Total No. of Questions : 8]

SEAT No. :

P1098

[Total No. of Pages : 4

[4659] - 267
B.E. (Petroleum Engineering)
RESERVOIR ENGINEERING - II
(2008 Course) (412381) (Semester - I)

Time : 3 Hours] *[Max. Marks : 100*

Instructions to the candidates:

1) ***Answers to the two sections must be written in separate answer books.***
2) ***Question No. 2 (two) and 8(eight) are compulsory.***
3) ***Figures to the right indicate full marks.***
4) ***Answer 3 questions from Section I and 3 questions from Section II.***
5) ***Neat diagrams should be drawn wherever necessary.***
6) ***Use of non-programmable calculator, log-log, and semi-log paper is allowed.***
7) ***Assume Suitable data if necessary.***

SECTION - I

Q1) a) Explain what is meant by the diffusivity equation. What is it used for, and what are the various solutions of the diffusivity equation? Explain in detail. **[6]**

b) Derive the diffusivity equation in Cartesian coordinates. How many conditions are required to solve the diffusivity equation? Explain in detail. **[10]**

Q2) Following data is given:

$q = 30$ stb/d

$h = 140$ ft

$B = 1.47$ RB/STB

$k = 0.2$ md

$c_t = 1.4 \times 10^{-5}$ psi^{-1}

$\mu = 0.72$ cp

$r_w = 0.5$ ft

$P_i = 3100$ psi

porosity = 20%

$r_e = 2800$ ft

Calculate the reservoir pressure at the radius of 1 ft, 5 ft, 10 ft and 50 ft after 3 hours of oil production. **[18]**

P.T.O.

Q3) a) What do you mean by ETR, MTR and LTR? Explain with figures. **[4]**

b) Describe the various flow regimes from a pressure standpoint. Also, write the equations for the different flow regimes. **[4]**

c) Derive the continuity equation for a single phase fluid flowing though a one dimensional porous media, in Cartesian coordinates. **[8]**

Q4) a) Explain the principle of superposition in time and space, with appropriate diagrams representing flow-rates and pressures. **[6]**

b) What are the objectives of a gas well test? How is a gas well test different from an oil well test? Explain in detail, the difference between an isochronal test and a modified isochronal test. **[10]**

SECTION - II

Q5) What are the various geometrics that can be encountered while testing a horizontal well? Explain in detail. Also, describe the various flow regimes that are encountered in fluid flow in a horizontal well, with appropriate figures.**[16]**

Q6) Explain the various flow regimes in a DST, with appropriate figures. How is a typical analysis done, for procured DST data, and what all are the methods for analyzing DST data? **[16]**

Q7) Write a detailed note on Horner's approximation, its significance, and why is it used. **[16]**

Q8) Explain in detail:

a) Write down Arp's equation, and show how the empirical decline curves are derived from the equation.

b) What are the assumptions used for Arp's equation?

c) Show graphs which are used for estimating decline parameters for all three types of decline curves - q vs. t, Np vs.t, q vs. Np, all on Cartesian, semi-log and log-log plots. **[18]**

Formulas for the exam

For E (i) function values, refer to the table given with the examination paper

$$p = p_i + 70.6\frac{qB\mu}{kh}\text{Ei}\left(-\frac{948\phi\mu c_t r^2}{kt}\right)$$

$$t_D = \frac{0.000264kt}{\phi\mu_o c_t r_w^2}$$

$$p_{ws} = p_i - \frac{162.6\,q_o\,\mu_o\,\beta_o}{kh}\log\left[\frac{t_p + \Delta t}{\Delta t}\right]$$

$$p_D = -\frac{1}{2}Ei\left(-\frac{r_D^2}{4t_D}\right)$$

$$s = 1.151\left[\frac{p_{1\,hr} - p_{ws(\Delta t=0)}}{m} - \log\left(\frac{k}{\phi\mu_o c_t r_w^2}\right) + 3.23\right]$$

$$p_{wf} = p_i - \frac{162.6q_o\mu_o\beta_o}{kh}\left[\log t + \log\left(\frac{k}{\phi\mu_o c_t r_w^2}\right) - 3.23 + 0.869s\right]$$

$$p = p_i + 70.6\frac{qB\mu}{kh}\left[\ln\left(\frac{1,688\phi\mu c_t r^2}{kt}\right)\right]$$

$$\frac{(3.975\times10^5)\phi\mu c_t r_w^2}{k} < t < \frac{948\phi\mu c_t r_e^2}{k}$$

$$p_{1h} = p_i + m\left[\log\left(\frac{k}{\phi\mu_o\beta_o c_t r_w^2}\right) - 3.23 + 0.869s\right]$$

$$p(r,t) = LS(r,t) = p_i - \frac{70.6\,Q\,\mu}{k\,h}\left[-E_i\left(-\frac{948.1\,\Phi\,\mu\,c_t\,r^2}{k\,t}\right)\right]$$

$$k = \frac{162.6\,q_o\,\mu_o\,\beta_o}{mh}$$

TABLE 1.1—VALUES OF THE EXPONENTIAL INTEGRAL, $-Ei(-x)$

$-Ei(-x)$, $0.000 < x < 0.209$, interval = 0.001

x	0	1	2	3	4	5	6	7	8	9
0.00	$+\infty$	6.332	5.639	5.235	4.948	4.726	4.545	4.392	4.259	4.142
0.01	4.038	3.944	3.858	3.779	3.705	3.637	3.574	3.514	3.458	3.405
0.02	3.355	3.307	3.261	3.218	3.176	3.137	3.098	3.062	3.026	2.992
0.03	2.959	2.927	2.897	2.867	2.838	2.810	2.783	2.756	2.731	2.706
0.04	2.681	2.658	2.634	2.612	2.590	2.568	2.547	2.527	2.507	2.487
0.05	2.468	2.449	2.431	2.413	2.395	2.377	2.360	2.344	2.327	2.311
0.06	2.295	2.279	2.264	2.249	2.235	2.220	2.206	2.192	2.178	2.164
0.07	2.151	2.138	2.125	2.112	2.099	2.087	2.074	2.062	2.050	2.039
0.08	2.027	2.015	2.004	1.993	1.982	1.971	1.960	1.950	1.939	1.929
0.09	1.919	1.909	1.899	1.889	1.879	1.869	1.860	1.850	1.841	1.832
0.10	1.823	1.814	1.805	1.796	1.788	1.779	1.770	1.762	1.754	1.745
0.11	1.737	1.729	1.721	1.713	1.705	1.697	1.689	1.682	1.674	1.667
0.12	1.660	1.652	1.645	1.638	1.631	1.623	1.616	1.609	1.603	1.596
0.13	1.589	1.582	1.576	1.569	1.562	1.556	1.549	1.543	1.537	1.530
0.14	1.524	1.518	1.512	1.506	1.500	1.494	1.488	1.482	1.476	1.470
0.15	1.464	1.459	1.453	1.447	1.442	1.436	1.431	1.425	1.420	1.415
0.16	1.409	1.404	1.399	1.393	1.388	1.383	1.378	1.373	1.368	1.363
0.17	1.358	1.353	1.348	1.343	1.338	1.333	1.329	1.324	1.319	1.314
0.18	1.310	1.305	1.301	1.296	1.291	1.287	1.282	1.278	1.274	1.269
0.19	1.265	1.261	1.256	1.252	1.248	1.243	1.239	1.235	1.231	1.227
0.20	1.223	1.219	1.215	1.210	1.206	1.202	1.198	1.195	1.191	1.187

$-Ei(-x)$, $0.00 < x < 2.09$, interval = 0.01

x	0	1	2	3	4	5	6	7	8	9
0.0	$+\infty$	4.038	3.335	2.959	2.681	2.468	2.295	2.151	2.027	1.919
0.1	1.823	1.737	1.660	1.589	1.524	1.464	1.409	1.358	1.309	1.265
0.2	1.223	1.183	1.145	1.110	1.076	1.044	1.014	0.985	0.957	0.931
0.3	0.906	0.882	0.858	0.836	0.815	0.794	0.774	0.755	0.737	0.719
0.4	0.702	0.686	0.670	0.655	0.640	0.625	0.611	0.598	0.585	0.572
0.5	0.560	0.548	0.536	0.525	0.514	0.503	0.493	0.483	0.473	0.464
0.6	0.454	0.445	0.437	0.428	0.420	0.412	0.404	0.396	0.388	0.381
0.7	0.374	0.367	0.360	0.353	0.347	0.340	0.334	0.328	0.322	0.316
0.8	0.311	0.305	0.300	0.295	0.289	0.284	0.279	0.274	0.269	0.265
0.9	0.260	0.256	0.251	0.247	0.243	0.239	0.235	0.231	0.227	0.223
1.0	0.219	0.216	0.212	0.209	0.205	0.202	0.198	0.195	0.192	0.189
1.1	0.186	0.183	0.180	0.177	0.174	0.172	0.169	0.166	0.164	0.161
1.2	0.158	0.156	0.153	0.151	0.149	0.146	0.144	0.142	0.140	0.138
1.3	0.135	0.133	0.131	0.129	0.127	0.125	0.124	0.122	0.120	0.118
1.4	0.116	0.114	0.113	0.111	0.109	0.108	0.106	0.105	0.103	0.102
1.5	0.100	0.0985	0.0971	0.0957	0.0943	0.0929	0.0915	0.0902	0.0889	0.0876
1.6	0.0863	0.0851	0.0838	0.0826	0.0814	0.0802	0.0791	0.0780	0.0768	0.0757
1.7	0.0747	0.0736	0.0725	0.0715	0.0705	0.0695	0.0685	0.0675	0.0666	0.0656
1.8	0.0647	0.0638	0.0629	0.0620	0.0612	0.0603	0.0595	0.0586	0.0578	0.0570
1.9	0.0562	0.0554	0.0546	0.0539	0.0531	0.0524	0.0517	0.0510	0.0503	0.0496
2.0	0.0489	0.0482	0.0476	0.0469	0.0463	0.0456	0.0450	0.0444	0.0438	0.0432

$-Ei(-x)$, $2.0 < x < 10.9$, interval = 0.1

x	0	1	2	3	4	5	6	7	8	9
2	4.89×10^{-2}	4.26×10^{-2}	3.72×10^{-2}	3.25×10^{-2}	2.84×10^{-2}	2.49×10^{-2}	2.19×10^{-2}	1.92×10^{-2}	1.69×10^{-2}	1.48×10^{-2}
3	1.30×10^{-2}	1.15×10^{-2}	1.01×10^{-2}	8.94×10^{-3}	7.89×10^{-3}	6.97×10^{-3}	6.16×10^{-3}	5.45×10^{-3}	4.82×10^{-3}	4.27×10^{-3}
4	3.78×10^{-3}	3.35×10^{-3}	2.97×10^{-3}	2.64×10^{-3}	2.34×10^{-3}	2.07×10^{-3}	1.84×10^{-3}	1.64×10^{-3}	1.45×10^{-3}	1.29×10^{-3}
5	1.15×10^{-3}	1.02×10^{-3}	9.08×10^{-4}	8.09×10^{-4}	7.19×10^{-4}	6.41×10^{-4}	5.71×10^{-4}	5.09×10^{-4}	4.53×10^{-4}	4.04×10^{-4}
6	3.60×10^{-4}	3.21×10^{-4}	2.86×10^{-4}	2.55×10^{-4}	2.28×10^{-4}	2.03×10^{-4}	1.82×10^{-4}	1.62×10^{-4}	1.45×10^{-4}	1.29×10^{-4}
7	1.15×10^{-4}	1.03×10^{-4}	9.22×10^{-5}	8.24×10^{-5}	7.36×10^{-5}	6.58×10^{-5}	5.89×10^{-5}	5.26×10^{-5}	4.71×10^{-5}	4.21×10^{-5}
8	3.77×10^{-5}	3.37×10^{-5}	3.02×10^{-5}	2.70×10^{-5}	2.42×10^{-5}	2.16×10^{-5}	1.94×10^{-5}	1.73×10^{-5}	1.55×10^{-5}	1.39×10^{-5}
9	1.24×10^{-5}	1.11×10^{-5}	9.99×10^{-6}	8.95×10^{-6}	8.02×10^{-6}	7.18×10^{-6}	6.44×10^{-6}	5.77×10^{-6}	5.17×10^{-6}	4.64×10^{-6}
10	4.15×10^{-6}	3.73×10^{-6}	3.34×10^{-6}	3.00×10^{-6}	2.68×10^{-6}	2.41×10^{-6}	2.16×10^{-6}	1.94×10^{-6}	1.74×10^{-6}	1.56×10^{-6}