

PGE381 L  
Ordinance Petrophysics  
HW4

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Question 1

$\phi = 15\%$

$K = 40 \text{ mD}$

$K_{fe} = 5 \text{ mD}$

$r_{fe} = 1.3 \text{ ft}$

$\mu = 4 \text{ cp}$

$r_w = 0.3 \text{ ft}$

$h = 35 \text{ ft}$

$r_e = 1000 \text{ ft}$

$p_e = 5000 \text{ psi}$

$p_w = 2200 \text{ psi}$

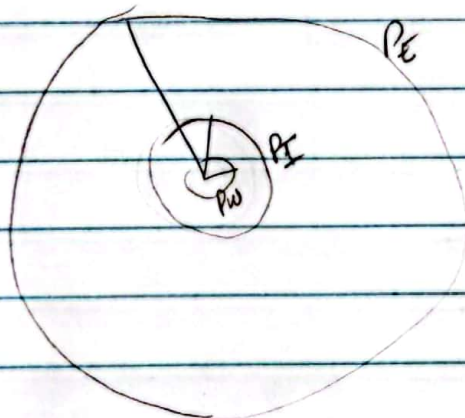
$K_{eq} = ?$

$q = ?$

Cylindrical coords:

$$q h \ln\left(\frac{r_e}{r_w}\right) = \frac{k}{\mu} 2\pi h (p_e - p_w)$$

$$q = \frac{1}{141.2} \frac{kh(p_e - p_w)}{\mu B \ln(r_e/r_w)}$$



$$(p_w - p_e) = \frac{141.2 q \mu B \ln(r_e/r_w)}{kh}$$

Q.

$$(p_w - p_e) = (p_w - p_{fe}) + (p_{fe} - p_e)$$

$$\frac{\ln(r_e/r_w)}{K_{eq}} = \frac{\ln(r_{fe}/r_w)}{K_{fe}} + \frac{\ln(r_e/r_{fe})}{K_e}$$

$$\frac{\ln 1000 - \ln 0.3}{K_{eq}} = \frac{\ln 1.3 - \ln 0.3}{5} + \frac{\ln 1000 - \ln 1.3}{40}$$

$$K_{eq} = 17.66 \text{ mD}$$

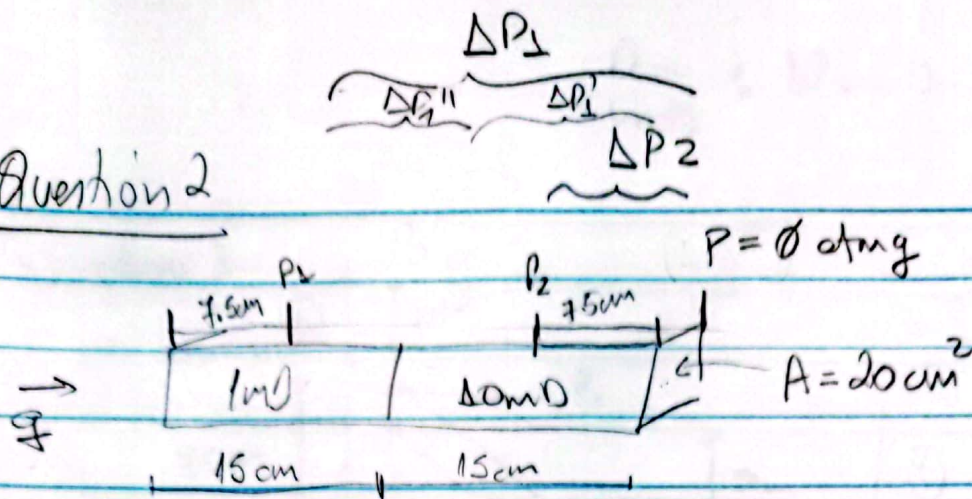
$$\textcircled{b} \quad q = \frac{1}{141.2} \frac{kh (P_e - P_w)}{\mu \ln(r_e/r_w)}$$

$$q = \frac{1}{141.2} \frac{(17.66) (35) (2200 - 5000)}{(4) \ln(1000/0.3)}$$

$$q = 377.69 \text{ rpd}$$



## Question 2



$$\mu = 1 \text{ cp} \quad q = 5 \text{ cm}^3/\text{h} \times \frac{\text{h}}{60 \text{ min}} \times \frac{\text{min}}{60 \text{ s}} = 0.00139 \text{ cm}^3/\text{s}$$

$$q = \frac{kA}{\mu} \frac{\Delta P}{L}$$

$$\Delta P_2 = \frac{q \cdot \mu \cdot L}{k \cdot A} = \frac{(0.00139)(1)(4.5)}{(10^{-2})(20)}$$

$$\Delta P_2 = 0.521 \text{ atm} \Rightarrow \boxed{P_2 = 0.521 \text{ atm}}$$

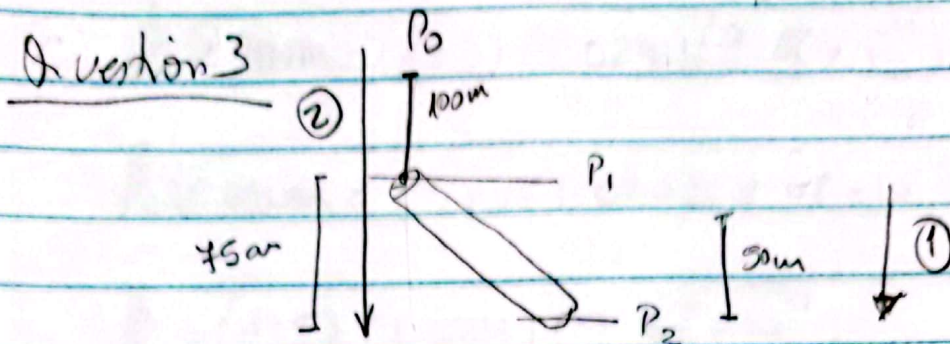
$$\Delta P_1 = \Delta P_1' + \Delta P_1''$$

$$\Delta P_1 = \frac{(0.00139)(1)(15)}{(10^{-2})(20)} + \frac{(0.00139)(1)(7.5)}{(10^{-3})(20)}$$

$$\boxed{\Delta P_1 = 0.625 \text{ atm}} \Rightarrow \boxed{P_1 = 0.625 \text{ atm}}$$



Dray :  $\Delta P_H = 0.4338 \text{ z}$   
 unit



$$\Delta P_H = \rho g h \Rightarrow [Pa] = \left[ \frac{kg}{m^3} \right] \cdot \left[ 9.81 \frac{m}{s^2} \right] [m]$$

$$[atm] = \frac{[Pa]}{101325} = \frac{1}{101325} \frac{kg}{m^3} \cdot \frac{10^6}{1000} \cdot 9.81 \cdot \frac{m}{1000}$$

$$[atm] = 0.000948 \text{ z} = \underbrace{9.68 \times 10^{-4}}_z \text{ z} \leftarrow \frac{g}{a} \text{ cm}$$

(a) Yes, there is flow downwards, because:

$$① = 50 \times G_F < ② = 175 \times G_F.$$

Therefore, the flow through the porous media results in a pressure drop of  $125 \text{ cm} \times G_F$ . where  $G_F$  is the fluid gradient.

(b) Downwards.



$$c) \Phi_1 @ 0.1 \text{ atm} = (125)(1.024)(9.68 \times 10^{-4})$$

$$\Phi_2 @ 0.1 \text{ atm} = (50)(1.024)(9.68 \times 10^{-4})$$

$$\Delta \Phi = (125)(1.024)(9.68 \times 10^{-4})$$

$$\Delta \Phi = 0.1239 \text{ atm}$$

$$q = \frac{\kappa A}{\mu L} \Delta \phi = \frac{(2)(100)(0.1239)}{(1.5)(100)} =$$

$$q = 0.165 \text{ cm}^3/\text{s}$$

$$V = \frac{0.165}{100} = 1.65 \times 10^{-3} \text{ cm}/\text{s}$$

$$d) Re = \frac{V \rho D}{\mu} = \frac{(1.65 \times 10^{-3}) \left[ \frac{\text{cm}}{\text{s}} \right] (1.024) \left[ \frac{\text{g}}{\text{cm}^3} \right] \frac{1}{16} [\text{mm}]}{1.5 [\text{cP}]}$$

$$Re = (7.04 \times 10^{-6}) \frac{\text{cm}}{\text{s}} \cdot \frac{\text{g}}{\text{cm}^3} \times \frac{\text{mm}}{\text{cm}} \times \frac{1}{\text{cP}} \cdot \frac{\text{cm}}{10 \text{ mm}} \times \frac{\text{kg}}{1000 \text{ g}} \cdot \frac{1000 \text{ cP}}{\text{kg/s}} \times 100 \frac{\text{cm}}{\text{mm}}$$

$$Re = 7.04 \times 10^{-4} \ll 1$$

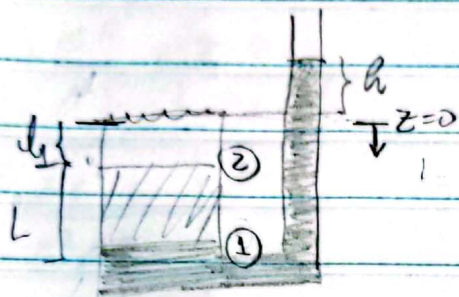
Thus, flow is laminar and Darcy's law is valid

(4)  
(a)

$$q = -\frac{KA}{\mu} \frac{d\phi}{dx}$$

$$\frac{dV}{dh} = a$$

$$q = \frac{dV}{dt} = \frac{dV}{dh} \frac{dh}{dt} = a \frac{dh}{dt}$$



$$\phi_1 @ \text{bottom} = pgh$$

$$\phi_2 @ \text{top} = 0$$

$$\Delta\phi = pgh$$

$$q = a \frac{dh}{dt} = -\frac{KA}{\mu} \frac{pgh}{L}$$

$$\boxed{\frac{dh}{dt} = -\frac{KA}{\mu a} \frac{pgh}{L}}$$

$$(b) \int_{h_0}^h \frac{dh}{h} = \int_{h_0}^h -\frac{KA}{\mu a} \frac{pg}{L} dt$$

$$\left[ \ln(h) \right]_{h_0}^h = -\frac{KA}{\mu a} \frac{pg}{L} \Delta t$$

$$\boxed{\ln\left(\frac{h}{h_0}\right) = -\frac{KA}{\mu a} \frac{pg}{L} \Delta t}$$



$$(c) \ln\left(\frac{h}{h_0}\right) = - \frac{kA}{\mu a} \frac{\rho g}{L} \Delta t = - \frac{kR^2}{\mu r^2} \frac{\rho g}{L} \Delta t$$

$$\text{Slope} = -401.33 \times 10^6 \text{ (1/s)}$$

$$\text{slope} = - \frac{kR^2}{\mu r^2} \frac{\rho g}{L}$$

$$k = - \frac{\mu r^2 L}{R^2 \rho g}$$

$$h_0 = 100 \text{ cm}$$

$$L = 10 \text{ cm}$$

$$D = 5 \text{ cm} \rightarrow R = 2.5 \text{ cm}$$

$$d = 1 \text{ cm} \rightarrow r = 0.5 \text{ cm}$$

$$\mu = 1 \text{ cp}$$

$$g = 981 \text{ cm/s}^2$$

$$\rho = 1.02 \text{ g/cm}^3$$

UNITS :

$$[k] = \text{cp} \cdot \frac{\text{cm}^2}{\text{cm}} \cdot \frac{\text{cm}}{\text{g}} \cdot \frac{\text{D}^2}{\text{cm}} = 10^{-3} \text{ Po} \cdot \text{s} \cdot 10^{-9} \frac{\text{m}^2}{\text{kg}} \cdot 10^3 \text{ s}^2$$

$$[k] = 10^{-6} \text{ m}^2 \cdot \frac{\text{D}}{9.8 \times 10^{-13}} = 1.013 \times 10^6 \text{ D}$$

—L

$$\Rightarrow k = 0.163 \text{ D}$$