrt{\frac{P_n}{P_0}} - 1$$

$$= \sqrt{\frac{88000}{5600}} - 1$$

$$= r\% = \underline{\underline{19.52}}$$

No.	Quanity m/day
56000	8400
80000	-12000
88000	?

$$80000 = 56000(1+0.1952)^n$$

Solution :

$P_0 = 56000$

$WD = 84000\ m^3/d$

$$APWP = \frac{84000 \times 10^3}{56000} = 150\ l/c/d$$

$$\text{Design population} = \frac{12000 \times 10^3}{150}$$

$= 80000$

$\%r$

$$P_2 = P_0(1+r)^2$$

$$88000 = 56000(1+r)^2$$

$1.25 = 1+r$

$r = 0.25$

$r\% = 25.35\%$

$$P_n = P_0(1+r)^n$$

$$80000 = 56000(1+0.2535)^n$$

$$\frac{10}{7} = (1.2535)^n$$

$$\log(10/7) = n(\log 1.2535)$$

$n = 1.578$ decades $= 15.78$ years.

(iv) Decreasing Rate of Growth Method

Year	Population (10^5)	$\%r$	decrease in $\%r$
1970	50		3.33%
		$20\% = \frac{60-50}{50}$	16.67-14.28 =2.39%
1980	60	16.67%	14.28-18.75 =-4.47
1990	70	14.28%	
2000	80	18.75	avg. of decrease in %r
2010	95	18.75-0.416 = 18.334	=3.33+2.386+(-4.47)
2020	?	18.334 - 0.416 = 17.918%	1.246
2030	?		$\boxed{=0.416\%}$

$$P_{2020} = P_{2010} + 18.334 \times P_{2010}$$

$$= [95 + 18.334\% \text{ of } 95] \times 10^5$$

$$= 112.41 \times 10^5$$

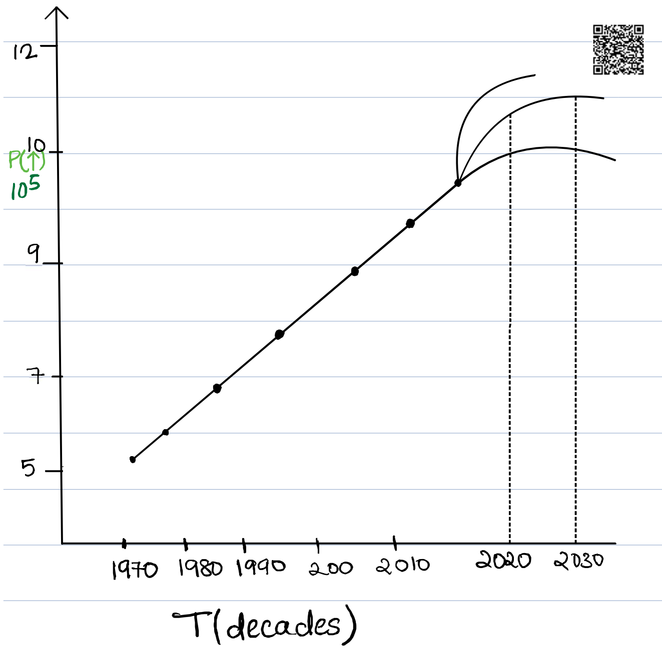
$$2030 = 112.41 + 17.918\% \text{ of } P_{2020}$$

$$= (112.41 + 17.9818\% \text{ of } 112.41) \times 10^5$$

$$= 132.62 \times 10^5.$$

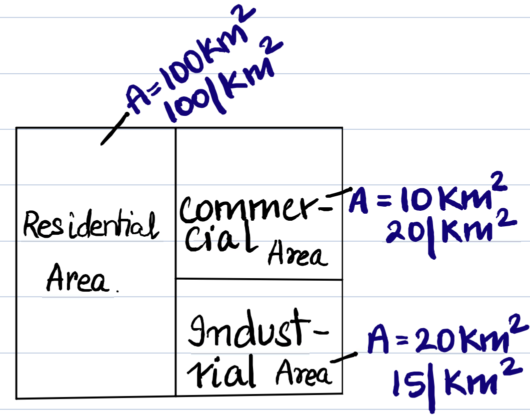
(v) Graphical Method

In this, we plot the graph of population for a community.



– If past data is missing, this method is used.

(vii) Master plan Method



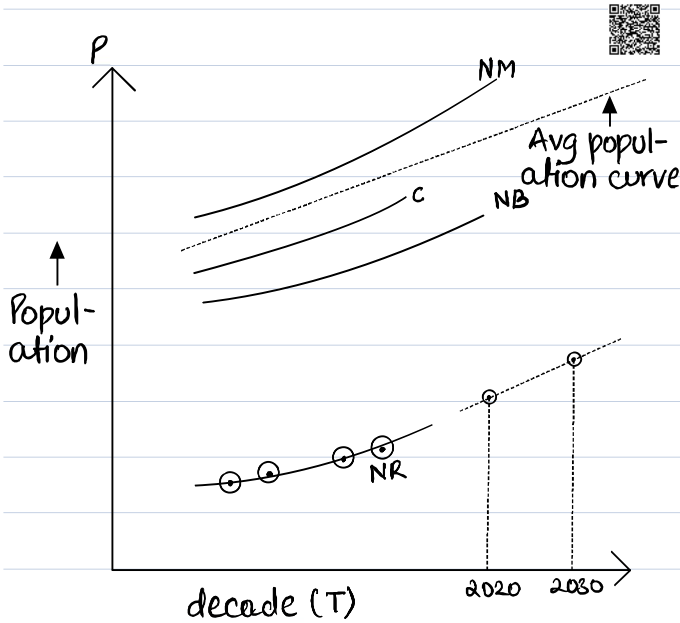
$P_R = 100\times100 = 10^4$

$P_c = 10\times20 = 200$

$P = 20\times15 = \underline{300}$

10500

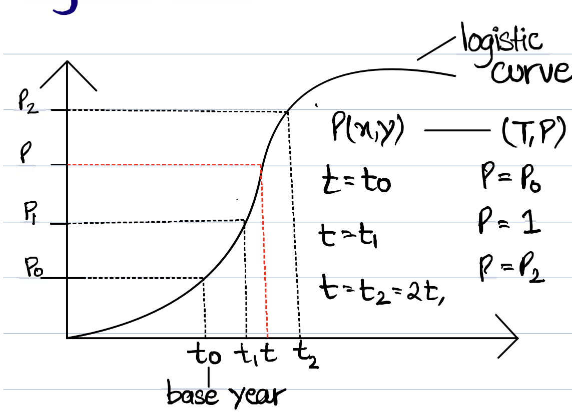
(vi) Comparative Graphical Method



* Comparative graphical method is more accurate as compare to graphical method.

(viii) Logistic Method

In logistic method, we find eq^n of logistic curve.



eq	1950	P_0	1950	P_0
	1970	P_1	1970	P_1
	2010	P_2	1990	P_2
			$t_2 = 2t_1$	

Equation of Logistic Curve

$$\ln\left(\frac{P_s-P}{P}\right)-\ln\left(\frac{P_s-P_0}{P_0}\right)=-KP_st$$

P_s = Saturation population
P_0 = base year population
P = Population at any time
K = Constant depend upon P_0, P, P_s

$P_s, P, K = ?$

$t = t_1$

$$\ln\left(\frac{P_s-P_1}{P_1}\right)-\ln\left(\frac{P_s-P_0}{P_0}\right)=-KP_st_1 \text{ — (ii)}$$

$$\ln\left(\frac{P_s-P_2}{P_2}\right)-\ln\left(\frac{P_s-P_0}{P_0}\right)=-KP_st_2 \text{ — (iii)}$$

$\boxed{\ln^{-1}=e}$

(i) $P_s = ?$
(ii) Eq^n of logistic curve
(iii) Population 2031

$P_0 = 25000 \quad P_1 = 30{,}000 \quad P_2 = 37000$
$t = 0 \quad t_1 = 10\text{yrs} \quad t_2 = 20\text{yrs}$

P_s = Saturation Population

$$= \frac{2P_0P_1P_2 - P_1^2(P_0+P_2)}{P_0P_2-P_1^2}$$

$$= \frac{2\times8\times25\times48-(25)^2(8+48)}{8\times48-(25)^2}$$

$$= 655602$$

(ii) $P = \dfrac{P_s}{1+m\ln^{-1}(nt)}$

Or, $P = \dfrac{P_s}{1+m\ln^{-1}(nt)}$

$$P_s = \frac{2P_0P_1P_2 - P_1^2(P_0+P_2)}{P_0P_2-P_1^2}$$

$$m = \frac{P_s-P_0}{P_0}$$

$$n = \frac{1}{t}\ln\left[\frac{P_0(P_s-P_1)}{P_1(P_s-P_0)}\right]$$

Q.

	Year	Population
	1991	$80000 = P_0 = 8$
	2001	$250000 = P_1 = 25$
	2011	$4800000 = P_2 = 48$
	2031	$P = ?$

$$m = \frac{P_s-P_0}{P_0}$$

$$= \frac{655602-80000}{80000} = 7.195$$

$$-n = \frac{1}{t}\ln\left[\frac{P_0(P_s-P_1)}{P_1(P_s-P_0)}\right]$$

$$= \frac{1}{10}\ln\left[\frac{80000(655602-2500000}{25000(655602-80000}\right]$$

$= -0.149$ take $t=1$

$$= P = \frac{655602}{1+7.195\ln^{-1}(-1.49\times t)}$$

$$P = \frac{P_s}{1+m\ln^{-1}(nt)}$$

$t = 4$ decades

$$P = \frac{655602}{1+7.195\ln^{-1}(-1.49\times4)}$$