Help/Work Sessions: As necessary, likely to be in the evenings.

Texts: (Available at MSC Bookstore, can also be ordered directly from SPE (probably at reduced rates), you must be an SPE member — SPE (800) 456-6863)


Reference Materials:

1. Reference materials (notes, papers, some text materials, homework, etc.) will be located at:

   [http://pumpjack.tamu.edu/~t-blasingame/P613_02A/](http://pumpjack.tamu.edu/~t-blasingame/P613_02A/)

   Note: Most reference notes will be in .pdf files and some of these files may be quite large — you should not open these files on the server, but rather, you should **DOWNLOAD** the .pdf to your local computer (or Zip disk) and open the file there.

2. Other text/reference materials will be given out as needed — either in paper or electronic form.

Basis for Grade:

- **Homework/Projects** ................................................................. 90%
- **Class Participation** ................................................................. 10%

**total = 100%**

(Participation is defined as: attendance, promptness to class, preparedness for class, participation in class discussions. Grade is subjective; decision of instructor is final.)

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. **Always** bring your textbook, notes, homework problems, and calculator to class.

3. Homework and other assignments will be given at the lecture session. All work shall be done in an acceptable engineering manner; work done shall be as complete as possible. Assignments are due as stated. **Late assignments will receive a grade of zero.**

4. Policy on Grading
   - a. It shall be the general policy for this class that homework 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 will be done by the instructor, or under his direction and supervision, and the decision of the instructor is final.
5. 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 correct, 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 and 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.

6. 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.

7. 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 allowed will be removed from the class roster and given an "F" (failure grade) in the course.
Course Description

**Graduate Catalog:** Flow of natural gas in reservoirs and in wellbores and gathering systems; deliverability testing; production forecasting and decline curves; flow measurement and compressor sizing.

**Translation:** From the reservoir through the sales line—we will try to study every aspect of natural gas systems. PVT properties, flow in porous media, flow in pipes and thermodynamic properties will be studied. We will use the Lee and Wattenbarger and the ERCB texts as guides — as well as numerous technical papers that go into much more depth of detail for a particular problem. We will focus on well testing, deliverability analysis, and decline curve analysis, as well as wellbore flow phenomena.

Prerequisites by Topic

- Differential and integral calculus
- Ordinary and partial differential equations
- Thermodynamics
- Fluid dynamics and heat transfer
- Reservoir fluid properties
- Reservoir petrophysics

Course Objectives

The student should be able to:

- Estimate oil, gas, and water properties pertinent for well test or production data analysis using industry accepted correlations and laboratory data.
- Sketch pressure versus time trends and pressure versus distance trends for a reservoir system exhibiting transient, pseudosteady-state, and steady-state flow behavior.
- Derive the steady-state and pseudosteady-state relations for gas flow (including rigorous and semianalytical relations for boundary-dominated flow behavior). In addition, the student must be able to derive, in complete detail, the pressure, pressure-squared, and pseudopressure forms of the diffusivity equation for a real gas.
- Derive the material balance equations for a volumetric dry gas reservoir, an "abnormally-pressured" gas reservoir, and a water-drive gas reservoir. The student should also be familiar with the generalized (i.e., compositional form) of the material balance equation for a gas condensate reservoir.
- Derive and apply the conventional relations used to calculate the static and flowing bottomhole pressures for the case of a dry gas. The student should also be familiar with proposed techniques for wet gases.
- Derive/present models for wellbore storage and phase redistribution (gas 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. The student should also be familiar with models for "variable" skin effects due to non-Darcy flow, well cleanup, and gas condensate banking (radial composite model).
- Analyze and interpret flow-after-flow (4-point) and isochronal flow tests.
- Derive the analysis and interpretation methodologies (i.e., "conventional" plots and type curve analysis) for pressure drawdown and pressure buildup tests (liquid or gas reservoir systems). Also, be able to apply dimensionless solutions ("type curves") and field variable solutions ("specialized plots") for the analysis and interpretation of well test data.
- Design and implement a well test sequence, as well as a long-term production/injection surveillance program. This includes the design of single and multipoint deliverability tests.
- 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 be able to use "decline curves," "decline type curves," and other techniques of analysis for production data.
- The student should be familiar with the reservoir engineering tools used to analyze/interpret the performance of the following gas reservoir types:
  - Gas condensate reservoir systems
  - Low permeability/unconventional reservoirs
  - Low pressure gas reservoirs
<table>
<thead>
<tr>
<th>Date</th>
<th>Reading</th>
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<tbody>
<tr>
<td>Module 1: Introductory Concepts</td>
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<tr>
<td>January</td>
<td></td>
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<tr>
<td>15 T</td>
<td>Course introduction/Review of syllabus</td>
<td>Syllabus</td>
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<tr>
<td>17 R</td>
<td>Introduction: historical perspectives, types of tests, etc.</td>
<td>ERCB Ch. 1</td>
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<td>22 T</td>
<td>Reservoir performance behavior (introduction)</td>
<td>ERCB Ch. 2, LW Ch. 5</td>
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<td>24 R</td>
<td>Properties of reservoir fluids</td>
<td>ERCB App. A, LW Ch. 1, Hnd</td>
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<td>29 T</td>
<td>Fundamentals of fluid flow in porous media (general)</td>
<td>ERCB Ch. 2, LW Ch. 5, Hnd</td>
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<tr>
<td>31 R</td>
<td>Fundamentals of fluid flow in porous media (gas)</td>
<td>ERCB Ch. 2, LW Ch. 5, Hnd</td>
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<td>Module 2: Gas Material Balance and Boundary Dominated Flow Behavior</td>
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<td>February</td>
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<td>5 T</td>
<td>Gas material balance (simple case)</td>
<td>LW Ch. 10, Hnd</td>
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<td>7 R</td>
<td>Gas material balance (&quot;abnormal&quot; pressure case)</td>
<td>LW Ch. 10, Hnd</td>
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<td>12 T</td>
<td>Gas material balance (water influx case)</td>
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<td>14 T</td>
<td>IPR concepts for gas wells</td>
<td>ERCB Ch. 3, LW Ch. 4, Hnd</td>
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<td>19 R</td>
<td>Semi-analytical performance equation ($q(t)$ vs. $t$) for gas wells</td>
<td>Hnd</td>
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<td>Module 3: Wellbore Phenomena and Near-Well Reservoir Behavior</td>
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<td>21 R</td>
<td>Wellbore phenomena: Calc. of static/flowing bottomhole pressures (gas)</td>
<td>ERCB App. B, LW Ch. 4, Hnd</td>
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<td>26 T</td>
<td>Wellbore phenomena: Wellbore storage/phase redistribution models (gas)</td>
<td>LW Ch. 5, Hnd</td>
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<td>28 R</td>
<td>Near-well impediments to flow — the skin factor and condensate banking</td>
<td>ERCB Ch. 2, LW Ch. 5, Hnd</td>
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<td>Module 4: Gas Well Testing</td>
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<td>March</td>
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<td>5 T</td>
<td>Deliverability testing of gas wells (Introduction)</td>
<td>Hnd (Rawlins/Schellhardt)</td>
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<tr>
<td>7 R</td>
<td>Deliverability testing of gas wells (Introduction)</td>
<td>ERCB Ch. 3, LW Ch. 7, Hnd</td>
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<tr>
<td>19 T</td>
<td>Well test analysis: Fundamentals (solutions, plots, simple analysis, etc.)</td>
<td>ERCB Ch. 4-5, LW Ch. 6</td>
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<tr>
<td>21 R</td>
<td>Well test analysis: Type curve analysis</td>
<td>ERCB Ch. 7, LW Ch. 6, Hnd</td>
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<td>26 T</td>
<td>Well test analysis: Well test design</td>
<td>ERCB Ch. 4-5, LW Ch. 8, Hnd</td>
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<td>Module 5: Analysis of Production Data</td>
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<td>April</td>
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<td>2 T</td>
<td>Analysis of production data: Data acquisition, cataloging, and retrieval</td>
<td>LW Ch. 9, Hnd</td>
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<td>4 R</td>
<td>Analysis of production data: EUR analysis</td>
<td>Hnd</td>
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<tr>
<td>9 T</td>
<td>Analysis of production data: Decline type curve analysis</td>
<td>LW Ch. 9, Hnd</td>
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<tr>
<td>11 R</td>
<td>Analysis of production data: Decline type curve analysis</td>
<td>Hnd</td>
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<td>Module 6: Special Topics in Gas Reservoir Engineering</td>
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<tr>
<td>16 T</td>
<td>Performance of gas condensate reservoir systems</td>
<td>handouts (Hnd)</td>
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<tr>
<td>18 R</td>
<td>Low permeability/unconventional reservoirs</td>
<td>handouts (Hnd)</td>
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<tr>
<td>23 T</td>
<td>Low pressure gas reservoirs</td>
<td>handouts (Hnd)</td>
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<tr>
<td>25 R</td>
<td>Special topics (or Course Review)</td>
<td>handouts (Hnd)</td>
</tr>
<tr>
<td>30 T</td>
<td>&quot;Dead Day&quot; (actually a &quot;Monday,&quot; but we may use it as a wrap-up day)</td>
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<tr>
<td>May</td>
<td>3 F Final Exam* RICH 301 from 3:00-5:00 p.m. (TR 11:10 a.m. - 12:25 p.m.)</td>
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* Due date for the Field Study Project if this is used in lieu of the Final Examination.
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.)

- Reservoir fluids — analysis/prediction of phase behavior
- Gas material balance
- IPR and other solutions for boundary dominated flow behavior
- Calculation of bottomhole pressures (gas case)
- Wellbore storage/phase redistribution models (gas)
- Skin factor/impediments to flow
- Deliverability testing (single point, multipoint, and isochronal tests)
- Analysis and interpretation of gas well test data
- Well test design
- Analysis and interpretation of gas well production data
- Special topics
  - Gas condensate reservoir systems
  - Low permeability/unconventional reservoirs
  - Low pressure gas reservoirs

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

Homework Format Guidelines:

I. General Instructions: You must use engineering analysis paper or lined notebook paper, and this paper must measure 8.5 inches in width by 11 inches in height

1. You must only write on the front of the page.
2. Number all pages in the upper right-hand corner and staple all pages together in the upper left hand corner. You must also put your name (or initials) in the upper right corner of each page next to the page number (e.g. John David Doe (JDD) page 4/6).
3. Fold inward lengthwise.
4. Place the following identification on the outside:
   Name: (printed)
   Course: Petroleum Engineering 613/Spring 2002
   Date: 25 January 2002
   Assignment: (Specific)

II. Outline of Homework Format

1. Given: (Data Base)
2. Required: (Problem Objectives)
3. Solution: (Methodology)
   A. Sketches and Diagrams
   B. Assumption, Working Hypotheses, References
   C. Formulas and Definitions of Symbols (Including Units)
   D. Calculations (Including Units)
4. Results
5. Conclusions: Provide a short summary that discusses the problem results.
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. Only students with university excused absences may ask for help from the instructor or teaching assistant (TA). Students with unexcused absences are on their own.
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. If you choose not to participate in your education, do not expect others to care.
3. Personal problems, a lack of motivation, anguish caused by too much TV or too many hangovers. If you have problems 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/major projects. 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.
Faculty-Student Contract:
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 by seeing it 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.