Assignment Coversheet
(This sheet must be included with your work submission)

Required Academic Integrity Statement: (Texas A&M University Policy Statement)

Academic Integrity Statement

All syllabi shall contain a section that states the Aggie Honor Code and refers the student to the Honor Council Rules and Procedures on the web.

Aggie Honor Code
"An Aggie does not lie, cheat, or steal or tolerate those who do."

Upon accepting admission to Texas A&M University, a student immediately assumes a commitment to uphold the Honor Code, to accept responsibility for learning and to follow the philosophy and rules of the Honor System. Students will be required to state their commitment on examinations, research papers, and other academic work. Ignorance of the rules does not exclude any member of the Texas A&M University community from the requirements or the processes of the Honor System. For additional information please visit: www.tamu.edu/aggiehonor/

On all coursework, assignments, and examinations at Texas A&M University, the following Honor Pledge shall be preprinted and signed by the student:

"On my honor, as an Aggie, I have neither given nor received unauthorized aid on this academic work."

Aggie Code of Honor:
An Aggie does not lie, cheat, or steal or tolerate those who do.

Required Academic Integrity Statement:
"On my honor, as an Aggie, I have neither given nor received unauthorized aid on this academic work."

_______________________________ (Print your name)
_______________________________ (Your signature)

Coursework Copyright Statement: (Texas A&M University Policy Statement)

The handouts used in this course are copyrighted. By "handouts," this means all materials generated for this class, which include but are not limited to syllabi, quizzes, exams, lab problems, in-class materials, review sheets, and additional problem sets. Because these materials are copyrighted, you do not have the right to copy them, unless you are expressly granted permission.

As commonly defined, plagiarism consists of passing off as one's own the ideas, words, writings, etc., that belong to another. In accordance with this definition, you are committing plagiarism if you copy the work of another person and turn it in as your own, even if you should have the permission of that person. Plagiarism is one of the worst academic sins, for the plagiarist destroys the trust among colleagues without which research cannot be safely communicated.

If you have any questions about plagiarism and/or copying, please consult the latest issue of the Texas A&M University Student Rules, under the section "Scholastic Dishonesty."
Example 2: Earlougher and Kersch Example (Including wellbore storage and skin effects)

These data were simulated using the analytical solution for a well centered in a bounded circular reservoir. Wellbore storage and skin effects are included.

Reservoir properties:
\[ \phi = 0.18 \quad r_w = 0.276 \text{ ft} \quad c_i = 8.2 \times 10^{-6} \text{ psi}^{-1} \quad h = 35 \text{ ft} \]

Oil properties:
\[ B_o = 1.2 \text{ RB/STB} \quad \mu_o = 1 \text{ cp} \]

Production parameters:
\[ p_r = 2214 \text{ psia} \quad q_o = 179 \text{ STB/D} \]

Required:

Using the attached plots, you are to perform "graphical" analysis on these data and provide estimates of the following parameters:

a. The formation permeability, \( k \).

b. The dimensionless wellbore storage coefficient, \( C_D \).

c. The near well skin factor, \( s \).
Petroleum Engineering 324
Analysis of Well Test Data Including Wellbore Storage and Skin Effects
(Transient Radial Flow Case)

Cartesian Plot: Early-Time Pressure Data (Example 2: Analysis of a Pressure Drawdown Case)
Semilog Plot: Pressure Data (Example 2: Analysis of a Pressure Drawdown Case)
Log-Log Plot: Pressure Drop and Pressure Drop Derivative Data (1 inch x 1 inch)
(Example 2: Analysis of a Pressure Drawdown Case)
Example 2: Earlougher and Kersch Example (Including wellbore storage and skin effects)

These data were simulated using the analytical solution for a well centered in a bounded circular reservoir. Wellbore storage and skin effects are included.

Reservoir properties:
\[ \phi = 0.18 \quad r_w = 0.276 \text{ ft} \quad c_s = 8.2 \times 10^{-6} \text{ psi}^{-1} \quad h = 35 \text{ ft} \]

Oil properties:
\[ B_o = 1.2 \text{ RB/STB} \quad \mu_o = 1 \text{ cp} \]

Production parameters:
\[ p_i = 2214 \text{ psia} \quad q_o = 179 \text{ STB/D} \]

**Required:**

Using the attached plots, you are to perform "type curve" analysis on these data and provide estimates of the following parameters:

a. The formation permeability, \( k \).
b. The dimensionless wellbore storage coefficient, \( C_D \).
c. The near well skin factor, \( s \).
Type Curve Analysis of Well Test Data Including Wellbore Storage and Skin Effects—
the Bourdet-Gringarten Type Curve (Transient Radial Flow Case)

Example 2: Earlougher and Kersch Example (Including wellbore storage and skin effects)
These data are taken from Earlougher and Kersch. The data are for a pressure "drawdown"
test sequence run on an oil (liquid) well. Wellbore storage and skin effects are included.

Reservoir properties:
\[ \phi = 0.18 \quad r_w = 0.276 \text{ ft} \quad c_T = 8.2 \times 10^{-6} \text{ psia}^{-1} \quad h = 35 \text{ ft} \]

Oil properties:
\[ B_o = 1.2 \text{ RB/STB} \quad \mu_o = 1.0 \text{ cp} \]

Production parameters:
\[ p_i = 2214 \text{ psia} \quad q_o = 179 \text{ STB/D} \]

Well Test Data Functions:

<table>
<thead>
<tr>
<th>Point</th>
<th>( t, \text{ hr} )</th>
<th>( p_{wf}, \text{ psia} )</th>
<th>( \Delta p, \text{ psi} )</th>
<th>( \Delta p', \text{ psi} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2</td>
<td>2194.3</td>
<td>19.7</td>
<td>25.5378</td>
</tr>
<tr>
<td>2</td>
<td>0.3</td>
<td>2185.9</td>
<td>28.1</td>
<td>30.7879</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>2170.9</td>
<td>43.1</td>
<td>37.2820</td>
</tr>
<tr>
<td>4</td>
<td>0.7</td>
<td>2155.7</td>
<td>58.3</td>
<td>43.6329</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>2138.9</td>
<td>75.1</td>
<td>51.5042</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>2099.5</td>
<td>114.5</td>
<td>50.0814</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>2078.5</td>
<td>135.5</td>
<td>42.3962</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>2061.8</td>
<td>152.2</td>
<td>29.6295</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
<td>2050.8</td>
<td>163.2</td>
<td>21.4945</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>2047.3</td>
<td>166.7</td>
<td>13.7056</td>
</tr>
<tr>
<td>11</td>
<td>20</td>
<td>2042.8</td>
<td>171.2</td>
<td>5.57621</td>
</tr>
<tr>
<td>12</td>
<td>30</td>
<td>2040.1</td>
<td>173.9</td>
<td>4.98589</td>
</tr>
<tr>
<td>13</td>
<td>50</td>
<td>2038.8</td>
<td>175.2</td>
<td>4.05955</td>
</tr>
<tr>
<td>14</td>
<td>70</td>
<td>2036.9</td>
<td>177.1</td>
<td>3.77671</td>
</tr>
</tbody>
</table>

References:
1. Earlougher, R.C., Jr. and Kersch, K.M.: "Analysis of Short-Time Transient Test
   Data by Type Curve Matching," JPT (July 1974) 793-800; Trans., AIME, 257.

Required:
Using the attached plots, you are to perform "type curve" analysis on these data and
provide estimates of the following parameters:

a. The formation permeability, \( k \).
b. The dimensionless wellbore storage coefficient, \( C_D \).
c. The near well skin factor, \( s \).
Example 2: Earlougher and Kersch Example (Including wellbore storage and skin effects)

**Early Time Cartesian Analysis:**

*Results from the Early Time Cartesian Plot:*

\[
m_{wbs} = 84 \text{ psi/hr} \\
p_i = 2211.1 \text{ psia (extrapolation of a line through the first two points)}
\]

The analysis relation for \( C_s \) is

\[
C_s = \frac{q_{sur} B}{24 m_{wbs}}
\]

Solving for \( C_s \) from our data we obtain

\[
C_s = \frac{(179 \text{ STB/D}) (1.2 \text{ RB/STB})}{24 (84 \text{ psi/hr})} = 0.1065 \text{ RB/psi}
\]

The identity for \( C_D \) is

\[
C_D = 0.894 \frac{C_s}{\phi h c r_w^2}
\]

Solving for \( C_D \) from our previous result \( (C_s) \), we have

\[
C_D = 0.894 \frac{(0.1065 \text{ RB/psi})}{(0.18) (35 \text{ ft}) (8.2 \times 10^{-6} \text{ psia}^{-1}) (0.276 \text{ ft})^2} = 24,194
\]

**Semilog Analysis:**

*Results from the Semilog Plot:*

\[
m = 10 \text{ psi/cycle} \\
p_{wf,1hr} = 2055.5 \text{ psia}
\]

**Permeability:**

The analysis relation for the permeability, \( k \), is

\[
k = 162.6 \frac{q B \mu}{m h}
\]

Solving for the permeability, \( k \), from our data, we obtain

\[
k = 162.6 \frac{(179 \text{ STB/D}) (1.2 \text{ RB/STB}) (1.0 \text{ cp})}{(10 \text{ psia/cycle}) (35 \text{ ft})} = 99.8 \text{ md}
\]
Petroleum Engineering 324
Well Performance
Type Curve Analysis of Well Test Data Including Wellbore Storage and Skin Effects—
the Bourdet-Gringarten Type Curve (Transient Radial Flow Case)

Example 2: Earlougher and Kersch Example (Including wellbore storage and skin effects)

Semilog Analysis: (continued)

Skin Factor:
The analysis relation for the skin factor, $s$, is given by
\[
s = 1.1513 \left[ \frac{p_i - p_{w,f,1hr}}{m} \cdot \log \frac{k}{\phi \mu c r_w^2} + 3.2275 \right]
\]
Solving for the skin factor, $s$, from our data we obtain
\[
s = 1.1513 \left[ \frac{(2211.1 \text{ psia}) - (2055.5 \text{ psia})}{(10 \text{ psia/cycle})} \right] + 1.1513 \left[ \log \frac{99.8 \text{ md}}{(0.18) (1.0 \text{ cp}) (8.2 \times 10^{-6} \text{ psia}^{-1}) (0.276 \text{ ft})^2} \right] + 3.2275
\]
Or finally, we have
\[
s = 11.3
\]

Type Curve Analysis:

Type Curve Match: Bourdet-Gringarten Type Curve
Matching Parameter, $C_{De}^{2s} = 1 \times 10^{15}$

\[
\left[ \frac{t_D}{C_D} \right]_{MP} = 1 \quad \left[ t \right]_{MP} = 0.089 \text{ hr}
\]
\[
\left[ p_D \right]_{MP} = 1 \quad \left[ \Delta p \right]_{MP} = 8.6 \text{ psi}
\]

Formation Permeability:
\[
k = 141.2 \left( \frac{179 \text{ STB/D}}{35 \text{ ft}} \right) \left( \frac{1.2 \text{ RB/STB}}{1.0 \text{ cp}} \right) \left( \frac{1.0 \text{ psi}}{8.6 \text{ psi}} \right) = 100.76 \text{ md}
\]

Dimensionless Wellbore Storage Coefficient:
\[
C_D = 0.0002637 \left( \frac{100.76 \text{ md}}{0.18 \text{ cp} (8.2 \times 10^{-6} \text{ psia}^{-1}) (0.276 \text{ ft})^2} \right) \left( \frac{0.089 \text{ hr}}{1.0} \right)
\]
or finally, we have
\[
C_D = 21,032
\]

Skin Factor:
\[
s = \frac{1}{2} \ln \left( \frac{1.0 \times 10^{15}}{21,032} \right) = 12.3
\]
Cartesian Plot: Early-Time Pressure Data (Example 2: Earlougher and Kersch Example)

Legend: Earlougher-Kersch Example
Early Time Linear Trend

$p_{wf} = 2211.1 - 84t$
Semilog Plot: Early-Time Pressure Data (Example 2: Earlougher and Kersch Example)

Legend: Earlougher-Kersch Example
Middle Time Radial Flow Trend

$p_{wf} = 2055.5 - 10 \log(t)$

Semilog Plot (Radial Flow)
Log-Log Plot: Pressure Drop and Pressure Drop Derivative Data (1 inch x 1 inch)
(Example 2: Earlougher and Kersch Example)