Course Introduction
19 January 2007

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Petroleum Engineering 324 — Well Performance
Syllabus and Administrative Procedures
Spring 2007

Instructor(s):

Instructor: Tom Blasingame
Office: RICH 815
Office Hours: If office door is open, instructor is available.
e-mail: t-blasingame@tamu.edu
Phone: +1.979.845.2292

Co-Instructor: Dilhan Ilk
Office: RICH 611
Office Hours: If office door is open, instructor is available.
e-mail: dilhan@tamu.edu
Phone: +1.979.458.1499

Lecture: MWF 08:00-08:50 a.m. RICH 106

Texts: (Can be ordered directly from SPE (you must be an SPE member) — SPE +1.800.456.6863)

Reference Materials:
1. Course materials for this semester are located at:
   http://www.pe.tamu.edu/blasingame/data/P324_07A/
2. An extensive compilation of reference notes, old exams, homeworks, etc. are located at:
   http://www.pe.tamu.edu/blasingame/data/P324_reference/
   Note: The most materials are in given in .pdf files and some of these files are quite large — you should not open these files on the server, but rather, you should DOWNLOAD the .pdf (or other format file(s)) to your local computer.
3. Journal articles (to be made available in electronic formats)
4. Other text materials:

Basis for Grade:
Homework .......................................................................................................................... 30%
Weekly Quizzes .................................................................................................................. 30%
Project(s) ............................................................................................................................. 30%
Class Participation ............................................................................................................. 10%
total = 100%

Grade Cutoffs: (Percentages)
A: < 90    B: 89.99 to 80    C: 79.99 to 70    D: 69.99 to 60   F: < 59.99

Policies and Procedures:
1. Students are expected to attend class every session.
2. Policy on Grading
   a. It shall be the general policy for this course that homework, quizzes, and exams shall be graded on the basis of answers only — partial credit, if given, is given solely at the discretion of the instructor.
   b. All work requiring calculations shall be properly and completely documented for credit.
   c. All grading shall be done by the instructor, or under his direction and supervision, and the decision of the instructor is final.
3. Policy on Regrading
   a. Only in very rare cases will exams be considered for regrading; e.g., when the total number of points deducted is not consistent with the assigned grade. Partial credit (if any) is not subject to appeal.
   b. Work which, while possibly correct, but cannot be followed, will be considered incorrect — and will not be considered for a grade change.
   c. Grades assigned to homework problems will not be considered for regrading.
   d. If regrading is necessary, the student is to submit a letter to the instructor explaining the situation that requires consideration for regrading, the material to be regraded must be attached to this letter. The letter and attached material must be received within one week from the date returned by the instructor.
4. The grade for a late assignment is zero. Homework will be considered late if it is not turned in at the start of class on the due date. If a student comes to class after homework has been turned in and after class has begun, the student's homework will be considered late and given a grade of zero. Late or not, all assignments must be turned in. A course grade of Incomplete will be given if any assignment is missing, and this grade will be changed only after all required work has been submitted.
5. Each student should review the University Regulations concerning attendance, grades, and scholastic dishonesty. In particular, anyone caught cheating on an examination or collaborating on an assignment where collaboration is not specifically authorized by the instructor will be removed from the class roster and given an F (failure grade) in the course.
Petroleum Engineering 324 — Well Performance
Course Syllabus, Prerequisites by Topic, and Course Topics
Spring 2007

Course Description

The purpose of this course is to provide the student with a working knowledge of the current methodologies used in well testing—including, but not limited to, single and multi-rate testing, single and multiwell testing, homogeneous and heterogeneous reservoirs, infinite and finite-acting reservoir behavior.

Specific topics to be studied include: steady-state and pseudosteady-state flow behavior, derivation of the diffusivity equation; solution of the diffusivity equation; analysis of pressure drawdown and buildup tests; wellbore storage and skin effects; behavior of vertically fractured wells; behavior of dual porosity reservoir systems; analysis of production performance; rate forecasting using semi-analytical; empirical; and IPR methods; deliverability testing.

Prerequisites by Topic: Differential and integral calculus, Ordinary and partial differential equations, Thermodynamics, Fluid dynamics and heat transfer, Reservoir fluid properties, and Reservoir petrophysics.

Course Topics (see reference notes and lecture materials on the website)

Module 1: Introductory Materials

- Course Introduction/Review of Syllabus
- Objectives of well testing: Review of petrophysics, review of fluid properties, reservoir models (and properties that can be obtained)
- Orientation—plots used in well testing (Cartesian, semilog, and log-log plots)

Module 2: Fundamentals of Flow in Porous Media

- Material balance concepts: Undersaturated and solution gas drive oil cases, and dry gas/abnormally-pressured gas reservoir cases.
- Steady-state flow concepts: (w/pressure distributions for linear and radial systems)
  - Liquid systems (pressure case)
  - Gas systems (pseudopressure and pressure-squared cases)
  - Development of the radial flow skin factor
- Pseudosteady-state flow concepts: (w/pressure distributions for radial systems)
  - Derivation of \((p-p_{wf}), (p - p_r), \text{ and } (p - p(r(t)))\) relations
  - Example applications, analysis of boundary-dominated flow data
- Development of the diffusivity equation for the "slightly compressible liquid" and "real gas" cases

Module 3: Solutions/Models for Well Test Analysis

- Transient flow concepts:
  - \(E_1(x)\) and log approximation solutions (and various permutations)
  - Illustration of pressure distributions in linear and radial flow systems
- Flow Solutions: (basic relations — dimensionless and field unit formulations)
  - Dimensionless variables—radial flow diffusivity equation
  - Solution of the radial flow diffusivity equation (various cases)
  - Variable-rate convolution: (superposition)
  - Wellbore phenomena: Well completions (as these pertain to well testing) and wellbore storage models and analysis of data

Module 4: Well Test Analysis

- Conventional* analysis of well test data (single and multi-rate pressure drawdown and buildup tests)
- Type curve analysis of well test data:
  - Radial flow case:
    - Wellbore storage and skin case: "Bourdet-Gringarten" type curve
    - Faulted reservoir case: "Stewart" type curve
    - Radial composite reservoir case: "Tang and Brigham" type curve
    - Vertically fractured well case: "Economides" type curve
    - Dual porosity reservoir case: "Onur-Satman-Reynolds" type curve
    - Analysis of gas well tests
- Design of well tests and software for the analysis and interpretation of well test data

Module 5: Analysis and Modelling of Production Data (In preparation)

- Analysis of production data: ("decline" curve analysis)
  - Data acquisition, cataloging, and retrieval
  - Empirical analysis of production data: Arps' equations, other models
  - Fetkovich-McCray decline type curve analysis
- Rate forecasting: Semi-analytical methods and inflow performance relations (IPR)
- Deliverability testing: Simplified 4-point testing and isochronal testing
- Software for the analysis and interpretation of production data
Course Objectives

The student should be able to:

- Describe the concepts of porosity and permeability and be able to relate their respective influences on fluid flow in porous media.
- Estimate oil, gas, and water properties pertinent for well test or production data analysis using industry accepted correlations and/or laboratory data.
- Sketch pressure versus time trends and pressure versus distance trends for a reservoir system which exhibits transient, pseudosteady-state, and steady-state flow behavior.
- Derive the material balance relation for a slightly compressible liquid (oil) in the presence of other phases (gas and water), as well as the material balance relation for a dry gas.
- Derive the steady-state flow equations for horizontal linear and radial flow of liquids and gases, including the pseudopressure and pressure-squared formulations.
- Develop and apply relations for pseudosteady-state flow in closed black oil or dry gas reservoir systems.
- Derive the "skin factor" variable from the steady-state flow equation and be able to describe the conditions of damage and stimulation using this skin factor.
- Derive and manipulate the diffusivity equations for the radial and linear flow of single and multiphase fluids (liquids and gases) through porous media.
- Define and use dimensionless variables and dimensionless solutions to illustrate the generic performance of a particular reservoir model. Given a particular set of parameters for a specified reservoir model, the student should be able to use dimensionless solutions to predict the performance of the specified reservoir system.
- Derive the analysis and interpretation methodologies (i.e., "conventional" plots and type curve analysis) for pressure drawdown and pressure buildup tests, for liquid, gas, and multiphase flow systems.
- Apply dimensionless solutions ("type curves") and field variable solutions ("specialized plots") for the following cases:
  - Unfractured and fractured wells in infinite and finite-acting, homogeneous and dual porosity reservoirs, for constant rate and constant pressure cases.
  - Variable-rate convolution and multi-well superposition.
- Define and apply the pseudopressure and pseudotime concepts for the analysis of well test and production data from dry gas and solution-gas drive oil reservoir systems.
- Design and implement a well test sequence, as well as a long-term production/injection surveillance program.
- Analyze production data (rate-time or pressure-rate-time data) to obtain reservoir volume and estimates of reservoir properties for gas and liquid reservoir systems. The student should also be able to make performance forecasts for such systems.
- Analyze and interpret flow-after-flow (4-point) and isochronal flow tests.
- Demonstrate the capability to integrate, analyze, and interpret well test and production data to characterize a reservoir in terms of reservoir properties and performance potential (field study project).

In addition to the specific objectives given above, the student should also be able to use modern, industry-accepted software for the analysis of well test and production data — in addition to being able to perform such analyses using "hand" (or computer-aided) calculations.
Please provide a self-evaluation of the course competencies by addressing the questions given below.

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<thead>
<tr>
<th>Competency</th>
<th>Not At All</th>
<th>Not Well</th>
<th>Adequate</th>
<th>Well with Effort</th>
<th>Easily</th>
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<tbody>
<tr>
<td>1. I can explain the relationships between porosity and permeability, and how these properties influence the flow of fluids in reservoir rocks.</td>
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<td>2. I can use correlations and laboratory data to estimate the properties of reservoir fluids which are relevant for reservoir engineering - analysis and modeling.</td>
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<td>3. I can sketch a plot of pressure versus logarithm of radius and identify the primary flow regimes (i.e., transient radial flow, pseudosteady-state flow, and steady-state flow behavior).</td>
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<td>4. I can derive and apply the material balance relation for a slightly compressible liquid (oil) system and the material balance relation for a dry gas system.</td>
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<td>5. I can derive and apply the steady-state flow equations for horizontal linear and radial flow of liquids and gases, including the pseudopressure and pressure-squared forms.</td>
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<tr>
<td>6. I can derive and apply the pseudosteady-state flow equations for the <em>black oil</em> and <em>dry gas</em> reservoir systems (<em>black oil</em> - pressure form, <em>dry gas</em> - pseudopressure form).</td>
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<td>7. I can derive and apply the <em>skin factor</em> concept derived from steady-state flow to represent damage or stimulation (including the apparent wellbore radius concept).</td>
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<td>8. I am familiar with and can derive the <em>diffusivity</em> equations for liquids and gases — and I am aware of the assumptions, limitations, and applications of these relations.</td>
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<td>9. I am familiar with and can use of dimensionless variables and dimensionless solutions to provide a generic mathematical representation for a particular reservoir model.</td>
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<td>10. I am familiar with and can use the concept of temporal (time) and spatial superposition - time superposition is used for variable rate/pressure problems; spatial superposition is used to generate reservoir boundary configurations (faults, closed boundaries, etc.).</td>
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<td>11. Well Test Analysis — Conventional Plots: For well test data, I can construct, interpret, and analyze &quot;conventional plots&quot; as follows:</td>
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<td>a. Pressure versus time to establish the parameters related to wellbore storage (domination) behavior (i.e., the &quot;early time&quot; plot).</td>
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<td>b. Pressure versus the logarithm of time (pressure drawdown case) or versus the logarithm of superposition time (e.g., <em>Horner Time</em> for the pressure buildup case) to establish the parameters related to radial flow behavior (i.e., the &quot;scaling&quot; plot).</td>
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<td>c. The logarithm of pressure drop and pressure drop derivative versus the logarithm of time (or an appropriate superposition time function) to establish the parameters for wellbore storage, radial flow, and vertical fracture behavior (i.e., the &quot;log-log&quot; plot).</td>
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<td>12. Well Test Analysis — Type Curve/Model-Based Analysis: For well test data, I can use a static type curve solution or a graphical model presentation from a software package to analyze well test data obtained from:</td>
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<td>a. An unfractured well which includes wellbore storage distortion and radial flow behavior (including damage/stimulation (i.e., skin effects)).</td>
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<td>b. A vertically fractured well (finite or infinite fracture conductivity cases) which includes wellbore storage distortion, fracture flow regimes, and radial flow behavior.</td>
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<td>c. A well test performed in a reservoir with closed boundaries or sealing faults.</td>
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<td>d. A well test performed in a &quot;dual porosity&quot; or &quot;naturally fractured&quot; reservoir system.</td>
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<td>13. Production Data Analysis: I can analyze, interpret, model, and forecast well production performance as follows:</td>
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<td>a. Estimate the &quot;absolute open flow&quot; from a gas well <em>&quot;deliverability&quot; test</em>.</td>
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<td>b. Develop and use an Inflow Performance Relation (IPR) which uses flowrate, wellbore pressure, and aver-age reservoir pressure data to create an interpretative/predictive relation.</td>
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<td>c. Estimate the &quot;reserves&quot; for an oil or gas well using plots of rate versus time (semilog rate format) and rate versus cumulative production.</td>
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<td>d. Use decline type curves (or an equivalent software-based tool) to analyze production data from an unfractured or hydraulically fractured oil or gas well.</td>
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<td>e. Provide a forecast of future rate or pressure performance of an oil or gas well using empirical methods (hand/software) and analytical/numerical models (software).</td>
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### Petroleum Engineering 324 — Well Performance
#### Course Outline
Spring 2007 (Spring Break: 12-16 March 2007)

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Reading — &quot;Old Notes&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module 1: Introductory Materials</strong></td>
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<tr>
<td>January 15</td>
<td>M University Holiday</td>
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<tr>
<td>17</td>
<td>W Course Introduction/Review of Syllabus</td>
<td>Mod1_01, Mod1_02, Mod1_03</td>
</tr>
<tr>
<td>19</td>
<td>F Objectives of Well Tests — Review of petrophysics/Review of fluid properties</td>
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<tr>
<td>22</td>
<td>M Discussion of reservoir models and properties that can be obtained</td>
<td>Mod1_03</td>
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<tr>
<td>24</td>
<td>W Plots used in well testing (Cartesian, semilog, and log-log plots)</td>
<td>Mod1_03</td>
</tr>
</tbody>
</table>

| **Module 2: Fundamentals of Flow in Porous Media**                                                                       |
| 26         | F Material balance concepts (constant compressibility and dry gas systems)   | Mod2_01                |
| 29         | M Steady-state flow concepts: Liquid and gas systems                     | Mod2_02                |
| 31         | W Steady-state flow concepts: Development of the radial flow skin factor  | Mod2_02                |

**February**

| 02         | F Pseudosteady-state flow concepts: Derivation of \( (p_r-p_w) \), \( (p_r-p_o) \), and \( (p_r-p(t, r)) \) relations | Mod2_03                |
| 05         | M Pseudosteady-state flow concepts: Example applications                | Mod2_03                |
| 07         | W Development of the diffusivity equation: Liquid and gas systems       | Mod2_03                |
| 09         | F Transient flow concepts: \( E_1(x) \) and log approximation solutions, other non-radial solutions, and reservoir pressure distributions (steady-state, pseudosteady-state, and transient radial flow) (text reading) |                        |

| **Module 3: Solutions/Models for Well Test Analysis**                                                                     |
| 12         | M Dimensionless variables — radial flow diffusivity equation           | Mod3_01                |
| 14         | W Solutions of the diffusivity equation (various solutions)            | Mod3_02                |
| 16         | F Solutions of the diffusivity equation (concept of "type curves")    | Mod3_02                |
| 19         | M Variable-rate convolution: General case                               | Mod3_03                |
| 21         | W Wellbore Phenomena: Well completions (as these pertain to well testing) | handouts               |
| 23         | F Wellbore Phenomena: Derivation of wellbore storage models/example analysis applications | Mod3_04                |
| 26         | M Variable-rate convolution: Single-rate pressure drawdown case         | Mod3_03                |

| **Module 4: Well Test Analysis**                                                                                         |
| 28         | W Variable-rate convolution: Single-rate pressure buildup case         | Mod3_03, Mod4_01        |
| March      | 02         | F Well test analysis: Conventional analysis of pressure drawdown/buildup test data | Mod3_03, Mod3_04, Mod4_01 |
| 05         | M Well test analysis: Conventional analysis of pressure drawdown/buildup test data | Mod3_03, Mod3_04, Mod4_01 |
| 07         | W Well test analysis: Conventional analysis of pressure drawdown/buildup test data | Mod3_03, Mod3_04, Mod4_01 |
| 09         | F Well test analysis: Analysis of gas well tests                       | Mod2_05                |

**Spring Break: 12-16 March 2007**

| 19         | M Well test analysis: Analysis of gas well tests                       | Mod2_05                |
| 21         | W Well test analysis: Radial flow case ("Bourdet-Gringarten" type curve) | Mod4_02                |
| 23         | F Well test analysis: Radial flow case (Faulted reservoir case; "Stewart" type curve) | Mod4_03                |
| 26         | M Well test analysis: Radial flow case (Radial composite case; "Tang and Brigham" type curve) | Mod4_03                |
| 28         | W Well test analysis: Fractured wells (dimensionless conductivity and penetration) | Mod4_04                |
| 30         | F Well test analysis: Fractured wells (type curve analysis)             | Mod4_04                |

**April**

| 02         | M Well test analysis: Dual porosity reservoir case (introduction)       | Mod4_05                |
| 04         | W Well test analysis: Dual porosity reservoir case (type curve analysis) | Mod4_05                |
| 06         | F Reading Day (No Classes — Good Friday)                                |                        |
| 09         | M Design of well tests                                                  |                        |
| 11         | W Software for the analysis of well test data                           |                        |
| 13         | F Software for the analysis of well test data                           |                        |

| **Module 5: Analysis and Modelling of Production Data (in preparation)**                                                 |
| 16         | M Analysis of production data: Introduction                            | Mod5_01                |
| 18         | W Analysis of production data: Empirical analysis/forecasting of production data | Mod5_01                |
| 20         | F Analysis of production data: Empirical analysis/forecasting of production data | Mod5_01                |
| 23         | M Analysis of production data: Deliverability testing                   | Mod5_02                |
| 25         | W Analysis of production data: Fetkovich-McCray decline type curve analysis | Mod5_03                |
| 27         | F Analysis of production data: Fetkovich-McCray decline type curve analysis | Mod5_03                |
| 30         | M (dead day) Software for the analysis of production data               |                        |

<p>| <strong>May</strong>     | T (redefined day (&quot;Friday&quot;)) Software for the analysis of production data |                        |
| 04         | F Final Exam/Project Due                                               |                        |</p>
<table>
<thead>
<tr>
<th>Date</th>
<th>&quot;Old Notes*&quot;</th>
<th>Lee Text (Lee)</th>
<th>Lee/Spivey/Rollins text (LSR)</th>
<th>Dake Text (Dake-1)</th>
<th>Dake Text (Dake-2)</th>
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<td>January</td>
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<td>15 M</td>
<td>University Holiday</td>
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<td>17 W</td>
<td>Course Introduction/Review of Syllabus</td>
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<tr>
<td>19 F</td>
<td>Mod1_01, 02, 03</td>
<td>App. D</td>
<td>App. L</td>
<td>Ch. 1, 2</td>
<td>Ch. 1, 2</td>
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<tr>
<td>22 M</td>
<td>Mod1_03</td>
<td>Ch. 1</td>
<td>Ch. 1</td>
<td>Ch. 5, 6</td>
<td>Ch. 2</td>
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<tr>
<td>24 W</td>
<td>Mod1_03</td>
<td>Ch. 1-4</td>
<td>Ch. 1-4</td>
<td>Ch. 7 (and 8)</td>
<td>Ch. 4</td>
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<td>February</td>
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<tr>
<td>26 F</td>
<td>Mod2_01</td>
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<td>Ch. 1, 3</td>
<td>Ch. 3, 6</td>
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<td>29 M</td>
<td>Mod2_02</td>
<td>Ch. 1</td>
<td>Ch. 1</td>
<td>Ch. 4, 5</td>
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<td>31 W</td>
<td>Mod2_02</td>
<td>Ch. 1</td>
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<td>12 M</td>
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<tr>
<td>23 F</td>
<td>handouts</td>
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Petroleum Engineering 324 — Well Performance
Homework Format Guidelines
Spring 2007

Homework Topics: (These are intended topics, addition and/or deletion of certain problems may occur as other problems become available. Multiple assignments from each topic are possible.)

- Petrophysics, fluid properties, and reservoir models.
- Plots used in well testing (Cartesian, semilog, and log-log).
- Material balance concepts.
- Steady-state flow concepts.
- Pseudosteady-state flow concepts.
- Transient flow concepts.
- Wellbore Phenomena: Wellbore storage models.
- Wellbore Phenomena: Calculation of bottomhole pressures.
- Development of the diffusivity equation: liquid and gas systems.
- Variable-rate convolution.
- Analysis and interpretation of oil and gas well test data:
  - Radial flow,
  - Vertically fractured well, and
  - Dual porosity reservoir.
- Analysis and interpretation of oil and gas well production data.
- Well test design.
- Analysis and interpretation of deliverability tests.

Computing Topics: In general, some programming (spreadsheet/Visual Basic) assignments may be required. Students must develop their own codes unless otherwise instructed.

Homework/Project Format Guidelines:

General Instructions:
0. Coversheet: You must use the required coversheet — such a coversheet will be provided by the instructor for EVERY assignment.
1. Paper: You must use engineering analysis paper or lined notebook paper (8.5 inches in width by 11 inches in height).
2. Writing: You are to ONLY write (or print) on the FRONT of any particular page (and you must write as neatly as possible).
3. Numbering: Number the pages of your work in the upper right corner of each page as follows:
4. Binding: Use a SINGLE staple (or binder clip) in the upper left hand corner (do not use a notebook or spiral bind).

Problem #/page #/total pages (for a particular problem)

Homework/Project Format:
1. Given: (Statement of Problem and Problem Data)
2. Required: (Problem Objectives)
3. Solution: (Methodology)
   a. Sketches and Diagrams
   b. Assumptions, Working Hypotheses, References
   c. Formulas and Definitions of Symbols (Including Units)
   d. Calculations (Including Units)
4. Results:
   a. Use properly-scaled plots — the data should be identified with symbols and the model (if used) should be presented using lines.
   b. Do NOT submit numerous pages of data/computer output — a single (example) page is sufficient.
5. Conclusions: Provide a short summary that discusses the problem results.
6. References: Any/all references used in the solution of the problem MUST be cited.
7. Appendices: Data, plots, computer codes, etc. which are not necessary for the body of the submission.

In all of your work, full detail (calculations, data, units, etc.) must be shown for credit — penalties will be assessed for incomplete work.

Instructor Responsibilities

The instructor is responsible for
1. A learning environment where students of all skills levels are appropriately challenged.
2. Showing respect and consideration to the students.
3. Being prepared for class and keeping on schedule with the syllabus.
4. Preparing exercises that follow the course objectives.
5. Covering the material that will be tested on exams.

The instructor is not responsible for
1. Work missed by absent students (unless a University-excused absence is provided to the instructor).
2. Poor performance by unattentive or uninterested students. This is a fundamental course in Reservoir Engineering, one that you will use actively in your career as a reservoir or production engineer.
3. Personal issues — if you have personal issues that impair your performance in this course, you are encouraged to discuss these problems with your instructor for possible remedies. However, the instructor is responsible for assigning your grade based solely on your performance and is not at liberty to allow personal appeals to influence your grade.

Student Responsibilities

The student is responsible for
1. Class attendance. Students should attend all scheduled class meetings.
2. Being prepared for class. In-class quizzes will be given. Always bring your books, course notes, and calculator to each class meeting.
3. Being prepared for exams. The instructor or TA may choose to review materials prior to exams, but do not rely on this review as your only exam preparation — nor should you rely on old exams for your exam preparation. The best preparation for exams is to stay current with the class, rework assignments, and get plenty of rest the night before the exam.
4. Showing respect and consideration to his classmates and the instructor. Do not talk excessively with your neighbors during class. Do not take up class time for discussions with the instructor that should be held outside of class. Students who disrupt the class will be asked to leave.

T.A. Blasingame — Spring 2007
Petroleum Engineering 324 — Well Performance
Assignment Coversheet — Required by University Policy
Spring 2007

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 course work, 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."

_______________________________ (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."
Faculty-Student Contract: (T. Blasingame)

The most important element of your education is your participation. No matter how hard we as faculty try (or don't try) to prepare you to learn, we cannot force you to work. We can only provide examples of how you should perform and we can only evaluate your performance — not your intentions or your personality, nor can we make allowances for your personal problems or your lack of preparation.

We can of course provide some pretty unpleasant alternatives as incentives (e.g., poor grades), but poor grades are a product of only two issues, a lack of subject mastery, or apathy. We as faculty can do much to prepare you for a rewarding career, not only as engineers, but also as productive members of society in whatever capacity you wish to serve. But—we cannot make you care, we cannot make you prepare, and we cannot make you perform — only you can do this.

We have chosen our path in life to help you find yours, we want you to succeed (perhaps sometimes more than you do) and we will do our best to make your education fulfilling and rewarding. As we embark on what will likely be a tedious and challenging experience, we reaffirm our commitment to seeing that you get the most out of your education. When it seems as though we are overbearing taskmasters (and we may well be), remember that we are trying to prepare you for challenges where there is no safety net — and where there may be no second chance.

Our goal is to be your guide — we will treat you with the respect and consideration that you deserve, but you must have the faith to follow, the dedication to prepare, and the determination to succeed — it will be your turn to lead soon enough.

General Procedures for Studying: (Adapted from Arizona State U., 1992)

1. Before each lecture you should read the text carefully, don't just scan topics, but try to resolve sections of the reading into a simple summary of two or three sentences, emphasizing concepts as well as methods.
2. During the lecture take careful notes of what your instructor says and writes, LISTEN to what is being said as well as how it is emphasized. Don't try to be neat, but do try to get every detail you can — think of the lecture as an important story that you will have to tell again later.
3. As soon as possible after the lecture (and certainly the same day), reread the text and your "messy" lecture notes, then rewrite your lecture notes in a clear and neat format — redrawing the figures, filling in missed steps, and reworking examples. You are probably thinking that no one in their right mind would do this—but the secret is that successful students always review and prepare well in advance of exams.
4. Prepare a list of questions or issues that you need clarified, ask your instructor at the start of the next class (so others can benefit) or if you need one-on-one help, see your instructor as soon as possible, do not assume that it will "come to you later."
5. Work one homework problem at a time, without rushing. You are not learning if you are rushing, copying, or scribbling. Spread the problems out in time and write down any questions you have.
6. ASK QUESTIONS. In class, during office hours, ANY chance you get. If you do not understand something you cannot use it to solve problems. It will not come to you by magic. ASK! ASK! ASK!
7. Practice working problems. In addition to assigned problems, work the unassigned ones. Where do you think faculty take exam questions? You should establish a study group and distribute the load — but you should work several of each type of problem that you are assigned.
8. Before a test, you should go over the material covered by preparing an outline of the important material from your notes as well as the text. Then rewrite your outline for the material about which you are not very confident. Review that material, then rewrite the notes for the material about which you are still not confident. Continue until you think that you understand ALL of the material.
9. "Looking over" isn't learning, reading someone else's solution is insufficient to develop your skills, you must prepare in earnest — work lots and lots of problems, old homework, old exams, and study guide questions.
10. Speed on exams is often critical. It is not just a test of what you know, but how well you know it (and how fast you show it). The point is not just to "understand" but to "get it in your bones."
11. Participate in class. The instructor must have feedback to help you. Force the issue if you must, it is your education.
Absence Policy:
Work missed due to absences will only be excused for University-approved activities in accordance with *TEXAS A&M UNIVERSITY STUDENT RULES* (see http://student-rules.tamu.edu/rule7.htm). Specific arrangements for make-up work in such instances will be handled on a case-by-case basis. In accordance with recent changes to Rule 7, please be aware that in this course, any "injury or illness that is too severe or contagious for the student to attend class" will require "a medical confirmation note from his or her medical provider" even if the absence is for less than 3 days (see 7.1.6.2 Injury or illness less than three days.).

Returned Work Protocol:
In this course, student work will be returned to students in a variety of ways:
- By direct return of work from instructor to student.
- By placing papers in a common box(s) located at the instructor's office for students to pick up personally.
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<tr>
<th>Specific Course Objectives</th>
<th>Learning Outcome</th>
<th>Program Outcome</th>
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<tr>
<td>1. Describe the concepts of porosity and permeability and be able to relate their respective influences on fluid flow in porous media.</td>
<td>Describe the relationships of porosity and permeability and explain the influence of each parameter on reservoir flow behavior.</td>
<td>17. Competency in characterization and evaluation of subsurface geological formations and their resources using geoscientific and engineering methods.</td>
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<td>2. Estimate oil, gas, and water properties pertinent for well test or production data analysis using industry accepted correlations and/or laboratory data.</td>
<td>Demonstrate the ability to estimate/calculate and plot the various fluid property variables as functions of pressure. Also demonstrate an understanding of laboratory data.</td>
<td>15. Competency in mathematics through differential equations, probability and statistics, fluid mechanics, strength of materials, and thermodynamics.</td>
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<td>3. Sketch pressure—time and pressure—distance trends for a reservoir system which exhibits transient, pseudosteady-state, and steady-state flow behavior.</td>
<td>Demonstrate via hand and/or computer plots (as appropriate) the graphical relations for pressure, distance, and time — for the prescribed flow regimes.</td>
<td>11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.</td>
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<td>4. Derive the material balance relations for a slightly compressible liquid (oil), as well as the material balance relations for a dry gas.</td>
<td>Demonstrate the derivation and application of the common material balance relations. Demonstrate use of field data.</td>
<td>19. Competency in application of reservoir engineering principles and practices for optimizing resource development and management.</td>
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<tr>
<td>5. Derive the steady-state flow equations for horizontal linear and radial flow of liquids and gases (including the pseudopressure and pressure-squared forms).</td>
<td>Demonstrate the derivation and application of the prescribed relations. Describe the applicability of each solution, and explain the influence of ‘non-Darcy effects.</td>
<td>15. Competency in mathematics through differential equations, probability and statistics, fluid mechanics, strength of materials, and thermodynamics.</td>
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<td>6. Develop and apply relations for pseudosteady-state flow in a black oil or dry gas reservoir system.</td>
<td>Demonstrate the derivation, application, and interpretation of pseudosteady-state flow relations — black oil and dry gas systems.</td>
<td>19. Competency in application of reservoir engineering principles and practices for optimizing resource development and management.</td>
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<td>7. Derive the &quot;skin factor&quot; variable from the steady-state flow equation and be able to describe the conditions of damage and stimulation using this skin factor.</td>
<td>Demonstrate the calculation of the skin factor using the steady-state flow model. Explain extensions of the general &quot;skin factor&quot; concept for transient radial flow behavior.</td>
<td>16. Competency in design and analysis of well systems and procedures for drilling and completing wells.</td>
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<tr>
<td>8. Develop and apply inflow performance relations (IPRs) for black-oil and gas condensate reservoir systems.</td>
<td>Demonstrate the derivation/development and application of IPR functions. Estimate/predict the flowrate at some future time.</td>
<td>16. Competency in design and analysis of well systems and procedures for drilling and completing wells.</td>
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<tr>
<td>9. Derive and manipulate the diffusivity equations for the radial and linear flow of single and multiphase fluids (liquids and gases) through porous media.</td>
<td>Demonstrate an understanding of the basic relations for mass continuity and motion — derive the diffusivity relations for the liquid and dry gas cases (all details).</td>
<td>15. Competency in mathematics through differential equations, probability and statistics, fluid mechanics, strength of materials, and thermodynamics.</td>
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<td>10. Define and use dimensionless variables and dimensionless solutions to illustrate and/or predict the generic performance of a particular reservoir model.</td>
<td>Explain the rationale for using dimensionless variables and demonstrate the derivation of dimensionless variables for the transient radial flow case.</td>
<td>5. An ability to identify, formulate, and solve engineering problems.</td>
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<td>11. Develop the analysis and interpretation methodologies (i.e., &quot;conventional&quot; plots and type curve analysis) for pressure tests (for oil, gas, and multiphase flow).</td>
<td>Demonstrate the development, construction, and application of specialized Cartesian, semi-log, and log-log plots used for &quot;conventional&quot; well test analysis.</td>
<td>19. Competency in application of reservoir engineering principles and practices for optimizing resource development and management.</td>
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<td>12. Apply dimensionless solutions (&quot;type curves&quot;) and field variable solutions (&quot;specialized plots&quot;) for constant rate behavior in an infinite-acting homogeneous reservoir</td>
<td>Demonstrate the construction and application or &quot;type curves&quot; (dimensionless solutions) for the analysis of pressure transient test data (log-log plot format)</td>
<td>19. Competency in application of reservoir engineering principles and practices for optimizing resource development and management.</td>
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<td>13. Define and apply the pseudopressure and pseudotime concepts for the analysis of well test and production data from dry gas and solution-gas drive oil reservoir systems.</td>
<td>Demonstrate the appropriate use of the pseudopressure and pseudotime transformations for analysis of well test and production data. The gas case must be demonstrated via analysis of field data.</td>
<td>15. Competency in mathematics through differential equations, probability and statistics, fluid mechanics, strength of materials, and thermodynamics.</td>
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<td>14. Design and implement a well test sequence, as well as a long-term production/injection surveillance program.</td>
<td>Demonstrate the proper design of a well test sequence using currently accepted practices and equipment.</td>
<td>2. An ability to design and conduct experiments, as well as to analyze and interpret data.</td>
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<td>15. Analyze production data to obtain reservoir volume and estimates of reservoir properties — the student should also be able to make performance forecasts.</td>
<td>Demonstrate the estimation of reservoir properties using &quot;decline curve&quot; techniques — and be able to estimate/extrapolate future performance using simplified rate models.</td>
<td>19. Competency in application of reservoir engineering principles and practices for optimizing resource development and management.</td>
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<td>16. Analyze and interpret deliverability test data.</td>
<td>Demonstrate the analysis of &quot;4-point&quot; and &quot;isochronal&quot; production test data using current techniques.</td>
<td>16. Competency in design and analysis of well systems and procedures for drilling and completing wells.</td>
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<td>17. Demonstrate the capability to integrate, analyze, and interpret well test and productivity data to characterize a reservoir in terms of reservoir properties and performance potential (field study project).</td>
<td>Provide an example case of a &quot;performance-based reservoir characterization&quot; specifically the integration of well performance, well completion, geological, and petrophysical data.</td>
<td>21. An ability to deal with the high level of uncertainty in petroleum reservoir problems in problem definition and solution.</td>
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