Carbon Energy
(탄소에너지) (38523)

- 2023 Final Examination -

Student ID (학번): **Student Name (성명):**

Notice

- Fill your name in the following:

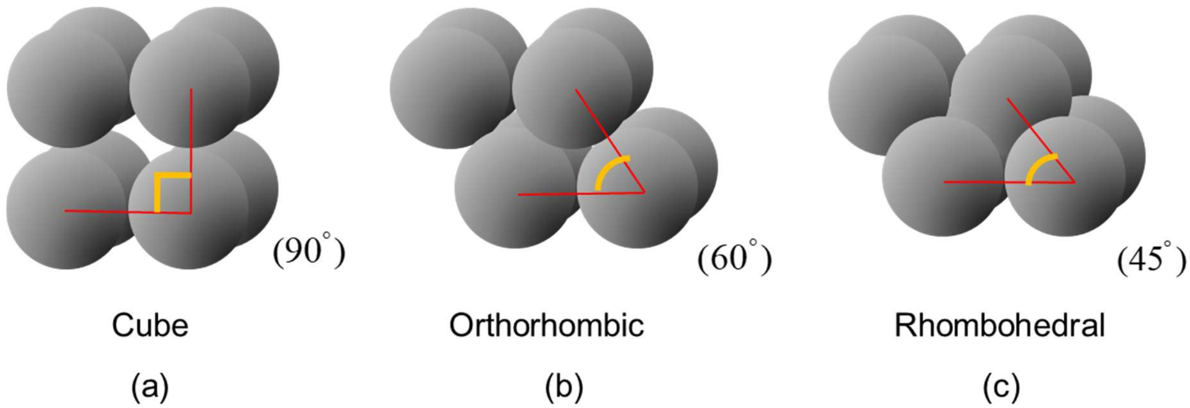
  "I, _________________, swear I solve all problems by myself in this final examination.

  I will take any disadvantages if any dishonesty such as cheating is acted on my solution."

  <u>5 points will be deducted from your total score if you do not fill in your name above.</u>

Problem 1.

Calculate porosity of a clean sandstone composed of orthorhombic grains to the first decimal place. [5 pts.]



Herein, $\pi \approx 3.14$, $\sqrt{2} \approx 1.41$.

Problem 2.

List the five assumptions for Darcy's law [10 pts.].

Problem 3.

Derive Equation (3-2) from Equation (3-1). [10 pts.]

In Darcy Unit: $$Q\left(\frac{\text{cc}}{\text{sec}}\right) = -\frac{k(\text{D})A(\text{cm}^2)}{\mu(\text{cp})}\frac{dp(\text{atm})}{dl(\text{cm})} \quad \text{Eq. (3-1)}$$

In Field Unit: $$Q\left(\frac{\text{bbl}}{\text{day}}\right) = -(\text{constant})\frac{k(\text{D})A(\text{ft}^2)}{\mu(\text{cp})}\frac{dp(\text{psi})}{dl(\text{ft})} \quad \text{Eq. (3-2)}$$

Problem 4.

4-1. See Figure 4(a). Show your work to solve the Darcy's Equation for the downward flow from ① to ② [5 pts.].

4-2. See Figure 4(b). Show your work to solve the Darcy's Equation for the upward flow from ① to ② [5 pts.].

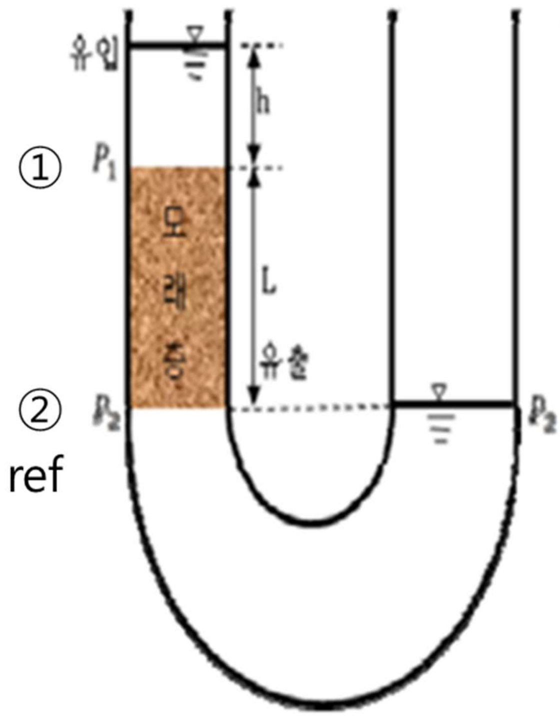


Figure 4(a)

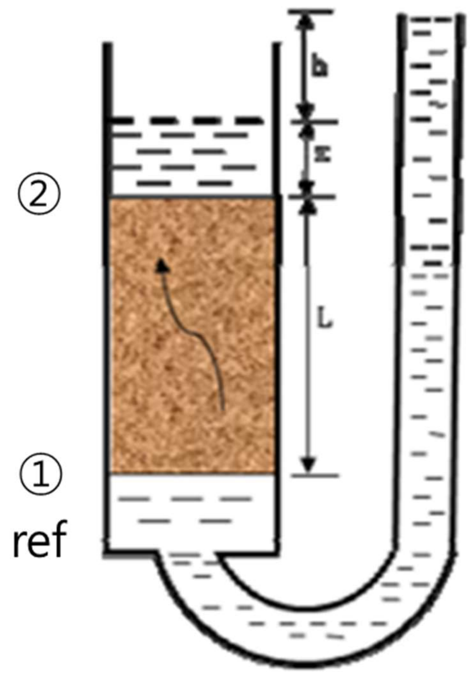


Figure 4(b)

Problem 5.

5-1. Show your work to derive the Archie's Equation [5 pts.].

5-2. Show your work to calculate water saturation (S_w) under the following condition [5 pts.].

Cementation factor, *m*	2.0	Porosity, φ (fraction)	0.25
Empirical constant, *a*	1.0	Resistivity of formation water, R_w (Ω·m)	0.1
Saturation exponent, *n*	2.0	True formation resistivity, R_t (Ω·m)	40.0

Problem 6.

A reservoir is composed of serial four layers whose thickness are the same as h.

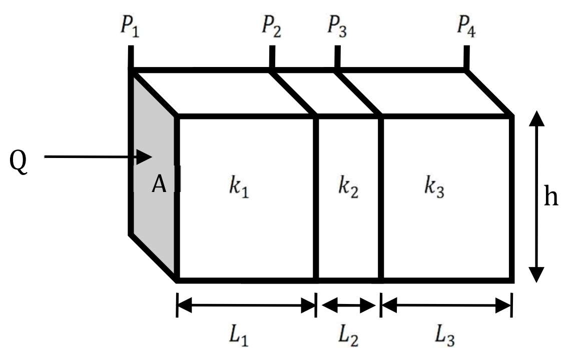
6-1. Calculate the average permeability $\underline{k}_{avg}$ for a linear flow system to the first decimal place [5 pts.]

Layer no.	Length of each layer, ft	Horizontal permeability, md
1	100	25
2	200	50
3	300	100
4	1,000	200

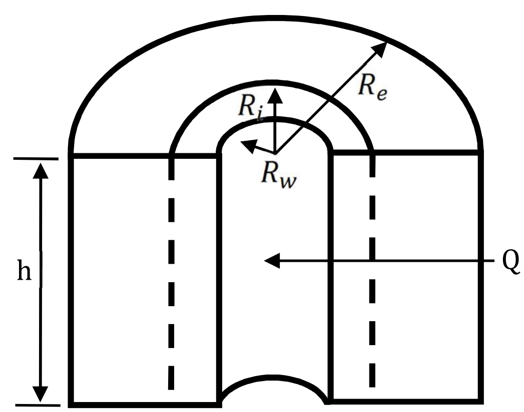
6-2. Calculate the average permeability $\underline{k}_{avg}$ for a radial flow system to the first decimal place. The radius of the production well is 6 in. and the effective radius of drainage area (r_e) is 1,000 ft according the table below. Note that the production well is located in the center of the layer no.1 [5 pts.]

Layer no.	Radius from the center of the well, ft	Horizontal permeability, md
1	100	25
2	200	50
3	300	100
4	1,000	200

(Example: The left and right figures are schematic diagrams for a serial linear flow system with three layers and a radial flow system with two layers, respectively.)



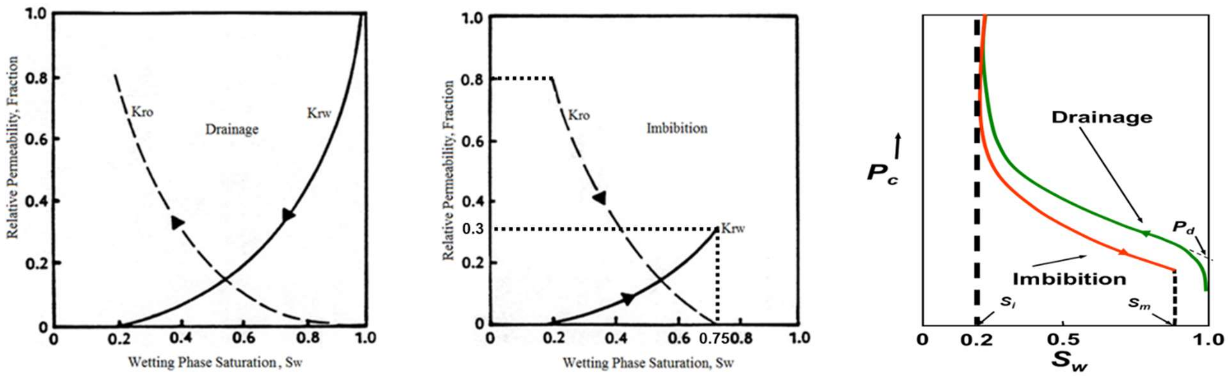
Serial linear flow composed of three layers



Serial radial flow composed of one production well and two serial layers.

Problem 7.

For a certain reservoir, relative permeability curves (a) and (b) and capillary pressure curves (c) are given as follows:



(a) Drainage

(b) Imbibition

(c) Capillary pressure

Let's assume the following reservoir condition:

- This reservoir is a greenfield, never produced yet, thus remains under initial reservoir conditions (i.e., initial reservoir pressure and temperature).
- This reservoir is a sandstone oil reservoir saturated with oil and water.
- Initially, there is no gas cap.

7-1. Based on your experience, choose this reservoir either water-wet or oil-wet [2 pts.].

7-2. How much is the initial water saturation [2 pts.]?

7-3. How much is the initial oil saturation [2 pts.]?

7-4. How much is the irreducible oil saturation [2 pts.]?

7-5. Explain why it is difficult to produce oil beyond the irreducible oil saturation [2 pts.].

7-6. Let's assume that the average absolute permeability of this reservoir is 1,000 md. If this reservoir is 100% saturated with a certain fluid type (e.g., oil, water, and gas), the expected daily fluid production rate is 5,000 STB/day. In reality, how much is the expected daily oil production when you start oil production from this greenfield? [5 pts.]

7-7. Based on the three figures, calculate the ultimate oil recovery factor. [5 pts.]

Problem 8.

Choose all correct drainage situation. You will gain 1 point for each correct answer you choose while losing 1 point for each incorrect answer you choose. You will gain 0 point if you do not choose any situation as your own answer.

(a) The wetting phase ceases to flow at the irreducible wetting phase saturation

(b) The non-wetting phase becomes discontinuous and ceases to flow when the non-wetting phase saturation reaches the residual non-wetting phase saturation

(c) Petroleum accumulation (secondary migration)

(d) Evolution of a secondary gas cap as reservoir pressure decreases

(e) Waterflooding water wet reservoir

(f) Evolution of a secondary gas cap as reservoir pressure decreases

(g) Waterflooding an oil reservoir in which the reservoir is oil wet

(h) Accumulation of condensate as pressure decreases in a dew point reservoir

(i) Decrease in capillary pressure

Problem 9.

Define the following formation volume factors. Also, draw graphs of three formation volume factors as a function of reservoir pressure. You MUST draw the graphs with a bubble point pressure (P_b), their conventional ranges, and their units.

9-1. Oil formation volume factor (B_o) [5 pts.]

9-2. Gas formation volume factor (B_g) [5 pts.]

9-3. Solution gas/oil ratio (R_s) [5 pts.]

9-4. Let's assume that your daily oil production rate is 100 STB/day of oil.

Calculate how much the reservoir volume is drained daily, where B_o = 1.3 rb/STB, B_g = 0.004 rb/scf, R_s = 510 scf/STB, and R = 4,000 scf/STB. [5 pts.]

-------------------- This is the End of the Final Examination --------------------