1 PE 3013 - Exam 2

Open Book, open notes, closed neighbor; no cell phones or internet access until you complete the exam. Save you file as ***Your_Name_Exam2.xls*** *and e-mail the results to lgt@utulsa.edu;* ***copy yourself*** *to make sure that the attachment came.* **Save your file before you try to run or debug! Example results are in the shares folder - see Exam2_Template.xls.**

If you do not Indent and Comment your Code you will lose 5 points

If a well is produced at a constant bottomhole flowing pressure, its rate declines with time; that is, the initial flowing rate is large, but it gradually decreases with time. The declining rate versus time behavior can be approximated by the following expression

$$q(t) = \begin{cases} q_i \left(1 + bD_i t\right)^{-\frac{1}{b}} & \text{for } 0 < b \leq 1 \\ q_i \exp\left(-D_i t\right) & \text{for } b = 0 \end{cases} \tag{1}$$

where $q(t)$ is the rate at a given time in STB/d, q_i is the initial rate (at $t = 0$) in STB/d, D_i is the initial decline rate as a fraction per day, t is time in days and b is a decline parameter that depends on the reservoir and fluid type; for example, for an undersaturated oil solution-gas drive reservoir, $b = 0$, whereas for a saturated solution-gas drive reservoir, b might be 0.2. The cumulative oil produced from a well at time t, $N_p(t)$ STB, is given by

$$N_p(t) = \int_0^t q(t)\, dt; \tag{2}$$

we can approximate this integral by

$$N_p(t) = \left[\frac{q_i + q(t)}{2} + \sum_{j=1}^{n-1} q(t_j)\right] \Delta t \tag{3}$$

Where n is the number of intervals that we want to use to approximate the integral,

$$\Delta t = \frac{t}{n} \tag{4}$$

and

$$t_j = j\Delta t. \tag{5}$$

For example, if we had a well with an initial rate of 100 STB/d, a decline rate of 0.001 per day and a b value of 0.2, the rate after 1000 days would be

$$\begin{aligned} q(1000) &= 100\left(1 + (0.2)(0.001)(1000)\right)^{-\frac{1}{0.2}} \\ &= 40.188 \text{ STB/d} \end{aligned}$$

- Write a function to compute the rate at a given time for provided values of t, q_i, D_i and b. If the user provides a b value outside the range $0 \leq b \leq 1$, put up an error message.

If we wanted to approximate the cumulative production at 1000 days from this well using two intervals (i.e., $n = 2$) we would proceed as follows:

- 1. Compute $\Delta t = \frac{t}{n} = \frac{1000}{2} = 500$ days.
  2. Compute the sum; (in this case, it would only have one term $q(500) = 100\left(1 + (0.2)(0.001)(500)\right)^{-\frac{1}{0.2}} = 62.092$ STB/d.
  3. Compute $N_p(1000) = \left(\frac{100+40.188}{2} + 62.092\right)(500) = 66093.$ STB.

- Write a function to compute cumulative production given n, t, q_i, D_i and b.