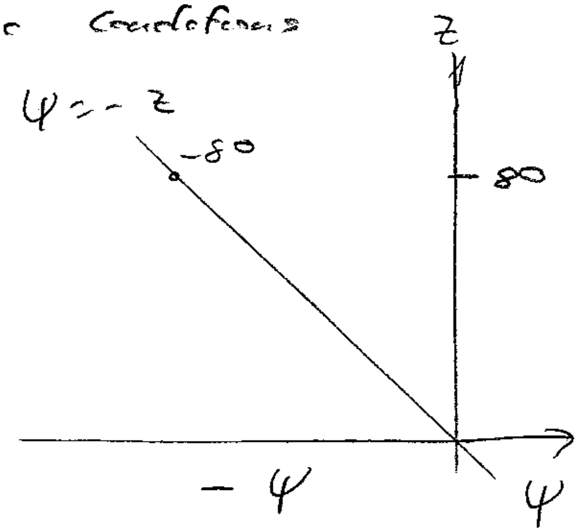
CEE 6400 MIDTERM SOLN

1\. a) Hydrostatic conditions



b) Capillary fringe at $z = |\psi_a| = \underline{21.8\,cm}$

c) $$|\psi| = |\psi_a| \left(\frac{\theta}{n}\right)^{-b}$$

$$\therefore \quad \theta = \begin{cases} n\left(\dfrac{|\psi|}{|\psi_a|}\right)^{-1/b} & \text{for } |\psi| > |\psi_a| \\ n & \text{for } |\psi| < |\psi_a| \end{cases}$$

at $z = 0$

$$\theta = n = 0.435$$

at $z = 21.8\,cm$

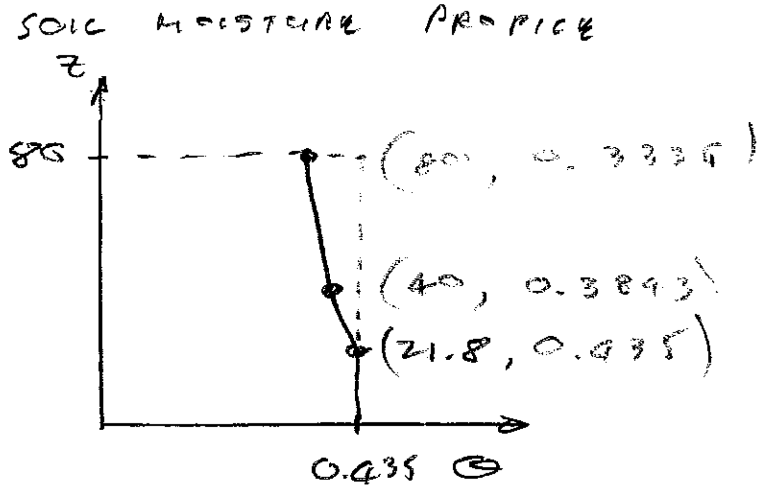
$$\theta = n = 0.435$$

at $z = 40$

$$\theta = 0.435\left(\frac{40}{21.8}\right)^{-1/4.9} = 0.3843$$

at $z = 80$

$$\theta = 0.435\left(\frac{80}{21.8}\right) = 0.3336$$



d) $D = \int_{Depth} (n - \theta)\, dz$

Evaluate using triangles

$$D = \frac{0.435 - 0.3843}{2} \times (40 - 21.8)$$

$$+ \left(0.435 - \left(\frac{0.3843 + 0.3336}{2}\right)\right) \times 40$$

$= 3.502$ cm

e) Rainfall rate $= \frac{6}{24} = 0.25$ cm/h

This is $< K_{sat}$ so only consider infiltration excess.

$F_p = 3.502$ cm $\qquad t_p = \frac{3.502}{0.25}$

$= 14$ h

f) Runoff $= 6$ cm $- 3.502$ cm

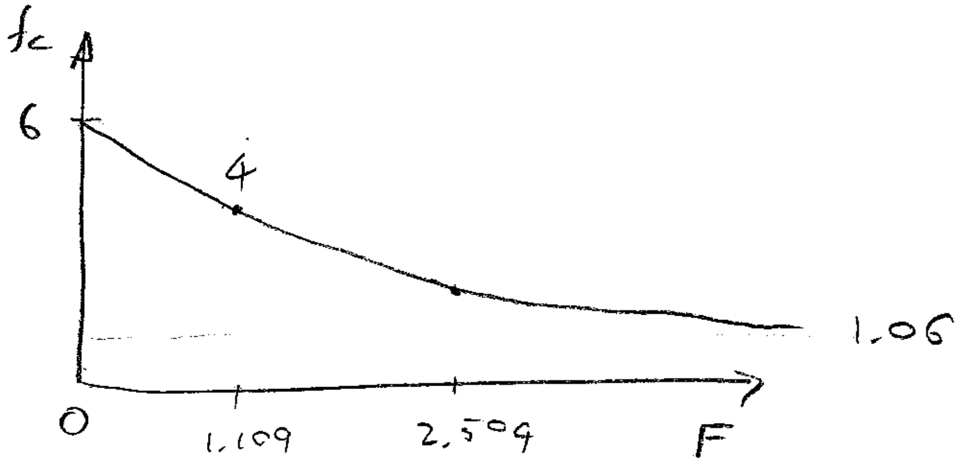
$= 2.5$ cm

2. a) $$F = \frac{f_0 - f_c}{k} - \frac{f_1}{k} \ln\left(\frac{f_c - f_1}{f_0 - f_1}\right)$$

$f_0 = 6$ cm/h
$f_1 = 1.06$ cm/h

$k = 2.3\ h^{-1}$

f_c cm/h	6	4	2	1.06
F cm	0	1.109	2.504	∞



b) No ponding at beginning
$F' = 2.5$ cm
$f_c = 2$ cm/h from Fig
< 5 cm/h
Ponding starts in interval

$$F_p = \frac{f_0 - \overset{5}{\downarrow}\omega}{k} - \frac{f_1}{k}\ln\left(\frac{\omega - f_1}{f_0 - f_1}\right)$$

$$= \frac{6-5}{2.3} - \frac{1.06}{2.3}\ln\left(\frac{5-1.06}{6-1.06}\right)$$

$$= 0.539\ \text{cm}$$

$$\Delta t' = \frac{0.53}{5} = 0.1078\ h$$

$$\therefore\ t_p = 0.1078\ h$$

Need to Solve for t_0 in

$$0.539 = 1.06(\underbrace{0.1078 - t_0}_{tf}) + \frac{6-1.06}{2.3}\left(1-e^{-2.3(0.1078-t_0)}\right)$$

Solve:

tf	:	0	0.05	0.08	0.09	0.1
Remainder	:	0.539	0.253	0.09	0.04	-0.0083

0.096
0.011

$\therefore$ Take $tf = 0.1$

$\therefore$ $t_0 = 0.1078 - 0.1 = 0.0078$

at $t = 0.5$

$$F = 1.06(0.5 - 0.0078) + \left(\frac{6-1.06}{2.3}\right)\left(1-e^{-2.3(0.5-0.0078)}\right)$$

$$= \underline{1.977\ \text{cm}}$$

This is infiltration from $\underline{0.1078\ h\ \text{to}\ 0.5\ h}$

in 1st half hour

$R = 2.5 - 1.977 = \underline{0.522 \text{ cm}}$

in 2nd half hour

$w = 1 \text{ cm/h} < f_1$

no runoff

Infiltration is $\underline{0.5 \text{ cm}}$

(6)

3 a) Mean annual flow = $\frac{80}{4} + \frac{80+200}{8} + \frac{200+100}{8} + \frac{100+80}{8}$

$= \underline{115 \text{ cfs}}$

b)

$\frac{20}{120} \times 3 = 0.5$ month

Vol = 20×3 months
$+ 10 \times 3$ months
$+ 10 \times 0.5$ months

$= 95 \ ft^3/s$ months

Take 1 month $= \frac{1}{12} \times 365.25 \times 24 \times 3600$ s

$= 2.6298 \times 10^6$ s/month

$\therefore$ Vol $= 95 \times 2.6298 \times 10^6$

$= 247.8 \times 10^6 \ ft^3 \simeq \underline{250 \times 10^6 \ ft^3}$

This is the storage required to support yield of $100 \ ft^3/s$

c) Annual Precip $P = 50$ in

Annual Runoff

Area $= 100 \ mi^2$
$\times 5280^2 = 2.7878 \times 10^9 \ ft^2$

$Q = 115 \times 365.25 \times 60 \times 60 \times 24$
$= 3.629 \times 10^9 \ ft^3$

$\therefore R = \frac{Q}{A} = 1.301 \ ft = 15.62 \ in$

$E = P - Q$
$= 50 - 15.6 = \underline{34.4 \ in}$

d) $w = \frac{Q}{P} = \frac{15.6}{50} = \underline{0.31}$