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CE 331

Environmental Engineering - I

-11. $\boxed{1(c)}$

According to Kuichling, No. of fire streams, $F = 2.8\sqrt{p}$

where p = population in thousands.

$$\therefore F = 2.8 \times \sqrt{\frac{164000}{1000}} = 35.85 \approx \boxed{36}$$

9-10. $\boxed{1(d)}$

$$V = (\pi r^2 \cancel{t} + 2\pi r h) \times t$$

again, $V = \pi r^2 h$

Now, $C = \pi r^2 \times 300 + 2\pi r h \times 400$

$$\Rightarrow C = 300\pi r^2 + 800\pi r \cdot \frac{V}{\pi r^2}$$

$$\Rightarrow C = 300\pi r^2 + 800 \cdot \frac{V}{r}$$

$$\Rightarrow \frac{dc}{dr} = 600\pi r \cancel{+} - \frac{800 \times V}{r^2} = 0$$

$$\Rightarrow r^3 = \frac{800 \times V}{600\pi}$$

Now, $V = 2 \times 10^5$ gallons $= 7.57 \times 10^5$ litre (US conversion)

$= 7.57 \times 10^5\ dm^3 = 7.57 \times 10^5 \times 10^{-3} \times 3.28^3\ ft^3$

$= 26.7 \times 10^3\ ft^3$.

otherwise, $V = \frac{2 \times 10^5}{7.48}\ ft^3 = 26.7 \times 10^3\ ft^3$.

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Now, $r^3 = \frac{800 \times 26.7 \times 10^3}{600\,\pi}$

$\therefore \boxed{r = 22.5'}$

Now, $V = 26.7 \times 10^3 = \pi r^2 h$

$\therefore \boxed{h = 16.8'}$

confirm

Example - Aziz (p-27)

$P = 10,000$

Fire stream, $F = 2.8\sqrt{P} = 2.8\sqrt{10} = 9$

$\therefore$ Total stream flow = $9 \times 250 = 2250$ gpm

But according to National Board of Fire underwriters,

$Q = 1020\sqrt{P}\,(1 - 0.01\sqrt{P})$

$= 1020\sqrt{10000}\,(1 - 0.01\sqrt{10,000})$

$= 3124 \approx 4000$ gpm

ample (P-22):

For 2,00,000 population,

Fire demand according to National Board of Fire Underwriters,

$$Q = 1020 \times \sqrt{P} \left(1 - 0.01 \sqrt{P}\right)$$

$$= 1020 \times \sqrt{200} \times \left(1 - 0.01 \sqrt{200}\right)$$

$$= 12385 \approx 13,000 \text{ gpm}$$

So, total flow $= 13000 \times 10 \times 60 = 7.8 \times 10^6$ gallons.

So, volume of storage tank will be 7.8×10^6 gallons.

Example (P-34):

$$P_{1960} = 124,000$$

$$P_{1970} = 156,000$$

annual rate of increase, $r = \sqrt[n]{\frac{P_2}{P_1}} - 1$

$$= \sqrt[10]{\frac{156}{124}} - 1 = \boxed{0.023}$$

$$\therefore P_{1990} = P_p (1+r)^n$$

$$= 156,000 \times (1 + 0.023)^{20}$$

$$= 245831 \approx 246,000.$$

lternatively, $P_{1990} = 124000 \times (1 + 0.023)^{30} = \boxed{246,000}$

Example (P-35) Let $x = 0$ at 1920 and 10 years in the unity of x.

Year	Population Y	x	x^2	x^3	x^4	xY	x^2Y
1870	23.2	-5	25	-125	625	-116	580
1880	31.4	-4	16	-64	256	-125.6	502.4
1890	39.8	-3	9	-27	81	-119.4	358.2
1900	50.2	-2	4	-8	16	-100.4	200.8
1910	62.9	-1	1	-1	1	-62.9	62.9
1920	76	0	0	0	0	0	0
1930	92.0	1	1	1	1	92	92
1940	105.7	2	4	8	16	211.4	422.8
1950	122.8	3	9	27	81	3684 ~~131.7~~	1105.2
1960	131.7	4	16	64	256	526.8	2107.2
1970	151.1	5	25	125	625	755.5	3777.5
	$\Sigma Y = 886.8$	$\Sigma x = 0$	$\Sigma x^2 = 110$	$\Sigma x^3 = 0$	$\Sigma x^4 = 1958$	$\Sigma xY = 1429.9$	$\Sigma x^2Y = 9209$

Now $\Sigma Y = N.a + \Sigma x.b + \Sigma x^2 \times c$

$\Sigma xY = \Sigma x.a + \Sigma x^2 \times b + \Sigma x^3 \times c$

$\therefore \Sigma x^2 Y = \Sigma x^2.a + \Sigma x^3.b + \Sigma x^4.c$

$\therefore 886.8 = 11a + 0.b + 110.c$ — (1)

$1429.8 = 0.a + 110.b + 0.c$ — (2)

$9209 = 110.\overset{a}{\cancel{b}} + 0.b + 1958 \times c$ — (3).

$\therefore a = 76.64, \; b = 13, \; c = 0.3974$

$\therefore Y = 76.64 + 13x + 0.3974x^2$

~~$Y_{1980} = 76.64 + 13 \times 1980 + 0.3974x$~~

$\therefore$ at 1980, $x = 6$

$\therefore Y_{1980} = 76.64 + 13 \times 6 + 0.3974 \times 6^2$

$= \boxed{168.9 \text{ million}}$

at 1990, $x = 7$.

$\therefore Y_{1990} = 76.64 + 13 \times 7 + 0.3974 \times 67^2$

$= \boxed{187.1 \text{ million}}$

Example - P-276

$V = 1 \times 10^5$ gallons $= \frac{1 \times 10^5}{7.48} = 13370$ ft3..

Now, $V = \pi r^2 + 2\pi r h = \pi r^2 + 2\pi r \cdot \frac{V}{\pi r^2} = \pi r^2 + 2 \cdot \frac{V}{r}$

$\Rightarrow \frac{dV}{dr} = 2\pi r - 2 \times \frac{V}{r^2} = 0$

$\Rightarrow 2\pi r = 2 \times \frac{\pi r^2 h}{r^2} \Rightarrow 2\pi r = 2 \times \frac{13370}{r^2}$

$\Rightarrow r = h$

$\therefore \boxed{r = 16.2'}$

Now, $13370 = \pi r^2 h$

$\therefore \boxed{h = 16.2'}$.

Example (p-277):

$C_{shell} = 1.5 \times C_{floor}$

Now, $C = \pi r^2 \times \overset{C_{floor}}{\cancel{C_{shell}}} + 2\pi rh \times \cancel{C_{floor}}\ C_{shell}$

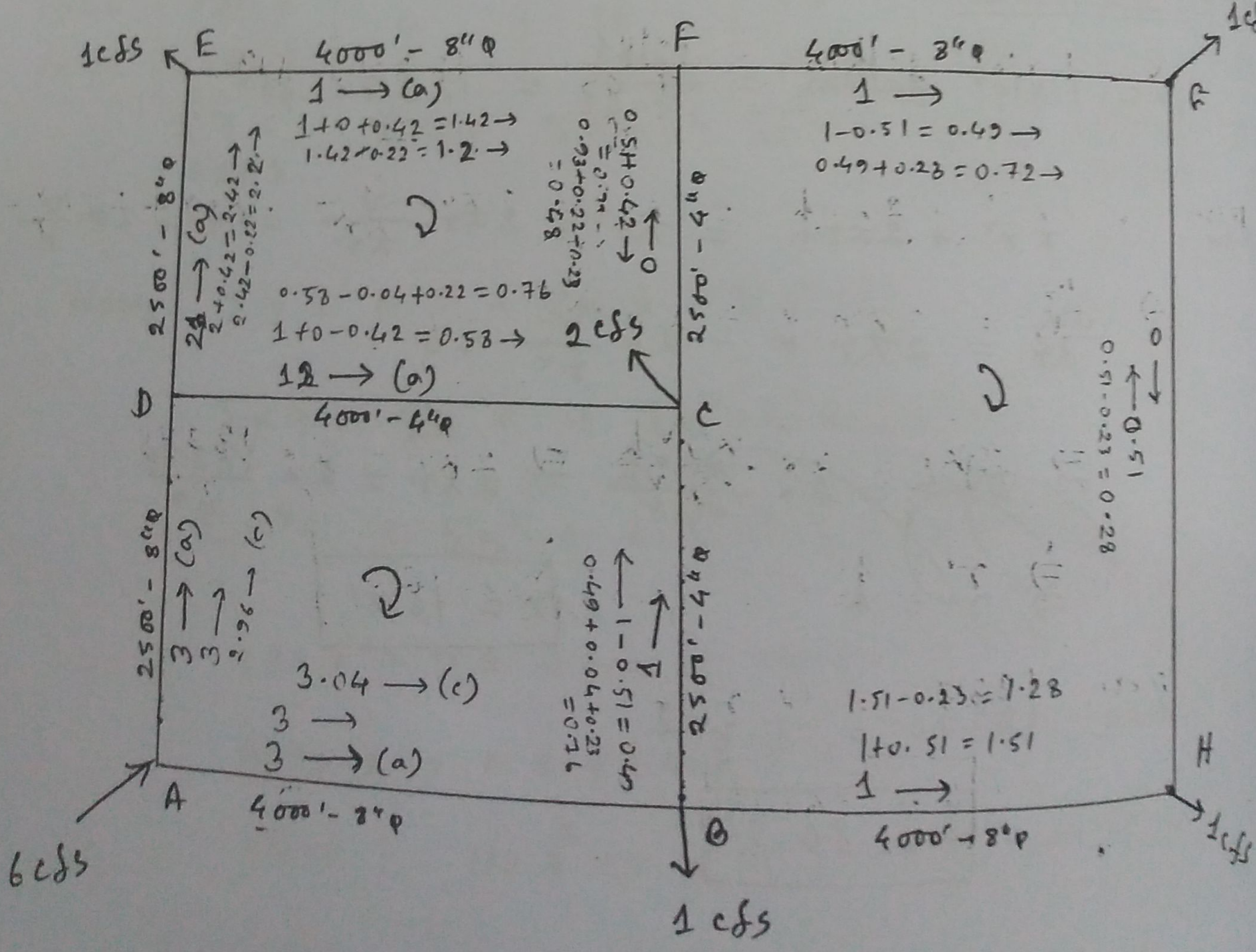
$\Rightarrow C = \pi r^2 \times \cancel{1.5} \times C_{floor} + 2\pi r \times \frac{V}{\pi r^2} \times C_{floor} \times 1.5$

$\Rightarrow \frac{dC}{dr} = 2 \times \cancel{1.5} \times \pi \times r \times C_{floor} - 2 \times \frac{V}{r^2} \times C_{floor} \times 1.5 = 0$

$\Rightarrow 2 \times \cancel{1.5} \times \pi \times r = 2 \times \frac{V}{r^2} = 2 \times \frac{\pi r^2 h}{r^2} \times 1.5$

$\Rightarrow \cancel{h = 1.5r}\ \boxed{r = 1.5h}$

$\boxed{2009\text{-}10.\ 2(b)}$



First Trial:

For loop ABCD

pipe	H	H/Q
AB	200 ~~50~~↻	~~16.67~~ 667
BC	200 ~~2~~↻	200
CD	200↺	200
DA	50↺	16.67
	ΣH = 0	ΣH/Q = 433

$\therefore \Delta Q = \frac{\Sigma H}{n \times \Sigma H/Q} = 0$

For loop CDEF

pipe	H	H/Q
CD	200↻	200
DE	25↺	12.5
EF	6.5↺	6.5
FC	0	0
	ΣH = 168.5↻	ΣH/Q = 219

$\therefore \Delta Q = \frac{168.5}{1.85 \times 219} = 0.42$↺

For loop BCFGH

pipe	H	H/Q
BC	2003↺	200
CF	0	0
FG	6.5↺	6.5
GH	0	0
HB	+ 6.5↻	6.5
	ΣH = 200↺	ΣH/Q = 213

$\therefore \Delta Q = \frac{200}{1.85 \times 213} = 0.51$↻

Second Trial:

For loop ABCD

pipe	H	H/Q
AB	50↻	16.67
BC	56↻	114.3
CD	763↺	131.
AD	50↺	16.7
	ΣH = 203↺	ΣH/Q = 278.64

$\Delta Q = \frac{\Sigma H}{n \Sigma H/Q} = \frac{20}{1.85 \times 278.64} = 0.04$↻

For loop . CDEF

pipe	H	H/Q
CD	762↻	131
DE	32↺	13.2
EF	12↺	8.45
FC	170↺	182.8
	ΣH = +138	335.45

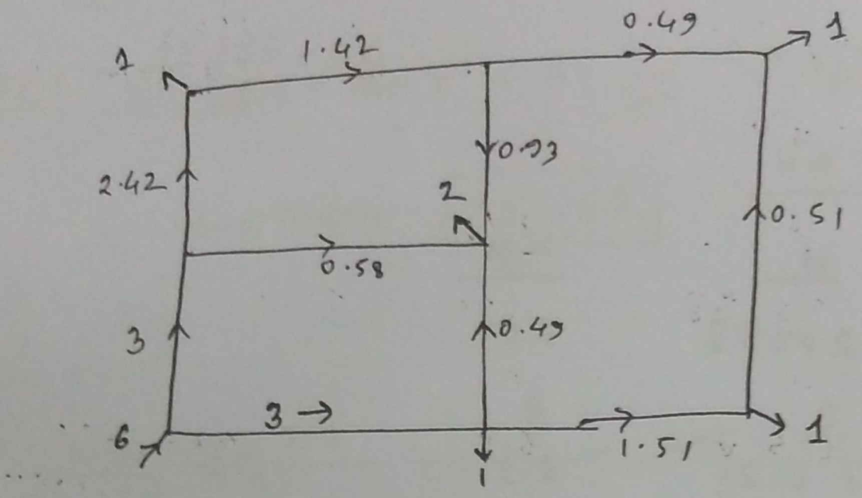
$\Delta Q = \frac{138}{1.85 \times 335.45} = 0.222$↻

~~Third~~ For loop BCFGH;

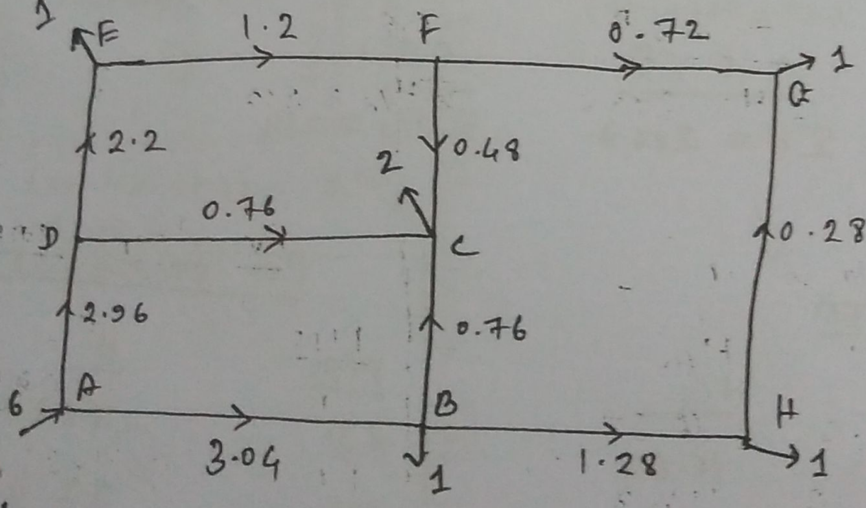
pipe	H	H/Q
BC	55 ↺	112.2
CF	180 ↻	193.5
FG	1.6 ↺	3.3
GH	1.8~~3~~ ↻	3.5
HB	13 ↻	8.6
	138.2 ↻	321.1

$$\Delta Q = \frac{138.2}{1.85 \times 321.1} = 0.23 ↺$$

After first trial



After second trial



For CDEF loop:

CD –	130 ↻	171.1
DE –	27 ↺	12.3
EF –	9 ↺	7.5
FC –	53 ↺	110.4
	–41	301.3

$$\Delta Q = \frac{41}{1.85 \times 301.3} = \underline{0.07}$$ which is quite negligible.

So, after second trial, the answer can be assumed as correct [illegible] 3

Let x = 0 at 1995 and 10 years in the unity of x.

Year	Y	X	X^2	X^3	X^4	XY	X^2Y
1980	0.9	−~~0~~1.5	2.25	−3.375	5.0625	−1.35	2.025
1990	1.2	−0.5	0.25	−0.125	0.0625	−0.6	0.3
2000	1.6	0.5	0.25	0.125	0.0625	0.7	0.33
2010	1.8	1.5	2.25	3.375	5.0625	2.7	4.05
	$\Sigma Y = 5.3$	$\Sigma x = 0$	$\Sigma x^2 = 5$	$\Sigma x^3 = 0$	$\Sigma x^4 = 10.25$	1.45	6.725

Now, $5.3 = 4a + 0.b + 5 \times c$

$1.45 = 0.a + 5.b + 0.c$

$6.725 = 5.a + 0.b + 10.25c$

$\therefore Y = 1.294 \cancel{b} + 0.29x + 0.025x^2$

At 2018, $x = \frac{(2018 - 1995)}{10} = 2.3$

$\therefore Y_{2018} = 1.294 + 0.29 \times 2.3 + 0.025 \times 2.3^2$

$= \underline{2.09}$ lac

ii) According to National Board of Fire underwriters.

$Q = 1020\sqrt{P}\,(1 - 0.01\sqrt{P})$

$= 1020\sqrt{2.09} \times (1 - 0.01\sqrt{2.09})$

$= 12614 \overset{\text{gpm}}{\text{gallons}} \approx 13,000$ gallons gpm

(iii) According to Kuichling,

$F = 2.8\sqrt{P} = 2.8\sqrt{209} = \boxed{41}$

(iv) Water requirement = fire demand + general service requirement

$= 13000 \times 60 \times 24 \times 365 + 40 \times 365 \times 2.09 \times 10^5$

$= \boxed{9.9 \times 10^9 \text{ gallons}}$

(v) For 6hr detention time,

$V = \frac{40 \times 2.09 \times 10^5}{\cancel{24}\ 6\ 24} \times 6 = 2.09 \times 10^6$ gallons

$= \frac{2.09 \times 10^6}{7.48} = 2.79 \times 10^5 \text{ ft}^3$ [US conversion]

Now, $C = 200 \times \pi r^2 + 250 \times 2\pi r h$

$= 200\pi r^2 + 500 \times \cancel{\pi} r \times \frac{V}{\cancel{\pi} r^2}$

$\frac{dc}{dr} = 400\pi r - 500 \cancel{\times \pi} \times \frac{V}{r^2} = 0$

$\Rightarrow 400 r = 500 \times \frac{\cancel{\pi r^2 \times} 2.79 \times 10^5}{\pi r^2} \cancel{=0}$

$\therefore \boxed{r = 48.1'}$

$V = 2.79 \times 10^5 = \pi \times 48.1^2 \times h$

$\therefore \boxed{h = 38.4'}$

confirm

[illegible] -03 3(c)

$P_{1990} = 55000$. $P_{2000} = 67500$

Now $r = \sqrt[n]{\frac{P_2}{P_1}} - 1$

$= \sqrt[10]{\frac{675}{550}} - 1 = 0.0207$

$P_{2015} = P_p(1+r)^n$

$= 67500 \times (1+0.0207)^{15}$

$= 91786$

water demand according to National Board of Fire underwriters,

$Q = 1020\sqrt{P}(1-0.01\sqrt{P})$

$= 1020\sqrt{91.79} \times (1-0.01\sqrt{91.79})$

$= 8836$ gpm $= \boxed{9000 \text{ gpm}}$

$F = 2.8\sqrt{P} = 2.8\sqrt{91.79}$

$= \boxed{27}$

$\boxed{2006-07 \mid 6(c)}$

$Q = 1020\sqrt{P} \times (1-0.01\sqrt{P}) = \boxed{7000 \text{ gpm}}$

$F = 2.3\sqrt{55} = \boxed{21}$

$\boxed{2006-07 \quad 8(d)}$

$V = 2,00000 \text{ gallons} = \frac{2\times 10^5}{7.48} = 26.74 \text{ cft}$

$= 757.1 \text{ m}^3.$

Now, $c = \pi r^2 t_1 c_1 + 2\pi r h \times t_2 c_2$

$= 8000 \times \pi r^2 \times 0.25 + 10,000 \times 2\pi r \times \frac{V}{\pi r^2} \times 0.2$

$\Rightarrow \frac{dc}{dr} = 2\times 8000 \times 0.25 \times \pi \times r - 2\times 10,000 \times \frac{757.1}{r^2} \times 0.2 = 0$

$\therefore \boxed{r = 6.221}$

$h = \frac{\cancel{2}\ 757.1}{\pi r^2} = \boxed{6.221}$

$\boxed{2004-05 \quad 1(b)}$

confirm

(i) $P_{2005} = 10,000 \quad , r = 0.01$

$\therefore P_{2010} = 10,000 \times (1+0.01)^5 = 10510$

(ii) $Q = 1020 \times \sqrt{10.5} \times (1 - 0.01\sqrt{10.5}) = 3198 \approx \boxed{4000 \text{ gpm}}$

(iii) $F = 2.8 \times \sqrt{10.5} = \boxed{10}$

2006-07 | 6(c)

$Q = 1020\sqrt{P} \times (1 - 0.01\sqrt{P}) = \boxed{7000 \text{ gpm}}$

$F = 2.8\sqrt{55} = \boxed{21}$

2006-07 8(d)

$V = 2,00000$ gallons $= \frac{2 \times 10^5}{7.48} = 26.74$ cft

$= 757.1 \; m^3.$

Now $c = \pi r^2 t_1 c_1 + 2\pi r h \times t_2 c_2$

$= 8000 \times \pi r^2 \times 0.25 + 10,000 \times 2\pi r \times \frac{V}{\pi r^2} \times 0.2$

$\Rightarrow \frac{dc}{dr} = 2 \times 8000 \times 0.25 \times \pi \times r - 2 \times 10,000 \times \frac{757.1}{r^2} \times 0.2 = 0$

$\therefore \boxed{r = 6.221}$

$h = \frac{757.1}{\pi r^2} = \boxed{6.221}$

confirm

2004-05. 1(b)

(i) $P_{2005} = 10,000$, $r = 0.01$

$\therefore P_{2010} = 10,000 \times (1 + 0.01)^5 = 10510$

(ii) $Q = 1020 \times \sqrt{10.5} \times (1 - 0.01\sqrt{10.5}) = 3198 \approx \boxed{4000 \text{ gpm}}$

(iii) $F = 2.8 \times \sqrt{10.5} = \boxed{10}$

chapter - 4 (Habibur)

Example - 4.1

$L = 0.1\ m, \quad A = 0.05\ m^2, \quad Q = 2\ m^3/day$

$$Q = K \cdot A \cdot \frac{\Delta h}{\Delta l}$$

$$\Rightarrow 2 = K \cdot 0.05 \times \frac{2}{0.1}$$

$$\therefore K = 2\ m^3/m^2\text{-}day$$

Example - 4.2

here, $K = 2\ m^3/day\text{-}m^2$; $\Delta h = 3m$, $\Delta L = 100m$.

$$Q = K \cdot A \cdot \frac{\Delta h}{\Delta l} = 2 \times 6 \times 1 \times \frac{3}{100} = 0.36\ m^3/day$$

Again, $Q = Av$

$$\therefore v = \frac{0.36}{1 \times 6} = \boxed{0.06\ m/day}$$

Example - 4.3

For an unconfined aquifer, $Q = \dfrac{\pi K (h_2^2 - h_1^2)}{\ln(r_2/r_1)}$

here, $Q = 1000\ m^3/day$,

$$\text{Now } Q = 1000 = \frac{\pi \times k \times (29.8^2 - 29.7^2)}{\ln\left(\frac{100}{50}\right)}$$

$$\therefore K = 37.1\ m^3/m^2\text{-}day.$$

Now, $Q = \frac{\pi K (h_2^2 - h_1^2)}{\ln(r_2/r_1)}$

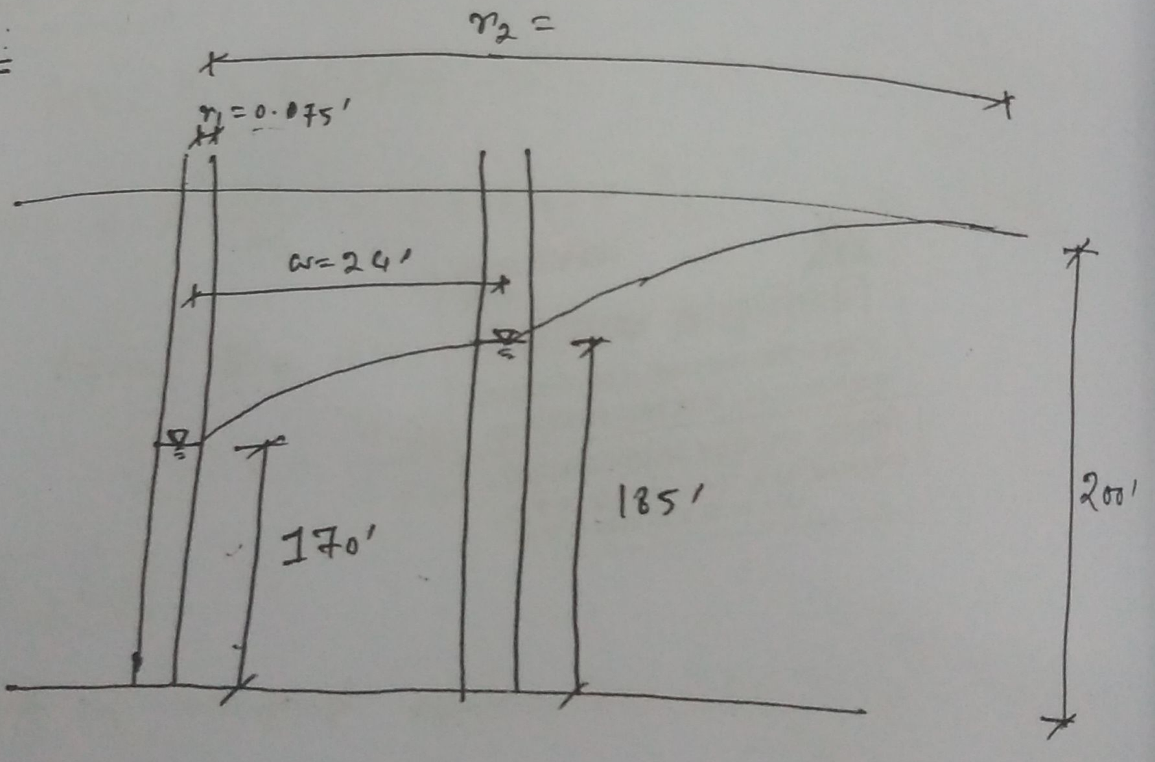
$\Rightarrow 1000 = \frac{\pi \times 37.1 \times (29.7^2 - h_1^2)}{\ln\left(\frac{50}{0.1}\right)}$

$\therefore h_1 = 28.8\,m$

$\therefore$ drawdown $= 30 - 28.8 = \boxed{1.2m}$

⊞ An 18" ordinary well is being pumped at a rate of 350 gpm with a drawdown of 30'. The static depth of water in the well is 200'. During pumping, the depth of water in a simillar well, not being pumped, at a distance of 24' is 185'. At what rates water must be pumped from the two wells, if both wells are being pumped together with a drawdown of 30' each?

Ans:



$$r_1 = \frac{18''}{2} = \frac{9}{12}' = 0.75'$$

for the first and the another well (not being pumped)

$$Q = \frac{\pi K (h_2^2 - h_1^2)}{\ln(r_2/r_1)}$$

$$\Rightarrow 350 = \frac{\pi \times K \times (185^2 - 170^2)}{\ln\left(\frac{24}{0.75}\right)}$$

$$\therefore K = 0.0725 \ \underline{gpm/ft^2}$$

if r_2 is the radius of the circle of the influence,

$$\text{then, } 350 = \frac{\pi \times 0.0725 \times (200^2 - 170^2)}{\ln(r_2/0.75)}$$

$$\therefore r_2 = 1028'$$

(ii) For two similar wells drawing water from the same aquifer situated at w ft apart, their rate of discharge is,

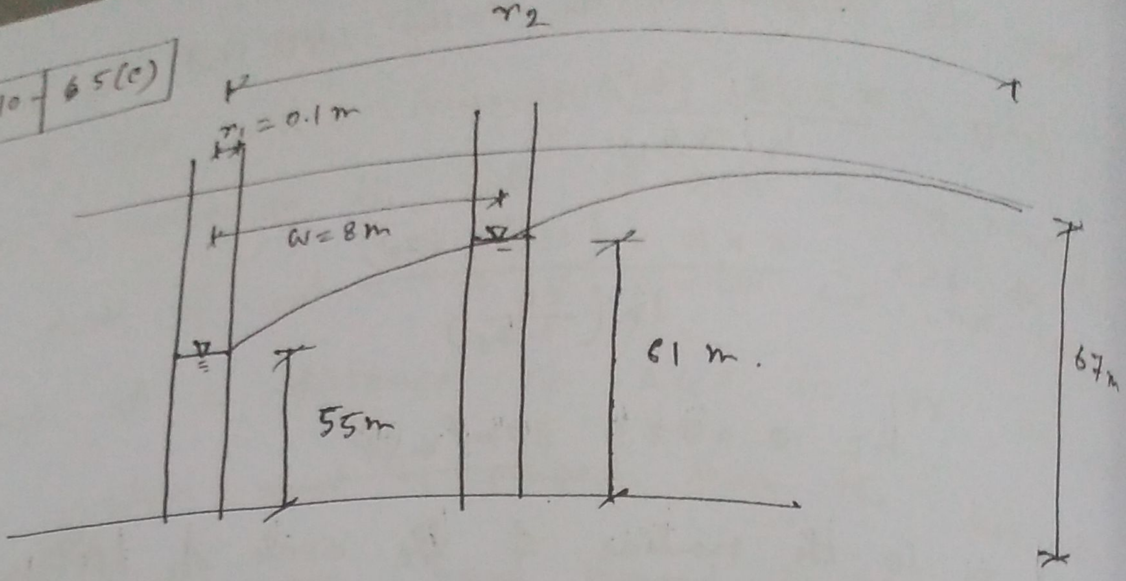
$$Q_1 = Q_2 = \frac{\pi K (h_2^2 - h_1^2)}{\ln\left(\frac{r_2^2}{r_1 w}\right)} = \frac{\pi \times 0.0725 \times (200^2 - 170^2)}{\ln\left(\frac{1028^2}{0.75 \times 24}\right)}$$

$$\therefore Q = 230 \text{ gpm}$$

∴ combined rate of flow for two wells

$$= 2 \times 230 = \boxed{460 \text{ gpm}}$$

2009-10 | 65(c)



$$r_1 = \frac{200}{2} \text{ mm} = 0.1 \text{ m}.$$

$$Q = 400 = \frac{\pi \times K \times (61^2 - 55^2)}{\ln(8/0.1)}$$

$$\therefore K = 0.802 \text{ gpm/m}^2$$

Now, $$400 = \frac{\pi \times 0.802 \times (67^2 - 55^2)}{\ln(r_2/0.1)}$$

$$\therefore r_2 = 1011.3 \text{ m}.$$

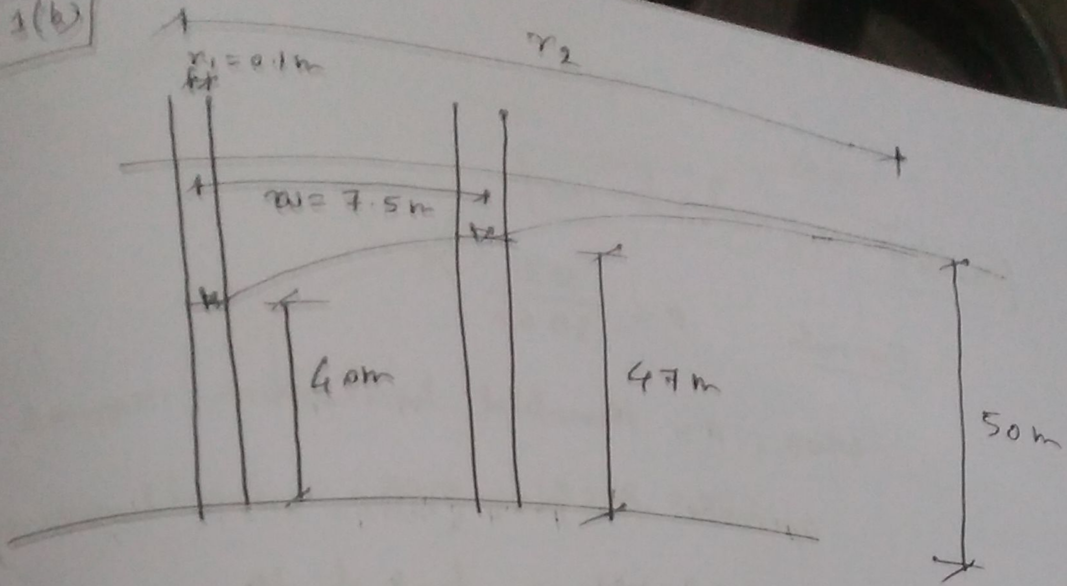
for combined drawing, $$Q_1 = Q_2 = \frac{\pi K (h_2^2 - h_1^2)}{\ln\left(\frac{r_2}{r_1 \omega}\right)}$$

$$\Rightarrow Q_1 = \frac{\pi \times 0.802 \times (67^2 - 55^2)}{\ln\left(\frac{1011.3}{0.1 \times 8}\right)}$$

$$= 516.5 \text{ gpm}.$$

∴ for both wells, $Q = 2 \times 516.5 = \boxed{1033 \text{ gpm}}$

Test 08 | 1(b)



$r_1 = \frac{200}{2} = 100$ mm $= 0.1$ m , $Q = 1000$ litre/min.

$$Q = 1000 = \frac{\pi K \times (47^2 - 40^2)}{\ln\left(\frac{7.5}{0.1}\right)}$$

$\therefore K = 2.26$ litre/min ~~[illegible]~~-m.

$$\text{Again, } 1000 = \frac{\pi \times 2.26 \times (50^2 - \cancel{40^2}\, 40.5^2)}{\ln\left(\frac{r_2}{0.1}\right)}$$

$\therefore r_2 = 59$ m

$$\text{Now, } Q_1 = Q_2 = \frac{\pi K (h_2^2 - h_1^2)}{\ln\left(\frac{r_2}{r_1 w}\right)}$$

$$= \frac{\pi \times 2.26 \times (50^2 - \cancel{40.5^2}\, 40.5^2)}{\ln\left(\frac{59}{0.1 \times 7.5}\right)}$$

$= 1398$ litre/min

$\therefore$ for both wells, $Q = 1398 \times 2 = \boxed{2797 \text{ litre/min}}$

Pump

Problem - 1. (Aziz) P-143

Formula: $P = \frac{HQ}{3960}$

where, P = theoretical horsepower required to operate the pump (WHP = work horse power)

H = total lift or head of the pump (ft)

Q = volume of water to be pumped (gpm).

$P' = \frac{P}{E}$

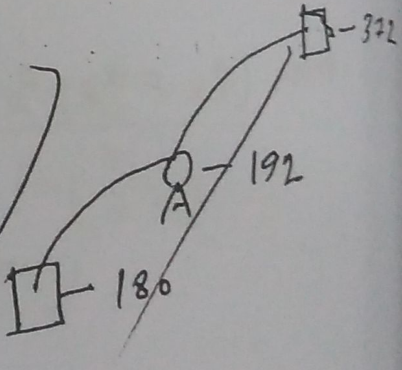
where, E = efficiency

P' = actual horsepower required to operate the pump (BHP = Break Horse power)

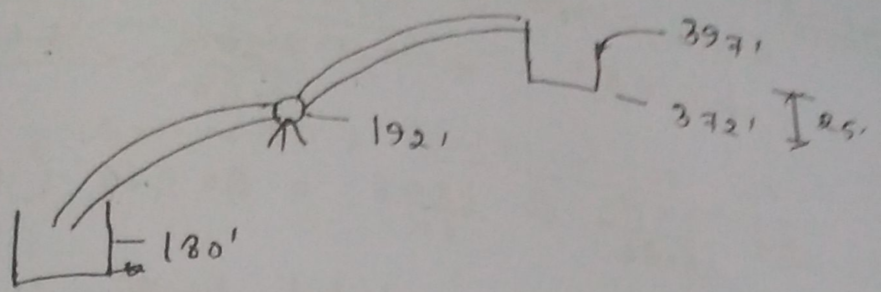
Math:

Q = 6750 gpm

elevation head = 372 - 180 = 192 ft.



$Q = 6750$ gpm



so, elevation head $= 397 - 180 = 217'$

so, total head $= 217 + 1.5 \times 2 = 220'$

Now, $P = \frac{QH}{3960} = \frac{6750 \times 220}{3960}$

$= 375$ (WHP)

$\therefore P' = \frac{P}{E} = \frac{375}{0.67} = \boxed{560 \text{ (BHP)}}$

~~Problem-2;~~ ~~$Q = 450,000$ gph $= \frac{450,000}{60} = 7500$ gpm~~

~~$v = 12$ fps.~~

Problem-2:

$Q = 4,50000$ gph $= \frac{450,000}{60} = 7500$ gpm

$= \cancel{\frac{7500}{7.48}} = \cancel{3.43}$

$\therefore Q = \frac{7500}{6.24} = \frac{1202}{60} = 20$ cfs (UK ~~US~~ conversion).

static head = 60'. total length = 800'.

$v = 12$ fps. $f = 0.075$, $E = 0.70$.

Now, $Q = Av = \frac{\pi}{4} D^2 \times v$

$\Rightarrow 20 = \frac{\pi}{4} \times D^2 \times 12$

$\therefore D = 1.5$ ft

Now total head loss, $H = 60 + \frac{v^2}{2g} + 4f \cdot \frac{L}{D} \cdot \frac{v^2}{2g}$

$= 60 + \frac{12^2}{2 \times 32} + \overset{0.0075}{\cancel{0.075}} \times 4 \times \frac{800}{1.5} \times \frac{\cancel{8}12^2}{2 \times 32}$

$= \cancel{422.25}$ 98.25 ft.

Now, $P = \frac{QH}{3960} = \frac{\cancel{20\times} 7500 \times 98.25}{3960}$

$\therefore P = \boxed{186 \text{ (WHP)}}$

Now, $P' = \frac{P}{E} = \frac{186}{0.7} = \boxed{266 \text{ (BHP)}}$

Problem-3 (Example 5.3)

$Q = 625$ mgd $= \frac{625\times10^6}{6.24\times24\times60\times60} = 788$ cfs

$f = 300$ ft $= 4\times.0075 \times \frac{30\times1.61\times10^3\times3.28}{D} \times \frac{v^2}{2g}$

Again, $Q = \frac{\pi}{4}\times D^2\times v$

$\Rightarrow 788 = \frac{\pi}{4}\times D^2\times v$

$\Rightarrow v^2 = \frac{1.007\times10^6}{D^4}$

Now, $300 = 4\times0.0075\times\frac{30\times1.61\times10^3\times3.28}{D^5}\times\frac{1.007\times10^6}{2\times32}$

$\therefore \boxed{D = 12'}$

Problem-4

$Q = 5$ mgd $= \frac{5\times10^6}{24\times60} = 3472$ gpm $= \frac{3472}{6.24\times60}$

$= 9.274$ cfs

Static head $= 60'$, $L = 120' + 400' = 520'$.

For pumping hours 16 hr/day

$Q = \frac{5\times10^6}{16\times60} = 5208$ gpm $= 13.9$ cfs.

Again, $13.9 = \frac{\pi}{4}\times D^2\times6$

$\therefore D = 1.72' \approx 1.75'$

Now, for $D = 1.75'$,

$13.9 = \frac{\pi}{4} \times 1.75^2 \times V \quad \therefore V = 5.78$ fps.

Total head $= 60 + \frac{5.78^2}{2 \times 32.2} + ~~4 \times 0.07 \times~~ 0.0075 \times \frac{520}{1.75} \times \frac{5.78^2}{2 \times 32.2}$

$= 65.14$ ft.

$\therefore P = \frac{65.14 \times 5208}{3960} = 86$ (WHP).

$\therefore P' = \frac{86}{0.75} =$ ~~12~~ $\boxed{115 \text{ (BHP)}}$

Problem - 53 (Example - 5.4)

$Q = 40$ gpcd $= \frac{40}{10 \times 60} \times 85000 = 5666.67$ gpm

$= \frac{5666.67}{6.24 \times 60} = 15.14$ cfs.

$Q = AV$

$\Rightarrow 15.14 = \frac{\pi}{4} \times D^2 \times 8$

$\therefore D = 1.55' \simeq 1.75'$

Now, for $1.75'$, $15.14 = \frac{\pi}{4} \times 1.75^2 \times V$

$\therefore V = 6.29$ fps.

Total head loss $= (193 - 102.5) + \frac{6.29^2}{2\times32.2} + 4\times0.01\times\frac{3500}{1.75}\times\frac{6.29^2}{2\times32.2}$

$\therefore H = 140.26$ ft.

$\therefore p = \frac{140.26\times5666.67}{3960} = \boxed{201 \text{ WHP}}$

$p' = \frac{201}{0.65} = \boxed{309 \text{ BHP}}$.

$\boxed{\text{Example - 5.5}}$

$p = 2\times10^5$, $Q = 135$ lpcd.

Now $Q = \frac{135\times0.22 \text{ gallon}}{24\times60}\times2\times10^5 = \boxed{4125 \text{ gpm}}$

$= \frac{4125}{6.24\times60} = 11.02$ cfs $= \underline{0.312 \text{ m}^3/\text{s}}$

Again, ~~H = (140-120) +~~ $Q = \frac{\pi}{4}\times D^2\times\frac{v^2}{\cancel{2g}}$

$\Rightarrow$ ~~11.02 = π/4~~ $\Rightarrow 0.312 = \frac{\pi}{4}\times0.9^2\times\frac{v^2}{\cancel{2\times9.81}}$

$\therefore v = 0.49$ m/s.

$H = 20 + \frac{0.49^2}{2\times9.81} + \cancel{4\times}2 = \underline{22.01 \text{ m}}$

Now, $p = \frac{22.01\times3.28\times4125}{3960} =$.

or, $p = \frac{QWH}{75} = \frac{0.312\times1000\times22.01}{75} = \underline{\underline{92 \text{ hp (WHP)}}}$

$\therefore p' = \frac{92}{0.9\times0.7} = \boxed{146 \text{ hp}}$ (BHP).

Example - 5.6

$Q = 120\ \text{lpcd} = 26.4\ \text{gpcd} = \frac{26.4 \times 50,000}{8 \times 60 \times 60 \times 6.24 \times 3.28^3} \times 1.5$

$= 0.312\ m^3/s.$

$v = 2m/s.$

Now, $0.312 = \frac{\pi}{4} \times D^2 \times 2 \quad \therefore D = 0.45m \approx 0.5m$

for, $D = 0.5m, \quad v = \frac{0.312 \times 4}{\pi \times 0.5^2} = 1.6\ m/s.$

Now, $H = 20 + \frac{1.6^2}{2 \times 9.81} + 4 \times 0.0075 \times \frac{3 \times 10^3}{0.5} \times \frac{1.6^2}{2 \times 9.81}$

$= 20 + 0.13 + 23.49 = 43.6m.$

Now, $P = \frac{QWH}{75} = \frac{0.312 \times 1000 \times 43.6}{75}$

$= 181\ hp$ (WHP)

$\therefore P' = \frac{181}{0.8} = \boxed{227\ \text{BHP}}$

well design math:

sieve No.	sieve opening	Matorials retained	percent Matorials retained	cumulative percent retained	percent finer
	4.75	–			
4	2.36	–			
8	1.18	–			
16	0.6	0.6	1	1	99
30	0.425	7.8	8	9	91
40	0.30	27.7	28	37	63
50	0.15	37.3	37	74	26
100	0.075	15.4	15	89	11
200		11.2	11	–	
pan					

from the curve. $D_{50} = 0.26\,mm > 0.25\,mm$

$$C_u = \cancel{\frac{D_{30}}{D_{60}}} \quad \frac{D_{60}}{D_{10}} = \frac{0.29}{0.07} = 4 > 3$$

Hence, we will design as graval pack.

Now, draw graval pack curve.

Let's miltiply the seive analysis curve by 4.5 times.

$$\text{Now, } \cancel{D_{60}} \; C_u = \frac{D_{60}}{D_{10}} = \cancel{1.2} \; \frac{1.1}{\cancel{4.1}\; 0.41} = 2.68 < 3$$

∴ the gravel pack curve is drawn properly.

Now slot size = size of 90% retained

= D_{10} = 0.41mm = 0.016 in.

Hence, slot No. is $\boxed{16}$

Given diameter of the well strainer = 100 mm

= 4" dia

opening area of strainer = 15%.

Now, cylindrical surface area = $\pi \times \frac{4}{12} \times 1$

= 1.047 ft^2

∴ Opening area = 1.047 × 0.15 = 0.157 sft.

$\boxed{\text{velocity} = 0.1 \text{ fps.}}$

∴ Discharge (per unit length), Q = 0.157 × 0.1

~~= 0.0157 cft/.~~

= 0.0157 cfs (per unit length).

∴ Yield = 0.0157 cfs = ~~0.0157 × 624 × 60 × 60~~

Now; let's assume, F.S = 2.5.

$$\therefore \text{Yield} = \frac{0.0157 \times 7.48}{2.5} \times 3600 = 169$$ US gallon/hr/ ft of strainer.

No.	Sieve opening	Cumulative % passing		Cumulative retained
	4.76	100	100	
4	2.36		98	—
8	1.68	90	86	2 ± 8 = 0 - 10
12	1.18	70	63	14 ± 8 = 6 - 22
16				17 ± 8 = 9 - 25
20	0.84	39	40	60 ± 8 = 52 - 68
30	0.6	15	21	79 ± 8 = 71 - 87
40	0.425	3	11	89 ± 8 = 81 - 97.

2009-10 | 6(c)

$$Q = \frac{45 \times 90{,}000 \times 3.785 \times 10^{-3}}{12 \times 60 \times 60} = 0.355 \ m^3/s.$$

~~$H = (58.5 - 30)$~~

Now $Q = 0.355 = \frac{\pi}{4} \times D^2 \times 2.5 \quad \therefore D = 0.425 \approx \boxed{0.5 \ m}$

for $D = 0.5$ m, $v = \frac{0.355 \times 4}{\pi \times 0.5^2} = 1.8$ m/s.

Now, $H = (58.5 - 30) + 4 \times 0.011 \times \frac{1100}{0.5} \times \frac{1.8^2}{2 \times 9.81}$

$= 44.5$ m

Now, $P = \frac{QWH}{75} = \frac{0.355 \times 1000 \times 44.5}{75} = 211$ (WHP)

$\therefore P' = \frac{211}{0.9 \times 0.75} = \boxed{313 \ hp}$

$\boxed{2008\text{-}09 \mid 7(c)}$

$$Q = 40,00,000 \text{ lpd} = \frac{40\cancel{0},00000 \times 10^{-3}\ m^3}{6 \times 3600 \times 2} = \overset{\overset{0.0925}{\cancel{0.925\ m^3/s}}}{\cancel{1.85\ m^3/s}}$$

suction head = ~~5~~ ~~300~~ 25 - 30 = -5 m

delivery head = 70 - 325 = 45 m

∴ total elevation head = suction head + delivery head

= - 5 + 45 = 40m

$$\text{Now, } \overset{\overset{0.0925}{\cancel{0.925}}}{\cancel{1.85}} = \frac{\pi}{4} \times D^2 \times 1.8$$

$$\therefore D = \cancel{1.14\,m}\ 0.81\ m$$

$$\text{Now, } H = 40 + \frac{\cancel{1}\,1.8^2}{2\times9.81} + 4 \times 0.009 \times \frac{1200}{\underset{0.81}{\cancel{1.14}}} \times \frac{1.8^2}{2\times9.81}$$

$$= \cancel{46.62\,m}\ 48.97\ m$$

$$\therefore P = \frac{QwH}{75} = \frac{\overset{0.925}{\cancel{1.85}} \times 1000 \times \overset{48.97}{\cancel{46.42}}}{75}\ \cancel{= 1145\ (WHP)}$$

$$= 604\ (WHP)$$

$$\therefore P' = \frac{604}{0.68} = \boxed{888\ (BHP)}$$

2007-08 | 3(a)

Sieve size No.	Sieve opening (mm)	Material retained	% material retained	Cumulative % retained	Cumulative % finer
	4.75	–	–	–	~~100~~
#4	2.38	–	–	–	~~100~~
#8	1.19	–	–	–	100
#16	0.60	0.5	1	1	99
#30	0.425	1.0	1	2	98
#40	0.30	4.4	4	6	94
#50	0.15	64.8	65	71	29
#100	0.075	27.1	27	98	2
#200		2.2	2		
pan					
		100			

here, $D_{50} = 0.18$, $C_u = \frac{D_{60}}{D_{10}} = \frac{0.135}{0.1} = 1.35 < 3$

since, $D_{50} < 0.25$ and $C_u < 3$, ← gravel

So, we will do screen well design.

Now, the slot size will be that size which retain 30 - 50% material i.e. D_{50} to D_{70}

$\therefore$ slot size $= D_{60} = 0.185$ mm $= 0.007^4$

$\therefore$ $\boxed{\text{Slot No} = 7}$

Diameter of well strainer = 100 mm

= 4"

∴ cylindrical surface = $\pi \times \frac{4}{12} \times$ [illegible] $\times 1$

= 1.047 sft.

∴ opening area = 1.047 × 0.1 = 0.01047 sft

∴ Yield / discharge = 0.01047 × 0.1

= 0.01047.

∴ ~~B~~ Yield = $\frac{0.01047}{2.5}$ ~~3~~ × 3600 × 7.48 = 113 US gallon/ hr / ft of strainer.