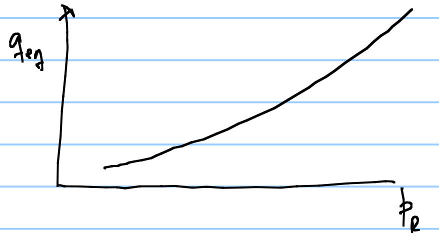
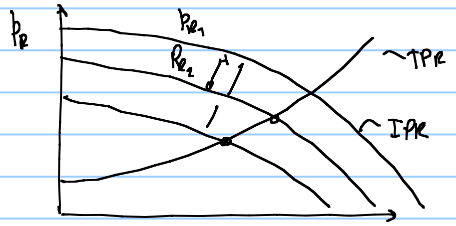
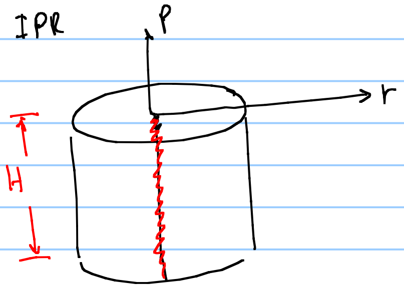
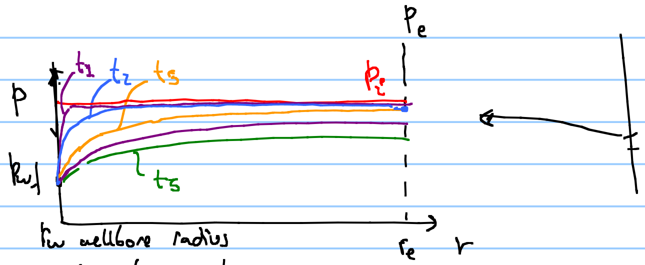
Class 3





Comment on IPR





$0 - t_3$ transient regime

IPR is a function of time

a function of p_i

p_e is constant, $t > t_3$ then steady state regime

p_e declines, $t > t_3$, the pseudo-steady states (PSS)

IPR is a function of

p_R (Average pressure in the drainage volume)

$\neq f(t)$

diffusivity equation for radial reservoir, homogeneous fluid and reservoir

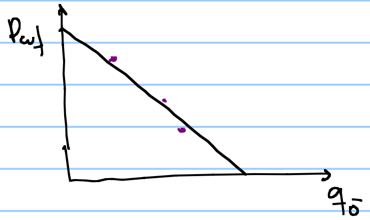
$$\frac{\partial^2 p}{\partial r^2} + \frac{1}{r}\frac{\partial p}{\partial r} = \underbrace{\frac{\phi \mu c}{k}}\frac{\partial p}{\partial t} \rightarrow \begin{array}{l} q_g = C\left(p_R^2 - p_{wf}^2\right)^n \\ q_o = J\left(p_R - p_{wf}\right) \end{array}$$

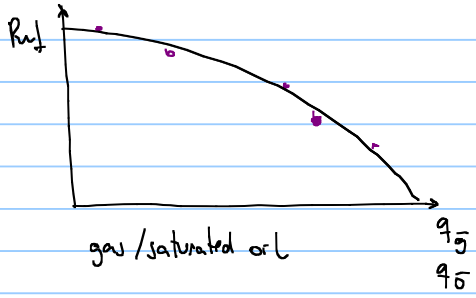
$$q_{sc} = U \int_{p_{wf}}^{\tilde{p}_R} F(p)\, dp$$

fluid properties, relative permeability

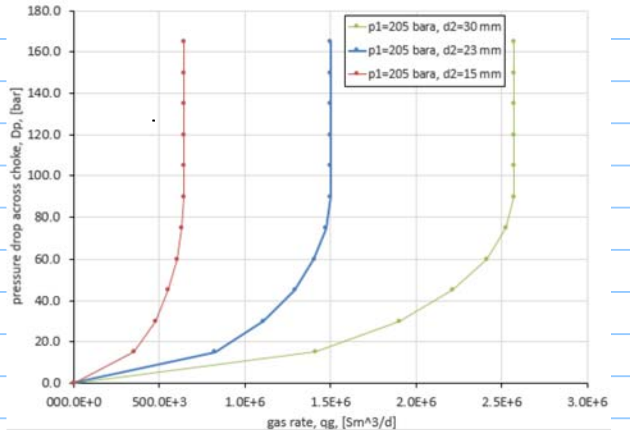
depends on the geometry skin, formation properties

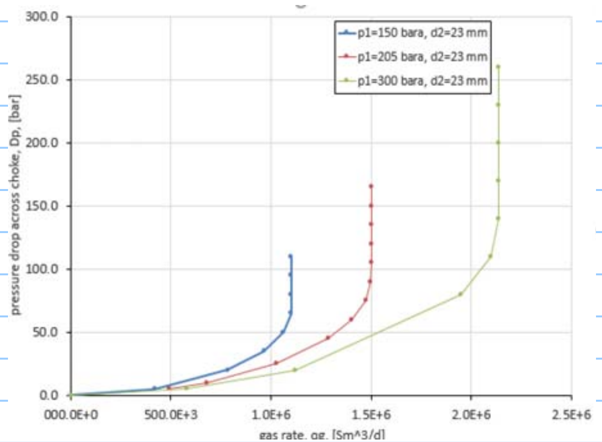
Liquid, undersaturated oil



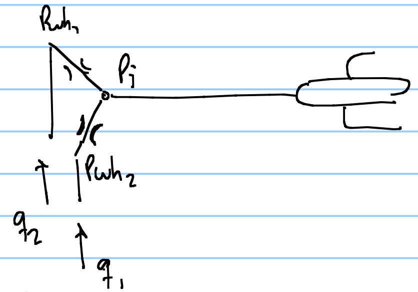


gas / saturated oil

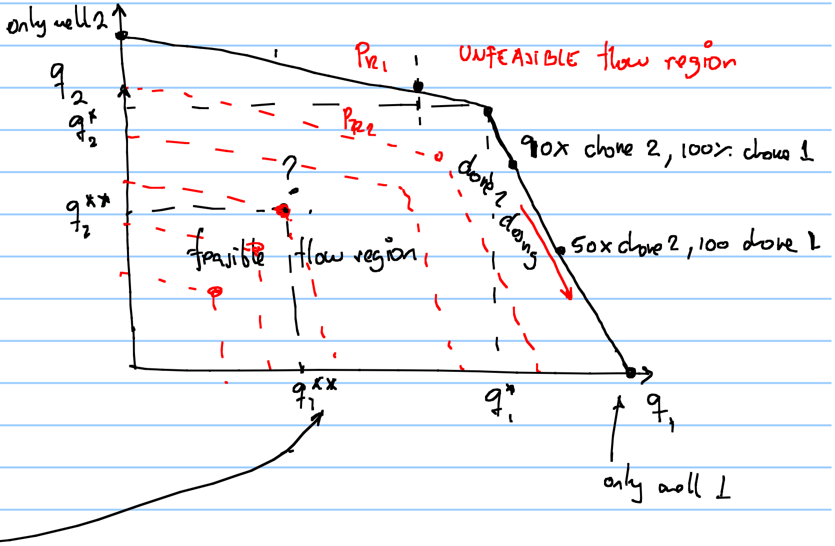




Network exercise



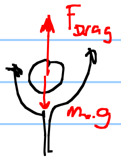
defined by reservoir management



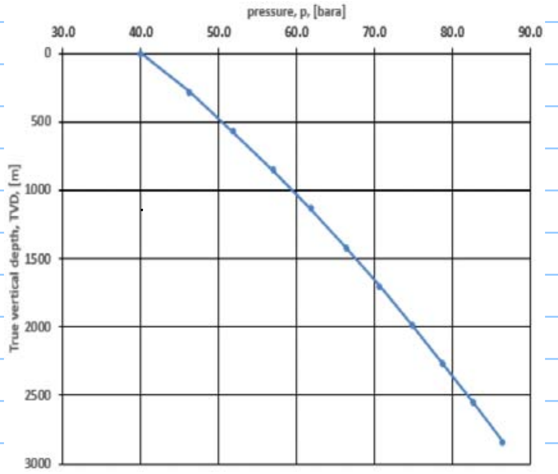
- exercise calculate this with the data from 2 wells network.

Verify liquid loading criteria

Turner

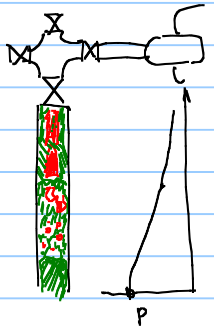


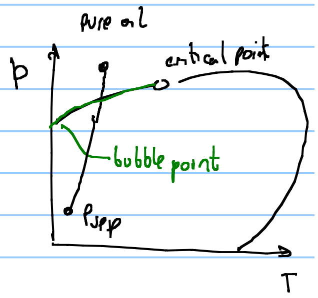
- exercise solve pressure traverse calculations

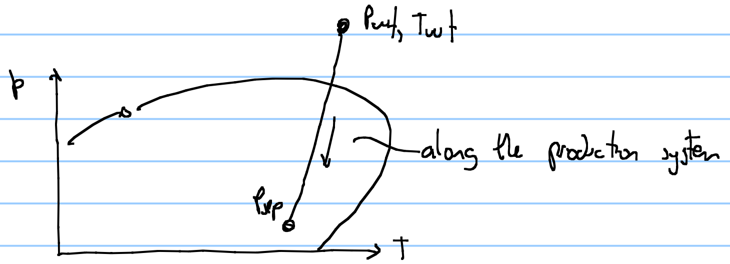


Erosion verification API 14E Erosion standard
DNV O501 Erosion

- PVT model { • Compositional (using Equation of state)
  • Black oil tables







EOS → SRK → Redlich Kwong Soave } cubic equations of state
PR → Peng Robinson

$$p = \frac{RT}{v - b} - \frac{a}{v(v+b) + b(v-b)} \quad \text{.............. (4.19)}$$

or, in terms of Z factor,

$$Z^3 - (1 - B)Z^2 + (A - 3B^2 - 2B)Z$$

$$- (AB - B^2 - B^3) = 0$$

applied for mixture → vapour
→ liquid
→ mixture → vapour
→ liquid

and $Z_c = 0.3074$. .... (4.20)

The EOS constants are given by

$$a = \Omega_a^o \frac{R^2 T_c^2}{p_c} \alpha, \quad \text{............................ (4.21a)}$$

where $\Omega_a^o = 0.45724$;

$$b = \Omega_b^o \frac{RT_c}{p_c}, \quad \text{............................ (4.21b)}$$

where $\Omega_b^o = 0.07780$;

$$\alpha = \left[1 + m\left(1 - \sqrt{T_r}\right)\right]^2; \quad \text{..................... (4.21c)}$$

and $m = 0.37464 + 1.54226\omega - 0.26992\omega^2$. ...... (4.21d)

z_i

	z_i
CH_4	
C_2	
C_3	
C_4	
C_5	
⋮	
C_nH_{2n+2}	

z_i ← molar fraction

$$A = a\frac{p}{(RT)^2} = \Omega_a^o \frac{p_r}{T_r^2} \alpha(T_r),$$

where $\alpha(T_r) = T_r^{-0.5}$;

$$B = b\frac{p}{RT} = \Omega_b^o \frac{p_r}{T_r}. \quad \text{.....}$$

Gibbs energy / chemical potential

Fugacity expressions are given by

$$\ln\frac{f}{p} = \ln\phi = Z - 1 - \ln(Z - B)$$

$$- \frac{A}{2\sqrt{2}B} \ln\left[\frac{Z + \left(1 + \sqrt{2}\right)B}{Z - \left(1 - \sqrt{2}\right)B}\right]$$

and $\ln\dfrac{f_i}{y_i p} = \ln\phi_i = \dfrac{B_i}{B}(Z - 1) - \ln(Z - B)$

$$+ \frac{A}{2\sqrt{2}B}\left(\frac{B_i}{B} - \frac{2}{A}\sum_{j=1}^{N} y_j A_{ij}\right) \ln\left[\frac{Z + \left(1 + \sqrt{2}\right)B}{Z - \left(1 - \sqrt{2}\right)B}\right],$$

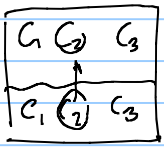
mixing rule

$$A = \sum_{i=1}^{N}\sum_{j=1}^{N} y_i y_j A_{ij},$$

$$B = \sum_{i=1}^{N} y_i B_i,$$

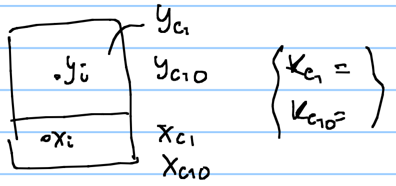
Binary interaction parameter (BIP)

and $A_{ij} = \left(1 - k_{ij}\right)\sqrt{A_i A_j}$,

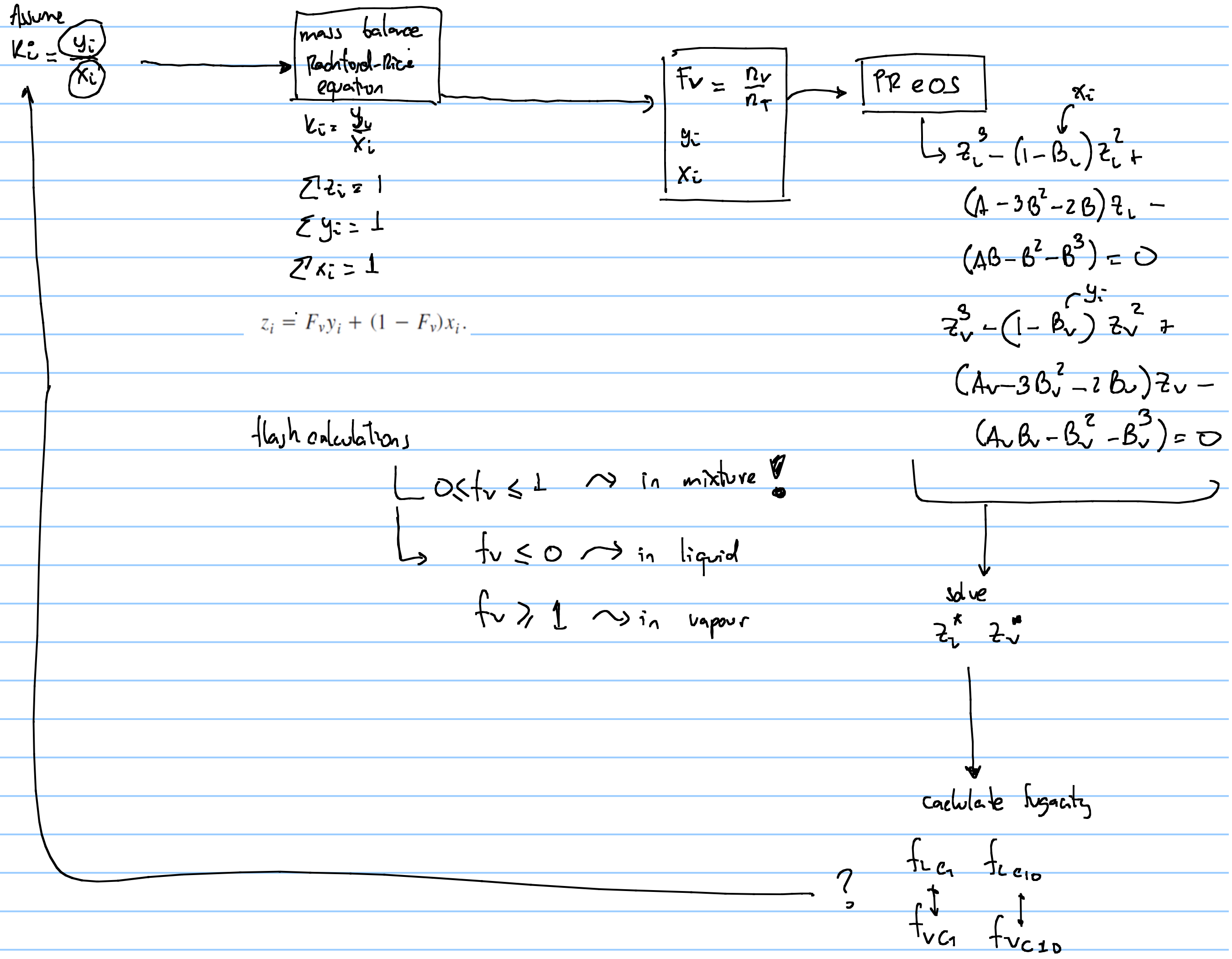


$f_{Li} = f_{vi}$ component "i"

	z_i
C_1	0.8
C_{10}	0.2



$\left\{ \begin{array}{l} K_{C_1} = \\ K_{C_{10}} = \end{array} \right\}$



$K_i = \frac{y_v}{x_i}$

$\Sigma z_i = 1$

$\Sigma y_i = 1$

$\Sigma x_i = 1$

$z_i = F_v y_i + (1 - F_v) x_i.$

$$Z_L^3 - (1 - B_L) Z_L^2 + (A - 3B^2 - 2B) Z_L - (AB - B^2 - B^3) = 0$$

x_i

$$Z_v^3 - (1 - B_v) Z_v^2 + (A_v - 3B_v^2 - 2B_v) Z_v - (A_v B_v - B_v^2 - B_v^3) = 0$$

y_i

flash calculations

- $0 < f_v \leq 1$ ⤳ in mixture !
- $f_v \leq 0$ ⤳ in liquid
- $f_v \geq 1$ ⤳ in vapour